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Software Requirements for the A-7E Aircraft

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The Software Cost Reduction (SCR) research project introduced a new approach to specifying requirements for real-time embedded systems. The principles were applied in the development of the *Software Requirements of the A-7E Aircraft*, as an example of the use of the approach.

The system software requirements specification document comprises the first product in a series of products which the SCR methodology produces. The methodology is intended to be adaptable for various types of systems.

Specification properties which it supports include: (1) conciseness, (2) preciseness, (3) aids to completeness, (4) avoidance of redundancy, (5) descriptions of all externally visible behavior, (6) ease of change, (7) good reference tool, (8) record of fundamental assumptions which might otherwise be only implicit, (9) record of responses to error conditions, (10) specification of constraints on the system, and (11) separation of concerns; that is, a division of the information into distinct, independent parts.

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Preface

This document is the second published release of the *Software Requirements of the A-7E Aircraft* [ref NRL Memorandum Report 3876]. The first release, published in November 1978, introduced a new approach to specifying requirements for real-time embedded systems in the form of an engineering model. That document has been perhaps the most successful of the publications of NRL's Software Cost Reduction project in terms of the interest generated and the number of copies requested since its introduction.

In spite of its success (in a sense, because of it) the specification has changed in many details over the years. This is not the result of flaws in its design, but the fulfillment of its creators' vision that the requirements should be a "living document;" i.e., that it would serve as the primary reference document for system designers, as well as the authoritative "test to" document for program validation, and be useful throughout the system development process. Because the document has served these purposes as well, it has changed over the years as requirements became better understood. Further, since the document is intended to serve as a model document, we have felt free to change it as better specifications techniques have been developed. This release represents the accumulation of those changes from the original publication in November 1978 to the end of the SCR project in December 1988.

In spite of many changes in its particulars, the reader will find the document remarkably unchanged in its overall structure and approach. One of the principles guiding the original design was that because requirements change, the requirements specification should be easy to change. As a result, incremental changes and improvements have been easy to accommodate over the years without disrupting the essential document structure.[Chmu82]

This remainder of this preface gives a brief overview of the software requirements specification methodology developed as part of the Software Cost Reduction (SCR) project at the Naval Research Laboratory. A good description of the role of requirements specification in the development process is given in [Heni80] and [Hest81].

PROCESS

In the SCR methodology, the first product of the software development process is the the system software requirements specification document. Initially, the requirements document provides a skeleton framework of sections and templates. Filling in the framework requires answering increasingly detailed questions regarding system requirements. At any point in the process, gaps in information indicate unresolved issues.

Since different types of systems have different characteristics, no single rigid framework or set of techniques will yield the best specification for all aspects of all systems. Rather than attempting to fit all specifications to a single mold, the SCR approach defines (1) a set of objectives that the specification must meet and (2) a set of principles to guide choices among possible specification techniques.

SPECIFICATION PROPERTIES

The primary objective is to provide a complete specification of required system behavior. In its final form the specification, and any documents to which it refers, should contain all of the information necessary to build an acceptable software system. All significant externally visible behavior of the software should be constrained to acceptable alternatives in the requirements document. Other objectives for the requirements documentation are:

(1) *Specify external behavior only:* The purpose of the document is to state only what behavior the system must have; it should not imply a particular implementation or constrain the set of implementations unnecessarily.

(2) *Be easy to change*: Software requirements can be expected to change both during development and as the system evolves into subsequent versions. The requirements document should be easy to change.

(3) *Serve as a reference tool*: The primary purpose of the document is to answer specific questions quickly and easily. It should be obvious where to put or find a given piece of information. It should be obvious where information is missing or incomplete.

(4) *Record forethought about the system life cycle*: We assume that system software should be designed for ease of subsetting and ease of change. Design for either requires forethought. The requirements should record (1) fundamental assumptions, characteristics of the system that are not expected to change, (2) changes anticipated or planned for subsequent releases, and (3) required subsets, subsets of the system functions that are expected to be useful for development, early release, or subsequent versions.

(5) *Specify responses to undesired events*: The systems response to undesired events such as hardware failure or user errors should be specified as part of the requirements and not left to the possibly arbitrary discretion of system implementors.

(6) *Specify constraints on implementation*: The requirements must specify any constraints on the set of possible implementations. For instance, the design may be constrained by the need to interface with specific hardware, meet certain timing and accuracy requirements, or even to use a particular algorithm or language.

In summary, the objective for producing the software requirements document is to produce a yardstick by which the acceptability of the delivered system may be judged. If the software meets all the constraints (behavioral and otherwise) imposed by the document, then it shall be considered acceptable *by definition*. Conversely, constraints not included in the requirements document shall not be considered to apply to the builders.

DOCUMENT DESIGN PRINCIPLES

Guiding principles allow one to make rational choices between alternative design possibilities. The primary guiding principles for the SCR requirements specification are:

(1) *Separation of concerns*: The ability to maintain intellectual control over a system depends on the number of details that must be considered at any one time[Mill80]. The principle of separation of concerns dictates that information be divided into clearly distinct and relatively independent parts. The division into distinct, identifiable parts make it easy to determine where a given piece of information belongs. If the parts are relatively independent they can be studied or changed independently.

(2) *Be as formal as possible*: Where possible, prose is avoided in favor of formal methods. Formal methods are more likely to be precise, concise, consistent, and complete. Examples include mathematical expressions, state transition tables, or other graphical representations with rigidly defined semantics.

(3) *Avoid redundancy*: Requirements should be stated only once. Where there is redundant information, the document is more difficult to change since the document must be changed in more than one place; failure to find all instances of redundant information leads to ambiguities. "Explanatory" material that repeats information included elsewhere in the specification belongs in a separate section or should be clearly labeled as not specifying a requirement.

These principles have been applied to the specification of the Navy A-7E avionics system. The following section gives a brief overview of the techniques used in that specification.

SUMMARY DESCRIPTION OF THE METHOD

In the NRL method, the externally visible behavior of the software is described in the form of "a set of functions associated with output data items." A *data item* is associated with each input or output of the software that can change value independently of the others. For instance, an input data item might be the barometric altitude or the setting of a cockpit switch; an output data item might denote a signal that turns a light on or off in the cockpit, or positions a symbol on a display. For each data item, a template gives the information necessary to write software that can read the inputs and write the outputs. For example, template entries for input data items include a description of the physical quantity or state that it represents, its range, resolution, how fast it can change, its accuracy, and its hardware representation. The set of templates for all the data items taken as a collection constitute a definition of the interface to the embedding hardware with which the software interacts.

Associated with each output data item is a function. Each function determines the possible values for one or more output data items. The possible values for a given output data item are determined by exactly one function.

Rather than describing output values as mathematical functions of the input values, the values are specified as functions of the external environment. For instance, in the specifications for the A-7E avionics system. conditions describe aircraft operating conditions such as the aircraft being at an altitude of 30,000 feet or having an airspeed of 500 knots. To describe the outputs in terms of external values, a language of *conditions* and *events* is created. A condition is defined to be a predicate that characterizes some aspect of the system for a measurable period of time. For instance, "barometric altitude > 5,000 feet" might be a condition. An event refers to a moment in time and is said to occur when the value of a condition changes from true to false or vice versa. Output functions are then written in terms of conditions and events. A consistent notation for expressing predicates concerning external conditions is developed as well.

By separating concerns, this approach simplifies the specification and avoids overspecifying the system. Concern for the output value produced is separated from concern for which inputs will be used by the code to produce that value. Inputs are considered only a means for obtaining the necessary values. This avoids overspecifying software because one need not dictate the choice between alternative sources of a value where more than one is available and because no particular sequence of transformations from input to an output need be specified.

The output functions are simplified by writing them in terms of system *modes*. Often a function describing an output data item will be affected by several external conditions. Describing the output value for all possible cases will require lengthy and complicated Boolean expressions of the condition values to adequately characterize the relevant system states. To keep the output value function descriptions simple the notion of a *mode* is introduced. A mode corresponds to a subset of the possible system states. Instead of giving the output value functions solely in terms of conditions, they are defined in terms of modes as well.

Since a mode describes the states of many conditions, the function descriptions are simpler in terms of modes than in terms of conditions alone. A separate section of the document describes the relationship between the modes and the condition values. This section describes the system modes by specifying the events that cause transition between system modes. A *mode class* is described as a set of modes between which transitions may occur. The set of modes in a mode class completely and uniquely partitions the system state space. The abstract model for a mode class is a finite state machine for which events are "input" and modes are machine states.

The technique of writing system output functions in terms of modes simplifies the specification and makes state information manageable by separating concerns. Concern for the details of exactly which conditions determine a particular system state is separated from concern for the system behavior in that state. Details of the relationship between conditions and system states are encapsulated in the specifications of the system modes.

The "heart" of the document consists of the data item templates, the output functions, and the mode definitions. Other information called for by the SCR methodology includes timing and accuracy requirements for each output function, a description of likely changes that should be anticipated in the design, and a specification of the computer or computing environment to be used.

CONCLUSIONS

Requirements specification is the process of answering the question "what should the software do?" Two kinds of information essential to answering that question are (1) what (specific) questions remain to be answered about the software and (2) how complete is the specification, i.e., how do we know when the job is done?

The SCR requirements method provides a framework for a requirements specification document and a set of document design principles. The document framework, from the table of contents to the formats of specific tables, guides the requirements analyst in determining what questions concerning system requirements remain to be answered. The document structure makes it evident where information is missing or inadequately specified. The design principles provide guidance for extending or otherwise modifying the structures used for the A-7E example.

The document structure and accompanying formalisms also provide a variety of checks for completeness. The completeness of the specification is often obvious from the degree to which the chapters, sections, tables, etc. are filled out. In addition, underlying formalisms provide checks for logical completeness and consistency of many parts of the specification. Often the consistency checks proceed downward in a hierarchical fashion. For example, there is exactly one function for each output data item; since the number of output data items may be easily determined, we immediately know at most how many functions are necessary. Within a function, the list of mode classes and modes within each class may be used as a checklist to assure that behavioral changes within each mode are accounted for. Recall that a mode class partitions the system state space completely; therefore, specifying the behavior of an output in each mode fully specifies it for all system states.

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Detailed contents follow for Chapters 0 through 11.

Detailed Contents

Detailed Contents

CHAPTER 0

Introduction

0.1. OVERVIEW

0.1.1. Document Purpose

This document will be maintained as a complete and up-to-date reference for the A-7 Operational Flight Program (OFP). Together with items referenced within the document, it should provide a complete picture of the functions that the OFP must perform and the constraints imposed by the hardware environment. The document describes *what* the software will do, not *how* it will do it. For example, it states that the software must display a symbol on a screen to indicate the direction of the aircraft velocity vector, but not how the display coordinates are computed from the input data. The document, and references where indicated, describes the aspects of the computer, sensors and display devices that must be known to verify that the software meets its requirements.

Chapters 1 through 6 of this document describe the current OFP, specifying the product that is currently required. Chapters 7 through 9 characterize the kinds of changes that are likely to be made during the life of the software. In a sense, these three sections provide additional constraints for the implementation, since they determine the types of flexibility that should be built into the program. A program that meets the constraints in the first six sections would be initially useful; a program based on the assumptions expressed in Chapters 7 through 9 would change easily to meet anticipated changes in requirements.

0.1.2. Document Design Decisions

The organization of the document is based on a distinction between the *interfaces* to other devices and the *software functions*. In the data item section, we describe all forms of communication between the software and the outside world without making any assumptions about the purpose of the computer system. In theory, the section could stay unchanged if the hardware configuration stayed unchanged, even if there were a drastic change in mission. In fact, the hardware is so specialized that our nomenclature often implies mission characteristics. In the software function sections, we describe the purpose of the program without referring to the details of data representation and the mechanics of data communication, which we assume are described in the data item section. The function section would stay the same if we were to replace a device with another that provided the same information but in a different format or through a different channel.

To present the information in a compact, precise form that is easily referenced, the following additional decisions were made:

(1) Much of the information is presented in tables which make it easy to find specific facts and to detect missing information and inconsistencies. The table formats are discussed later in this chapter.

(2) To fit the information into tables, we introduced many standard definitions in the form of short phrases delineated by exclamation marks. Usually these terms refer to conditions that are complex or appear very frequently. The !terms! are defined in the dictionary section at the end of the document.

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(3) To provide compact descriptions of conditions, much notation is introduced, including standard acronyms for all inputs and outputs and standard mnemonic values for all switch settings and other input and output values. These are denoted by "/input/," "//output//," and "$mnemonics$." We have also introduced a terminology for describing events using the "@" symbol. The notation is discussed later in this chapter.

0.1.3. Document Structure

This section contains a brief abstract for each of the chapters of the document. In addition, some important terms are defined that will be used throughout the document.

Chapter 1: The TC-2 Computer

This section describes the distinguishing characteristics of the TC-2 computer. As an introduction for experienced programmers, it highlights the differences between the TC-2 and commercial computers. A complete description of the computer is provided in references 18 and 20.

Chapter 2: Input and Output Data Items

This section describes the interfaces between the TC-2 and the other devices in the aircraft. Information is transmitted in the form of ***data items***. Data items are transmitted through one of the TC-2 ***channels*** (see Chapter 1). Each channel is used to transmit many data items. We refer to data items that are transmitted ***to*** the TC-2 from other devices as ***input data items***. We refer to data items that are transmitted ***from*** the TC-2 to other devices as ***output data items***. This section is the only place in the requirements document that contains information about the physical representation of data items and the details of transmission over channels. Other sections refer to data items and their values in terms of symbolic names defined in this section.

Provided for each data item are (a) a standard acronym to be used through- out the document and during system development; (b) a verbal description of its significance or meaning in terms of device with which it is associated; (c) characteristics of each numerical data item, such as range and accuracy, or mnemonic names for the possible value of each non-numerical data item; (d) the format of the data representation; and (e) the TC-2 instruction sequence that must be executed in order to read the item in or transmit it to the external device. Where such information is available and meaningful, the document describes any timing restrictions that must be observed.

Chapter 3: Modes of Operation

We have grouped the possible states of the OFP into modes that correspond to A/C operating conditions. Because the functions performed by the OFP differ greatly in different modes, a description of the OFP requirements on a mode-by-mode basis is simpler than a general description.

There are five classes of modes described in this section: alignment, navigation, navigation update, weapon delivery and test. Each mode class is a partition of the possible states of the system into a set of modes. That is, the system can be in only one mode of a given mode class at a given time. The system may be in more than one mode where the modes belong to different mode classes. There may also be exclusion relations among the modes in different classes. For each of these mode classes, we indicate the mode that the system will be in when started up. We then indicate the events that will cause the system to change from one mode to another. This fully specifies the mode of the system, provided that we know the history of events.

Chapter 3 includes introductory overviews of each mode, and the mode transition tables. The functions are described in Section 4.

Chapter 4: Time Independent Descriptions of A-7 Software Functions

This chapter describes the functions that the OFP must perform. Each one of these functions is the computation of values for one or more output data items. For each one, we specify the relation that the output value must have to the current state of the inputs and A/C operating conditions. To simplify the function descriptions, we use the modes described in Chapter 3 as a shorthand notation.

Each function is classified as either demand or periodic. A *demand function* is performed when requested by the occurrence of some external event (e.g., a pilot action). A *periodic function* is performed at regular intervals without being requested each time.

Chapter 5: Timing Requirements

In Chapter 4, each of the functions is described without reference to clock time. Chapter 5 states the known timing requirements for the functions. This section is not complete. Ideally one should state the maximum delay between request and completion of response for each of the demand functions, and the minimum and possibly maximum frequency for the periodic functions. Unfortunately, many of the data that should be in this section are not known. The present delay and the present rate of performance are listed, but no experiments have been done to record the minimum and maximum acceptable values of these figures.

Chapter 6: Accuracy Constraints on Software Functions

Chapter 6 reports the known constraints on accuracy. As yet, we have not been able to find the information that we wanted. We will take the behavior of the present system as a statement of requirements until more information becomes available.

Chapter 7: Undesired Event (UE) Responses

This chapter is a systematic description of the desired behavior of the system when undesired events occur. We list the behavior that system engineers and pilots consider the best response, given that full functioning is not possible. This chapter describes behavior that does not always correspond to the behavior of the present system. The information in this chapter is present to assist in designing for future changes.

Chapter 8: Required Subsets

This chapter describes the subsets that should be obtainable by omitting parts of the code. We identify those services that would be useful if all remaining services were not performed. These requirements greatly restrict the software design. They are motivated by a desire to extend the area of applicability of the software.

Chapter 9: Expected Types of Change

This chapter characterizes the family of programs that includes the present OFP and possible future modifications. We have identified those aspects of the present OFP behavior that appear not to be so fundamental that they could not change during the life of the aircraft. Included in this section are characterizations of changes that have been requested by the Fleet as well as improvements that system engineers and others thought might be desirable if they could be made at reasonable cost. These changes are not necessarily planned: we included any change we could imagine, if no one could find a good reason to rule it out.

Chapter 10: Glossary of Abbreviations, Acronyms, and Technical Terms

This chapter is a glossary of acronyms and technical terms that are in use in the A-7 community.

Chapter 11: References and Sources of Further Information

This chapter is an annotated list of other reference material and personnel. The information that is specifically referenced in Chapters 1 to 9 is considered a part of the requirements defined by this document.

Indices

Three alphabetical indices are provided:

(1) an index of data item acronyms;

(2) an index by mode name acronyms; and

(3) an index of output data items affected by functions.

These indexes appear after the Dictionary.

Dictionary of Terms

All standard terms used in the mode and function descriptions are listed in alphabetical order in this section, along with their definitions.

0.2. NOTATION

0.2.1. Bracketing Symbols In order to be both brief and precise, the document contains many abbreviations, acronyms and symbols. These are used to refer to a broad variety of objects: definitions, input data items, output data items, mnemonic names for data item values, system modes etc. To make it easier to recognize the type of object referred to by an abbreviation or acronym, we use special symbols to bracket them.

/input/ — /SAP/ indicates that SAP is the name of one of the hardware inputs to the TC-2. These items are described in Chapter 2.

//output// — //SOUP// indicates that SOUP is the name of one of the hardware outputs from the TC-2. These items are described in Chapter 2.

$value$ — If /SAP/ and //SOUP// are non-numeric data items, we have defined mnemonic names for values. These mnemonic names are enclosed in "$" brackets. Thus possible values for /SAP/ might be defined as $Dave$, $John$, and $Karin$, while $Bean$ and Pea might be possible values for //SOUP//. A condition (a statement about the system that is always either true or false) would then be given as /SAP/ = $Dave$. However, /SAP/ = Pea is clearly an error because Pea is not a legal value for /SAP/. To indicate that we assign the output data item //SOUP// the value denoted by PEA, we would write //SOUP//:= Pea. We may also refer to the value of an output data item in a condition (e.g. //SOUP//=$Bean$).

!term! — When an expression is complex and is used repeatedly, we have given it a mnemonic name and included it in a dictionary at the end of the document. Such items are enclosed in "!" brackets. Thus, !Dictionary Term! would be found in the dictionary as an entry with an explanation such as "a term that is defined in this section."

mode — We have described our systems in terms of classes of system states called modes. Mode names are always enclosed in "*" brackets. Thus, the appearance of

SEARCH would indicate that SEARCH was the name of one of the system modes. Chapter 3 contains a definition for each system mode.

mode Certain system modes are described in terms of other modes. These so-called "extended modes" are defined in Chapter 3.

0.2.2. Operators

To describe conditions of numeric items we use the following relational operators:

Operator	Meaning
$<$	less than
$\leq$	less than or equal to
$>$	greater than
$\geq$	greater than or equal
$\neq$	not equal to

In arithmetic expressions we may also use:

Operator	Meaning
ABS(x)	Absolute value or magnitude of x
MAX(x,y)	Maximum of x and y
MIN(x,y)	Minimum of x and y
SIGN(x)	Sign of x

We use the following logical operators to form compound conditions in the standard way:

AND
OR
NOT

0.2.3. Conditions and Events

A *condition* is an expression such as /SAP/=$Dave$ AND //SOUP//=Pea that has a value true or false. A condition characterizes the system for some measurable time period. Conditions usually refer to the values of data items, though some conditions refer to the completion of some calculation or adjustment. Conditions may be compound, that is, they may be composed of simple conditions connected by the logical operators AND, OR and NOT.

Sometimes, we wish to refer to a specific moment in time, rather than to a time period. These moments, or *events*, occur when a condition changes from true to false or vice versa. We have introduced a notation to describe such events.

@T(condition 1)

describes any moment that condition 1 becomes true. For example, the expression @T(/RADALT/ $\leq$ 0) denotes the event that the input RADALT no longer shows a positive value. It refers to moments in time when this condition changes from false to true. Similarly, the expression

@F(condition 2)

describes the moment that condition 2 becomes false. For example, @F(/MOTOR/=On) refers to the event of the condition /MOTOR/=On changing from true to false. To describe an event in which one condition changes at a time when another is true we write

@T(Condition 1) WHEN (Condition 2).

For example, @T(!Wheels Retracted!) WHEN (/RADALT/ = 0) refers to the event that the pilot retracted the wheels while at zero altitude. This event only occurs if the condition !Wheels Retracted! changes. For contrast consider @T(/RADALT/=0) WHEN (!Wheels Retracted!). The latter would refer to events in which the value of /RADALT/ changes and the wheels are already retracted.*

Note the difference between

@T(Condition1 OR Condition2)
and
@T(Condition1) OR @T(Condition2)

The former event occurs when the disjunction of the two conditions becomes true. Note that the event does NOT occur when one condition becomes true if the other condition is already true. The latter specifies a disjunction that is true whenever either event occurs.

0.3. TABLE FORMATS

Much of the information in Section 4 is presented in tables to make it easy to answer specific questions. The table formats have been chosen to promote completeness and to achieve conciseness not possible with straight text.

Each table defines some aspect of a function that varies depending on the current mode and conditions. Some tables specify *when* a function should be performed. For example, a table might show that a light should be turned on in one mode when it is entered, and in another mode when a switch setting changes. Some tables characterize the actual values that should be assigned to output data items. For example, a table might show that an output should be barometric altitude in some modes, and radar altitude in others. Finally, some tables define terms or conditions that are meaningful in characterizations of output values. For example, an output value might be characterized as the distance to some reference point. A table would then be given to define "reference point," which might be the designated target in some modes under some conditions, and the offset aimpoint in others.

There are three types of tables used in this document: Selector tables, Condition tables and Event tables.

0.3.1. Selector Tables

These tables are useful if the information is determined completely by an active mode. Selector tables have a row for each mode, or for each group of modes that give the same information. The rows must be mutually exclusive. The columns give the information appropriate for each mode.

* This notation theoretically calls for the evaluation of a condition simultaneously with the detection of an event. Since this is not possible in any real implementation, we define the meaning of an expression such as @T(X) WHEN(Y) thus: Let t_x be the time at which @T(X) is detected by the software. Then there is a time interval ϵ such that if Y is true (false) for all of $[t_x - \epsilon, t_x]$, or for all of $[t_x, t_x + \epsilon]$, or for all of $[t_x - \epsilon, t_x + \epsilon]$, then the expression is (is not) considered to be satisfied. The behavior of the system when Y is true for only a part of the interval is not defined: it may or may not behave as though the expression were satisfied. Which interval we use as the requirement, as well as the value of ϵ is defined in the Accuracy chapter for each such event.

Format:

Selector Table x: Description of ACT and BE		
MODE	//ACT//	//BE//
MODISH	$Vogue$	$Cool$
LASTING	X	$Warm$

Thus, in mode *MODISH*, //ACT//:=$Vogue$ and //BE//:=$Cool$; in mode *LASTING*, //BE//:=$Warm$. If an X appears as an entry in a selector table, it indicates that no statement is being made about the value of that variable in that mode.

0.3.2. Condition Tables

Condition tables are used when the information is determined by the active mode and a set of mutually exclusive conditions that occur in the mode. Condition tables are especially useful in describing periodic functions. Each row in a condition table corresponds to a mode or group of modes.

In each row of the table, a set of conditions exists: one and only one condition should be true at a time. At the bottom of the column for each condition is the information appropriate for that mode/condition pair. Thus to find the value for a given mode and given condition, first find the row corresponding to the mode, then within that row find the column corresponding to the condition, then follow the column to the bottom of the table to find the information. An "X" entry in a row of a condition table means that the information at the bottom of the column is never appropriate for that mode.

The conditions are the entries in the body of the table rather than the column headings because there are usually many more conditions than there are different values for the information presented by the table, and because different conditions are applicable in different modes. To draw attention to this inverted way of organizing a table, we put the values at the bottom, rather than at the top of the table.

A benefit of this organization is that a row in a table completely describes the intervals within a mode that are meaningful for that particular value. The conditions must be mutually exclusive and together they must describe the entire time that the program is within the mode. In addition, the rows must also be mutually exclusive: the current mode must be unambiguously defined. Condition tables therefore define precisely the time intervals when each value holds.

Format:

Condition Table x: Definition of !Point!		
MODE	CONDITIONS	
M1	A	B
M2 *M3*	C	D
M4	E	F
!Point!	V1	V2

In *M3*, when condition C holds, !Point! is V1.

!Point! is also V1 in *M1* when condition A is satisfied, or in *M2* when condition C is satisfied, or in *M4* when condition E is satisfied.

Whenever the system is in mode *M1*, (A OR B) must be true and (A AND B) must be false. If those conditions are met, we are guaranteed that the table defines !Point! completely in mode *M1*. Similar conditions apply to the other rows.

0.3.3. Event Tables

These tables are useful to characterize demand functions or to specify when periodic functions should be performed. Each row in an event table corresponds to a mode or a group of modes. In each row, there is a set of events that causes the function to be performed in the mode(s). Usually, an event table also specifies some action to be carried out, depending on the mode/event pair. The events are arranged so that each column in the table corresponds to a common action. Thus, to find the action to be taken for a given mode and given event, first find the row corresponding to the mode, then within that row find the column corresponding to the event, then follow the column to the bottom of the table to find the action. An "X" entry means that action is never taken in the mode(s) listed on that row.

Two events appear so frequently that they are worth mentioning here:

@T(In mode) WHEN(condition A)

- the event that condition A is true when the mode is entered.

@F(In mode)

- occurrence of one of the events that causes exit from the mode. These exit events are listed in Chapter 3.

If either of these events occurs on a row corresponding to more than one mode, they refer to the event of entering or leaving the modes *taken as a group*. Thus, if *M1* and *M2* occur on the same row of an event table, and @T(In mode) appears as one of the events on that row, then leaving *M1* and entering *M2* does *not* count as an occurrence of that event (assuming no other mode transitions took place in the interim).

Format:

Event Table x: When Zip is Turned On/Off		
MODES	EVENTS	
Mode21	X	@T(Condition B)
Mode22 *Mode23*	@F(Condition C)	@T(In mode AND Condition D)
Mode24	@F(In mode)	@T(In mode) WHEN (Condition E)
ACTION:	Turn Zip On	Turn Zip Off

In *Mode24*, the function is requested at mode entry if condition E is true, and the Zip is turned off. It is also requested at mode exit, when Zip is turned on. Zip is never turned on in *Mode21*.

0.3.4. Mode Tables

Information about the mode transitions within a mode class is given via two types of tables; one shows which mode the system will start in when initialized and one shows the possible mode transitions and the events associated with each possible transition.

0.3.4.0. Initial Modes Table

These tables show which mode of a class the system will be in when it is initialized, provided there is more than one possibility. Subsequent behavior is determined by the transition events. Initial Modes tables have a row for each candidate mode, with a set of defining conditions. If the conditions are true at system initialization, the system will start in the corresponding mode. The rows must be mutually exclusive, and there may only be one mode per row.

Format:

MODES	DEFINING CONDITIONS
Mode1	A
Mode2	B

0.3.4.1. Mode Transition tables

The Mode Transition tables describe the possible transitions between system modes. Each row of the table describes an event that will cause a mode transition. To find the event(s) causing a transition from a mode *A* to a mode *B*, first find the entry for *A* under the left column labeled "Current Mode." Then, in the *A* section of the table, find the row(s) with *B* in the righthand column labeled "New Mode." Each row in that section describes an event causing a transition from *A* to *B*.

The event corresponding to each row of the table is interpreted by looking at the column headings. Each column heading names a condition. The entry in a row under a condition denotes how that condition will be used in the expression of the event. An entry of "@T" under a condition X means "@T(X)." An entry of "@F" means "@F(X)." Other entries correspond to the WHEN clause of an event. An entry of "t" means "WHEN(X)". An entry of "f" means "WHEN(NOT X)". There may be two or more "t" and/or "f" entries in a row; this means that the WHEN clause is the conjunction of the corresponding conditions. Column entries that are not used for a particular event are marked with a "-".

Current Mode	!present position entered!	/ACAIRB/=Yes	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	/IMSFAIL/=Yes	!latitude! gt 70 deg	!latitude! gt 80 deg	!Doppler up!	!Doppler coupled!	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!Air velocity test passed!	!Pitch small! AND !Roll small!	New Mode
IMS fail	-	-	-	-	-	@T	-	-	-	-	-	-	-	t	-	-	-	*Mag sl*
	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	t	-	-	*Grid*
PolarI	@T	-	f	-	-	-	-	-	-	-	t	-	-	-	-	-	-	*Landaln*
	-	-	-	f	-	-	-	-	@T	-	t	-	-	-	-	-	-	*Airaln*
	-	-	-	f	-	-	-	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	

The first row in the example above specifies a transition from mode *IMS fail* to mode *Mag sl* when the event

@T(/IMSFAIL/ = Yes) WHEN(/IMSMODE/=$Mag sl$)

occurs. Similarly, the third row specifies a transition from *PolarI* to *Landaln* when the event

@T(!present position entered!)
WHEN(!Data 23!≠Sea AND /IMSMODE/=$Gndal$)

occurs.

CHAPTER 1

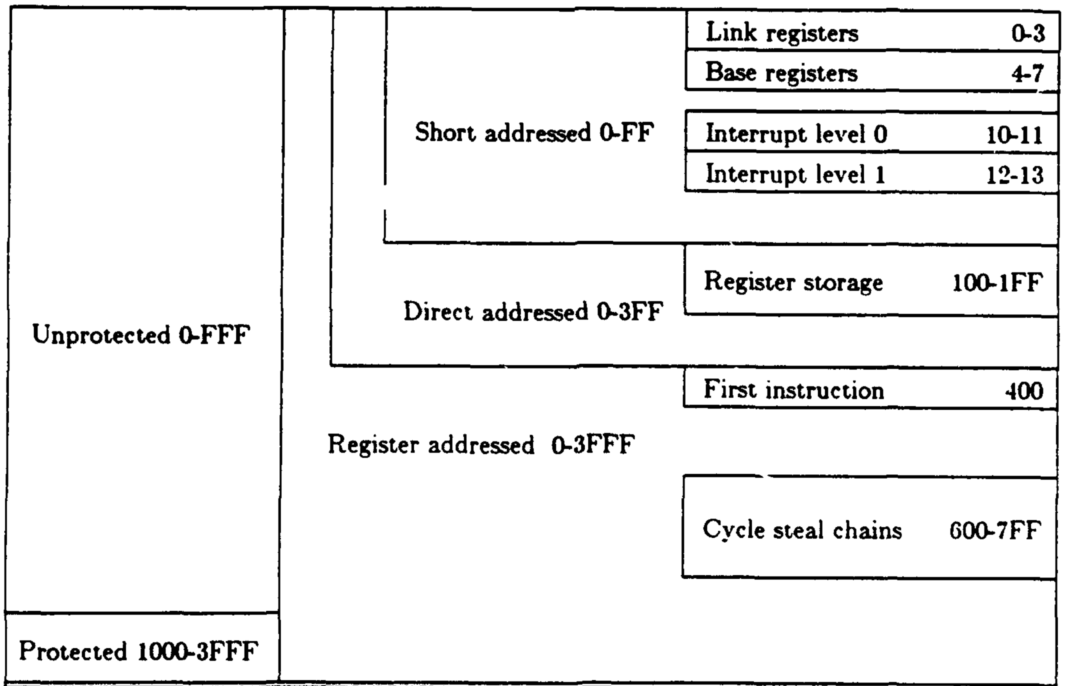
The TC-2 Computer

1.0. INTRODUCTION

The A-7 software is required to run on the IBM 4PI TC-2 computer. This section provides an introduction for those unfamiliar with the TC-2. A more complete description is given in references (18,20).

1.1. MEMORY

The organization of the TC-2 memory is given in the diagram below: all addresses there are hexadecimal. Each memory location is 16 bits long. Three-quarters of the locations are protected, or read-only. Certain areas of memory may be used for special purposes. All of memory may be addressed using base registers; the first one-sixteenth may also be addressed directly. Only the first one-sixty-fourth, whose addresses may be expressed using just 8 bits, may be used by certain instructions.



TC-2 Memory
(All addresses given in hexadecimal notation)

1.2. ACCUMULATOR

The accumulator is in two parts, called the Areg and Qreg. The Areg is the accumulator for single-precision instructions, and the Areg and Qreg together are the accumulator for double-precision instructions, with the Qreg acting as the low-order half of the accumulator. Most instructions take one operand in memory and the other in the accumulator, and leave the result of the instruction in the accumulator.

1.3. INDIRECT ADDRESSING

Most instructions may address their memory operand either directly, if it is in the direct addressed part of memory, or indirectly through a base register. An instruction using indirect addressing names a base register containing a pointer and gives an offset in the range [0,255], the register and offset together determining what location is addressed; if the pointer has value A and the offset is I, the location with address (A+I) is addressed. Note from the diagram that the base registers are themselves memory locations, with addresses 4 through 7.

The accumulator load and store instructions, the arithmetic and logical instructions, and the C (compare) and T (tally) instructions may address their data directly or indirectly.

1.4. DATA MOVEMENT, ARITHMETIC, AND LOGICAL INSTRUCTIONS

The accumulator is loaded from and stored into memory by the LA, LD, STA, and STD instructions. LD and STD are double precision. For double precision instructions, the memory operand is two consecutive locations, the first of which must have an even address.

The arithmetic instructions provided are A, AD, S, SD, M, and D, for addition, subtraction, multiplication, and division. AD and SD are double precision. The minuend of subtraction instructions is the accumulator operand. M takes single precision operands and leaves a double precision result in the accumulator; D takes a single precision divisor in memory and a double precision dividend in the accumulator, and leaves a single precision result in the accumulator. All these instructions use two's complement representation. M and D assume the most significant bit represents 1/2.

The logical instructions are N (and), O (or), and X (exclusive or).

1.5. SHIFT INSTRUCTIONS

The shift instructions shift the Areg and Qreg as a unit. SLD (shift left double) shifts left, with 0's shifted in at the right end of the Qreg. SRDA (shift right double arithmetic) and SRDL (shift right double logical) shift right; SRDL shifts 0's in at the left end of the Areg, and SRDA shifts in whatever value the sign bit had before the instruction, the sign bit being the leftmost bit in the Areg. The number of bits shifted may be specified in two ways: (1) directly, by a number in the range [0,31]; (2) indirectly, as the sum modulo 32 of such a number and the contents of a base register.

1.6. BRANCH INSTRUCTIONS

BF and BB are unconditional branches forward and backward, respectively, up to 255 locations. BFC and BBC are analogous conditional branches; possible conditions are that the Areg is positive, negative, or zero, or the negation of any of those three, or that the carry bit is set (see "*The CPU Status Word*", below). BIA (branch indirect address) is an indirect branch, and B is an indirect branch to a location 0 to 255 locations beyond the address given by a pointer. B requires a pointer in a base or link register, and BIA a pointer in short addressed memory.

Subroutine linkage may be done using BIAL (branch indirect and link). It is like BIA but additionally places the current address in a base or link register, so that a return from the subroutine may be done with a BIA or B using that pointer.

C (compare) is a three-way conditional branch; if the Areg is greater than, less than, or equal to the contents of a location in memory, it branches to the next instruction, the second instruction following, or the third instruction following, respectively.

T (tally) is an instruction for indexed loops. It increments the contents of a location in memory; if the result is zero, it branches to the second succeeding instruction, otherwise it continues to the next instruction.

1.7. OPERATIONS ON REGISTERS

LR and STR load or store the contents of a register from or to the register storage area of memory. MDR increments a register by a fixed offset in the range [1,255].

1.8. OPERATIONS ON THE ACCUMULATOR

ZQ sets the Qreg to all zeroes. XAQ exchanges the contents of the Areg and Qreg. SAZ stores the contents of the Areg in the Qreg and sets the Areg to all zeroes. CA takes the two's or arithmetic complement of the Areg, and CL the one's or logical complement.

1.9. MISCELLANEOUS INSTRUCTIONS

NOP has no effect. STIC stores the current value of the instruction counter in a base or link register.

1.10. THE CPU STATUS WORD

The CPU status word is 16 bits long. Bits 2, 3, and 6 through 15 have no function. LSW and STSW load or store the CPU status word from or to short address memory.

Bit 0 of the CPU status word is the carry bit of the TC-2. Its value is the carry from the sign bit of the accumulator in an addition, raction, or an arithmetic complement (CA) instruction, or the last bit shifted out of the sign bit by SLD. Synchronous I/O instructions set the carry bit to 1 if an error is detected.

When bit 1 is changed to '1', the TC-2 is put into a wait state, in which no instructions are executed until an unmasked interrupt occurs.

Bits 4 and 5 mask level 0 and 1 interrupts, respectively.

1.11. INTERRUPTS

The TC-2 has two levels of interrupts, level 0 and level 1; if two interrupts are simultaneous, the level 0 is accepted first. When an interrupt occurs, a number of things occur if it is not masked:

(1) A bit that identifies the cause of the interrupt is set; these bits may be read with an I/O command (see "*Synchronous I/O*", below).

(2) The wait state bit in the CPU status word is cleared to 0.

(3) The current value of the instruction counter is saved at location 10 (level 0) or 12 (level 1) hexadecimal.

(4) The next instruction executed is the one whose address is given at location 11 (level 0) or 13 (level 1) hexadecimal.

Masked interrupts remain pending until they are unmasked using the CPU status word.

1.12. BUILT-IN TEST EQUIPMENT AND THE DIAGNOSE INSTRUCTION

Certain functions of the TC-2's built-in test equipment are controlled by the DIAGNOSE instruction:

(1) Output channels may be wrapped to input channels, to test that both are working.

(2) Interrupts and parity errors may be generated.

(3) Output channels may be placed in or out of a fail-safe state. In this state all critical outputs are forced to zeroes, and whatever data would otherwise be written to those channels is wrapped back to input channels.

The TC-2 is initially in this fail-safe state when powered up, and must be removed from it using DIAGNOSE before any output on those channels can occur.

(4) Certain failure indicators can be set.

The built-in test equipment also has functions that are independent of the DIAGNOSE instruction, including hardware that detects attempts to store into protected memory, and a hardware "GO/NO-GO" timer that, if not reset frequently (see "*Synchronous I/O*", below), generates an interrupt and sets failure indicators.

1.13. POWER-ON AND RESET

When the computer is turned on or manually reset, the first instruction executed is the one at location 400 hexadecimal.

1.14. ASYNCHRONOUS I/O

The TC-2 has three cycle steal channels over which data is transmitted asynchronously; the three channels are identified as A, B, and C. Data sent over each channel is obtained from a linked list of locations called a cycle steal chain. These chains reside in the cycle steal area of memory; each chain consists of a list of pairs of adjacent locations, the first of which identifies the pair's datum (by giving its "word identity code") and points to the next pair in the chain, and the second of which contains the datum. For normal operation, the chains are circular, with a dummy head pair and the last pair in the chain pointing back to the second pair. Each of the three channels has its own chain, starting at a fixed location.

Once the chains are set up, data is transmitted essentially continuously while the TC-2 is not in a wait state. Transmission over a particular channel may be stopped by linking the last pair in its chain to the dummy head pair.

1.15. SYNCHRONOUS I/O

The TC-2 has eight synchronous I/O channels (0 through 7), each of which may have several devices attached. A particular device is indicated by a numeric code combining a channel code and a device code. The READ and WRITE instructions transfer data from a device to the Areg and vice versa. READM (modified read) sends control commands to a device to prepare it for a READ; it is only used for I/O channel 3.

TC-2 I/O is most unusual. It was designed specifically for the A-7 and the channels are tailored to specific I/O devices; instruction sequences for each channel are distinctly different. Some I/O devices require a succession of commands; some require a relatively long wait for input or output, and some have their data available for input for only a short time.

Some I/O devices are part of the TC-2 itself. Interrupts set identifying bits that may only be read by an I/O instruction. The "Go/No Go counter" (see "*Built-in test equipment and the DIAGNOSE instruction*", above) may only be set with a WRITE command. Two other counters and the IMS control registers are only accessible through READ and WRITE commands.

Of the eight channels, four are currently used for output (0,4,6,7) and seven for input (all but 5). Two channels may be used in communicating with a single device; e.g., channel 0 is used to send single discretes to the Doppler Radar, and channel 1 is used to receive numerical inputs from the same device. The remainder of this section summarizes each channel.

1.15.1. Channel 0

Channel 0 is used for communication with relatively low speed discretes such as IMS mode switches. It is also used to read and write the interrupt status registers and to communicate with the various counters.

1.15.2. Channel 1

Channel 1 is used for communication with the Serial Input Data Register (SIDR). This register is connected with the Doppler Radar, Forward Looking Radar, and digital Shipboard Inertial Navigation System (SINS). Any one of those devices can write data into the SIDR but will do so only on request. The request is made over Channel 0, and it is vital to make only one request and wait for the complete response before making another. If two devices try to write into the SIDR at once, no error will be detected but meaningless data will be produced. When data are written into the SIDR, identifying data are written into the Serial Input Address Register, which is read over Channel 2. Reading the SIDR transfers the contents to the accumulator and clears the contents of the SIDR. To obtain useful data, the contents of the SIDR should be cleared before a data request.

Interrupts are generated during the read sequences for the following input data items. The interrupts indicate that the device has loaded the Serial Input Data Register and the Serial Input Address Register.

/ANTGOOD/	/SINLON/	/WAYLAT/
/DGNDSP/	/SINLAT/	/WAYLON/
/DRFTANG/	/SINHDG/	/WAYNUM1/
/DRSFUN/	/SINNVEL/	/WAYNUM2/
/DRSMEM/	/SINROL/	
/DRSREL/	/SINEVEL/	
/ELECGOOD/	/SINPTH/	
/SLTRNG/		

Reading from the Doppler radar over Channel 1 is especially complex because the Doppler always sends its data in sets of three words. It may be necessary to read the register three times even if only one of the items is wanted. Further, the data arrive at a rate that is independent of the computer. The need to clear the register before the next word arrives imposes severe time constraints on the programs.

1.15.3. Channel 2

Channel 2 is used for communication with the Serial Input Address Register (SIAR). The SIAR contains bits that identify the source of the data in the Serial Input Data Register. Unfortunately, the address bits do not unambiguously identify the data source; to determine the source, one must also use information about the most recent request made over Channel 0.

Bit 0:	Data Valid	Set to 1 when SIDR contains a valid data word.
Bit 1:	Data Parity	Set to 1 hen the Data Word in the SIDR has passed the hardw re parity test.
Bit 2:	Address Parity	Set to 1 when the address word in the SIAR has passed the hardware parity test.
Bit 7:	Serial Input in Progress	Set to 1 after a serial input has been requested and data transmission not yet complete.
Bits 10-14:	Identity	This field contains the address code for identifying the source of the SIDR word.

1.15.4. Channel 3

Channel 3 is used for communication with the TACAN receiver. It requires a READM and a READ command.

1.15.5. Channel 4

Channel 4 is used for the IMS torque and accelerometer registers.

Dealing with the torque registers is difficult for two reasons. First, there is never a zero torque on the IMS. One must alternate between positive and negative torques to maintain the IMS in its present state. Second, one must be aware of the values in the torque counters before setting new values. These values change periodically. If the count is about to change, it is necessary to wait before sending data to the counters. A Channel 0 input bit /DIMWC/ warns of this possibility and must be checked before changing the torque counters.

Each READ of an accelerometer register clears it.

1.15.6. Channel 5

Channel 5 is intended for Loran communication. Channel 5 is not used presently.

1.15.7. Channel 6

Channel 6 is devoted to communication with the TC-2 panel. Pushing a digit, KEYBD, MARK, or ENTER button generates an interrupt signal and sets a bit to indicate which button has been pushed. A bit will be 1 for each button that has been pushed since the last time the bits were read. The bits are cleared when read. Response is time critical although the time periods involved are relatively long. Delays in reading can result in missing a Panel Interrupt. There can be ambiguity about the sequence in which buttons were pushed if two buttons have been pushed since the last time that the interrupt was serviced.

The following input data items generate Panel Interrupts:

/ENTERSW/
/KBDENBL/
/KBDINT/ (10 data items)
/MARKSW/

Channel 6 output is straightforward.

1.15.8. Channel 7

Channel 7 is used for reading data that come from other aircraft systems in analog form. To read one of these signals one must transmit a request to the signal converter with a READ command, wait for a Data Ready interrupt, and then issue a READ that transfers the data into the accumulator. Because the data received by the last READ in the sequence are determined by the request expressed in the first READ, care must be taken to assure exclusive use of the device during the period of time it takes to complete a sequence. For angle inputs, the second READ gets the sine and an additional READ gets the cosine. In this case, there is no delay for conversion before the additional READ.

The signal converter data conversion times for the two types of signals requiring input conversion are 1.373 to 3.0 ms for synchro to digital data and 135 to 300 μs for DC voltage to digital data. These timing characteristics apply to the following data items, which generate Data Ready interrupts:

DC Conversion	Synchro Conversion
/AOA/	/MAGHCOS/
/BAROADC/	/MAGHSIN/
/MACH/	/PCHCOS/
/RADALT/	/PCHSIN/
/SLEWRL/	/ROLLCOSI/
/SLEWUD/	/ROLLSINI/
/TAS/	/THDGCOS/
	/THDGSIN/

Channel 7 Output is somewhat simpler: data are transferred to the converter by a channel 7 WRITE command that specifies the destination device. One must wait for completion of the conversion before starting another output operation. Conversion Complete is signaled by an interrupt.

The Signal Converter data conversion times for the two types of signals requiring output conversion are .188 to 1.8 milliseconds for digital to synchro data and 1.46 to 3.2 milliseconds for digital to DC voltage data. These timing characteristics apply to the following data items, which generate conversion complete interrupts:

DC Conversion	Synchro Conversion
//FPANGL	//BRGDEST//
//GNDTRVEL//	//GNDTRK//
//STERROR	/RNGHND//
	//RNGTEN//
	//RNGUNIT//
	//STEERAZ//
	//STEEREL//

CHAPTER 2

Input and Output Data Items

2.0. INTRODUCTION

This chapter describes the individual data items communicated between the TC-2 and other devices in the aircraft. There is a separate subsection for each hardware device. Within each subsection, input items precede output items. The data items are alphabetized within each category.

Provided for each data item are (a) a standard acronym enclosed in brackets (/input/ and //output//) to be used throughout the document and during system development; (b) a verbal description of its significance or meaning in terms of the device with which it is associated; (c) characteristics of each numerical data item, such as range, accuracy or mnemonic names enclosed in brackets ($value$) for the possible values of each non-numerical data item; (d) the format of the data representation; and (e) the TC-2 instruction sequence that must be executed in order to read the item in or transmit it to the external device. For numerical data items, the range gives the maximum and minimum values encountered in actual use. This may be smaller than the range of values that can be represented. Where such information is available and meaningful, the document describes any timing restrictions that must be observed.

2.0.1. Accumulator as Default Data Item Location

An input data item is always located in the accumulator after an input instruction sequence. Except for cycle-steal outputs, an output instruction starts with the output value in the accumulator.

2.0.2. Value Representations

Both the verbal description and the list of value characteristics refer to the data items using "standard" units, such as degrees, knots, or Mach number. We shall refer to the units in the I/O representation as "indicated" units. For most numerical data items, values in standard and indicated units are related by a multiplicative scale factor and an additive offset factor as follows:

$$\text{indicated} = \text{scale} \times (\text{standard} + \text{offset}) \text{ (output conversion)}$$

$$\text{standard} = (\text{indicated} \ / \ \text{scale}) - \text{offset} \text{ (input conversion)}$$

where "indicated" is the value in indicated units, "standard" is the value in standard units, "scale" is the scale factor, and "offset" is the offset factor in standard units. The scale factor is to be interpreted as a quantity in "indicated/standard" units, and the offset in standard units. In each case, we will define the data representation by stating the bit field covered by the indicated value, stating whether these fields are to be interpreted as positive, two's complement, or signed-magnitude quantities, and stating values for scale and offset. In all cases, the least significant bit of a numerical bit field is the highest-numbered (rightmost) bit, and that bit represents one indicated unit.

In some cases, the exact scale factor for an input data item is not known, but an approximate value of 1/scale is available. In these cases, we will give the approximate value for 1/scale using the symbol :=: to mean "approximately equals."

For example, the indicated representation of the Doppler Drift Angle input data item, /DRFTANG/, is a 14 bit positive count with scale = 175 and offset = 9375/175. The standard units of /DRFTANG/ are degrees. Thus, an indicated value of 9375 corresponds to 0°, and a value of 9200 corresponds to -1°.

Many of the data items are described in terms of particular units of measurement, such as degrees, feet/second, or knots. It should be clear that by altering the scale (and offset) the data items could be described in different units. The units used here were chosen for convenience in writing this document. The implementor of programs using these data items should alter the scale to produce the values in the appropriate units.

2.0.3. Coordinate Systems

The description of the input and output data items will often refer to three coordinate systems:

(1) the airframe coordinate system,
(2) the IMS platform coordinate system, and
(3) the SINS coordinate system.

All three coordinate systems are right-handed systems.

The airframe coordinate system has axes Xa, Ya, and Za. The Ya axis lies along the A/C boresight line with the positive direction being forward (toward nose, from tail). The A/C boresight line is 3° below A/C waterline – see Ref. 15a, p. 1-4-4. The Xa axis points out in the direction of the right wing and is defined so that the Xa - Ya plane is horizontal and the Za axis points upward when the A/C wings are level and the A/C is not inverted.

The Inertial Measurement Set (IMS) platform coordinate system has axes Xp, Yp, and Zp. These are often referred to as East, North, and Up (away from the center of the earth), respectively, because in normal operation the OFP attempts to align them in these directions. Note that when the A/C is flying north and level and the platform is aligned, Ya aligns with Yp, Xa aligns with Xp, and Za aligns with Zp.

The Shipboard Inertial Navigation System (SINS) coordinate system has axes Xs, Ys, and Zs. The Ys axis is toward the forward end of the ship, the Xs axis is to the starboard side of the ship, and the Zs axis is vertical and points upward.

2.0.4. Definition of Data Item Classes

Some instruction sequences, particularly those that read and write single-bit discretes, affect more than one data item. For example, //BMBTON//, //FIRRDY//, //BMBREL//, //CURENABL//, and //ANTSLAVE// are all written by the same TC-2 instruction. This introduces dependencies between data items: when writing one data item, it is important to know which other data items will also be affected.

To provide this information, we have defined classes of data items, one class for each instruction sequence that affects more than one data item. The names of the classes, along with their acronyms, and the class members are listed in Section 2.5, each class name followed by the acronyms for the data items it affects. The class acronym, if any, is given in the data item description. A data item may belong to more than one class if it is affected by more than one instruction sequence.

2.0.5. Data Items for More than One Device

If a single output data item is sent to more than one device, there will be a descriptions of the data item included for each device to which it is sent. The main description, including data representation, instruction sequence, etc. appears in only one place. The other descriptions explain how the data item affects that particular device, and refers to the section that contains the main description.

2.0.6. Data Items That Affect Signal Converter Tests

The following data items affect the values read in for /DCTEST/. After the WRITE instruction for these data items, if the conversion complete interrupt does not occur within 280 μsec, a hardware error is indicated.

//STERROR//
//FPANGL//
//GNDTRVEL//

The following data items affect the values read in for /ACTESTCOS/ and /ACTESTSIN/. After the WRITE instruction for these data items, if the conversion complete interrupt does not occur within 3.2 msec, a hardware error is indicated.

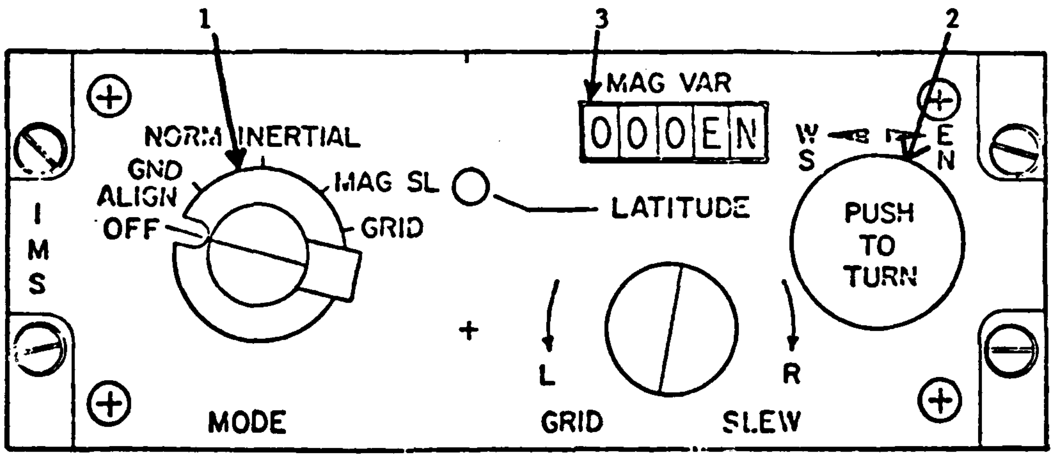
//RNGUNIT//	//RNGTEN//
//RNGHND//	//ANTSLAVE//
//STEERAZ//	//GNDTRK//
//STEEREL//	//BRGDEST//
//SPARE1//	//SPARE2//

2.1. DEVICES WITH TWO-WAY COMMUNICATION PATHS

2.1.1. Inertial Measurement Set (IMS)

The IMS is the primary heading, attitude, and velocity reference. It measures and transmits to the TC-2 velocity increments along three mutually perpendicular axes Xp, Yp, and Zp (right-hand coordinate system). The IMS also measures and transmits to the TC-2 three angles that give the relative orientation of the (Xp, Yp, Zp) frame to the A/C (Xa, Ya, Za) frame. The IMS also transmits to the TC-2 a measurement of A/C magnetic heading.

Figure 2.1.1-a shows the control panel for the IMS.



Control panel for inertial measurement set
Figure 2.1.1-a

(1) The mode switch permits selection of IMS mode (see /IMSMODE/).

(2) The pilot can enter the magnetic variation using this knob. This quantity is sometimes transmitted to the TC-2 (see /THDGSIN/ and /THDGCOS/).

(3) This dial shows the magnetic variation entered by the pilot using the knob.

2.1.1.1. Diminishing wait count

Input data item(s): Diminishing Wait Count

Class: DIW5

Acronym: /DIMWC/

Hardware: Inertial Measurement Set (Physically in the TC-2 but associated with IMS)

Description: /DIMWC/ indicates whether or not a change in the torque counters is imminent. See //XGYCOM//, //YGYCOM//, //ZGYCOM// for more information.

Characteristics of values:

> **Value encoding:** $Ready$ (0); $Changing$ (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 14

Timing characteristics:

> @T(/DIMWC/ = $Changing$) occurs once every 5 ms, approximately 200-300 microseconds before changes of the IMS torque counters.
>
> @T(/DIMWC/ = $Ready$) occurs several nanoseconds after changes of the IMS torque counters.

2.1.1.2. Gyro torque counters (residual inputs)

Input data item(s): X, Y, and Z Axis Gyro Torque Counters

Acronym: /XGYCNT/ /YGYCNT/ /ZGYCNT/

Hardware: Inertial Measurement Set (Physically in the TC-2, but associated exclusively with the IMS)

Description: /XGYCNT/, /YGYCNT/, and /ZGYCNT/ indicate the current value of the two least significant two bits of the corresponding torque counters. See //XGYCOM//, //YGYCOM//, and //ZGYCOM// for more information.

Characteristics of values:

Value encoding:

Value	Bit representation	Torque counter bits
A	10	00
B	11	01
C	00	10
D	01	11

Instruction sequence: READ # (Channel 4) (valid only if /DIMWC/ = $Ready$)

= 144 for X Axis
= 136 for Y Axis
= 152 for Z Axis

Data representation: Bits 13-14

Timing characteristics: See /DIMWC/ and //XGYCOM//, //YGYCOM//, //ZGYCOM//

Comments: When the torque counter is toggling (see //XGYCOM//, etc.), the values A and D will be read when the torque counter values are 0 and −1 respectively.

2.1.1.3. IMS AUTO/CAL mode

Input data item(s): IMS AUTO/CAL Mode

Class: DIW5

Acronym: /IMSAUTOC/

Hardware: Inertial Measurement Set

Description: /IMSAUTOC/ indicates the position of a momentary pushbutton on Adaptor/Power Supply in Avionics Bay)

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 9

Timing characteristics: When the button is pushed, (/IMSAUTOC/ = On) is known to be true for at least 40 ms.

2.1.1.4. IMS mode switch

Input data item(s): IMS Mode Switch

Class: DIW5

Acronym: /IMSMODE/

Hardware: Inertial Measurement Set

Description: /IMSMODE/ indicates the position of a six-position rotary switch on the IMS control panel. This switch determines the IMS's mode of operations, as described in Ref. 33a, §3.4.1.5. Switch nomenclature: OFF; GND ALIGN; NORM; INERTIAL; MAG SL; GRID

Characteristics of values:

Value encoding:

$Offnone$	(00000)	Occurs when the switch is off or between two positions.
$Gndal$	(10000)	
$Norm$	(01000)	
$Iner$	(00100)	
$Grid$	(00010)	
$Magsl$	(00001)	

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bits 3-7

2.1.1.5. IMS system ready

Input data item(s): IMS System Ready

Class: DIW5

Acronym: /IMSREDY/

Hardware: Inertial Measurement Set

Description: /IMSREDY/ indicates whether or not the IMS has completed its self-controlled alignment sequence and is ready for operation under TC-2 control.

Characteristics of values:

  Value encoding: Yes (0); No (1)

Instruction sequence: READ 24 (channel 0)

Data representation: Discrete input word 5, bit 8

2.1.1.6. IMS system reliable

Input data item(s): IMS System Reliable

Class: DIW5

Acronym: /IMSREL/

Hardware: Inertial Measurement Set

Description: /IMSREL/ indicates whether or not the IMS is reliable based on a hardware self-check internal to the IMS. /IMSREL/ cannot be Yes if /IMSREDY/ is not Yes.

Characteristics of values:

Value encoding: No (0); Yes (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 0

2.1.1.7. IMS incremental velocities

Input data item(s): Incremental Velocities (Accelerometer Pulses)

Acronym: /XVEL/ /YVEL/ /ZVEL/

Hardware: Inertial Measurement Set

Description: /XVEL/, /YVEL/, /ZVEL/ are incremental velocities along the Xp, Yp, and Zp axes. The values are sums of the positi.e and negative pulses received from the corresponding accelerometer since the last completed read of the corresponding counter. Each count must be multiplied by the scale factor corresponding to the value of //IMSSCAL// to obtain the corresponding incremental velocity.

/XVEL/ is positive in the positive Xp direction;
/YVEL/ is positive in the positive Yp direction;
/ZVEL/ is positive in the negative Zp direction.

After @T(//COMPCTR// = Off), these data items are not updated by the IMS. Hence, /XVEL/, /YVEL/, and /ZVEL/ remain 0 after they are read.

Characteristics of values:

Units: fps

Range: varies based on particular IMS and scale.

Max for coarse: −19.456 to 19.418.
Max for fine: −.19456 to .19418.

Maximum derivative: varies per IMS

Max for coarse: 380 fps^2
Max for fine: 3.8 fps^2

Instruction sequence: READ * (Channel 4) valid only if //COMPCTR// = On

* = 129 for Xp Axis
* = 130 for Yp Axis
* = 132 for Zp Axis

Data representation: 10-bit two's complement number, bits 6-15; scale = !inc vel scale!; offset = !acc bias!. (See //IMSSCAL// for scale factors to calculate incremental velocities.)

2.1.1.8. IMS attitudes

Input data item(s):

Input data items:	Acronyms:
Magnetic Heading - Cosine	/MAGHCOS/
Magnetic Heading - Sine	/MAGHSIN/
Pitch Angle - Cosine	/PCHCOS/
Pitch Angle - Sine	/PCHSIN/
Roll Angle - IMS - Cosine	/ROLLCOSI/
Roll Angle - IMS - Sine	/ROLLSINI/
True Heading - Cosine	/THDGCOS/
True Heading - Sine	/THDGSIN/

Hardware: Inertial Measurement Set

Description:

/THDGCOS/, /THDGSIN/: When (/IMSREL/ = Yes AND /IMSREDY/ = Yes), the angle determined by /THDGCOS/ and /THDGSIN/ is the angle measured clockwise in the Xp-Yp plane (looking in the -Zp direction: i.e., down) from the Yp axis to the projection into the Xp-Yp plane of the Ya axis. When /IMSREL/ = No), the angle determined by /THDGCOS/ and /THDGSIN/ is the magnetic variation input by pilot to the IMS panel (see Fig. 2.1.1-a).

/ROLLCOSI/, /ROLLSINI/: The angle determined by these data items is thus: Let Yap be the projection of the Ya axis into the Xp-Yp plane. Let Xap be a ray in the Xp-Yp plane that is perpendicular to Yap and that extends to the right (when viewed looking at the Xp-Yp plane in the Yap direction) of Yap. Then the angle is measured from the Xap ray to the Xa axis. The angle is positive when the positive Xa axis is below the Xp-Yp plane (negative Zp component) and negative otherwise.

/PCHCOS/, /PCHSIN/: The angle determined by these data items is the angle between the Ya axis and its projection into the Xp-Yp plane. The angle is negative when the positive Ya axis is below the Xp-Yp plane (negative Zp component) and positive otherwise.

/MAGHCOS/, /MAGHSIN/: The angle determined by these data items is the magnetic heading of the aircraft. The magnetic heading is the angle measured CW from magnetic north (looking down) to the horizontal component of the Ya axis.

Pitch: The pitch angle output is limited to a range of -90° to $+90^\circ$. If the A/C pitches up through 90° then its pitch will start back down toward 0°, but its roll will shift by 180° when the pitch crosses 90°.

Characteristics of values:

Units: None

Range: -1 to $+1$

Resolution: 1/4096

Angular Accuracy:

Magnetic Heading: $\pm 0.25^\circ$;
Pitch Angle: $\pm 0.1^\circ$;
Roll Angle: $\pm 0.1^\circ$;
True Heading: $\pm 0.1^\circ$

Maximum derivative:

Roll: 300 deg/s;

Pitch: 60 deg/s;
Heading 200 deg/s

Maximum second derivative:

Roll: 1500 deg/s^2;
Pitch: 200 deg/s^2;
Heading: 200 deg/s^2

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already done)
READ * (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - Request acknowledged.
If not, try again
When DATA READY interrupt occurs, conversion complete
READ 225 (Channel 7) (SIN)
Save Accumulator value
READ 255 (Channel 7) (COS) (Also resets Signal Converter)

where * is replaced by
228 for Magnetic Heading
225 for Pitch Angle
226 for Roll Angle
227 for True Heading

Data representation: K × SIN(A) and K × COS(A) (relative SIN and COS), where K depends on temperature and other conditions (see comments), and A is the angle for Pitch, Roll and True Heading, and the angle minus 180° for Magnetic Heading.

13 bit two's complement number, bits 0-12; bits 13-15 = 0. Scale = 4096; offset = 0.

Timing characteristics: Sychro (analog) to digital conversion (see §1.15.8).

Comments: If the Xp axis and Yp axis are aligned with (true) East, and North respectively, then /THDGCOS/ and /THDGSIN/ determine true A/C heading. If the Zp axis is aligned with vertical (Z positive in the Up direction), then /ROLLCOSI/ and /ROLLSINI/ determine A/C roll angle and /PCHCOS/ and /PCHSIN/ determine A/C pitch. Roll is positive when the right wing is down and pitch is positive when the nose is up.

The factor K, which is close to 1, is introduced by the synchro converter. Techniques to recover A from K × SIN(A) and K × COS(A) for small angles A are discussed in Ref. 6, §2.

The scale is given assuming K = 1.

2.1.1.9. AUTO/CAL light

Output data item(s): AUTO/CAL Light

Class: DOW2

Acronym: //AUTOCAL//

Hardware: Inertial Measurement Set

Description: //AUTOCAL// = On turns on the AUTO/CAL light on the IMS Adapter/Power Supply in the left hand avionics bay.

Characteristics of values:

Value encoding: On (0); Off (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2. bit 0

Comments: The light is in the pushbutton (see /IMSAUTOC/)

2.1.1.10. Computer control

Output data item(s): Computer Control

Class: DOW2

Acronym: //COMPCTR//

Hardware: Inertial Measurement Set

Description: //COMPCTR// = On commands the IMS to accept TC-2 control (see //XGYCOM//, //XSLEW//, etc.) and to update accelerometer pulses (see /XVEL/, /YVEL/, /ZVEL/).

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 13

2.1.1.11. Computer system fail

Output data item(s): Computer System Fail

Class: DOW2

Acronym: //COMPFAIL//

Hardware: Inertial Measurement Set

Description: //COMPFAIL// = Yes commands the IMS to revert to either Magnetic Slave or Grid mode depending on the most recent value of //LATGT70//. See Ref. 33a. §3.4.1.5 for IMS mode definitions. //COMPFAIL// is output also to the FLR, the ADI, and the Caution and Advisory Panel; see those sections for the effects on those devices. Turned on by hardware whenever @T(!In-time test failed!) occurs, or when certain other hardware or BITE tests fail. See Ref. 19, §3.17. Setting //COMPFAIL//=No reverses the effects of setting it to Yes, unless one of the hardware-detected anomalies still exists. In that case, the assignment has no effect.

Characteristics of values:

Value encoding: No (0): Yes (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 10

2.1.1.12. Gyro-torquing commands

Output data item(s): X/Y/Z-Axis Gyro-Torquing Commands

Acronym: //XGYCOM// //YGYCOM// //ZGYCOM//

Hardware: Inertial Measurement Set (Physically in the TC-2 but associated with IMS)

Description: //XGYCOM//, //YGYCOM//, and //ZGYCOM// reset the contents of three TC-2 hardware registers, called torque counters, that are associated with the X, Y, and Z axis gyros respectively. The TC-2 hardware is always torquing the gyros in one of two directions, positive or negative for each gyro. A positive torque rotates the X, Y, and Z axes at a constant rate CW looking along each axis in a positive direction from the origin. A negative torque rotates these axes at a constant rate CCW. The rotation rate for both positive and negative torques is approximately 80 deg/hour.

The direction of torquing for the three axes can change only at fixed times, once every 5 ms. The torquing signals delivered to each gyro during the minimum 5 ms. of constant torquing are referred to as torque pulses, which can be either positive or negative. Specifically, the directions of torquing can change shortly after the event @T(/DIMWC/ = $Changing$) occurs; this event occurs once every 5 ms. (see /DIMWC/).

Each torque pulse results in a specific amount of rotation. The amount varies slightly from platform to platform. The nominal amount is ±0.4 arcsec, but the actual amount can be entered in the TC-2 by maintenance personnel for each axis (see §4.6.22).

The signs of the next torque pulse for each gyro depend on the signs of the corresponding torque counters at the time of @T(/DIMWC/ = $Changing$). A value greater than or equal to zero results in the next torque pulse being positive. A torque counter value less than zero results in the next torque pulse being negative. Also at the time of every allowable change in torquing direction, the TC-2 increments or decrements the current value of each torque counter (the current value is the value when @T(/DIMWC/ = $Changing$) occurs). If the current value is zero or positive, it is decremented. If the current value is negative, it is incremented. The change takes place only during the condition (/DIMWC/ = $Changing$). For each torque counter, the foregoing can be summarized by the following loop:

```
while true do
begin
   if (count ≥ 0)
        then torque:= positive; count:= count -1;
        else torque:= negative; count:= count +1 fi
   pause until @T(/DIMWC/ = $Changing$)
end;
```

where count (the torque counter value) can be reset by means of //XGYCOM//, etc., during the pause.

Resetting a torque counter to a positive value n will result in n+1 positive pulses followed by alternating negative and positive pulses, provided that the counter is not reset again. Resetting a torque counter to a negative value −n will result in n negative pulses followed by alternating positive and negative pulses, again assuming that the counter is not reset again. In both cases, the condition of alternating positive and negative pulses is referred to as "toggling" or "dithering." During toggling, the torque counter value alternates between −1 and 0.

Characteristics of values:

Units: Integer Count

Range: −8 to +7

Resolution: 1

Instruction sequence: WRITE * (Channel 4) (valid only when /DIMWC/ = $Ready$) (where * = 129 for X Axis, 130 for Y Axis, 132 for Z Axis)

Data representation: 4 bit two's complement number, bits 11-14; bits 0-10 and bit 15 are not used. Scale = 1, offset = 0.

Timing characteristics: See /DIMWC/. See also Description and Comments.

Comments: Because //XGYCOM//, //YGYCOM//, and //ZGYCOM// reset the current values of the torque counters, and since only two bits of information are available about the current values of the four bit counters, pulses can be "lost" if care is not taken. (See /XGYCNT/, /YGYCNT/, and /ZGYCNT/ for more information.) In general, it is easiest to wait until a counter is toggling before resetting it.

An additional problem is the need to make sure that an equal number of positive and negative torquing pulses are output during toggling so as not to introduce an unintentional bias. This can be accomplished by determining the current value of the torque counter (−1 or 0) and resetting the counter so that the desired number of positive or negative pulses is output prior to the counter returning to the value it had at the time it was reset. The action to be taken in each case is given in the following table:

Current (toggling) value of counter	Number of desired pulses	Reset value for counter
0	n	n
0	-n	-n
-1	n	n-1
-1	-n	-(n+1)

This table can be understood by referring back to the pseudo-code and diagram given in the Description. In each case, the time required to return to the starting value (left most column) is 5n ms. From the table, it can be seen that the appropriate reset value is equal to the sum of the desired number of pulses and the current (toggling) value of the counter. During toggling, the current value of a torque counter (−1 or 0) can be determined through use of /XGYCNT/, /YGYCNT/, or /ZGYCNT/. For example, if the X axis torque counter is toggling, /XGYCNT/ = A will hold when the counter value is zero, and /XGYCNT/ = D will hold when the counter value is −1. Note that when the counter is not toggling, /XGYCNT/ does not contain sufficient information to determine the reset value.

Note: In the current OFP, the IMS equations assume an opposite rotation sense for X and Y than defined under Description. The results of the calculation are negated (thus converting into the present standard reference frame) before being output to the device.

2.1.1.18. IMS scale factor change

Output data item(s): IMS Scale Factor Change

Class: DOW2

Acronym: //IMSSCAL//

Hardware: Inertial Measurement Set

Description: //IMSSCAL// tells the IMS which of two scale factors to use for calculating incremental velocities from /XVEL/ and /YVEL/. The /ZVEL/ scale factor always remains set at $Coarse$.

Characteristics of values:

Value encoding:

$Coarse$ (0):	incremental #–velocity = low gain scale × /#VEL/ pulses
$Coarse$ (0):	incremental Z–velocity = low gain scale × /ZVEL/ pulses
$Fine$ (1):	incremental #–velocity = high gain scale × /#VEL/ pulses
where # ∈ {X Y}	

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 14

Comments: The amount of incremental velocity indicated by each /XVEL/, /YVEL/ or /ZVEL/ count varies from platform to platform. The nominal values for the scale factors are .032 for the low gain scale and .000327 for the high gain scale. The actual value for each scale factor for each axis can be entered by maintenance personnel (see §4.6.23 for low gain scale and §4.6.24 for high gain scale.)

Note: The above example of velocity calculation does not show the adjustment required for accelerometer bias.

2.1.1.14. IMS slews

Output data item(s): IMS X,Y,Z Slews

Acronym: //XSLEW// //YSLEW// //ZSLEW//

Class: DOW2

Hardware: Inertial Measurement Set

Description: //XSLEW//, //YSLEW//, //ZSLEW// command the IMS to slew the IMS platform cluster about its X, Y, and Z Axes, respectively. The directions of the slews are determined by //XSLSEN//, //YSLSEN//, //ZSLSEN//, respectively.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2;

//XSLEW//: bit 6,
//YSLEW//: bit 2,
//ZSLEW//: bit 4

Timing characteristics: X slewing and Y slewing occur at the rate 30°/min; Z slewing occurs at the rate 90 deg/min.

2.1.1.15. IMS slew directions

Output data item(s): X,Y,Z Slew Sense

Acronym: //XSLSEN// //YSLSEN// //ZSLSEN//

Class: DOW2

Hardware: Inertial Measurement Set

Description: //XSLSEN//, //YSLSEN//, //ZSLSEN// advise the IMS of the directions of the slews for X slewing, Y slewing, and Z slewing, respectively. The values designate the directions of the slew when looking in the positive direction from the origin along the X, Y, and Z axes, respectively. //XSLSEN//, //YSLSEN//, //ZSLSEN// are meaningful only when the corresponding //XSLEW//, //YSLEW//, //ZSLEW// = On.

Characteristics of values:

Value encoding:

CW (1); CCW (0):	//XSLSEN// and //YSLSEN//
CW (0); CCW (1):	//ZSLSEN//

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2;

//XSLSEN//: bit 7,
//YSLSEN//: bit 3,
//ZSLSEN//: bit 5

2.1.1.16. Latitude > 70

Output data item(s): Latitude > 70°

Acronym: //LATGT70//

Class: DOW2

Hardware: Inertial Measurement Set

Description: //LATGT70// = No directs the IMS to revert to Magnetic Slave Mode when @T(//COMPFAIL// = Yes) occurs. //LATGT70// = Yes directs the IMS to revert to Grid Mode when @T(//COMPFAIL// = Yes) occurs.

Characteristics of values:

  Value encoding: No (0), Yes (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 8

Comments: See Ref. 33a, §3.4.1.5 for IMS mode definitions.

2.1.2. Air Data Computer (ADC)

The Air Data Computer (ADC) processes inputs from the A/C pitot-static system and from a temperature probe to provide outputs that represent barometric altitude, Mach number, and true airspeed.

2.1.2.1. ADC failure

Input data item(s): ADC Failure

Acronym: /ADCFAIL/

Class: DIW5

Hardware: Air Data Computer

Description: /ADCFAIL/ = YES indicates either

(a) The ADC detects errors during its own continuous self-monitoring.

(b) The ADC is in the middle of a special self-test initiated by the self-test switch on the ADC computer.

Note that @T(/ADCFAIL/ = No) may occur after @T(/ADCFAIL/ = Yes).

Characteristics of values:

Value encoding: No (0); Yes (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 12

Timing characteristics: For a catastrophic failure, the ADC input data may be bad for 400 ms before @T(/ADCFAIL/ = Yes). A gradual degradation, e.g., icing of the probes, may result in bad data for a long period (5-10 minutes or more) before @T(/ADCFAIL/ = Yes).

2.1.2.2. ADC barometric altitude

Input data item(s): Barometric Altitude - ADC

Acronym: /BAROADC/

Hardware: Air Data Computer

Description: /BAROADC/ provides the altitude above or below sea level. /BAROADC/ is based on air pressure. The ADC calculation is based on the assumption that the sea level pressure is 29.92 inches of mercury.

Characteristics of values:

Units: Feet

Range: −1024 to 50,000

Accuracy: Ranges from ± MAX (40 ft, .3% /BAROADC/) at −54° C to ± MAX (25 ft, .25% /BAROADC/) at 10° C to 50° C.

Resolution: 14.90 ft

Maximum derivative: ±1000 ft/s

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ 235 (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again.
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Resets Signal Converter also).

Data representation: 12-bit positive number, bits 1-12. Bit 0, bits 13-15 = 0. Scale = 4096/61020 :=: 0.0671255; offset = 0

Timing characteristics: Analog (DC voltage) to digital conversion. See §1.15.8.

2.1.2.3. ADC Mach number

Input data item(s): Mach number

Acronym: /MACH/

Hardware: Air Data Computer

Description: /MACH/ provides the ratio of the speed of the A/C to the speed of sound in the surrounding atmosphere.

Characteristics of values:

Units: Mach

Range: .2 to 1.2 (accuracy above .96 may be degraded)

Accuracy: ±0.010 (at 30,000 ft and 10° C to 50° C)

Resolution: .00061

Maximum derivative: ±05 mach/s

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ 236 (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Also resets Signal Converter).

Data representation: 12-bit positive number, bits 1-12; bit 0, bits 13-15 = 0. Scale = 2048/1.25 = 1638.4; offset = 0

Timing characteristics: Analog (DC voltage) to digital conversion. See §1.15.8.

2.1.2.4. ADC true airspeed

Input data item(s): True Airspeed (TAS)

Acronym: /TAS/

Hardware: Air Data Computer

Description: /TAS/ provides the true airspeed which is the indicated airspeed corrected by the ADC for air density (altitude), temperature, and pressure.

Characteristics of values:

- **Units:** Feet/Second
- **Range:** 200 to 1013
- **Accuracy:** ±8 (at 20,000 ft and 10° C to 50° C)
- **Resolution:** .4883
- **Maximum derivative:** ±34 ft/s^2

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ 234 (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7). (Also resets Signal Converter).

Data representation: 12-bit positive number, bits 1-12; bit 0, bits 13-15 = 0. Scale = 2048/1000 = 2.048. If !Data 26! = !L-probe! then offset = 0; else offset = −12.

Timing characteristics: Analog (DC voltage) to digital conversion. See §1.15.8.

2.1.2.5. Test select ADC/FLR

Output data item(s): Test Select ADC/FLR

Class: DOW2

Acronym: //TSTADCFLR//

Hardware: Air Data Computer

Description: @T(//TSTADCFLR// = On) causes the ADC to execute a self-test yielding the following values:

/TAS/: 400 ± 20 knots
/BAROADC/ = 10,000 ft ± 1000 ft.
/MACH/ = .63 ±0.04 Mach

Characteristics of values:

Value encoding: Off (0); On (1)

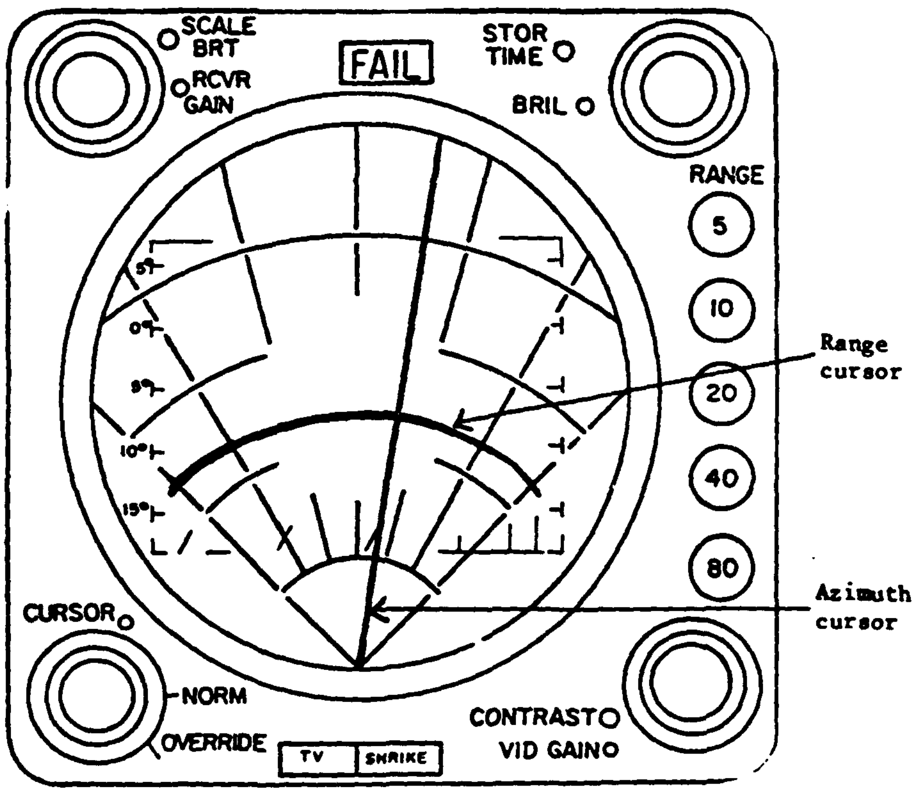
Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 1

Comments: //TSTADCFLR// is also output to the FLR.

2.1.3. Forward Looking Radar (FLR)

The FLR consists of (1) a sensor for measuring the range to an object at which it is pointed; (2) steering controls for the antenna, and (3) a radarscope display located on the main instrument panel. The TC-2 computer can control both antenna steering and cursor placement on the display. Fig. 2.1.3-a shows the FLR radarscope display, with the cursors that appear on the display.



Forward looking radar—radarscope display
Figure 2.1.3-a

2.1.3.1. FLR locked-on

Input data item(s): Locked-On

Class: SFLR-DOW3

Acronym: /LOCKEDON/

Hardware: Forward Looking Radar

Description: /LOCKEDON/ indicates whether or not the FLR antenna is locked on to an object on the ground. /LOCKEDON/ = Yes may be obtained by the hardware pointing the antenna at the point on the ground when the FLR is in the AGR mode.

Characteristics of values:

Value encoding: **No** (0); **Yes** (1)

Instruction sequence: Available after READ 64 in /SLTRNG/ instruction sequence

Data representation: Serial Input Address word, bit 0.

Comments: /LOCKEDON/ is a hardware function of the FLR. See Ref. 33e, §3.4.3.7.4.

2.1.3.2. Slant range to target

Input data item(s): Slant Range to Target

Class: SFLR-DOW3

Acronym: /SLTRNG/

Hardware: Forward Looking Radar

Description: /SLTRNG/ is the distance from the A/C to the selected point on the ground. Data valid only if /LOCKEDON/ = Yes.

Characteristics of values:

Units: Feet

Range: 1,000 to 60,000

Accuracy: ±25 below 10,000; ±0.25% of /SLTRNG/ above 10,000

Resolution: 20

Maximum derivative: 10,000 ft/s

Instruction sequence:

LA '4000' Hex (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable FLR)
Wait for External Control Interrupt
READ 64 (Channel 2) (Read Serial Input Address)
Save address data to verify identity code = 00001*
Check if !Serial Input OK!
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: 13-bit positive number, bits 0-12; bits 13-15 = 0. Scale = 1/20 = .05; offset = 0.

Comments: Note that the FLR Slant Range and the DRS status have the same device address (00001).

2.1.3.3. Antenna slave command

Output data item(s): Antenna Slave Command

Class: DOW1

Acronym: //ANTSLAVE//

Hardware: Forward Looking Radar

Description: //ANTSLAVE// = On directs the FLR to slave the antenna in azimuth and elevation to //STEERAZ// and //STEEREL//. See Ref. 13e, §3.4.3.7.1.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 8 (Channel 0)

Data representation: Discrete output word 1, bit 13

Comments: See //STEERAZ//, //STEEREL//

2.1.3.4. Computer system fail

Output data item(s): Computer System Fail

Class: DOW2

Acronym: //COMPFAIL//

Hardware: Forward Looking Radar

Description: When //COMPFAIL// = Yes, the FLR does not perform functions that require TC-2 input.

Comments: //COMPFAIL// is defined in the IMS section. //COMPFAIL// is also output to the ADI and the Caution and Advisory Panel.

2.1.3.5. Cursor azimuth

Output data item(s): Cursor Azimuth Sine and Cosine

Acronym: //CURAZSIN// //CURAZCOS//

Hardware: Forward Looking Radar

Description: These outputs control the placement of the azimuth cursor on the radarscope; they determine the angle measured from the vertical center line of the display to the cursor line drawn from the bottom of the vertical center line. Positive angles are measured clockwise looking at the display; negative angles counterclockwise. Figure 2.1.3-a shows the azimuth cursor.

The display range is only -45° to $+45^\circ$. The azimuth cursor is removed from the display when //CURAZCOS// is set to −1. Has no effect unless //CURENABL// = On.

Characteristics of values:

Units: None

Range: −1 to +1

Resolution: 1/4096

Data representation: 13-bit two's complement number, bits 0-12; bits 13-15 not used. Scale = 4096; offset = 0.

Instruction sequence: Cycle Steal Channel B, Word Identity Code:

//CURAZCOS//: 0C
//CURAZSIN//: 08

2.1.3.6. FLR cursor enable

Output data item(s): Cursor Enable

Class: DOW1

Acronym: //CURENABL//

Hardware: Forward Looking Radar

Description: //CURENABL// directs the FLR to display Range and Azimuth Cursors as specified by //CURPOS//, //CURAZCOS//, //CURAZSIN//.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 8 (Channel 0)

Data representation: Discrete output word 1, bit 12

Comments: See Ref. 33e.

2.1.3.7. FLR cursor position

Output data item(s): Cursor Position

Acronym: //CURPOS//

Hardware: Forward Looking Radar

Description: The value of //CURPOS// determines the position of the range cursor on the FLR display. Figure 2.1.3-a shows the range cursor. The FLR calculation is based on the assumption that the value of //CURPOS// is slant range and converts the number to ground range itself in order to position the cursor. Has no effect unless //CURENABL// = On.

Characteristics of values:

> **Units:** Feet
>
> **Range:** 0 to 120,000
>
> **Accuracy:** ±0.2% of //CURPOS//
>
> **Resolution:** 40

Instruction sequence: Cycle Steal Channel B, Word Identity Code 04.

Data representation: 12-bit positive number, bits 1-12; bit 0 = Scale = 1/40 = .025; offset = 0.

2.1.3.8. Flight path angle

Output data item(s): Flight Path Angle

Acronym: //FPANGL//

Hardware: Forward Looking Radar

Description: Flight Path Angle is the angle between the A/C velocity vector and its projection onto the horizontal plane. The positive direction is above the horizontal plane. The FLR calculation is based on the assumption that //FPANGL// is this angle in determining the climb or dive angle that should be used in terrain following.

Characteristics of values:

Units: Degrees

Range: −30 to +30

Accuracy: ±0.2

Resolution: .029

Instruction sequence:

WRITE 228 (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart.

Data representation: 11-bit two's complement number, bit 0 and bits 3-12; bits 1-2 not used, bits 13-15 = 0. Scale = 512/15 :=: 34.13333; offset = 0.

Timing characteristics: Digital to DC voltage conversion. See §1.15.8.

Comments: //FPANGL// is only used by the FLR when in TF mode (see /MFSW/). //FPANGL// is also output to the ADI.

2.1.3.9. FLR ground track velocity

Output data item(s): Ground Track Velocity (Ground Speed)

Acronym: //GNDTRVEL//

Hardware: Forward Looking Radar

Description: The FLR calculation is based on the assumption that //GNDTRVEL// is the A/C ground speed in determining the climb or dive angle that should be used for terrain following.

Characteristics of values:

Units: Knots

Range: 0 to 900

Accuracy: MAX (2.5, 1% of //GNDTRVEL//)

Resolution: .879

Maximum derivative: 250 knots/s^2

Instruction sequence:

WRITE 227 (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart.

Data representation: 10-bit positive number, bits 3-12; bits 0, 13-15 = 0. Scale = 512/450 :=: 1.14; offset = 0.

Timing characteristics: Digital to DC voltage conversion. See §1.15.8.

Comments: //GNDTRVEL// is only used by the FLR when it is in TF mode (see /MFSW/).

2.1.3.10. Steering commands

Output data item(s): Steering Commands - Azimuth and Elevation

Acronym: //STEERAZ// //STEEREL//

Hardware: Forward Looking Radar

Description: When //ANTSLAVE// = On, //STEERAZ// and //STEEREL// determine the direction in which the FLR antenna is pointed. Let the "antenna pointing vector" be any vector that points away from the A/C in the antenna pointing direction. Then the angle determined by //STEEREL// is the angle between the antenna pointing vector and its projection into the platform Xp-Yp plane. This angle is positive when the Zp component of the antenna pointing vector is positive, i.e., pointing up is positive when the platform is aligned.

The angle determined by //STEERAZ// is the angle between the projection of the A/C Y_a axis and the FLR antenna pointing vector into the platform Xp-Yp plane.

When //ANTSLAVE// = Off, the FLR calculation is based on the assumption that //STEERAZ// is the A/C drift angle and uses it in certain modes to position the center of the scan around the A/C ground track. Drift angle is the angle between the projection of the A/C Y_a-axis onto the horizontal plane and the projection of the A/C velocity vector onto the horizontal plane. The angle is positive when measured CW from the projection of the A/C Y_a-axis (looking down) and negative when measured CCW.

The FLR antenna is restrained by hardware stops if out-of-range angles are output.

Characteristics of values:

Units: degrees

Range:

Azimuth: −40° to +40°;
Elevation: −20° to +20°.

Accuracy: ±0.1

Maximum derivative: TBD

Instruction sequence:

WRITE * (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart.

* = 235 for Azimuth
* = 234 for Elevation

Data representation: These two data items and //BRGDEST// and //GNDTRK// are represented with two fields, an Octant and a Magnitude. To calculate the indicated value of //STEERAZ//, use the translation table below. To calculate the indicated value of //STEEREL//, //BRGDEST// and //GNDTRK//, add 180° to the standard value, and then use the translation table below.

Angle-to-Octant/Magnitude Translation Table		
Angle α, in degrees	**Octant**	**Magnitude in Indicated Units**
0	0	1023
0 $< \alpha <$ 45	0	$\lfloor$ ABS(tan α) $\times$ 1024 $\rfloor$
45	1	1023
45 $< \alpha <$ 90	1	$\lfloor$ ABS(cotan α) $\times$ 1024 $\rfloor$
90	2	1023
90 $< \alpha <$ 135	2	$\lfloor (2^{13} - \lfloor$ABS(cotan α)$\rfloor \times 2^{13})/2^3 \rfloor$
135	3	1023
135 $< \alpha <$ 180	3	$\lfloor$ ABS(tan α) $\times$ 1024 $\rfloor$
180	4	1023
180 $< \alpha <$ 225	4	$\lfloor (2^{13} - \lfloor$ABS(tan α)$\rfloor \times 2^{13})/2^3 \rfloor$
225	5	1023
225 $< \alpha <$ 270	5	$\lfloor (2^{13} - \lfloor$ABS(cotan α)$\rfloor \times 2^{13})/2^3 \rfloor$
270	6	1023
270 $< \alpha <$ 315	6	$\lfloor$ ABS(cotan α) $\times$ 1024 $\rfloor$
315	7	1023
315 $< \alpha <$ 360	7	$\lfloor (2^{13} - \lfloor$ABS(tan α)$\rfloor \times 2^{13})/2^3 \rfloor$

Octant: 3-bit positive number, bits 0-2;
Magnitude: 10-bit positive number, bits 3-12.
Bits 13-15 not used.

Timing characteristics: Digital to synchro conversion. See §1.15.8.

2.1.3.11. Test select ADC/FLR

Output data item(s): Test Select ADC/FLR

Class: DOW2

Acronym: //TSTADCFLR//

Hardware: Forward Looking Radar

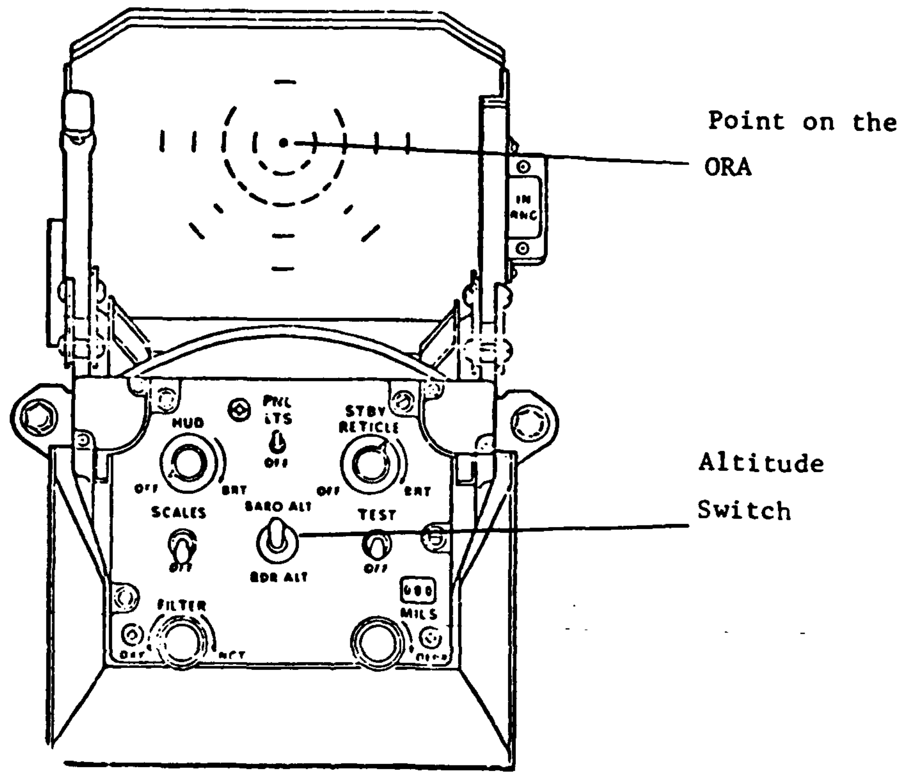
Description: The event @T(//TSTADCFLR//=On) causes the FLR to execute a self-test yielding /LOCKEDON/=Yes and /SLTRNG/= 10,000 ± 1000 ft

Comments: This data item is defined in the ADC section.

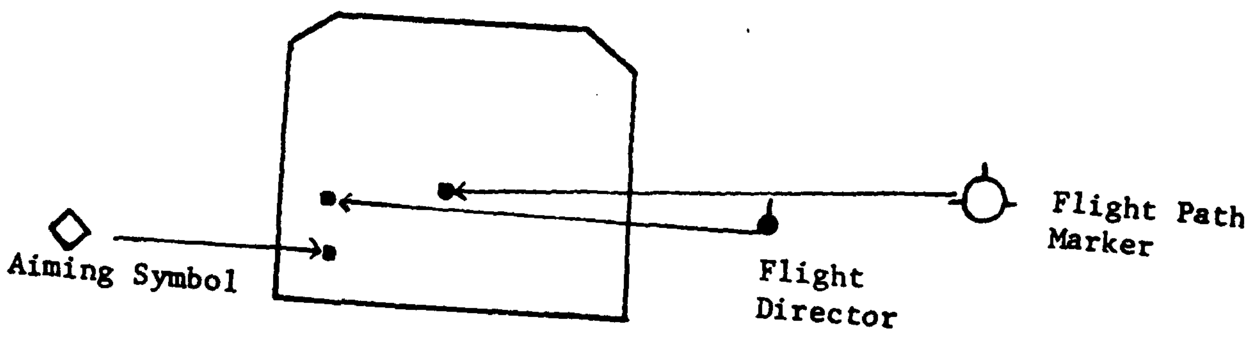
2.1.4. Head-Up Display (HUD)

The Head-Up Display (HUD) (Fig. 2.1.4-a.) is an electro-optical device that projects attack and flight information in symbolic form into the pilot's forward field of view. All azimuth and elevation angles of HUD symbols are defined with respect to the HUD Optical Reference Axis (ORA). The HUD is mounted so that the pilot sees the ORA as parallel to A/C boresight. The HUD displays all symbols so that they appear to be at infinite distance from the A/C. The position of the center of each symbol is described in terms of a line from a point on the ORA to the apparent location of the symbol. The azimuth is the angle between the projection of this line on the X_a-Y_a plane and the ORA. The elevation is the angle between the projection of this line on the Y_a-Z_a plane and the ORA. Because the points are apparently at infinite distance, the angles are not sensitive to the exact location of the reference point on the ORA and one may assume that it coincides with the pilot's eyes.

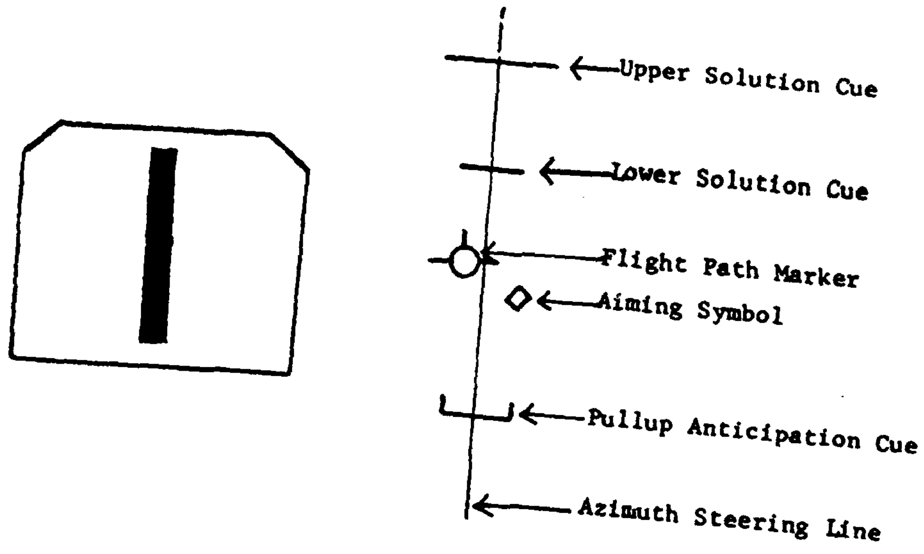
The HUD refreshes display symbols at the rate of 50 times/s. and does not display symbols that are out of the display range.



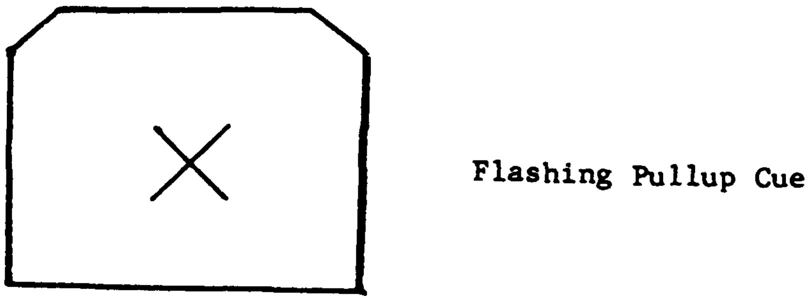
Head-up display
Figure 2.1.4-a



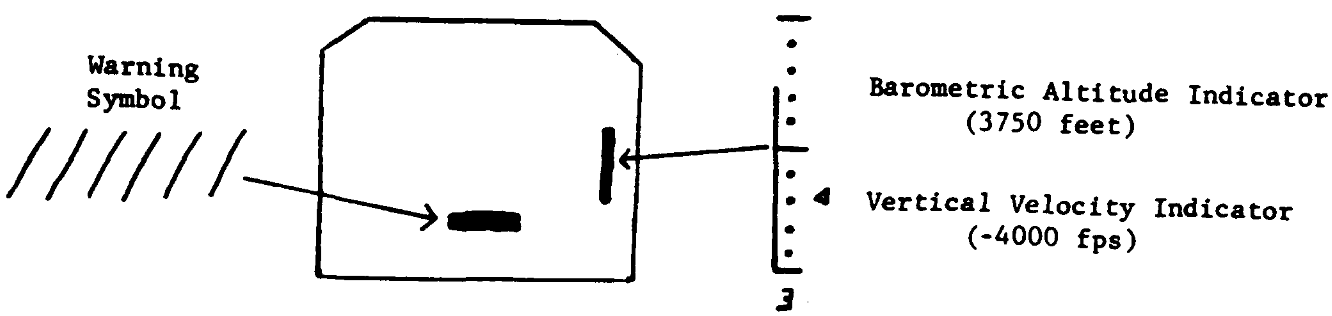
HUD aiming symbol, flight director, and flight path marker
Figure 2.1.4-b



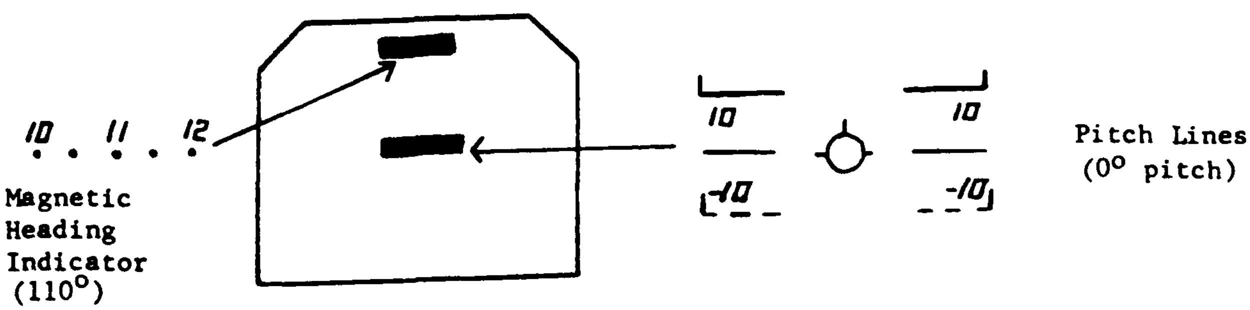
HUD cues
Figure 2.1.4-c



HUD pullup cue
Figure 2.1.4-d



HUD barometric altitude indicator and vertical velocity indicator
Figure 2.1.4-e



HUD magnetic heading indicator and pitch
Figure 2.1.4-f

2.1.4.1. HUD reliable

Input data item(s): HUD Reliable

Class: DIW4

Acronym: /HUDREL/

Hardware: Head Up Display

Description: /HUDREL/ indicates whether or not the HUD is reliable. The HUD continuously runs its own self-tests when turned on. /HUDREL/ = No when the HUD is off.

Characteristics of values:

Value encoding: No (0); Yes (1)

Instruction sequence: READ 1 (Channel 0)

Data representation: Discrete input word 4, bit 15

2.1.4.2. HUD AS, ASL, FPM, LSC, PUAC, and USC

Output data item(s):

Item	Acronym
Aiming Symbol - Azimuth	//ASAZ//
Aiming Symbol - Elevation	//ASEL//
ASL Center Point - Azimuth	//ASLAZ//
ASL Center Point - Elevation	//ASLEL//
Flight Path Marker - Azimuth	//FPMAZ//
Flight Path Marker - Elevation	//FPMEL//
Lower Solution Cue - Azimuth	//LSOLCUAZ//
Lower Solution Cue - Elevation	//LSOLCUEL//
Pull-up Anticipation Cue - Azimuth	//PUACAZ//
Pull-up Anticipation Cue - Elevation	//PUACEL//
Upper Solution Cue - Azimuth	//USOLCUAZ//
Upper Solution Cue - Elevation	//USOLCUEL//

Hardware: Head Up Display

Description: These data items control the angular azimuth and elevation displacements of the corresponding HUD symbols from the HUD ORA.

Elevation angles are angles in the A/C Y_a-Z_a plane and are positive if upward from the ORA when looking at the HUD from the pilot's viewpoint.

Azimuth angles are in the A/C X_a-Y_a plane and are positive if to the right of the ORA when looking at the HUD from the pilot's viewpoint. See Fig. 2.1.4-c for pictures of the symbols and Ref. 33g for more information.

Characteristics of values:

Units: Degrees

Range: ±16

Accuracy: ±5 milliradians (worst case)

Resolution: 1/128

Maximum derivative: ±30 deg/s

Instruction sequence: Cycle Steal Channel A, Word Identity Code:

//ASAZ//:	03,	[illegible]	04,
//ASLAZ//:	07,	//ASLEL//:	08,
//FPMAZ//:	01,	//FPMEL//:	02,
//LSOLCUAZ//:	09,	//LSOLCUEL//:	OA,
//PUACAZ//:	OD,	//PUACEL//:	OE,
//USOLCUAZ//:	OB,	//USOLCUEL//:	OC

Data representation: 12-bit two's complement number, bits 0-11; bits 12-15 not used. Scale = 128; offset = 0.

2.1.4.8. Azimuth steering line angle and roll angle

Output data item(s):

Item	Acronym
ASL Cosine of angle	//ASLCOS//
ASL Sine of angle	//ASLSIN//
Roll Angle - HUD - Cosine	//ROLLCOSH//
Roll Angle - HUD - Sine	//ROLLSINH//

Hardware: Head Up Display

Description: //ASLCOS// and //ASLSIN// control the angular rotation of the Azimuth Steering Line (ASL). The angle is zero when the ASL is vertical (parallel to A/C Y_a-Z_a plane) and is measured CW when looking at the HUD from the pilot's viewpoint.

//ROLLCOSH// and //ROLLSINH// control the angular rotation of the horizon and pitch lines, the flight director symbol, and the landing director. The angles of the horizon/pitch lines are zero when the lines are horizontal (parallel to A/C X_a-Y_a plane) with the strike marks on the ends pointing up. They are measured CCW when looking at the HUD from the pilot's point of view. See Fig. 2.1.4-f for a picture of the horizon/pitch lines, and Ref. 33g for more information.

Characteristics of values:

Units: None

Range: −1 to +1

Accuracy: ±5 milliradians (worst case)

Resolution: 1/2048

Maximum derivative:

ASL Angle: ±180 deg/s
Roll Angle: ±120 deg/s.

Instruction sequence: Cycle Steal Channel A. Word Identity Code:

//ASLCOS//: 06;
//ASLSIN//: 05;
//ROLLCOSH//: 16;
//ROLLSINH//: 15

Data representation: 12-bit two's complement number. bits 0-11: bits 12-15 not used. Scale = 2048: offset = 0.

2.1.4.4. HUD barometric altitude

Output data item(s): Barometric Altitude - HUD

Acronym: //BAROHUD//

Hardware: Head Up Display

Description: When the HUD Altitude switch is set to BARO ALT, //BAROHUD// determines the two digits and a bar position for the altitude display on the HUD. (The TC-2 can not sense the altitude switch). The switch is shown in Fig. 2.1.4-a, and the display symbology is shown in Fig. 2.1.4-e.

The digits displayed are //BAROHUD// − (//BAROHUD// MOD 1000).

The bar height indicates (//BAROHUD// MOD 1000) on a scale from 0 to 1000.

Characteristics of values:

Units: None

Range: −1,000 to +50,000

Resolution: 12.207

Maximum derivative: ±10,000/min.

Instruction sequence: Cycle Steal Channel A, Word Identity Code 18

Data representation: 13-bit two's complement number, bits 0-12; bits 13-15 not used. Scale = 4096/50000 :=: 0.08192; offset = 0.

2.1.4.5. HUD Flight director

Output data item(s): Flight Director - Azimuth (Heading Error Cue Azimuth)

Acronym: //FLTDIRAZ//

Hardware: Head Up Display

Description: //FLTDIRAZ// controls the azimuthal placement of the Flight Director symbol. The azimuthal angle is measured in the X_a-Y_a plane and is positive if the Flight Director symbol is to the right of the ORA when looking at the HUD from the pilot's viewpoint. The Flight Director Symbol is shown in Fig. 2.1.4-b.

Because of hardware constraints, the flight director is not displayed if a master function switch is selected.

Characteristics of values:

- **Units:** Degrees
- **Range:** −8 to +8
- **Accuracy:** ±5 milliradians (worst case)
- **Resolution:** 1/256
- **Maximum derivative:** ±30 deg/s

Instruction sequence: Cycle Steal Channel A, Word Identity Code: 0F

Data representation: 12-bit two's complement number, bits 0-11: bits 12-15 not used. Scale = 256; offset = 0.

2.1.4.6. HUD symbol controls

Output data item(s): HUD Symbol Controls (7 Data Items)

Acronym: //HUDWARN// //HUDPUC// //HUDVEL// //HUDFPM// //HUDAS// //HUDSCUE// //HUDASL//

Class: HUDCTL

Hardware: Head Up Display

Description:

//HUDWARN//: tells the HUD whether or not to display the warning symbol

//HUDPUC//: tells the HUD whether or not to display a blinking pull up cue

//HUDVEL//: tells the HUD whether or not to display the vertical velocity and altitude scale, the vertical velocity marker, and the altitude marker. The vertical velocity indicator is used in all flight modes, the HUD also interprets //HUDVEL// as an indication of TC-2 operating condition. When //HUDVEL// = Off, the HUD uses non-computer inputs to position the Flight Path Marker.

//HUDFPM//: the HUD will blink the flight path marker on and off for two seconds following @T(//HUDFPM// = $Blink$). At other times the HUD displays the FPM constantly

//HUDAS//: tells the HUD whether or not to display the aiming symbol

//HUDSCUE//: tells the HUD whether or not to display the solution cues; because of a hardware constraint, not displayed if no master function switch is selected.

//HUDASL//: tells the HUD whether or not to display the azimuth steering line; because of a hardware constraint, not displayed if no master function switch is selected.

Characteristics of values:

Value encoding:

//HUDWARN//	On (1);	Off (0)	bit 0
//HUDPUC//	$Blink$ (1);	Off (0)	bit 1
//HUDVEL//	Off (1);	On (0)	bit 2
//HUDFPM//	$Blink$ (1);	$Constant$ (0)	bit 3
//HUDAS//	Off (1);	On (0)	bit 4
//HUDSCUE//	Off (1);	On (0)	bit 5
//HUDASL//	Off (1);	On (0)	bit 6

Note: Bits 7-15 must be set to 0.

Instruction sequence: Cycle Steal Channel A, Word Identity Code 17

Timing characteristics: To blink the FPM for two seconds, (//HUDFPM// = $Blink$) must hold for at least 100 ms. and not more than two seconds.

2.1.4.7. HUD magnetic heading

Output data item(s): Magnetic Heading - HUD

Acronym: //MAGHDGH//

Hardware: Head Up Display

Description: The HUD displays the two most significant digits of up to three integers that are multiples of 10. A fixed pointer indicates the position of //MAGHDGH// within the displayed range. The pointer is called the lubber line. The display simulates a horizontal tape moving past a fixed pointer. See Fig. 2.1.4-f for a picture of the Magnetic Heading display.

Characteristics of values:

> **Units:** Degrees
>
> **Range:** 0 to 360
>
> **Resolution:** .17578
>
> **Maximum derivative:** ±30 deg/s

Instruction sequence: Cycle Steal Channel A, Word Identity Code: 12

Data representation: 11-bit positive number, bits 1-11; bit 0 = 0, bits 12-15 not used. Scale = 2048/360 :=: 5.6888; offset = 0.

2.1.4.8. HUD pitch angle

Output data item(s): Pitch Angle

Acronym: //PTCHANG//

Hardware: Head Up Display

Description: //PTCHANG// controls the spacing between and numerical labeling of the pitch/horizon lines as well as their horizontal positions with respect to the Flight Path Marker. The pitch/horizon lines simulate a vertical tape moving past the FPM. The "tape" can be rotated by means of //ROLLCOSH// and /ROLLSINH//. Figure 2.1.4-f shows a picture of the pitch/horizon lines, and Ref. 33g provides more information.

Characteristics of values:

Units: Degrees

Range: ±90

Resolution: .02197

Maximum derivative: ±30 deg/s

Instruction sequence: Cycle Steal Channel A. Word Identity Code: 14

Data representation: 12-bit two's complement number, bits 0-11; bits 12-15 not used. Scale = 4096/90 :=: 45.511; offset = 0.

Comments: The HUD hardware changes scaling (6 possibilities) as //PTCHANG// increases. Regardless of the scale, the pitch lines are 5° apart on the HUD.

2.1.4.9. HUD vertical velocity/acceleration

Output data item(s): Vertical Velocity/Acceleration

Acronym: //VERTVEL// //VTVELAC//

Hardware: Head Up Display

Description: The HUD uses either //VERTVEL// or //VTVELAC// to place the vertical velocity pointer on the vertical velocity scale. Which one is used is not under TC-2 control.

The pointer displacement from the bottom of the vertical velocity scale is a linear function of the output values. The value −1000 results in zero displacement, and the value +1000 results in maximum displacement. The value that may be output has a range of ±10,000, but only ±1000 is displayed. That is, the pointer on the HUD moves off the scale if the value is greater than 1000, but is limited to the field of view.

The vertical velocity indicator is shown in Fig. 2.1.4-e.

Characteristics of values:

- **Units:** None
- **Range:** ±10,000
- **Resolution:** 4.882
- **Maximum derivative:** ±10,000/min

Instruction sequence: Cycle Steal Channel A, Word Identity Code:

10 for //VTVELAC//
11 for //VERTVEL//

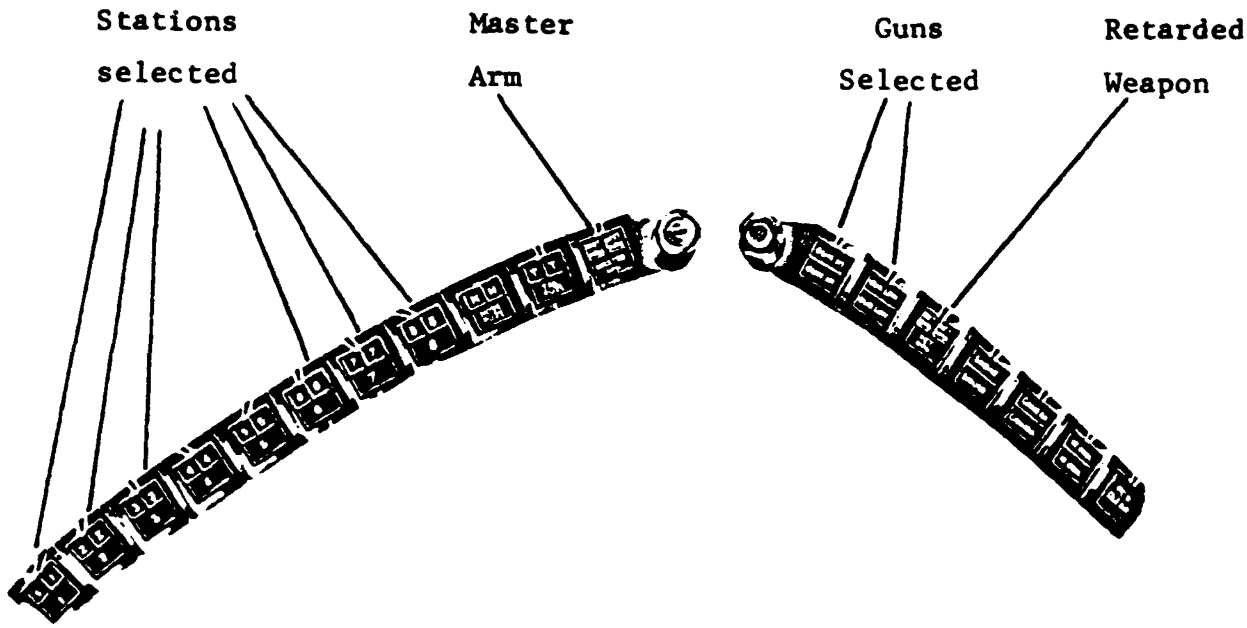
Data representation: 12-bit two's complement number, bits 0-11; bits 12-15 not used. Scale = 2048/10000 = .2048; offset = 0.

Comments: //VERTVEL// is displayed when the HUD detects landing mode (not a software condition). //VTVELAC// is displayed at all other times.

2.1.5. Armament Station Control Unit (ASCU)

The Armament Station Control Unit (ASCU) provides control and release functions for weapons and external stores.

Also included in this section are several cockpit switches that provide input to both the TC-2 and the ASCU. These switches are shown in Fig. 2.1.5-a.



Cockpit switches
Figure 2.1.5-a

2.1.5.1. Bomb drag

Input data item(s): Bomb Drag (also called Retarded Weapon)

Class: DIW4

Acronym: /BMBDRAG/

Hardware: None

Description: /BMBDRAG/ indicates the position of the cockpit switch labeled RET WPN. See Ref. 14a, Fig. 8-7.

Characteristics of values:

Value encoding: Low (0); $High$ (1)

Instruction sequence: READ 1 (Channel 0)

Data representation: Discrete input word 4, bit 0

2.1.5.2. Guns selected

Input data item(s): Guns Selected

Class: DIW3

Acronym: /GUNSSEL/

Hardware: Armament Station Control Unit

Description: /GUNSSEL/ indicates whether or not the pilot has selected guns by means of the GUN HI and/or GUN LO armament selector pushbuttons.

Characteristics of values:

Value encoding: Yes (0); No (1)

Instruction sequence: READ 2 (Channel 0)

Data representation: Discrete input word 3, bit 7

2.1.5.3. Master arm switch

Input data item(s): Master Arm

Class: DIW5

Acronym: /MA/

Hardware: Cockpit Switch connected to Armament Station Control Unit

Description: /MA/ indicates the position of the Master Arm switch. See Ref. 14a, Fig. 8-8. The value is also input directly to the ASCU, which will not release weapons unless /MA/ = On.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 15

2.1.5.4. Multiple rack switch

Input data item(s): Multiple Rack

Class: DIW3

Acronym: /MULTRACK/

Hardware: Armament Station Control Unit

Description: /MULTRACK/ indicates whether or not the highest priority selected station has a multiple ejector rack (either Multiple Ejector Rack (MER) with 6 stores or Triple Ejector Rack (TER) with 3 stores).

Characteristics of values:

Value encoding: No (0); Yes (1)

Instruction sequence: READ 2 (Channel 0)

Data representation: Discrete input word 3, bit 9

Comments: See /STA1RDY/, /STA2RDY/, etc.

2.1.5.5. Stations ready

Input data item(s): Station Ready (6 data items)

Class: DIW3

Acronym: /STA1RDY/ /STA2RDY/ /STA3RDY/ /STA6RDY/ /STA7RDY/ /STA8RDY/

Hardware: Armament Station Control Unit

Description: An item will be Yes if and only if the pilot has selected the corresponding station using the pushbutton station selectors. See Ref. 14a. Fig. 8-7.

Characteristics of values:

  Value encoding: No (0); Yes (1)

Instruction sequence: READ 2 (Channel 0)

Data representation: Discrete input word 3

/STA1RDY/: bit 1
/STA2RDY/: bit 2
/STA3RDY/: bit 3
/STA6RDY/: bit 4
/STA7RDY/: bit 5
/STA8RDY/: bit 6

Comments: See /WEAPTYP/.

2.1.5.6. Weapon type

Input data item(s): Weapon Type

Class: DIW1

Acronym: /WEAPTYP/

Hardware: Armament Station Control Unit

Description: When no weapons station is selected, the value of /WEAPTYPE/ is 00. When one or more weapons stations are selected, /WEAPTYPE/ is a two digit code specifying the type of weapon in the highest priority weapons station. (The priority is determined by the ASCU and is not under TC-2 control.) The ASCU code table is given in Section 2.4. This table also gives mnemonic names for the ASCU codes.

Characteristics of values:

Range: 0 to 99

Instruction sequence: READ 8 (Channel 0)

Data representation: Discrete input word 1. BCD encoded in bits 0-7. Bits 0-3 hold the tens digit, bits 4-7 hold the units digit.

Comments: See /STA1RDY/, /STA2RDY/, etc.

2.1.5.7. Bomb release

Output data item(s): Bomb Release

Class: DOW1

Acronym: //BMBREL//

Hardware: Armament Station Control Unit

Description: When @T(//BMBREL// = On) occurs, the ASCU issues the start of a release pulse to the highest priority ready station. If /ARPPAIRS/ = Yes, the pulse is also issued to the station symmetrically placed about the Ya axis, if it is also ready. See /ARPPAIRS/ and /STA1RDY/, etc.

Symmetrically placed station pairs are (1,8), (2,7) and (3,6).

Station priority (from highest to lowest) is 1, 8, 2, 7, 3, 6.

When @T(//BMBREL// = Off) occurs, the ASCU ends the release pulse.

If the A/C is on the ground (/ACAIRB/ = No), the ASCU will not issue release pulses. If the A/C is airborne with wheels down, the ASCU will not issue release pulses to stations 3 or 6.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 8 (Channel 0)

Data representation: Discrete output word 1, bit 10

Timing characteristics: //BMBREL// = Off must hold for at least 1 ms before @T(//BMBREL// = On).

Required //BMBREL// pulse width varies with weapon. The pulse width range is about 21 to 134 ms. Pulse widths are given in §2.4.

2.1.5.8. Fire ready

Output data item(s): Fire Ready

Class: DOWI

Acronym: //FIRRDY//

Hardware: Armament Station Control Unit

Description: //FIRRDY// = On readies the ASCU for weapon release. The ASCU will not issue release pulses unless /FIRRDY/ = On.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: WRITE 8 (Channel 0)

Data representation: Discrete output word 1, bit 9

Timing characteristics: //FIRRDY// = On can be issued simultaneously with //BMBREL// = On for all weapons except SHRIKE. For SHRIKE, @T(//FIRRDY// = On) must occur approximately 1 to 2.5 seconds before @T(//BMBREL// = On) in order to turn on thermal batteries.

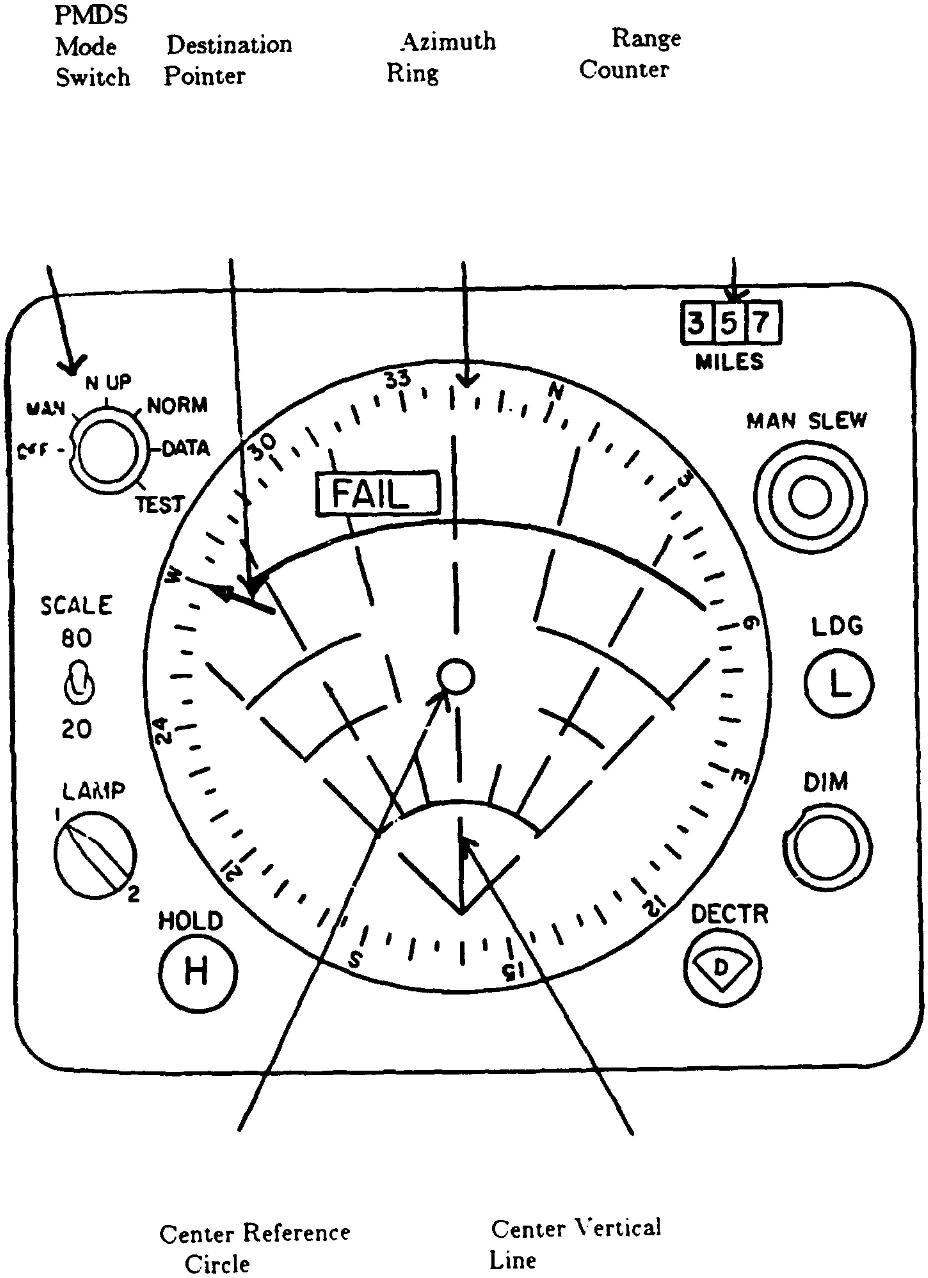
2.1.6. Projected Map Display Set (PMDS)

The Projected Map Display Set (PMDS) is driven by the TC-2 to give a continuous indication of the A/C geographical position on filmed maps projected upon a screen in the cockpit. Control of the PMDS requires an understanding of the film-strip formats. These are described in detail in Ref. 33h. This section provides an introduction. The film-strips are prepared by dividing maps into rows and then placing images of the rows along the film-strip.

The maps known as "A", cover approximately 800 nautical miles (nmi) by 1000 nmi; the maps known as "B", cover approximately 1500 nmi by 2500 nmi. The long axis may be either east-west or north-south. "A" maps are photographed in two scales. The photographs of the large scale maps alternate with those of the low scale maps, the latter being much longer and using more of the film.

Cassettes within this specification are characterized by six parameters giving for Area A and Area B the following information: longitude of the center of the map area, the latitude of the southernmost part, and the map orientation (whether long axis is north-south or east-west).

Fig. 2.1.6-a shows the PMDS display unit in the cockpit.



Projected map display set
Figure 2.1.6-a

2.1.6.1. PMDS decenter switch

Input data item(s): PMDS Decenter

Class: DIW6

Acronym: /PMDCTR/

Hardware: Projected Map Display Set

Description: /PMDCTR/ indicates the setting of the DECTR Switch on the PMDS panel (Fig. 2.1.6-a). This switch has no hardware effect on the PMDS.

Characteristics of values:

  Value encoding: No (0); Yes (1)

Instruction sequence: READ 16 (Channel 0)

Data representation: Discrete input word 6, bit 2

2.1.6.2. PMDS hold switch

Input data item(s): PMDS Hold

Class: DIW6

Acronym: /PMHOLD/

Hardware: Projected Map Display Set

Description: /PMHOLD/ indicates the setting of the HOLD Switch on the PMDS panel (Fig. 2.1.6-a). This switch has no hardware effect on the PMDS.

Characteristics of values:

  Value encoding: \$No\$ (0); \$Yes\$ (1)

Instruction sequence: READ 16 (Channel 0)

Data representation: Discrete input word 6, bit 1

2.1.6.3. PMDS north-up switch

Input data item(s): PMDS North Up

Class: DIW6

Acronym: /PMNORUP/

Hardware: Projected Map Display Set

Description: /PMNORUP/ indicates whether or not the six-position PMDS mode rotary switch is set to N UP (Fig. 2.1.6-a). Computer commands are only accepted by the PMDS when this switch is in the position MAN or N UP. However, the TC-2 is not able to distinguish between the other 4 switch settings.

Switch nomenclature: OFF, MAN, N UP, NORM, DATA, TEST

Characteristics of values:

Value encoding: No (0); Yes (1)

Instruction sequence: READ 16 (Channel 0)

Data representation: Discrete input word 6, bit 3

2.1.6.4. PMDS scale switch

Input data item(s): PMDS Scale

Class: DIW6

Acronym: /PMSCAL/

Hardware: Projected Map Display Set

Description: /PMSCAL/ indicates the position of a two-position toggle switch marked "SCALE" on the PMDS Panel (Fig. 2.1.6-a). This switch has no hardware effect on the PMDS. Switch nomenclature: 80, 20

Characteristics of values:

Value encoding: \$20\$ (0); \$80\$ (1)

Instruction sequence: READ 16 (Channel 0)

Data representation: Discrete input word 6, bit 0.

2.1.6.5. PMDS landing switch

Input data item(s): PMDS Landing

Class: DIW6

Acronym: /PMSLAND/

Hardware: Projected Map Display Set

Description: /PMSLAND/ indicates the position of the two-position switch marked "LDG" on the PMDS Panel (Fig. 2.1.6-a). The switch has no hardware effect on the PMDS.

Characteristics of values:

  Value encoding: \$No\$ (0), \$Yes\$ (1)

Instruction sequence: READ 16 (Channel 0)

Data representation: Discrete input word 6, bit 4

2.1.6.6. Azimuth ring angle

Output data item(s): Azimuth Ring Angle

Acronym: //AZRING//

Hardware: Projected Map Display Set

Description: //AZRING// positions the azimuth ring, a scale ring with direction markers that rotates around the PMDS display. When looking at the PMDS display, //AZRING// is the angle measured CW from the N marker on the azimuth ring to the central vertical line on the display face.

For example, the //AZRING// value for the azimuth ring position in Fig. 2.1.6-a is 340°.

Characteristics of values:

Units: degrees

Range: 0 - 360°

Accuracy: ±1.0°

Resolution: .087912°

Instruction sequence: Cycle Steal Channel A, Word Identity Code: 22

Data representation: 12-bit positive number, bits 1-12. Bit 0 = 0, bits 13-15 not used. Scale = 4096/360 :=: 11.377; offset = 0.

Timing characteristics: Position change occurs at approximately 18 deg/s

2.1.6.7. Destination pointer angle

Output data item(s): Destination Pointer Angle

Acronym: //DESTPNT//

Hardware: Projected Map Display Set

Description: //DESTPNT// positions the destination pointer, an arrow on the face of the PMDS. //DESTPNT// determines the angle between the central vertical line on the display face and the arrow. The angle is measured CW when looking at display. For example, the //DESTPNT// value to position the destination pointer in Fig. 2.1.6-a is 290°.

Characteristics of values:

- **Units:** degrees
- **Range:** 0 - 360°
- **Accuracy:** ±1.0°
- **Resolution:** .087912°

Instruction sequence: Cycle Steal Channel A, Word Identity Code: 23

Data representation: 12-bit positive number, bits 1-12; bit 0 = 0, bits 13-15 not used. Scale = 4096/360 :=: 11.377; offset = 0.

Timing characteristics: Position change occurs at approximately 18 deg/s

2.1.6.8. Map orientation angle

Output data item(s): Map Orientation Angle

Acronym: //MAPOR//

Hardware: Projected Map Display Set

Description: //MAPOR// determines the rotation angle of the map itself. It gives the angle, measured CCW looking at the display, from the center vertical line to a line drawn from the center reference circle in the north direction of the projected map.

Characteristics of values:

Units: degrees

Range: 0 - 360°

Accuracy: ±1°

Resolution: .087912°

Instruction sequence: Cycle Steal Channel A, Word Identity Code: 21

Data representation: 12-bit positive number, bits 1-12; bit 0 = 0, bits 13-15 not used. Scale = 4096/360 :=: 11.377; offset = 0.

Timing characteristics: Position change occurs at approximately 18 deg/s

2.1.6.9. Range digits

Output data item(s): Range Digits

Acronym: //RNGUNIT// //RNGTEN// //RNGHND//

Hardware: Projected Map Display Set

Description: These three data items control the units-digit (//RNGUNIT//), tens-digit (//RNGTEN//), and hundreds-digit (//RNGHND//) of a 3-digit range counter on the PMDS.

Characteristics of values:

Value encoding: bits 0 to 7 of associated words

0 (01010101);
1 (01100010);
2 (01001001);
3 (00011100);
4 (10101110);
5 (11011101);
6 (11101010);
7 (11000001);
8 (10010100);
9 (00100110)

Instruction sequence:

WRITE * (Channel 7)
Test Carry BIT = 0 for request acknowledged
If not, restart.

* = 224 for //RNGUNIT//
* = 225 for //RNGTEN//
* = 226 for //RNGHND//

Timing characteristics: Digital to synchro torque receiver conversion. See §1.15.8.

Comments: //RNGUNIT//, //RNGTEN//, and //RNGHND// are also output to the HSI.

2.1.6.10. Horizontal map position commands

Output data item(s): X-Command - Coarse and Fine

Acronym: //XCOMMC// //XCOMMF//

Hardware: Projected Map Display Set

Description: Together, //XCOMMC// and //XCOMMF// determine the PMDS film-strip horizontal position

Characteristics of values:

Units: Inch

Range: 0 - 523.09

Resolution: .00049886

Instruction sequence: Cycle Steal Channel A, Word Identity Code:

//XCOMMC//: 1D
//XCOMMF//: 1E

Data representation: 20-bit positive number. The 20-bit indicated value is composed of 8 bits from //XCOMMC// (bits 1-8; bit 0 = 0, bits 9-15 not used) followed by 12 bits from //XCOMMF// (bits 1-12; bit 0 = 0, bits 13-15 not used).

1/scale :=: .00049886; offset = 0.

Timing characteristics: When the value is changed, the map moves to the new position at the rate of 3.5 inches per second.

Comments: The film-strip formats are described in *detail in Ref.* 33h.

2.1.6.11. Vertical map position command

Output data item(s): Y-Command

Acronym: //YCOMM//

Hardware: Projected Map Display Set

Description: //YCOMM// determines the vertical position of the PMDS film-strip.

Characteristics of values:

Units: Inch

Range: 0 - 1.020928

Resolution: .00049854

Instruction sequence: Cycle Steal Channel A Word Identity Code: 1F

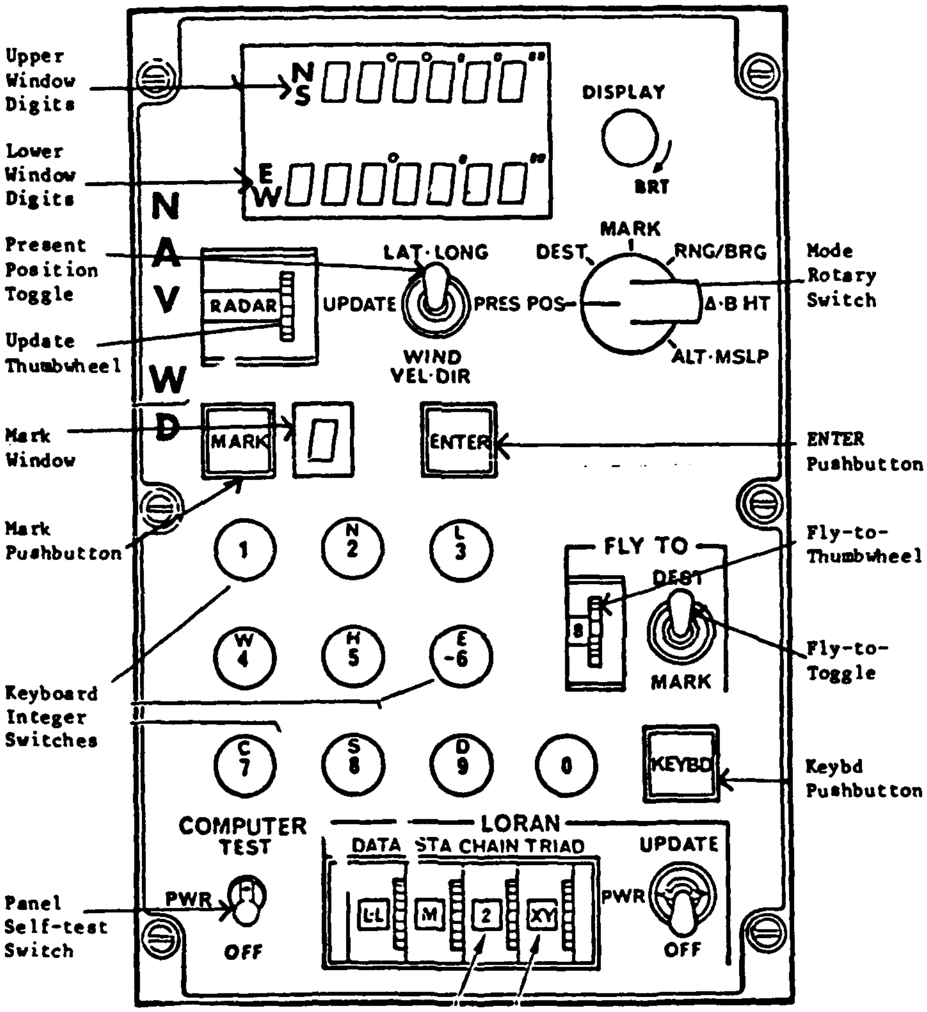
Data representation: 11-bit positive number, bits 1-11; bit 0 = 0. bits 12-15 not used. 1/scale := .00049854; offset = 0.

Timing characteristics: When the register's value is changed, the film is moved to the new position at a rate of 1.25 inches per second.

Comments: The film-strip formats are described in detail in Ref. 33h. Using the film format described in Ref. 33h. 0.510464 inches is the vertical center of the filmstrip.

2.1.7. TC-2 Panel

The TC-2 Panel provides an interface between the pilot and the TC-2 with both data entry via pushbuttons, toggles, and rotaries, and display of data via two windows, a numeric indicator, and several illuminated switch-indicators. Figure 2.1.7-a shows the various switches, buttons and indicators.



TC-2 panel
Figure 2.1.7-a

2.1.7.1. Enter button

Input data item(s): Enter Pushbutton Switch

Class: PIW1

Acronym: /ENTERSW/

Hardware: TC-2 Panel

Description: The ENTER button is a momentary contact pushbutton switch on the TC-2 panel. /ENTERSW/ indicates whether or not the ENTER button was pushed since the last time Panel Input Word 1 was checked. The event @T(/ENTERSW/ = On), i.e.. pushing the button, generates a Panel Interrupt.

Characteristics of values:

Value encoding: Off (0); On (1)

Data representation: TC-2 Panel Input Word 1, bit 10

Instruction sequence: READ 208 (Channel 6)

Timing characteristics: The thirteen buttons that generate Panel Interrupts are not interlocked. If one is pressed before the previous panel interrupt is serviced, both bits will be set. The software cannot resolve such ambiguities. The other input data items that cause panel interrupts are /KBDENBL/, /KBDINT/, and /MARKSW/.

Comments: READ 208 resets all bits of TC-2 Panel Word 1 to 0. Spurious interrupts occasionally occur; when they do, there is no change to TC-2 Panel Word 1.

2.1.7.2. Fly-to thumbwheel

Input data item(s): Fly-to Thumbwheel

Class: PIW2

Acronym: /FLYTOTW/

Hardware: TC-2 Panel

Description: /FLYTOTW/ indicates the setting of a ten-position BCD thumbwheel switch. The ten positions are labeled with decimal digits.

Characteristics of values:

Value encoding:

0 (1111);
1 (1110);
2 (1101);
3 (1100);
4 (1011);
5 (1010);
6 (1001);
7 (1000);
8 (0111);
9 (0110)

Instruction sequence: READ 200 (Channel 6)

Data representation: TC-2 Panel Input Word 2, bits 2-5

Timing characteristics: When the thumbwheel is moved, the previous setting is retained until the next position is reached. There is no momentary "0" value.

2.1.7.3. Fly-to toggle

Input data item(s): Fly-to Toggle

Class: PIW2

Acronym: /FLYTOTOG/

Hardware: TC-2 Panel

Description: /FLYTOTOG/ indicates the current setting of a two-position toggle switch on the panel. Switch Nomenclature: DEST, MARK

Characteristics of values:

Value encoding: \$DEST\$ (10); \$MARK\$ (01)

Instruction sequence: READ 200 (Channel 6)

Data representation: TC-2 Panel Input Word 2, bits 0-1

2.1.7.4. Keyboard enable switch

Input data item(s): Keybd Enable Switch

Class: PIW1

Acronym: /KBDENBL/

Hardware: TC-2 Panel

Description: The KEYBD button is a momentary contact pushbutton switch on the TC-2 Panel. /KBDENBL/ indicates whether or not the KEYBD button was pushed since the last time Panel Input Word 1 was checked. The event @T(/KBDENBL/ = On), i.e., pushing the button, generates a Panel Interrupt.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 208 (Channel 6)

Data representation: TC-2 Panel Input Word 1, bit 11

Timing characteristics: See /ENTERSW/.

Comments: See /ENTERSW/.

2.1.7.5. Keyboard integer buttons

Input data item(s): Keyboard Integer Switches

Class: PIW1

Acronym: /KBDINT/

Hardware: TC-2 Panel

Description: The keyboard integer switches are ten momentary contact pushbutton switches on the TC-2 Panel. /KBDINT/ indicates which of the switches have been pushed since the last time Panel Input Word 1 was checked. Pushing any switch causes a Panel Interrupt.

Each pushbutton is labeled with up to three symbols, as follows: (0); (1); (N,2); (L,3); (W,4); (H,5); (-,E,6); (C,7); (S,8); (D,9).

Characteristics of values: /KBDINT/ has 2^{10} possible values, each represented by **$'*n*'$** where *n* is the decimal value corresponding to the bit representation (n = 0,1,...,$2^{10}-1$). We also define twelve special synonyms for certain of the values as follows:

$None$	=	$'0'$	(0000000000)
0	=	$'512'$	(1000000000)
1	=	$'256'$	(0100000000)
$N2$	=	$'128'$	(0010000000)
$L3$	=	$'64'$	(0001000000)
$W4$	=	$'32'$	(0000100000)
$H5$	=	$'16'$	(0000010000)
$-E6$	=	$'8'$	(0000001000)
$C7$	=	$'4'$	(0000000100)
$S8$	=	$'2'$	(0000000010)
$D9$	=	$'1'$	(0000000001)
$Multiple$	=	$'*m*'$	∀ *m* ≠ 0,1,2,4,...,2⁹

Instruction sequence: READ 208 (Channel 6)

Data representation: TC-2 Panel Input Word 1, bits 0-9

Timing characteristics: See /ENTERSW/.

Comments: See /ENTERSW/.

2.1.7.6. Mark button

Input data item(s): Mark Pushbutton Switch

Class: PIW1

Acronym: /MARKSW/

Hardware: TC-2 Panel

Description: The MARK button is a momentary contact pushbutton switch on the TC-2 panel (see Fig. 2.1.7-a). /MARKSW/ indicates whether or not the MARK button was pushed since the last time Panel Input Word 1 was checked. The event @T(/MARKSW/ = On), i.e., pushing the button, generates a Panel Interrupt.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 208 (Channel 6)

Data representation: TC-2 Panel Input Word 1, bit 12

Timing characteristics: See /ENTERSW/.

Comments: See /ENTERSW/.

2.1.7.7. *Mode rotary switch*

Input data item(s): Mode Rotary Switch

Class: PIW3

Acronym: /MODEROT/

Hardware: TC-2 Panel

Description: /MODEROT/ indicates the setting of the Mode Rotary Switch, a six position rotary switch on the TC-2 Panel. Switch nomenclature: PRES POS, DEST, MARK, RNG/BRG, D-BHT, ALT-MSLP.

Characteristics of values:

Value encoding:

$None$	(000000),
$PRESPOS$	(100000),
$DEST$	(010000),
$MARK$	(001000),
RNG/BRG	(000100),
$DBHT$	(000010),
$ALTMSLP$	(000001)

Instruction sequence: READ 196 (Channel 6)

Data representation: TC-2 Panel Input Word 3, bits 0-5

Timing characteristics: /MODEROT/ = $None$ indicates that the switch is in transition between two positions.

Comments: The Mode Rotary Switch has growth capability to eight positions.

2.1.7.8. Panel self-test

Input data item(s): Panel Self Test Switch

Class: DIW5

Acronym: /PNLTEST/

Hardware: TC-2 Panel

Description: /PNLTEST/ indicates the setting of a three-position toggle switch on the TC-2 Panel. The switch will not stay in the COMPUTER TEST position unless the pilot holds it there. Switch Nomenclature: OFF, PWR, COMPUTER TEST

If the TC-2 is on, the switch must be either in PWR or COMPUTER TEST position.

Characteristics of values:

Value encoding: PWR (0); $TEST$ (1)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 10

2.1.7.9. *Present position toggle*

Input data item(s): Present Position Toggle Switch

Class: PIW3

Acronym: /PRESPOS/

Hardware: TC-2 Panel

Description: /PRESPOS/ indicates the position of a three-position toggle switch on the TC-2 Panel. Switch Nomenclature: LAT.LONG, UPDATE, WIND VEL.DIR Sometimes when the switch position is changed, the software can momentarily detect a fourth value for this switch, corresponding to a position in between the others. We refer to this value as $None$.

Characteristics of values:

Value encoding:

Panel label	Enumerated value	Binary Value
LAT.LONG	\$LATLONG\$	100
UPDATE	\$UPDATE\$	010
WINDVEL.DIR	\$WIND\$	001
	\$None\$	000

Instruction sequence: READ 196 (Channel 6)

Data representation: TC-2 Panel Input Word 3, bits 8-10

2.1.7.10. Update thumbwheel

Input data item(s): Update Thumbwheel Switch

Class: PIW2

Acronym: /UPDATTW/

Hardware: TC-2 Panel

Description: /UPDATTW/ gives the current setting of the Update Thumbwheel Switch, a ten position thumbwheel switch on the panel. Switch Nomenclature: See below under Value Encoding.

Characteristics of values:

Value encoding:

$DATA$	(1111);
HUD	(1110);
$RADAR$	(1101);
$FLYOVER$	(1100);
$LORAN$	(1011);
$TACL-L$	(1010);
$TACMV$	(1001);
$IMS-HUD$	(1000);
$SINSX-Y$	(0111);
$Z-DHDG$	(0110)

Instruction sequence: READ 200 (Channel 6)

Data representation: TC-2 Panel Input Word 2, bits 6-9

Timing characteristics: When the thumbwheel is moved, the previous setting is retained until the next position is reached. There is no intervening "0".

2.1.7.11. *Lower window digits*

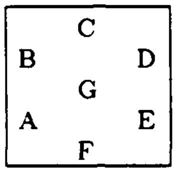
Output data item(s): Lower Window Digits (7 Data Items)

Class: POALL POW2 POW3 POW4 POW5

Acronym: //LWDIG1// //LWDIG2// //LWDIG3// //LWDIG4// //LWDIG5// //LWDIG6// //LWDIG7//

Hardware: TC-2 Panel

Description: These data items control the seven LED seven-segment indicators in the lower window of the TC-2 Panel. The indicators or digits are numbered 1-7, left to right. The seven straight-line segments of each indicator are referred to by the letters in the following sketch:



C, G, and F are horizontal line segments. A, B, D and E are vertical line segments.

Characteristics of values: Each data item has 2^7 possible values, each represented by \${*string*}\$, where *string* is a string composed of any subset of the seven letter codes (above) in alphabetic order. For example, //LWDIG1// = \${CDEFG}\$ displays a 3 in the first digit.

For convenience, we also define the following synonyms for commonly occurring values of the data items namely, for displaying the ten digits and the twenty-six letters: \$0\$, \$1\$, \$2\$, ..., \$9\$, \$A\$, \$B\$, \$C\$, ..., \$Z\$. See Ref. 18, Table 5.2-14 and Fig. 5.2-3 for segment definitions of the synonyms. The special value \$Blank\$ means that no segments are lit.

Instruction sequence: WRITE * (Channel 6)

* = 194 for //LWDIG1// and //LWDIG2//
* = 196 for //LWDIG3// and //LWDIG4//
* = 198 for //LWDIG5// and //LWDIG6//
* = 208 for //LWDIG7//

Data representation: Each data item is represented as a 7-bit quantity, with each bit corresponding to one line segment in the order ABCDEFG, left to right. When a bit is set to 1, the corresponding line segment is turned on. For example, the representation of \$3\$ = \${CDEFG}\$ is (0011111).

The seven bits are located in the output data word according to the table below:

	bits	TC-2 Panel Output Word
//LWDIG1//	0-6	2
//LWDIG2//	8-14	2
//LWDIG3//	0-6	3
//LWDIG4//	8-14	3
//LWDIG5//	0-6	4
//LWDIG6//	8-14	4
//LWDIG7//	0-6	5

Timing characteristics: The lights for a digit stay lit until the next WRITE * for the digit, or till the next WRITE 192 (see below).

Instruction sequence: WRITE 192 (Channel 6)

The instruction above causes the value in the accumulator to be written out to all Channel 6 outputs simultaneously. Thus, it acts as a simultaneous execution of WRITE *, where * is 194, 196. 198 200, 202, 204, 206, 208, 210, 212, and 214. Other output data items affected by this instruction are //UWDIG*n*//, //MARKWIN//, the other panel lights.

2.1.7.12. Mark window

Output data item(s): Mark Window

Class: POALL

Acronym: //MARKWIN//

Hardware: TC-2 Panel

Description: //MARKWIN// controls the seven segment LED indicator in the MARK window of the TC-2 Panel. For a description of the indicator, characteristics of values, data representation, and timing characteristics, see the lower window digits (//LWDIG1//, etc.).

Instruction sequence: WRITE 214 (Channel 6)

Data representation: TC-2 Panel Output Word 9, bits 0-6

Timing characteristics: The specified lights stay on until the next WRITE 214 or WRITE 192.

Comments: See //LWDIG1//, etc.

2.1.7.18. Other panel lights

Output data item(s):

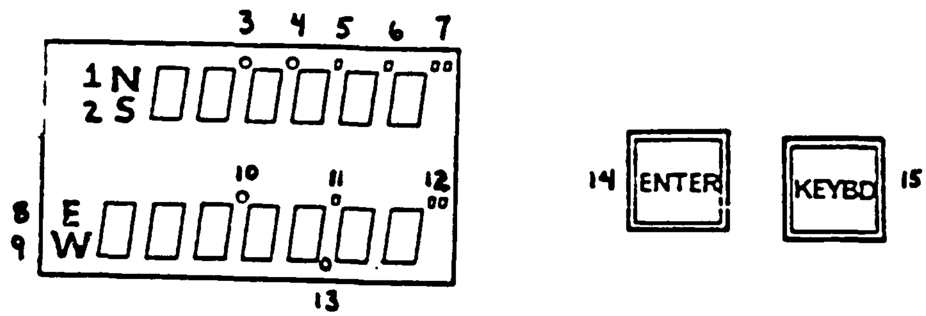
Item	Acronym
North light for Upper Window	//ULITN//
South light for Upper Window	//ULITS//
3 lights for Upper Window, pattern 2,2,2	//ULIT222//
3 lights for Upper Window, pattern 3,2,1	//ULIT321//
ENTER button light	//ENTLIT//
KEYBD and ENTER button lights	//KELIT//
East light for Lower Window	//LLITE//
West light for Lower Window	//LLITW//
3 lights for Lower Window, pattern 3,2,2	//LLIT322//
Decimal point for Lower Window	//LLITDEC//

Class: POW1 POALL

Hardware: TC-2 Panel

Description: Each of these output data items controls one or more lights on the TC-2 Panel, according to the table below. In the table, the numbers correspond to the labels in Fig. 2.1.7-b.

Data Item	Lights
//ULITN//	1
//ULITS//	2
//ULIT222//	3,5,7
//ULIT321//	4,6
//ENTLIT//	14
//KELIT//	14,15
//LLITE//	8
//LLITW//	9
//LLIT322//	10,11,12
//LLITDEC//	13



Lights on TC-2 panel
Figure 2.1.7-b

Characteristics of values:

Value encoding: On (1), Off (0)

Instruction sequence: WRITE 200 (Channel 6)

Data representation: TC-2 Panel Output Word 1

//ULITN//	bit 0
//ULITS//	bit 1
//ULIT222//	bit 2
//ULIT321//	bit 3
//ENTLIT//	bit 6
//KELIT//	bit 7
//LLITE//	bit 8
//LLITW//	bit 9
//LLIT322//	bit 10
//LLITDEC//	bit 11

Timing characteristics: The specified lights stay on until the next WRITE 200 or WRITE 192.

Comments: Light 14 is turned on if either //ENTLIT// = On or //KELIT// = On
See //LWDIG1//, etc.

2.1.7.14. Upper window digits

Output data item(s): Upper Window Digits (6 Data Items)

Acronym: //UWDIG1// //UWDIG2// //UWDIG3// //UWDIG4// //UWDIG5// //UWDIG6//

Class: POALL POW6 POW7 POW8

Hardware: TC-2 Panel

Description: These data items control the six LED seven segment indicators in the upper window of the TC-2 Panel. The digits are numbered 1-6, left to right. For a description of the indicators, characteristics of values, data representation, and timing characteristics, see the lower window digits (//LWDIG1//, etc.).

Instruction sequence: WRITE * (Channel 6)

* = 202 for //UWDIG1// and //UWDIG2//
* = 204 for //UWDIG3// and //UWDIG4//
* = 206 for //UWDIG5// and //UWDIG6//

Data representation: The seven bits are located in the output data word according to the table below:

	bits	TC-2 Panel Output Word
//UWDIG1//	0-6	6
//UWDIG2//	8-14	6
//UWDIG3//	0-6	7
//UWDIG4//	8-14	7
//UWDIG5//	0-6	8
//UWDIG6//	8-14	8

Timing characteristics: The lights for a digit stay lit until the next WRITE * for the digit, or until the next WRITE 192.

Comments: See //LWDIG1//, etc.

2.1.8. Built-In Test Equipment (BITE)

2.1.8.1. Introduction

The Built-In Test Equipment hardware provides features that allow programs to test for and identify TC-2 computer and hardware interface malfunctions. The BITE hardware also has functions that operate automatically and independently of any written program code: they will not be described here. Further information about BITE hardware can be found in Refs. 18, 19, and 20.

The BITE interface to the software consists of the following:

- A set of commands to cause the BITE to wrap I/O data, to turn on computer fail displays, to send computer fail indicators to other hardware, and to set certain output data items to failsafe values.
- A GO/NO-GO counter that signals situations where program control may be lost.
- A circuit that signals when the program attempts to write into the protected area of storage.
- Check values generated by the hardware from sets of outputs.

2.1.8.2. BITE functions

The Input/Output Wrap causes an output data path to be connected or "wrapped" to an input data path. This allows both paths to be tested by writing out a value on the output path and checking to see that the same value can be read on the input path.

In case of computer malfunction, the failsafe feature prevents dangerous output signals from being sent inadvertently by setting critical output data items to a predetermined state. The critical output data items are //FIRRDY//, //BMBREL//, //CURENABL//, //ANTSLAVE//, //IMSNA//, and //COMPCTR//.

2.1.8.3. GO/NO-GO counter

A GO/NO-GO Counter is a real-time readable and resettable timing counter that increments independently of any program action. This counter can be used both as a system clock and as a time-out detector. The counter will overflow after 1.3 seconds if it is not reset. This overflow condition automatically generates a level-one interrupt and has the same hardware effect as //BITE1// := $FORCEFAIL$ and //BITE2// := $DETECTMAL$, except that the LRU malfunction flag is not tripped. This counter is used to detect improper OFP execution sequences, infinite iterative loops, and program execution stoppages.

2.1.8.4. Storage protect violation detection

A storage protect violation detection circuit senses if the program attempts to store into the protected area of storage. A violation generates a level-one interrupt and has the same hardware effect as //BITE1// := $FORCEFAIL$ and //BITE2// := $DETECTMAL$.

2.1.8.5. Signal converter hardware-generated values

The Signal Converter hardware generates check values used to verify results in the AC and DC self-tests.

2.1.8.6. AC self-test

Input data item(s): AC Self-Test - Cosine and Sine

Acronym: /ACTESTCOS/ /ACTESTSIN/

Hardware: Built-In Test Equipment

Description: /ACTESTCOS/ and /ACTESTSIN/ provide the result of a Signal Converter AC Test. The result is an angle generated by the Signal Converter hardware from the most recently written values of:

Data Item	Abbreviation used below
//BRGDEST//	(= A_1),
//GNDTRK//	(= A_2),
ANG(//RNGUNIT//)	(= A_3),
ANG(//RNGTEN//)	(= A_4),
ANG(//RNGHND//)	(= A_5),
//STEEREL//	(= A_6),
//STEERAZ//	(= A_7),
//SPARE1//	(= A_8),
//SPARE2//	(= A_9),

where ANG converts an integer output value (0 to 9) to degrees of angle (0° to 360°) with 36° per unit of the output value (i.e. //RNGUNIT// = 0, ANG(//RNGUNIT//) = 0°; //RNGUNIT// = 1, ANG(//RNGUNIT//)= 36°; etc.)

The test indicates whether the accuracy of conversions of the output channels are correct; correctness is indicated by !AC test angle! being within ±1.4° of the expected angle, EXA, which can be determined from the following equation:

$$\tan(EXA) = exp1/exp2$$

where

A_i = value of angle output on channel i,

$$exp1 = 0.32937 \times [\sin(A_3 - 120°) + \sin(A_4 - 120°) + \sin(A_5 - 120°)] + N_i$$

$$exp2 = 0.32937 \times [\cos(A_3 - 120°) + \cos(A_4 - 120°) + \cos(A_5 - 120°)] + D_i$$

The summations are over i = 1, 2, 6, 7, 8, 9.

N_i and D_i are dependent on the octant of A_i as tabulated below. The range of A_i for an octant is from an angle greater than the first angle to and including the second angle.

A_i	Octant	N_i	D_i
0° - 45°	1	tan A_i	1
45° - 90°	2	1	cot A_i
90° - 135°	3	1	-cot A_i
135° - 180°	4	tan A_i	-1
180° - 225°	5	-tan A_i	-1
225° - 270°	6	-1	-cot A_i
270° - 315°	7	-1	cot A_i
315° - 360°	8	-tan A_i	1

Characteristics of values:

Units: None

Range: −1 to +1

Resolution: 1/4096

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already done)
READ 224 (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - Request acknowledged.
If not, read sequence not successfully initiated
When DATA READY interrupt occurs, conversion complete
READ 225 (Channel 7) (SIN)
Save Accumulator value
READ 255 (Channel 7) (COS) (Also resets Signal Converter)

Data representation: 13-bit two's complement number, bits 0-12; bits 13-15 Scale = 4096, offset = 0.

Timing characteristics: Synchro (analog) to digital conversion, see §1.15.8.

Comments: A delay of 4 seconds should be allowed between writing out //RNGUNIT//, //RNGTEN//, and //RNGHND// and reading in /ACTESTCOS/ and /ACTESTSIN/, to allow the servos to settle down. If they haven't settled, !AC test angle! will not reflect the expected value.

A hardware error is indicated if the DATA READY interrupt does not occur in 3.2 msec after READ 224 or if the request is not acknowledged after READ 224.

2.1.8.7. DC self-test

Input data item(s): DC Self-Test

Acronym: /DCTEST/

Hardware: Built-In Test Equipment

Description: /DCTEST/ provides the result of a Signal Converter DC Test. The result is a number generated by the Signal Converter hardware from the most recently written values of //GNDTRVEL//, //FPANGL//, and //STERROR//. The test indicates whether the accuracy of conversions of the output channels are correct; correctness is indicated by /DCTEST/ being within ±0.04 of the following expected value:

$$-0.0454 \times (\mathrm{IND}(//\mathrm{GNDTRVEL}//) + \mathrm{IND}(//\mathrm{FPANGL}//)) - 0.32 \times \mathrm{IND}(//\mathrm{STERROR}//)$$

Characteristics of values:

Units: None

Range: −2 to +2

Resolution: 1/1024

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already done)
READ 232 (Channel 7) (Request Signal Converter start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, read sequence not successfully initiated
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Also resets Signal Converter)

Data representation: 12-bit two's complement number, bits 1-12; bit 0 used. Scale = 1024; offset = 0.

Timing characteristics: Analog (DC voltage) to Digital conversion, see §1.15.8.

Comments: A hardware error is indicated if the DATA READY interrupt does not occur in 280 μsec after READ 232.

2.1.8.8. Discrete input words 1-3

Input data item(s): Discrete Input Words 1, 2, and 3

Acronym: /DIW1/ /DIW2/ /DIW3/

Hardware: Built-In Test Equipment

Description: The values of these data items are the most recently written values of //DOW1//, //DOW2//, and //DOW3//, respectively. These data items are only available when //BITE1// = $WRAPDISCR$ OR $WRAP12$ OR $WRAP13$ OR $WRAP123$ OR $FORCEFAIL$.

Characteristics of values:

Units: None

Instruction sequence: READ * (Channel 0)

* = 8 for /DIW1/
* = 4 for /DIW2/
* = 2 for /DIW3/

Data representation: bits 0 - 15 for /DIW1/ and /DIW2/, bits 4 - 7 for /DIW3/

Comments: In the rest of this document, the values are represented in hexadecimal. Thus, /DIW1/ = HEX(0000) means all the bits in /DIW1/ are zero and /DIW3/ = HEX(0) means bits 4 - 7 are zero.

2.1.8.9. Serial wrap 1

Input data item(s): Serial Wrap 1

Acronym: /SERIAL1/

Hardware: Built-In Test Equipment

Description: /SERIAL1/ reads the data output on //CSADATA*n*//. This data item is available only when //BITE1// = $WRAPSERA1$ OR $WRAP13$ OR $WRAP23$ OR $WRAP123$ OR $FORCEFAIL$.

Characteristics of values:

Units: None

Instruction sequence:

LA '4000' Hex (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable FLR)
Wait for External Control Interrupt
READ 64 (Channel 2) (Read First Data Word)
Save address data in temporary location
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: 22-bit bit string, bits 10-31; bits 0-9 unused.

Timing characteristics: See Timing Characteristics for //CSADATA*n*//.

Comments: A hardware error is indicated if the external control interrupt fails to occur within 540 μsec of WRITE 2.

/SERIAL1/ = HEX(000000) means all bits are set to 0. The first hex digit represents 2 bits. The succeeding hex digits each represent 4 bits.

2.1.8.10. Serial wrap 2

Input data item(s): Serial Wrap 2

Acronym: /SERIAL2/

Hardware: None

Description: /SERIAL2/ reads the data output on //CSBDATA*n*//. This data item is available only when //BITE1// = $WRAPSERA1$ OR $WRAP13$ OR $WRAP23$ OR $WRAP123$ OR $FORCEFAIL$.

Characteristics of values:

Units: None

Instruction sequence:

LA '8000' Hex (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable FLR)
Wait for External Control Interrupt
READ 64 (Channel 2) (Read Serial Input Address)
Save address data in temporary location
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: 22-bit bit string, bits 10-31; bits 0-9 unused.

Timing characteristics: See timing characteristics for //CSADATA*n*//.

Comments: A hardware error is indicated if the external control interrupt fails to occur within 800 μsec of WRITE 2.

/SERIAL2/ = HEX(000000) means all bits are set to 0. The first hex digit represents 2 bits. The succeeding hex digits each represent 4 bits.

2.1.8.11. Accelerometer tests

Input data item(s): Accelerometer Tests

Acronym: /XVELTEST/ /YVELTEST/ /ZVELTEST/

Hardware: Built-In Test Equipment

Description: The values of these data items are the most recently written values of //XTORTEST//, //YTORTEST//, and //ZTORTEST//, respectively. These data items are only available when //BITE2// = $WRAPGYACC$.

Characteristics of values:

Units: None

Instruction sequence: READ * (Channel 4) (valid only if /DIMWC/

* = 130 for /XVELTEST/
* = 129 for /YVELTEST/
* = 132 for /ZVELTEST/

Data representation: 16-bit string

2.1.8.12. Discrete output words 1-3

Output data item(s): Discrete Output Words 1, 2, and 3

Acronym: //DOW1// //DOW2// //DOW3//

Hardware: Built-In Test Equipment

Description: The values written to these data items determine the next values read in by /DIW1/, /DIW2/, and /DIW3/, respectively. These data items are only available when //BITE1// = $WRAPDISCR$ OR $WRAP12$ OR $WRAP13$ OR $WRAP123$ OR $FORCEFAIL$.

Characteristics of values:

Units: None

Instruction sequence: WRITE * (Channel 0)

* = 8 for //DOW1//
* = 4 for //DOW2//
* = 2 for //DOW3//

Data representation: bits 0 - 15 for //DOW1// and //DOW2//, bits 4 - 7 for //DOW3//.

2.1.8.13. BITE register function 1

Output data item(s): BITE Register Function 1

Acronym: //BITE1//

Hardware: Built-In Test Equipment

Description: //BITE1// enables the Built-In Test Equipment.

$FORCEFAIL$:	This code performs $WRAPDISCR$, $WRAPSERB2$, and $WRAPSERA1$, as well as the //BITE2// functions of $FORCEINT$, $LOADBADPR$, and $RESETCYCS$.
$WRAPDISCR$:	This code wraps //DOW1//, //DOW2//, and //DOW3// to /DIW1/, /DIW2/, and /DIW3/, respectively.
$WRAPSERB2$:	This code wraps //CSBDATA// to /SERIAL2/.
$WRAPSERA1$:	This code wraps //CSADATA// to /SERIAL1/.
$WRAP12$:	This code performs $WRAPDISCR$ and $WRAPSERB2$.
$WRAP13$:	This code performs $WRAPDISCR$ and $WRAPSERA1$.
$WRAP23$:	This code performs $WRAPSERB2$ and $WRAPSERA1$.
$WRAP123$:	This code performs $WRAPDISCR$, $WRAPSERB2$, and $WRAPSERA1$.
$None$:	This code cancels any of the above BITE1 commands.

Characteristics of values:

Value encoding:

$FORCEFAIL$	(1000),
$WRAPDISCR$	(0100),
$WRAPSERB2$	(0010),
$WRAPSERA1$	(0001),
$WRAP12$	(0110),
$WRAP13$	(0101),
$WRAP23$	(0011),
$WRAP123$	(0111),
$None$	(0000)

Data representation: BITE Register bits 0 - 3.

Instruction sequence: BITE *op* where *op* is a 4-bit encoding associated with current value

Comments: //BITE1// = $FORCEFAIL$ and //BITE1// = $WRAPDISCR$ cause hardware-determined failsafe values to be transmitted to certain hardware. See the explanation of the BITE functions.

2.1.8.14. BITE register function 2

Output data item(s): BITE Register Function 2

Acronym: //BITE2//

Hardware: Built-In Test Equipment

Description: //BITE2// enables the Built-In Test Equipment (see §2.1.8).

\$WRAPGYACC\$:	This code wraps //XTORTEST//, //YTORTEST//, and //ZTORTEST// to /XVELTEST/, /YVELTEST/, and /ZVELTEST/, respectively. This code is only available when /DIMWC/ := \$Changing\$.
\$DETECTMAL\$:	This code sets a mechanical malfunction latch, trips the computer LRU malfunction flag, and causes //COMPFAIL//:= \$On\$. The computer must be reset manually before the program can resume running.
\$FORCEINT\$:	This code sets all bits in the Interrupt Registers.
\$LOADBADPR\$:	This code generates bad parity for the cycle steal channel A.
\$RESETCYCS\$:	This code resets all Cycle Steal channels to the initialized state and causes cycle steal to stop.
\$None\$:	This code cancels any of the above BITE2 commands.

Characteristics of values:

Value encoding:

\$WRAPGYACC\$	(1110),
\$DETECTMAL\$	(1100),
\$FORCEINT\$	(0110),
\$LOADBADPR\$	(0101),
\$RESETCYCS\$	(0100),
\$None\$	(0000)

Data representation: BITE Register bits 4 - 7.

Instruction sequence: BITE *op*, where *op* is a 4-bit encoding associated with current value.

2.1.8.15. Cycle steal channel A

Output data item(s): Cycle Steal Channel A

Acronym: //CSADATA*n*//

Hardware: Built-In Test Equipment

Description: //CSADATA*n*// refers to the data items in the channel A cycle steal list, //CSADATA1// . . . //CSADATA*n*// for any integer 1≤n≤128. See §1.14 for information about the cycle steal list. When //CSADATA*n*// is enabled, these data items are transmitted one at a time, in sequence. Depending on how the list is constructed, //CSADATA*n*// can be followed by any //CSADATA*j*//, 2≤j≤n. The data item that was most recently transmitted determines the next value read in for /SERIAL1/. //CSADATA*n*// is enabled when //BITE1// = $WRAPSERA1$ OR $WRAP13$ OR $WRAP23$ OR $WRAP123$ OR $FORCEFAIL$

Characteristics of values:

Units: None

Instruction sequence: See §1.14.

Data representation: 22 bits (bits 9-14 and 16-31) in a 32-bit word; bits 0-8 and 15 not used.

Timing characteristics: At least 360 μsec elapse between the transmission of two //CSADATA*n*// data items.

2.1.8.16. Cycle steal channel B

Output data item(s): Cycle Steal Channel B

Acronym: //CSBDATA*n*//

Hardware: Built-In Test Equipment

Description: //CSBDATA*n*// refers to the data items in the channel B cycle steal list. //CSBDATA1// . . . //CSBDATA*n*// for any integer $1 \leq n \leq 128$. See §1.14 for information about the cycle steal list. When //CSBDATA*n*// is enabled, these data items are transmitted one at a time, in sequence. Depending on how the list is constructed, //CSBDATA*n*// can be followed by any //CSBDATA*j*//, $2 \leq j \leq n$. The data item that was most recently transmitted determines the next value read in for /SERIAL1/. //CSBDATA*n*// is enabled when //BITE1// = $WRAPSERA1$ OR $WRAP13$ OR $WRAP23$ OR $WRAP123$ OR $FORCEFAIL$

Characteristics of values:

Units: None

Instruction sequence: See §1.14.

Data representation: Same as //CSADATA*n*//.

Timing characteristics: At least 360 μsec elapse between the transmission of two //CSBDATA*n*// data items.

2.1.8.17. Spare synchro outputs

Output data item(s): Spare Synchro Outputs

Acronym: //SPARE1// //SPARE2//

Hardware: None

Description: //SPARE1// and //SPARE2// affect the value of /ACTESTCOS/ and /ACTEST-SIN/. They have no other observable effects.

Characteristics of values:

Units: Degrees

Range: 0 to 360°

Accuracy: ±0.1°

Instruction sequence:

WRITE * (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart

* = 236 for //SPARE1//, 237 for //SPARE2//

Data representation: Each angle is represented by two fields, an octant and a magnitude. See //STEERAZ//.

Timing characteristics: Digital to Synchro conversion. See §1.15.8.

2.1.8.18. Gyro torque tests

Output data item(s): Gyro Torque Tests

Acronym: //XTORTEST// //YTORTEST// //ZTORTEST//

Hardware: Built-In Test Equipment

Description: The values written to these data items determine the next values read by /XVEL-TEST/, /YVELTEST/, and /ZVELTEST/, respectively. These data items can only be output when //BITE2// = $WRAPGYACC$.

Characteristics of values:

Units: None

Instruction sequence:

WRITE * (Channel 4) (valid only if /DIMWC/ = $Ready$)

* = 129 for //XTORTEST//
* = 130 for //YTORTEST//
* = 132 for //ZTORTEST//

Data representation: 16-bit string

2.2. DEVICES WITH INPUT COMMUNICATION PATHS

2.2.1. Radar Altimeter (RADALT)

The Radar Altimeter (RADALT) provides a continuous, accurate indication of absolute altitude above terrain or water to the TC-2, FLR, and HUD.

2.2.1.1. Radar altitude

Input data item(s): Radar Altitude

Acronym: /RADALT/

Hardware: Radar Altimeter

Description: /RADALT/ provides the distance above terrain as determined by the Radar Altimeter.

Characteristics of values:

Units: Feet

Range: 0 to 5000

Accuracy: ±5 ft

Resolution: 1.2207031

Maximum derivative: 1000 ft/s

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ 233 (Channel 7) (Request Signal Converter start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Also resets Signal Converter)

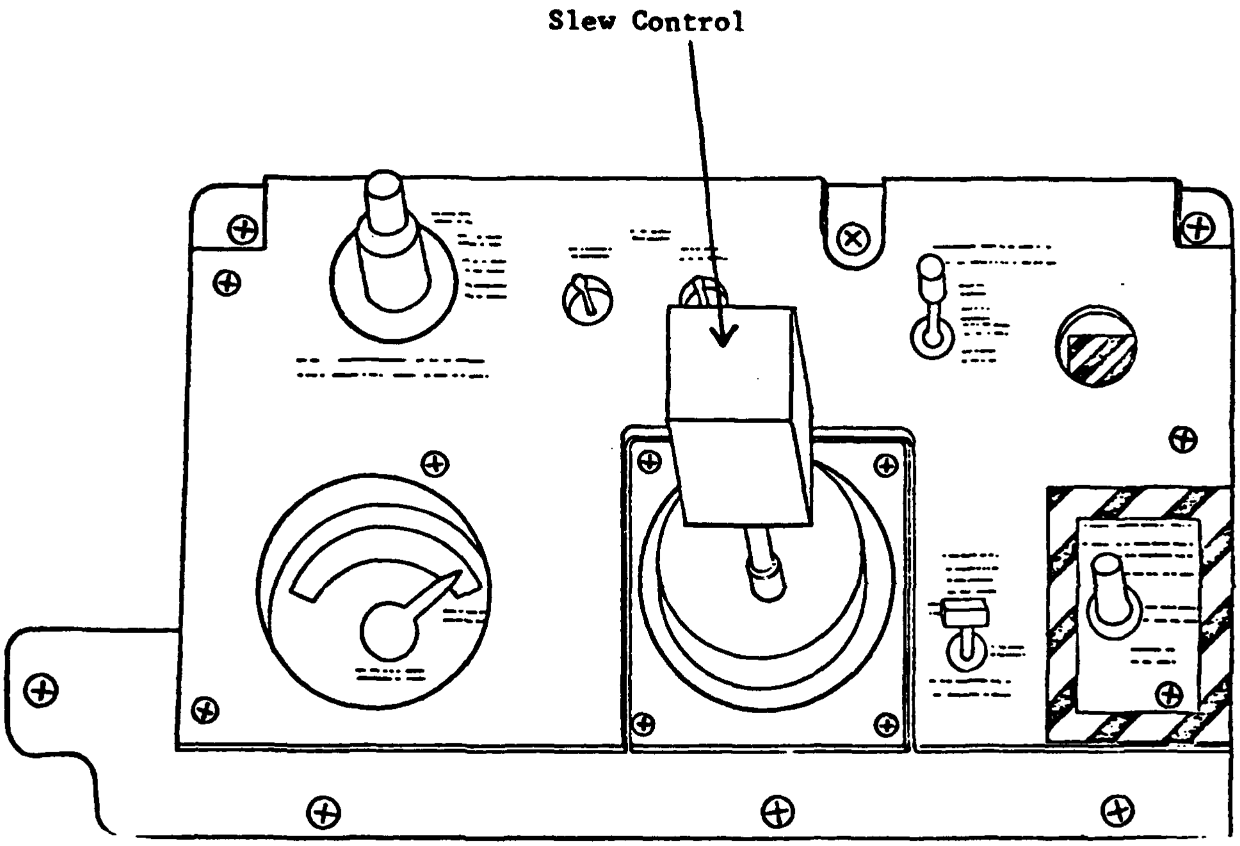
Data representation: 12-bit positive number, bits 1-12; bit 0 = 0, bits 13-15 not used. Scale = 2048/2500 :=: 0.8192; offset = 0.

Comments: Analog (DC voltage) to digital conversion. See §1.15.8.

If the data is not valid, e.g., A/C upside down, a value of 0 is transmitted.

2.2.2. Slew Control

The Slew Control is used as a direction-of-motion control. It is a "joystick" with 2 degrees of freedom. See figure 2.2.2-a.



Slew control
Figure 2.2.2-a.

2.2.2.1. Slew commands

Input data item(s): Slew Right-Left. Slew Up-Down

Acronym: /SLEWRL/ /SLEWUD/

Hardware: Slew Control

Description: The Slew Control is a cube shaped control located forward on the cockpit left console. The input value is proportional to the displacement from center. Positive values of /SLEWRL/ and /SLEWUD/ indicate displacements to the right and up respectively.

Characteristics of values:

Units: None

Range: –4 to +4

Resolution: 1/1024

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ * (Channel 7) (Request Signal Converter to start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Also resets Signal Converter)

* = 240 for Slew Right-Left
* = 239 for Slew Up-Down

Data representation: 13-bit two's complement number, bits 0-12; bits 13-15 = 0. Scale = 2048/2 = 1024; offset = 0.

Timing characteristics: Analog (DC voltage) to digital conversion. See §1.15.8.

Comments: The Slew control "snaps back" to central position. The values of /SLEWRL/ and /SLEWUD/ are not always 0 in this position. Slew values less than .148 are known to be a reliable indication that the control is in the central position.

2.2.3. Master Function Selectors (MFS)

The Master Function Selectors (MFS) are push-button switches for selection of attack modes and navigation or landing modes. These switches are shown in the figure below.

	BOC	NORM ATTACK	TF
DATA LINK	CCIP	OFFSET	LDG

Master function selection switches
Figure 2.2.3-a

2.2.3.1. Master function switches

Input data item(s): Master Function Switches

Class: DIW4

Acronym: /MFSW/

Hardware: Master Function Switch

Description: /MFSW/ indicates the settings of a series of pilot selectable pushbuttons.

Characteristics of values:

Value encoding:

$NATT$	(10000)	- only NORM ATT pushed
BOC	(00100)	- only BOC pushed
$CCIP$	(00010)	- only CCIP pushed
TF	(00001)	- only TF pushed
$NATTOFF$	(11000)	- NORM ATT and OFFSET pushed
$BOCOFF$	(01100)	- BOC and OFFSET pushed
$NONE$	(00000)	- none of the above pushed

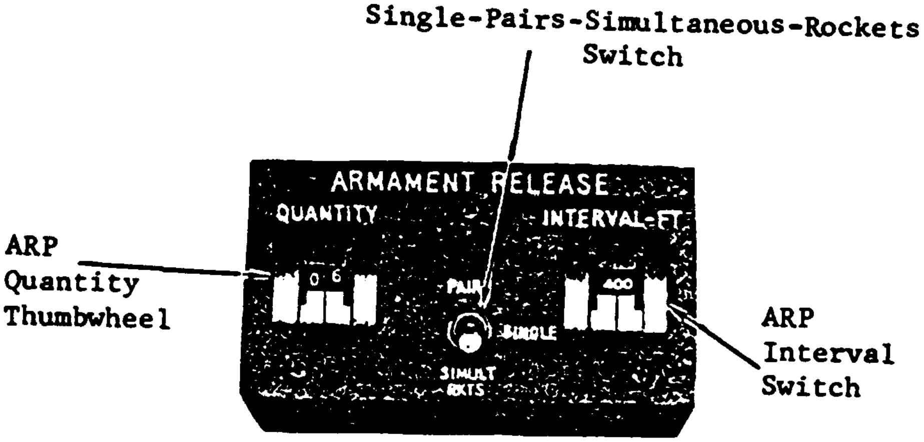
Instruction sequence: READ 1 (Channel 0)

Data representation: Discrete Input Word 4, bits 1-5

Comments: Hardware constrains NORM ATT, BOC, CCIP, and TF to be mutually exclusive. OFFSET can only be pushed in conjunction with NORM ATT or BOC.

2.2.4. Armament Release Panel (ARP)

The Armament Release Panel (ARP) contains switches for weapons controls. They are located in the cockpit and communicate with both TC-2 and ASCU.



Armament release panel
Figure 2.2.4-a

2.2.4.1. ARP interval

Input data item(s): ARP Interval

Class: DIW2

Acronym: /ARPINT/

Hardware: Armament Release Panel

Description: /ARPINT/ indicates the position of a dual thumbwheel switch. See Ref. 14a, Fig. 8-12. Switch Nomenclature: The left wheel (hundreds) runs from 0 to 9 by units; the right wheel (tens) runs from 00 to 90 by tens.

Characteristics of values:

> **Range:** 0 to 990
>
> **Resolution:** 10

Instruction sequence: Read 4 (Channel 0)

Data representation: Discrete input word 2, 2 digits BCD encoded in bits 8-15 (hundreds digit in bits 8-11, tens digit in bits 12-15).

Standard value = (HUNDREDS DIGIT) × 100) + (TENS DIGIT) × 10)

2.2.4.2. ARP pairs switch

Input data item(s): ARP Pairs

Class: DIW5

Acronym: /ARPPAIRS/

Hardware: Armament Release Panel

Description: The Single-Pair-Simultaneous-Rockets switch is a three-position toggle switch in the cockpit. (See Ref. 14a, Fig. 8-12). /ARPPAIRS/ indicates whether the switch is in PAIR position or in one of the other two positions. The TC-2 is not able [illegible]guish between the other two values. The switch is also input to the ASCU (see //BMBREL//). [illegible]h nomenclature: PAIR; SINGLE; SIMULT RKTS.

Characteristics of values:

Value encoding: \$Yes\$ (1); \$No\$ (0)

Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 13.

2.2.4.3. ARP quantity

Input data item(s): ARP Quantity

Class: DIW2

Acronym: /ARPQUANT/

Hardware: Armament Release Panel

Description: /ARPQUANT/ indicates the position of a dual thumbwheel switch. Both wheels have 10 positions, labeled from 0 to 9.

Characteristics of values:

Range: 0 to 99

Instruction sequence: READ 4 (Channel 0)

Data representation: Discrete input word 2, BCD encoded in bits 0-7 (tens digit in bits 0-3, units digit in bits 4-7).

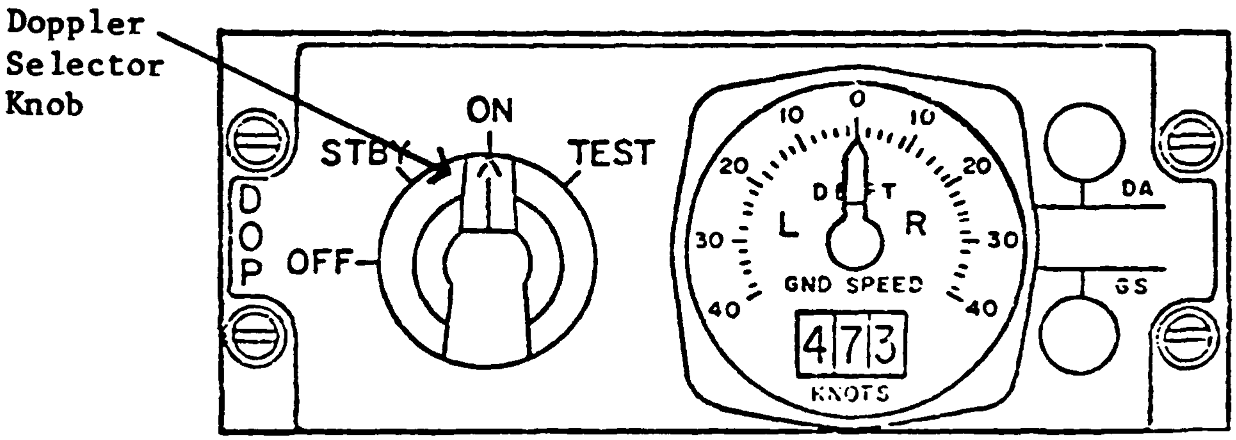
Comments: The /ARPQUANT/ is also input to the ASCU – the ASCU can sense when /ARPQUANT/ = 1. When /ARPQUANT/ = 1 and /MFSW/ = $None$, the ASCU will permit a manual release.

2.2.5. Doppler Radar Set (DRS)

The Doppler Radar Set (DRS) continuously measures the A/C ground speed and drift angle during flight and transmits this information to the TC-2.

The DRS sends three data words (DRS Status, Ground Speed, and Drift Angle) continuously in sequence. One word arrives every 400 microseconds. Since a request for one of these must be made before the word arrives, and since only one request can be made at a time, the fastest program can only read every second word of the DRS three word sequence. Obtaining a particular word can therefore require two requests and as long as 2.4 milliseconds. Obtaining all three words requires three requests and 2.4 milliseconds.

Figure 2.2.5-a shows the Doppler Control Panel. This panel has no direct connection to the TC-2, since the displays are driven directly by the DRS. But the setting of the Doppler Selector Knob affects the inputs received by the TC-2.



Doppler control panel
Figure 2.2.5-a

2.2.5.1. Doppler drift angle

Input data item(s): Doppler Drift Angle

Class: SDOP-DOW3

Acronym: /DRFTANG/

Hardware: Doppler Radar Set

Description: /DRFTANG/ provides the DRS estimate of the angle from the projection of the A/C Ya axis onto the horizontal plane to the projection of the A/C velocity vector onto the horizontal plane. The angle is positive when measured CW from the projection of the A/C Ya axis (looking down). Thus, drift is positive when ground track is to the right of the A/C heading.

Characteristics of values:

> **Units:** Degrees
>
> **Range:** -53.5714 to 40.045714
>
> **Range:** ±45
>
> **Accuracy:** ±0.06
>
> **Resolution:** .0057
>
> **Maximum derivative:** ±50 deg/s
>
> **Maximum second derivative:** 100 deg/s^2

Instruction sequence:

```
LA '8000' Hex        (Discrete Output Word 3)
WRITE 2  (Channel 0)  (Enable DRS)
Wait for External Control Interrupt
READ 64  (Channel 2)  (Read Serial Input Address)
Save address data to verify identity code = 00011
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32  (Channel 1)  (Read Serial Input Data)
```

Data representation: 14-bit positive number, bits 1-14; bits 0 and 15 = 0. Scale = 175; offset = 9375/175.

Timing characteristics: See §2.2.5.

Comments: /DRFTANG/ is a current estimate only if /DRSMEM/ = No. It is a valid estimate only if /DRSREL/ = Yes.

2.2.5.2. *Doppler groundspeed*

Input data item(s): Doppler Ground Speed

Class: SDOP-DOW3

Acronym: /DGNDSP/

Hardware: Doppler Radar Set

Description: /DGNDSP/ provides the DRS estimate of the magnitude of the projection of the A/C velocity vector onto the horizontal plane.

Characteristics of values:

- **Units:** Knots
- **Range:** 100 to 999
- **Accuracy:** -(.11% GS + .081) to +(.11% GS + .081)
- **Resolution:** .129
- **Maximum derivative:** 999 knots/s
- **Maximum second derivative:** $\pm$ 250 ft/s^2.

Instruction sequence:

```
LA '8000' Hex        (Discrete Output Word 3)
WRITE 2  (Channel 0)  (Enable DRS)
Wait for External Control Interrupt
READ 64  (Channel 2)  (Read Serial Input Address)
Save address data to verify identity code = 00010
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32  (Channel 1)  (Read Serial Input Data)
```

Data representation: 14-bit positive number, bits 1-14; bits 0 and 15 = 0. 1/scale :=: .129032; offset = 0;

Timing characteristics: See §2.2.5.

Comments: /DGNDSP/ is a current estimate only if /DRSMEM/ = No. It is valid only if /DRSREL/ = Yes. /DGNDSP/ is not true doppler ground speed, which is given by !DGNDSP!.

2.2.5.3. Doppler function switch

Input data item(s): DRS Function Switch

Class: SDOP-DOW3

Acronym: /DRSFUN/

Hardware: Doppler Radar Set

Description: /DRSFUN/ indicates the current setting of the rotary switch on the DRS control panel (OFF; STBY; ON; TEST). The setting of the switch affects the values of /ANTGOOD/ and /ELECGOOD/.

Characteristics of values:

Value encoding: \$Stby\$ (010); \$On\$ (001); \$Test\$ (100); \$Off\$ (000)

Instruction sequence:

LA '8000' HEX (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable DRS)
Wait for external control interrupt
READ 64 (Channel 2) (Read Serial Input Address)
Save address data to verify identity code = 00001
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: DRS Status Word, bits 4-6

Comments: A hardware interlock currently prevents /DRSFUN/ = \$Test\$ when A/C airborne.

Note that the DRS Status Word and the FLR Slant Range both have the same identity code (00001).

2.2.5.4. *Doppler memory mode*

Input data item(s): Doppler Memory Mode

Class: SDOP-DOW3

Acronym: /DRSMEM/

Hardware: Doppler Radar Set

Description: /DRSMEM/ indicates whether or not the DRS signal-to-noise ratio is below some threshold. If so, /DRSMEM/ = Yes indicating that the DRS is assumed to be in memory mode. When the DRS is in memory mode, both /DRFTANG/ and /DGNDSP/ provide stale values.

Characteristics of values:

Value encoding: \$Yes\$ (1); \$No\$ (0)

Instruction sequence:

LA '8000' HEX (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable DRS)
Wait for external control interrupt
READ 64 (Channel 2) (Read Serial Input Address)
Save address data to verify identity code = 00001
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: DRS Status Word, bit 7

Timing characteristics: See §2.2.5.

Comments: Note that the DRS Status Word and the FLR Slant Range have the same identity code (00001).

2.2.5.5. Doppler reliable

Input data item(s): Doppler Reliable

Class: SDOP-DOW3

Acronym: /DRSREL/

Hardware: Doppler Radar Set

Description: /DRSREL/ indicates the result of a continuously running DRS hardware self test.

Characteristics of values:

Value encoding: Yes (1); No (0)

Instruction sequence:

LA '8000' Hex (Discrete Output Word 3)
WRITE 2 (Channel 0) (Enable DRS)
Wait for external control interrupt
READ 64 (Channel 2) (Read Serial Input Address)
Save address data to verify identity code = 00001
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32 (Channel 1) (Read Serial Input Data)

Data representation: DRS Status Word, bit 1

Comments: /DRSREL/ = No can result both from DRS hardware problems and from A/C exceeding certain attitude limitations.

Note that the DRS Status Word and the FLR Slant Range have the same identity code (00001).

2.2.5.6. Doppler self-test

Input data item(s): Doppler Test Results (2 Data Items)

Class: SDOP-DOW3

Acronym: /ANTGOOD/ /ELECGOOD/

Hardware: Doppler Radar Set

Description: /ANTGOOD/ and /ELECGOOD/ indicate the results of the test initiated by @T(/DRSFUN/ = $Test$), which occurs when the pilot sets the knob on the DRS control panel to "TEST" (See Fig. 2.2.5-a).

Characteristics of values:

Value encoding:

/ANTGOOD/ (antenna good): Yes (1); No (0)
/ELECGOOD/ (electronics good): Yes (1); No (0)

Instruction sequence:

LA '8000' HEX (Discrete output word 3)
WRITE 2 (Channel 0) (Enable DRS)
Wait for external control interrupt
READ 64 (Channel 2) (Read serial input address)
Save address data to verify identity code = 00001
Check if !Serial Input OK!
If not, try again in 20 to 400 microseconds
READ 32 (Channel 1) (Read Serial Input Data)

Data representation:

/ANTGOOD/: DRS Status Word, bit 2
/ELECGOOD/: DRS Status Word, bit 3

Timing characteristics: See §2.2.5.

Comments: Note that the DRS Status Word and the FLR Slant Range both have the same identity code (00001).

2.2.6. Tactical Air Navigation (TACAN)

The Tactical Air Navigation (TACAN) system provides bearing and range from a selected TACAN station.

2.2.6.1. Bearing from station

Input data item(s): Bearing from Station

Acronym: /BRGSTA/

Hardware: TACAN

Description: /BRGSTA/ gives the angle measured CW (+) from magnetic north to the line from the currently selected TACAN station to the A/C.

Characteristics of values:

Units: Degrees

Range: 0 to 360

Resolution: .25

Maximum derivative: 30 deg/s

Instruction sequence:

READM 96 (Channel 3)
READ 96 (Channel 3)

Data representation: 11-bit positive number, bits 4-14; bit 0 = 0, bits 1-3 not used, bit 15 = validity bit. Scale = 1/.25 = 4; offset = 0.

Timing characteristics: READM, READ sequence delays the required 5 microseconds for TACAN to place the requested data into the output shift register.

Comments: Bit 15 equals 1 when data is valid.

2.2.6.2. Range from station

Input data item(s): Range from station

Acronym: /RNGSTA/

Hardware: TACAN

Description: /RNGSTA/ provides the TACAN-measured slant range between the A/C and the currently selected TACAN station.

Characteristics of values:

Units: Nautical miles

Range: 0 to 400

Resolution: .025

Maximum derivative: 800 nmi/s.

Instruction sequence:

```
READM 97   (Channel 3)
READ  97   (Channel 3)
```

Data representation: 14-bit positive number, bits 1-14; bit 0 = 0, bit 15 = validity bit. Scale = 1/.025 = 40; offset = 0.

Timing characteristics: READM, READ sequence delays the required 5 microseconds for TACAN to place the requested data into the output shift register.

Comments: bit 15 equals 1 when the data is valid

2.2.7. Angle of Attack (AOA) Transducer

The Angle of Attack (AOA) transducer provides information about the aircraft attitude relative to the air flowing by the aircraft as a result of the aircraft motion. True angle of attack is the angle between the aircraft Ya axis and the projection into the A/C Ya-Za plane of the A/C velocity vector. True angle of attack is positive when the Za component of the A/C velocity vector projection is negative (below the wings).

2.2.7.1. Angle of attack

Input data item(s): Angle of Attack

Acronym: /AOA/

Hardware: AOA Transducer

Description: The Angle of Attack (AOA) Transducer transmits the angle of the angle of attack vane with respect to a reference position 8° below waterline. /AOA/ is not true angle of attack, which is given by:

$$\text{true} = .76 \times /AOA/ - 8.68$$

Angle of attack measured with respect to waterline rather than boresight (Ya), is given by: $.76 \times /AOA/ - 5.68$ (see Ref. 6, p. 3-3)

If the corrected value is less than $-5.6°$, then the AOA vane has stopped sending values to the TC-2 in order to send them to the Automatic Power control.

Characteristics of values:

- **Units:** Degrees
- **Range:** 1 to 31
- **Accuracy:** ±0.18 (at speeds above 115 knots)
- **Resolution:** .0073

Instruction sequence:

READ 255 (Channel 7) (Reset Signal Converter if not already reset)
READ 237 (Channel 7) (Request Signal Converter start conversion)
Test Carry Indicator for 0 - request acknowledged
If not, start again
When DATA READY interrupt occurs, conversion complete
READ 255 (Channel 7) (Also resets Signal Converter)

Data representation: 12-bit positive number, bits 1-12; bits 0 and 13-15 = 0. Scale = 4096/31 := 132.12903; offset = 0.

Timing characteristics: DC voltage to digital conversion, see §1.15.8.

2.2.8. Shipboard Inertial Navigation System (SINS)

The Ship's Inertial Navigation System (SINS) may be connected to the TC-2 through the peripheral IN/OUT lines to permit the ship's navigation system data to be used during the on-deck alignment process. In addition, the TC-2 receives waypoint data over these lines.

These data items are defined in §2.2.8 of the classified addendum. For additional information, see Ref. 39.

/SINLAT/
/SINLON/
/SINHDG/
/SINPTH/
/SINROL/
/SINEVEL/
/SINNVEL/

2.2.9. Weight-On-Gear (WOG) sensor

The Weight-On-Gear (WOG) detects whether or not the A/C is airborne.

2.2.9.1. Aircraft airborne

Input data item(s): A/C Airborne

Class: DIW5

Acronym: /ACAIRB/

Hardware: Weight on Gear

Description: /ACAIRB/ is a switch in the landing gear. /ACAIRB/ = \$Yes\$ indicates that there is no weight on the wheels, i.e., that the aircraft is airborne.

Characteristics of values:

Value encoding: \$Yes\$ (0); \$No\$ (1)

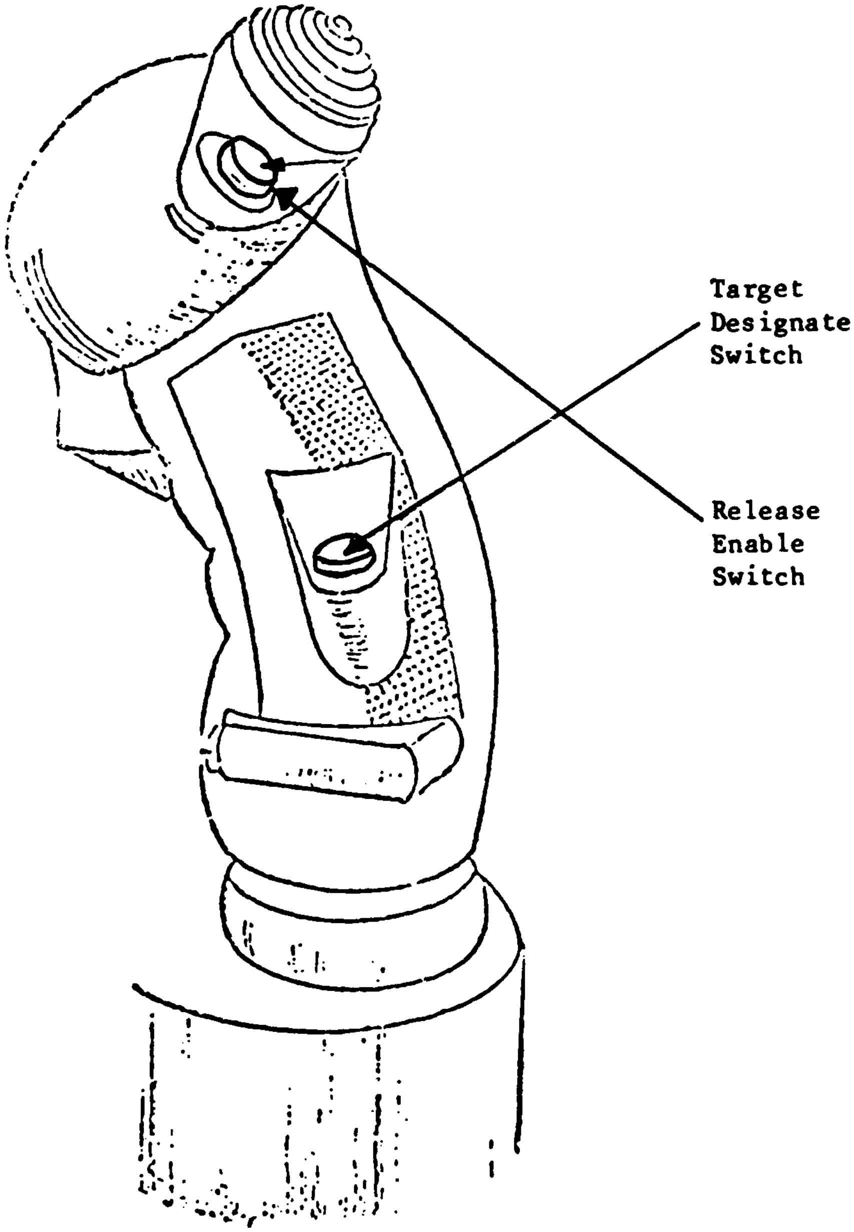
Instruction sequence: READ 24 (Channel 0)

Data representation: Discrete input word 5, bit 1

Comments: There is a separate switch that directly prevents bomb release when the aircraft is on the ground. Its value is normally equivalent to /ACAIRB/. As a result, bomb release is normally not possible when /ACAIRB/ = \$No\$.

2.2.10. Pilot Grip Stick (PGS)

Two pushbutton switches used for weapons delivery are on the pilot's grip stick. These switches are shown in Fig. 2.2.10-a.



Pilot grip stick
Figure 2.2.10-a

2.2.10.1. Release enable button

Input data item(s): Release Enable

Class: DIW3

Acronym: /RE/

Hardware: Pilot Grip Stick

Description: /RE/ indicates the position of a momentary contact pushbutton switch on the PGS.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 2 (Channel 0)

Data representation: Discrete input word 3, bit 8

Timing characteristics: /RE/ = On which is true only as long as the button is depressed, is known to be true for at least 40 milliseconds after @T(/RE/ = On).

2.2.10.2. Target designate button

Input data item(s): Target Designate

Class: DIW3

Acronym: /TD/

Hardware: Pilot Grip Stick

Description: /TD/ indicates the position of a momentary contact pushbutton switch on the PGS.

Characteristics of values:

Value encoding: Off (0); On (1)

Instruction sequence: READ 2 (Channel 0)

Data representation: Discrete input word 3, bit 15

Timing characteristics: /TD/ = On, which is true only as long as the button is pushed, is known to be true for at least 40 milliseconds following @T(/TD/ = On).

2.2.11. Waypoint Data System

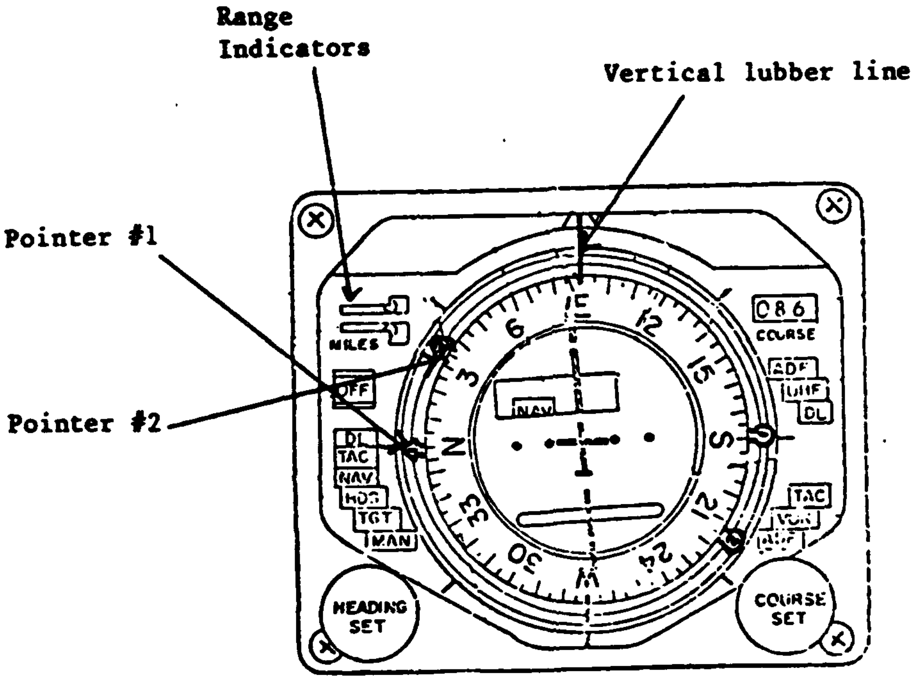
The TC-2 receives position data over a set of data items defined in the classified addendum.

/WAYLON/
/WAYLAT/
/WAYNUM1/
/WAYNUM2/

2.3. DEVICES WITH OUTPUT COMMUNICATION PATHS

2.3.1. Horizontal Situation Indicator (HSI)

The Horizontal Situation Indicator (HSI) displays course, heading, distance, and bearing information to the pilot. Under some conditions, the TC-2 controls the two pointers and the range indicators shown in Fig. 2.3.1-a below.



Horizontal situation indicator
Figure 2.3.1-a

2.3.1.1. Bearing to destination

Output data item(s): Bearing to Destination

Acronym: //BRGDEST//

Hardware: Horizontal Situation i.. :icator

Description: //BRGDEST// controls the pointing angle of the HSI #1 pointer The angle is measured CW from the vertical lubber line.

Characteristics of values:

> **Units:** Degrees
>
> **Range:** 0 to 360
>
> **Accuracy:** ±0.1

Instruction sequence:

WRITE 232 (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart.

Data representation: The angle is represented by two fields, an octant and a magnitude. It is offset by 180°. See //STEERAZ//.

Timing characteristics: Digital to Synchro conversion. See §1.15.8.

2.3.1.2. *Ground track pointer*

Output data item(s): Ground Track

Acronym: //GNDTRK//

Hardware: Horizontal Situation Indicator

Description: //GNDTRK// controls the pointing angle of the HSI #2 pointer. The angle is measured CW from the vertical lubber line.

Characteristics of values:

- **Units:** Degrees
- **Range:** 0 to 360
- **Accuracy:** ±0.1

Instruction sequence:

WRITE 233 (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart.

Data representation: The angle is represented by two fields, an octant and a magnitude. It is offset by 180°. See //STEERAZ//.

Timing characteristics: Digital to Synchro conversion. See §1.15.8.

2.3.1.3. Left digit flag

Output data item(s): Left Digit Flag

Class: DOW2

Acronym: //LFTDIG//

Hardware: Horizontal Situation Indicator

Description: //LFTDIG// controls a flag with a 1 on it that can drop down in place to the left of the three digits of the HSI distance indicator, which are controlled by //RNGUNIT//, //RNGTEN//, and //RNGHND//.

Characteristics of values:

Value encoding: $Blank$ (0); One (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 12

2.3.1.4. Range digits

Output data item(s): Range Digits

Acronym: //RNGUNIT// //RNGTEN// //RNGHND//

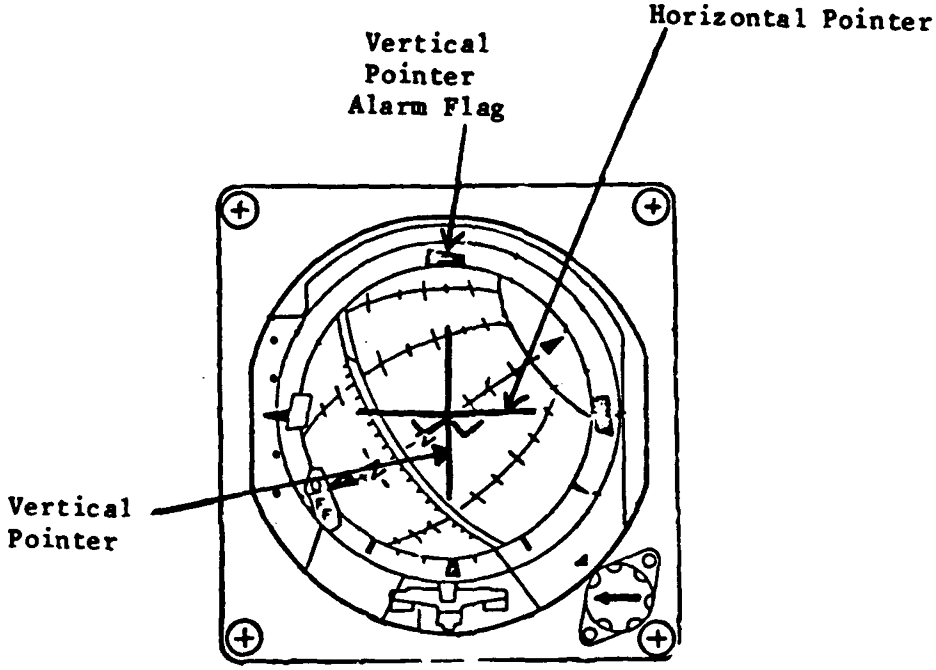
Hardware: Horizontal Situation Indicator

Description: These data items control the setting of a mileage indicator on the HSI. (See Fig. 2.3.1-a).

Comments: The data items are defined as outputs to the PMDS.

2.3.2. Attitude Director Indicator (ADI)

The Attitude Direction Indicator (ADI) displays A/C information, including heading, attitude (pitch, bank, and heading in relation to the miniature aircraft), rate of turn, slip, glideslope deviation, bank, and failure indications. Most of these displays are not based on TC-2 outputs. Under some conditions, the ADI vertical needle, horizontal needle and vertical pointer alarm flag are controlled by the TC-2. Figure 2.3.2-a shows the two needles.



Attitude director indicator
Figure 2.3.2-a

2.3.2.1. Computer fail

Output data item(s): Computer System Fail

Class: DOW2

Acronym: //COMPFAIL//

Hardware: Attitude Direction Indicator

Description: When //COMPFAIL// = Yes, the vertical pointer alarm flag is in view.

Comments: //COMPFAIL// is defined in the IMS section. //COMPFAIL// is also output to the FLR and the Caution and Advisory Panel.

2.3.2.2. Flight path angle

Output data item(s): Flight Path Angle

Acronym: //FPANGL//

Hardware: Attitude Direction Indicator

Description: //FPANGL// positions the horizontal needle of the ADI. Positive direction is up when looking at the ADI. A value of zero centers the needle. The value −20 puts the needle out of view.

Comments: //FPANGL// is defined in the FLR section.

//FPANGL// is not assumed to be Flight Path Angle by the ADI. Other quantities can be displayed provided the FLR is not in Terrain Following mode.

2.3.2.3. Steering error

Output data item(s): Steering Error

Acronym: //STERROR//

Hardware: Attitude Direction Indicator

Description: //STERROR// controls the position of the vertical needle on the ADI. A positive value moves the pointer to the right when looking at the ADI. A value of zero centers the needle.

Characteristics of values:

> **Units:** Degrees
>
> **Range:** -2.5 to +2.5
>
> **Accuracy:** ±0.1
>
> **Resolution:** .00244°

Instruction sequence:

WRITE 229 (Channel 7)
Test Carry Bit = 0 for request acknowledged
If not, restart

Data representation: 11-bit two's complement number, bit 0 and bits 3-12; bits 1-2 not used, bits 13-15 = 0. Scale = 512/1.25 = 409.6; offset = 0.

Timing characteristics: Digital to DC voltage conversion. See §1.15.8.

Comments: The pointer hits a mechanical stop at ±2.5°.

2.3.3. Flight Recorder (FLTREC)

The Flight Recorder (FLTREC) is a magnetic tape recording device. It was intended for flight testing of the A/C system units in its early versions and is available in some production models. It records blocks of 100 words periodically.

2.3.3.1. Flight recorder data

Output data item(s): : Flight Recorder Data Items

Acronym: //FLTREC//

Hardware: Flight Recorder

Description: //FLTREC// consists of 100 16-bit data words. There is no requirement for which words are used to make up //FLTREC//.

Instruction sequence: Cycle Steal Channel C

Timing characteristics: 100 16-bit words are output every 40 milliseconds.

Comments: It is not necessary to output 100 different words to //FLTREC//. Any smaller number (greater than zero) may be output simply by building the cycle-steal chain with a loop in it.

2.3.4. Bomb Tone (BMBTON)

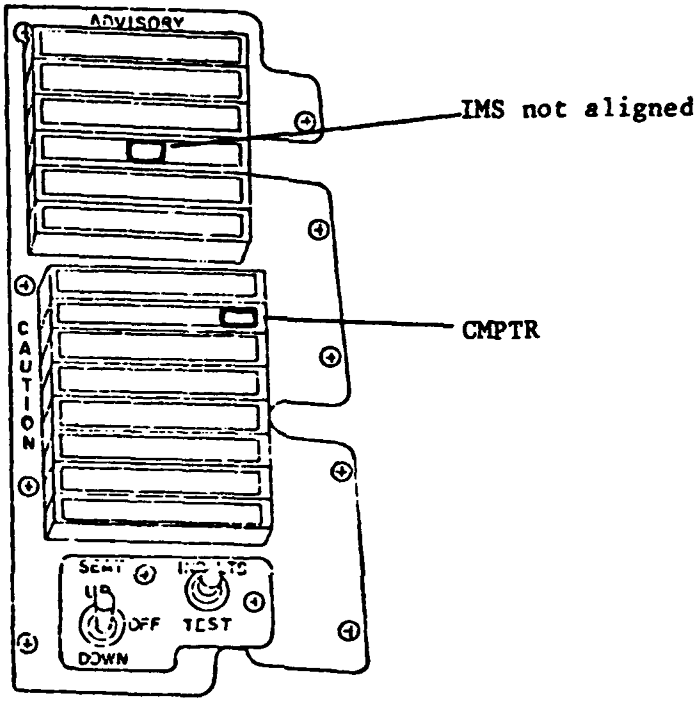
The Bomb Tone (BMBTON) is an audio cockpit signal.

2.3.4.1. Bomb tone

Output data item(s): Bomb Tone
Class: DOW1
Acronym: //BMBTON//
Hardware: Bomb Tone
Description: There is an audible tone in the cockpit when //BMBTON// = On.
Characteristics of values:
    Value encoding: Off (0); On (1)
Instruction sequence: WRITE 8 (Channel 0)
Data representation: Discrete output word 1, bit 8

2.3.5. Caution and Advisory Panel (CAPANL)

The Caution and Advisory Panel (Fig. 2.3.5-a) contains a set of signal lights. Two of these lights are controlled by the TC-2.



Caution and advisory panel
Figure 2.3.5-a

2.3.5.1. Computer fail

Output data item(s): Computer System Fail

Class: DOW2

Acronym: //COMPFAIL//

Hardware: Caution and Advisory Panel

Description: The light labeled CMPTR on the caution and advisory panel is turned on when //COMPFAIL// = Yes.

Comments: //COMPFAIL// is defined in the IMS section. //COMPFAIL// is also output to the FLR and the ADI.

2.3.5.2. Non-aligned light

Output data item(s): IMS Non-Align Light

Class: DOW2

Acronym: //IMSNA//

Hardware: Caution and Advisory Panel

Description: //IMSNA// turns on and off the IMS NOT ALIGNED light on the Caution and Advisory Panel.

Characteristics of values:

Value encoding: Off (0), On (1)

Instruction sequence: WRITE 4 (Channel 0)

Data representation: Discrete output word 2, bit 9

2.4. WEAPON CHARACTERISTICS

Table 2.4-a gives characteristics of the different weapons that are used with the A-7 aircraft.

The first three columns give parameters identifying the type of delivery, i.e., the weapon, the drag characteristics, and the rack mounting. These parameters are communicated to the computer by the input data items /WEAPTYP/, /BMBDRAG/, and /MULTRACK/. NOTE: For safety reasons, in the case of OD and $SL weapons, the OFP will ignore the setting of the /MULTRACK/ switch and assume it is Yes if the number of weapons selected exceeds the number of stations selected (i.e., if the OFP deduces that a multiple or triple ejector rack is loaded on one of the selected stations). The number of weapons is taken to be the value of /ARPQUANT/, doubled if /ARPPAIRS/=Yes.

The last four columns provide characteristics associated with the identified type of delivery.

Column 4 gives the two-letter code and the common name associated with the weapon.

Column 5 (Fire Pulse Width) gives the time in milliseconds that (//BMBREL// = On) must be true to eject the weapon.

Column 6 (!Weapon Class!) specifies to which of the following classes each weapon belongs.

Guns	GN	Shrike	SK
High Dual	HD	Simple High	SH
Medium Dual	MD	Simple Low	SL
Mines/Flares	MF	Simple Medium	SM
Optional Drag	OD	Special Optional Drag	SOD
Optional Rockeye	OR	Special Simple High	SSH
Rockets	RK	Uncataloged	UN
		Walleye	WL

Column 7 (MRI Class) assigns each weapon, where applicable, a number referring to one of the three Minimum-release-interval curves in Fig. 2.4-a. These curves give the minimum safe time interval between release of two weapons of that type. See also Ref. 24, part 1, §5.6.

TABLE 2.4-a: A-7 Weapons Characteristics

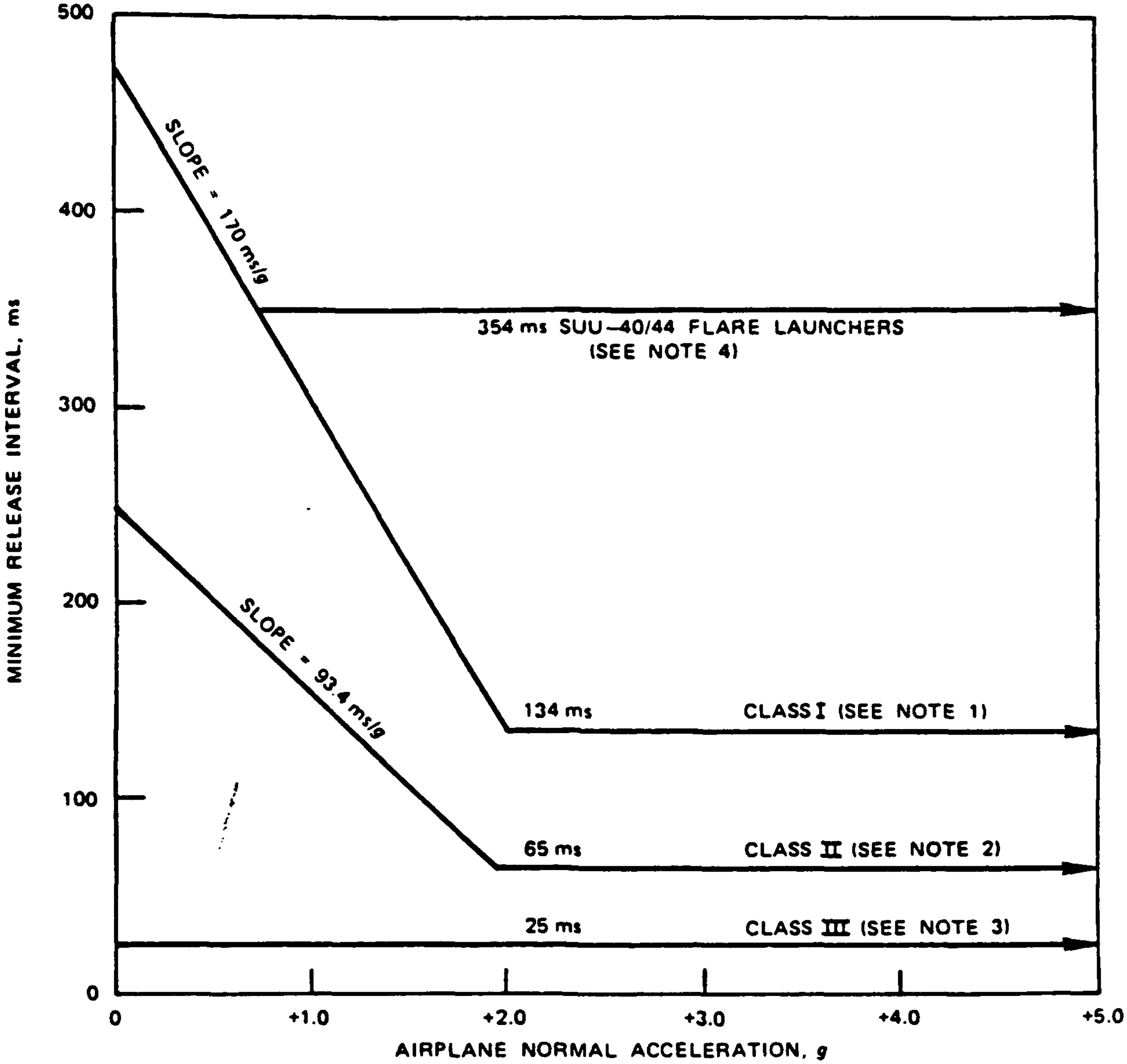
Weapon Identification			Weapon Characteristics			
/WEAP TYP/	/BMB DRAG/	/MULT RACK/	(Letter Code) and Description	Fire Pulse Width	!Weapon Class!	MRI Class
00	X	X	(AK) Empty or no station selected	N/A	GN	N/A
02	X	X	(AM) 2.75" rockets	N/A	RK	N/A
03	X	X	(AN) 5.0" Zuni rockets	N/A	RK	N/A
10	X	X	(BK) Walleye I and II	24	WL	N/A
13	X	X	(BN) Air-to-ground guns (M61A1 gun)	N/A	GN	N/A
17	X	X	(BR) Shrike	24	SK	N/A
21	X	X	(CL) SUU-40/44 - flare launcher	150	MF	I
22	X	X	(CM) Mk 24/45 flare, Mk 58, Mk 6	27	MF	I
24	X	X	(CO) Practice mine (Mk 106 ballistic)	27	MF	I
30	X	X	(DK) Mk 36 mine	24	MF	I
31	X	X	(DL) Mk 52 mine	24	MF	I
32	X	X	(DM) Mk 55 mine	24	MF	I
33	X	X	(DN) Mk 56 mine	24	MF	I
41	X	X	(EL) NUKE	24	SOD	N/A
42	X	X	(EM) NUKE	24	SOD	N/A
43	X	X	(EN) NUKE (retard only)	24	SSH	N/A
44	X	X	(EO) NUKE	24	SOD	N/A
45	X	X	(EP) NUKE (retard only)	24	SSH	N/A
46	X	X	(EQ) NUKE	24	SOD	N/A
47	X	X	(ER) NUKE	24	SOD	N/A
48	X	X	(ES) NUKE	24	SOD	N/A
50	X	No	(FK) M 117 AL	24	SL	III
50	X	Yes	(FK) M 117 AL	27	SL	II
53	X	No	(FN) Mk 83 and DST 40 SEFF	24	SL	III
53	X	Yes	(FN) Mk 83 and DST 40 SEFF	27	SL	II
55	$High$	X	(FP) Practice NUKE-Mk 106	27	SOD	N/A
55	Low	X	(FP) Practice NUKE-Mk 76	27	SOD	N/A
56	X	X	(FQ) Mk 83 SEHD	24	MD	I
57	X	X	(FR) DST 40 SEHD	24	MF	I
58	X	X	(FS) DST 36 SEHD	24 27	MF	I
59	X	X	(FT) Mk 77	24	SM	I
60	X	No	(GK) Mk 81 LDGP	24	SL	III
60	X	Yes	(GK) Mk 81 LDGP	27	SL	II
61	X	No	(GL) Mk 81 SEFF	24	SL	III
61	X	Yes	(GL) Mk 81 SEFF	27	SL	II
62	X	No	(GM) Mk 81 SEHD	24	MD	II
62	X	Yes	(GM) Mk 81 SEHD	27	MD	I
63	Low	No	(GN) Mk 81 SEFF	24	OD	III
63	Low	Yes	(GN) Mk 81 SEFF	27	OD	II
63	$High$	No	(GN) Mk 81 SEHD	24	OD	II
63	$High$	Yes	(GN) Mk 81 SEHD	27	OD	I
64	X	No	(GO) Mk82, Mk124 (blunt nose), DST 36 LDGP	24	SL	III
64	X	Yes	(GO) Mk82, Mk124 (blunt nose), DST 36 LDGP	27	SL	II
65	X	No	(GP) Mk 82, Mk 124 and DST 36 SEFF	24	SL	III
65	X	Yes	(GP) Mk 82, Mk 124 and DST 36 SEFF	27	SL	II

TABLE 2.4-a: A-7 Weapons Characteristics

Weapon Identification			Weapon Characteristics			
/WEAP TYP/	/BMB DRAG/	/MULT RACK/	(Letter Code) and Description	Fire Pulse Width	!Weapon Class!	MRI Class
66	X	No	(GQ) Mk 82 and Mk 124 SEHD	24	MD	II
66	X	Yes	(GQ) Mk 82 and Mk 124 SEHD	27	MD	I
67	$High$	Yes	(GR) Mk 82 and Mk 124 SEHD (pilot option)	27	OD	I
67	$High$	No	(GR) Mk 82 and Mk 124 SEHD (pilot option)	24	OD	II
67	Low	Yes	(GR) Mk 82 and Mk 124 SEFF (pilot option)	27	OD	II
67	Low	No	(GR) Mk 82 and Mk 124 SEFF (pilot option)	24	OD	III
68	X	No	(GS) Mk 83 and DST 40 LDGP	24	SL	III
68	X	Yes	(GS) Mk 83 and DST 40 LDGP	27	SL	II
69	X	Yes	(GT) Mk 84	24	SL	II
69	X	No	(GT) Mk 84	24	SL	III
70	X	X	(HK) Mk 86 WSF	24 27	SL	II
72	X	X	(HM) Mk 88 WSF	24 27	SL	II
73	X	No	(HN) Mk 83 LDGP (electric fuze only)	24	SL	III
73	X	Yes	(HN) Mk 83 LDGP (electric fuze only)	27	SL	II
74	X	X	(HO) Mk 82, 83, and 84 LGB	24 27	SL	II
75	X	X	(HP) Mk 106	27	SM	I
77	X	X	(HR) Mk 76	27	SL	II
78	X	No	(HS) Mk 81 LDGP (electric fuze only)	24	SL	III
78	X	Yes	(HS) Mk 81 LDGP (electric fuze only)	27	SL	II
79	X	No	(HT) Mk 82 thermal coated	24	SL	III
79	X	Yes	(HT) Mk 82 thermal coated	27	SL	II
90	X	No	(JK) CBU-24/29/49, 5.0-sec fuze	24	MD	II
90	X	Yes	(JK) CBU-24/29/49, 5.0-sec fuze	27	MD	I
91	X	No	(JL) Mk 20 Rockeye, 1.2-sec fuze (tail fuze selected)	24	MD	II
91	X	Yes	(JL) Mk 20 Rockeye, 1.2-sec fuze (tail fuze selected)	27	MD	I
93	X	No	(JN) Mk 20 Rockeye, 4.0-sec fuze (nose and tail fuze selected)	24	MD	II
93	X	Yes	(JN) Mk 20 Rockeye 4.0-sec fuze (nose and tail fuze selected)	27	MD	I
94	Low	No	(JO) Mk 20 Rockeye 4.0-sec fuze (nose and tail fuze selected)	24	OR	II
94	$High$	No	(JO) Mk 20 Rockeye 1.2-sec fuze (tail fuze selected)	24	OR	II
94	Low	Yes	(JO) Mk 20 Rockeye 4.0-sec fuze (nose and tail fuze selected)	27	OR	I
94	$High$	Yes	(JO) Mk 20 Rockeye 1.2-sec fuze (tail fuze selected)	27	OR	I
95	X	No	(JP) Mk 82 LDGP (electric fuze only) Mk 124 LDGP (sharp nose)	24	SL	III
95	X	Yes	(JP) Mk 82 LDGP (electric fuze) Mk 124 (sharp nose), Mk 87	27	SL	II
97	X	No	(JR) APAM 1.2-sec fuze (tail fuze selected)	24	MD	II
97	X	Yes	(JR) APAM 1.2-sec fuze (tail	27	MD	I

TABLE 2.4-a: A-7 Weapons Characteristics

Weapon Identification			Weapon Characteristics			
/WEAP TYP/	/BMB DRAG/	/MULT RACK/	(Letter Code) and Description	Fire Pulse Width	!Weapon Class!	MRI Class
			fuze selected)			
98	X	No	(JS) APAM 4.0-sec fuze (nose and tail fuze selected)	24	MD	II
98	X	Yes	(JS) APAM 4.0-sec fuze (nose and tail fuze selected)	27	MD	I
99	Low	No	(JT) APAM 4.0-sec fuze (nose and tail fuze selected)	24	OR	II
99	$High$	No	(JT) APAM 1.2-sec fuze (tail fuze selected)	24	OR	II
99	Low	Yes	(JT) APAM 4.0-sec fuze (nose and tail fuze selected)	27	OR	I
99	$High$	Yes	(JT) APAM 1.2-sec fuze (tail fuze selected)	27	OR	I
All others	X	X	Uncatalogued	N/A	UN	N/A



NOTE

1. CLASS I: BELOW +1.98 *g*; MRI = 470 ms–170 ms/*g*
   ABOVE +1.98 *g*; MRI = 134 ms
2. CLASS II: BELOW +1.95 *g*; MRI = 246.8 ms–93.4 ms/*g*
   ABOVE +1.95 *g*; MRI = 65 ms
3. CLASS III: MRI = 25 ms (*g*-INDEPENDENT)
4. SUU-40/44 FLARE LAUNCHER: BELOW +0.68 *g*; MRI = 470 ms–170 ms/*g*
   ABOVE +0.68 *g*; MRI = 354 ms

Figure 2.4-a MRI Curve Chart

Minimum Release Interval Curve

2.5. DATA ITEM CLASSES

A data item class consists of all data items that are affected by the same instruction sequence.

Class	Data Items		
Discrete Input Word 1			
DIW1	/WEAPTYP/		
Discrete Input Word 2			
DIW2	/ARPINT/	/ARPQUANT/	
Discrete Input Word 3			
DIW3	/GUNSSEL/	/MULTRACK/	/RE/
	/STA1RDY/	/STA2RDY/	/STA3RDY/
	/STA6RDY/	/STA7RDY/	/STA8RDY/
	/TD/		
Discrete Input Word 4			
DIW4	/BMBDRAG/	/HUDREL/	/MFSW/
Discrete Input Word 5			
DIW5	/ACAIRB/	/ADCFAIL/	/ARPPAIRS/
	/DIMWC/	/IMSAUTOC/	/IMSMODE/
	/IMSREDY/	/IMSREL/	/MA/
	/PNLTEST/		
Discrete Input Word 6			
DIW6	/PMDCTR/	/PMHOLD/	/PMNORUP/
	/PMSCAL/	/PMSLAND/	
Discrete Output Word 1			
DOW1	//ANTSLAVE//	//BMBREL//	//BMBTON//
	//CURENABL//	//FIRRDY//	
Discrete Output Word 2			
DOW2	//AUTOCAL//	//COMPCTR//	//COMPFAIL//
	//IMSNA//	//IMSSCAL//	//LATGT70//
	//LFTDIG//	//TSTADCFLR//	//XSLEW//
	//XSLSEN//	//YSLEW//	//YSLSEN//
	//ZSLEW//	//ZSLSEN//	
HUD Control			
HUDCTL	//HUDAS//	//HUDASL//	//HUDFPM//
	//HUDPUC//	//HUDSCUE//	//HUDVEL//
	//HUDWARN//		
Magnetic Heading			
IMAGH	/MAGHCOS/	/MAGHSIN/	
Pitch			
IPCH	/PCHCOS/	/PCHSIN/	

Class	Data Items		
Roll			
IROLL	/ROLLCOSI/	/ROLLSINI/	
True Heading			
ITHDG	/THDGCOS/	/THDGSIN/	
Panel Input Word 1			
PIW1	/ENTERSW/	/KBDENBL/	/KBDINT/
	/MARKSW/		
Panel Input Word 2			
PIW2	/FLYTOTOG/	/FLYTOTW/	/UPDATTW/
Panel Input Word 3			
PIW3	/MODEROT/	/PRESPOS/	
Panel Output-All			
POALL	//ENTLIT//	//KELIT//	//LLITDEC//
	//LLITE//	//LLITW//	//LLIT322//
	//LWDIG1//	//LWDIG2//	//LWDIG3//
	//LWDIG4//	//LWDIG5//	//LWDIG6//
	//LWDIG7//	//MARKWIN//	//ULITN//
	//ULITS//	//ULIT222//	//ULIT321//
	//UWDIG1//	//UWDIG2//	//UWDIG3//
	//UWDIG4//	//UWDIG5//	//UWDIG6//
Panel Output Word 1			
POW1	//ENTLIT//	//KELIT//	//LLITDEC//
	//LLITE//	//LLITW//	//LLIT322//
	//ULITN//	//ULITS//	//ULIT222//
	//ULIT321//		
Panel Output Word 2			
POW2	//LWDIG1//	//LWDIG2//	
Panel Output Word 3			
POW3	//LWDIG3//	//LWDIG4//	
Panel Output Word 4			
POW4	//LWDIG5//	//LWDIG6//	
Panel Output Word 5			
POW5	//LWDIG7//		
Panel Output Word 6			
POW6	//UWDIG1//	//UWDIG2//	
Panel Output Word 7			
POW7	//UWDIG3//	//UWDIG4//	
Panel Output Word 8			
POW8	//UWDIG5//	//UWDIG6//	

Class	Data Items		
Serial Input Register - Discrete Output Word 3			
SDOP-DOW3 (DRS)	/ANTGOOD/	/DGNDSP/	/DRFTANG/
	/DRSFUN/	/DRSMEM/	/DRSREL/
	/ELECGOOD/		
SFLR-DOW3 (FLR)	/LOCKEDON/	/SLTRNG/	
SSIN-DOW3 (SINS)	/SINHDG/	/WAYLAT/	
	/SINLAT/	/WAYLON/	
	/SINLON/	/WAYNUM1/	
	/SINEVEL/	/WAYNUM2/	
	/SINNVEL/		
	/SINPTH/		
	/SINROL/		

2.6. UNUSED INPUTS AND OUTPUTS

The following table contains those words and bits which are not used by the Input/Output operations of the Navy version of the OFP. The unused bits of the Cycle Steal outputs are not included since the OFP does not directly control their output.

The first column (Instruction) gives the basic I/O command of the instruction sequence.

The second column (I/O Item) gives an identification of the input or output item. The letter in parentheses designates the category of the I/O item; e.g., data item class, data item, etc. The definitions of the letters follows:

(a) The reference is to the data item class defined in §2.0.4.

(b) The reference is to the register or counter defined in Ref. 18, pp. 5-6 and 5-10.

(c) The reference is the to the thumbwheel encoder counter defined in Ref. 18, pp. 5-6.

(d) The reference is to the Doppler Radar Status word as defined in Ref. 18, pp. 5-16.

(e) The reference is to the data item word defined in §2.1-2.3.

(f) The reference is to the LASER word defined in Ref. 18, pp. 5-21.

(g) The reference is to the Serial Input Address word defined in Ref. 18, pp. 5-20.

(h) The reference is to the LORAN words or bits defined in Ref. 18, §5.

(i) The reference is to the Lower Window 7 word defined in Ref. 18, pp. 5-56.

(j) The reference is to the Mark Window word defined in Ref. 18, pp. 5-56.

(k) The reference is to the self-test signals defined in Ref. 18, pp. 5-60 and 5-62.

(l) The reference is to the SINS analog data defined in Ref. 18, pp. 5-59 and 5-60.

(m) The reference is to the spare signals defined in Ref. 18, pp. 5-59, 5-62, 5-71, 5-73, and 5-74.

(n) The reference is to the signal converter defined in Ref. 18, pp. 5-60.

The third column (Bit(s)) gives the bit(s) of the I/O Item that are unused.

The last column (Description) gives a description of the I/O Item. The number in parentheses describes why the bits of the I/O Item are unused. The definition of the numbers follows:

(1) Used by the USAF version of the OFP.

(2) Not used by the Navy version of the OFP.

(3) Bit always set to 1. Not used by the Navy version of the OFP.

(4) Not physically implemented.

Instruction	I/O ITEM	Bit(s)	Description
READ 8	DIW1(a)	8-13	
READ 8	DIW1(a)	14	ASCU SSU-20 (1,2)
READ 8	DIW1(a)	15	BITE FAIL SAFE (2)
READ 2	DIW3(a)	0	TACAN PARITY VALID (3)
READ 2	DIW3(a)	10-14	AGE TEST EQUIPMENT (2)
READ 1	DIW4(a)	6-14	LORAN (2)
READ 24	DIW5(a)	2	
READ 24	DIW5(a)	11	SIGNAL CONV OVER TEMP (2)
READ 16	DIW6(a)	4-7	
READ 16	DIW6(a)	8-15	ZERO (4)
READ/WRITE 20	Interrupt Level 1(b)	4	SPARE MEMORY PARITY

Instruction	I/O ITEM	Bit(s)	Description
READ/WRITE 20	Interrupt Level 1(b)	5-14	ZERO (4)
READ/WRITE 18	Interrupt Level 0(b)	4	SPARE LORAN (2)
READ/WRITE 18	Interrupt Level 0(b)	5	
READ/WRITE 18	Interrupt Level 0(b)	6-15	ZERO (4)
READ 22	TW Encoder(c)	0-7, 11-15	THUMBWHEEL ENCODER (2)
READ 22	TW Encoder(c)	8-10	ZERO (4)
WRITE 8	DOW1(a)	0-7, 11, 15	
WRITE 8	DOW1(a)	14	NAV/WD PANEL MAL.IND. (2)
WRITE 4	DOW2(a)	11, 15	
WRITE 2	SIR-DOW3(a)	2	ENAB. LASER (2)
WRITE 2	SIR-DOW3(a)	4-6	AGE TEST EQUIPMENT (2)
WRITE 2	SIR-DOW3(a)	7	LIFT STO. PRO (2)
WRITE 2	SIR-DOW3(a)	8-15	
WRITE 24	10-bit Counter(b)	10-15	
READ 32	DRS STATUS(d)	0, 8-15	
READ 32	/DGNDSP/(e)	0	SIGN ALWAYS SET TO 1
READ 32	/DGNDSP/(e)	15	ZERO (4)
READ 32	/DRFTANG/(e)	0	SIGN ALWAYS SET TO 1
READ 32	/DRFTANG/(e)	15	ZERO (4)
READ 32	/SLTRNG/(e)	13-15	ZERO (4)
READ 32	LASER(f)	0-15	
READ 64	SIA Word(g)	5	LASER ENABLE (2)
READM 97	??	??	/RNGSTA/ADDRESS
READM 96	??	??	/BRGSTA/ADDRESS
READ 129	/XVEL/(e)	0-5	
READ 130	/YVEL/(e)	0-5	
READ 132	/ZVEL/(e)	0-5	
READ 144	/XGYCNT/(e)	0-12, 15	
READ 136	/YGYCNT/(e)	0-12, 15	
READ 152	/ZGYCNT/(e)	0-12, 15	
WRITE 129	//XGYCOM//(e)	0-10, 15	
WRITE 130	//YGYCOM//(e)	0-10, 15	
WRITE 132	//ZGYCOM//(e)	0-10, 15	
READ 161	LORAN(h)	0-13	LORAN (4)
READ 161	LORAN(h)	14-15	ZERO (4)
READ 162	LORAN(h)	0-13	LORAN (4)
READ 162	LORAN(h)	14-15	ZERO (4)
WRITE 161	LORAN(h)	0-13	LORAN (4)
WRITE 161	LORAN(h)	14-15	ZERO (4)
READ 208	PIW1(a)	13-15	ZERO (4)
READ 200	PIW2(a)	10-15	ZERO (4)
READ 196	PIW3(a)	6-7	/MODEROT/ SPARE (2)
READ 196	PIW3(a)	11-13	/PRESPOS/ SPARE (2)
READ 196	PIW3(a)	14	NOT KBD (2)
READ 196	PIW3(a)	15	ZERO (4)
READ 194	LORAN(h)	0-13	LORAN (4)
READ 194	LORAN(h)	14-15	ZERO (4)
WRITE 200	POW1(a)	12-15	

Instruction	I/O ITEM	Bit(s)	Description
WRITE 202	POW2(a)	7, 15	
WRITE 204	POW3(a)	7, 15	
WRITE 206	POW4(a)	7, 15	
WRITE 194	POW5(a)	7, 15	
WRITE 196	POW6(a)	7, 15	
WRITE 198	POW7(a)	7, 15	
WRITE 208	POW7(i)	7-15	
WRITE 210	LORAN(h)	0-15	LORAN (4)
WRITE 212	LORAN(h)	0-7, 9-12	LORAN (4)
WRITE 212	LORAN(h)	8, 13-15	LORAN (4)
WRITE 214	MARK WINDOW(j)	7-15	
READ 224	/ACTESTCOS/(e)	13-15	ZERO (4)
READ 224	/ACTESTSIN/(e)	13-15	ZERO (4)
READ 225	/PCHCOS/(e)	13-15	ZERO (4)
READ 225	/PCHSIN/(e)	13-15	ZERO (4)
READ 226	/ROLLCOSI(e)	13-15	ZERO (4)
READ 226	/ROLLSINI(e)	13-15	ZERO (4)
READ 227	/THDGCOS/(e)	13-15	ZERO (4)
READ 227	/THDGSIN/(e)	13-15	ZERO (4)
READ 228	/MAGHCOS/(e)	13-15	ZERO (4)
READ 228	/MAGHSIN/(e)	13-15	ZERO (4)
READ 232	/DCTEST/(e)	0	ZERO (4)
READ 232	/DCTEST/(e)	13-15	ZERO (4)
READ 233	/RADALT/(e)	13-15	ZERO (4)
READ 234	/TAS/(e)	13-15	ZERO (4)
READ 235	/BAROADC/(e)	13-15	ZERO (4)
READ 236	/MACH/(e)	13-15	ZERO (4)
READ 237	/AOA/(e)	13-15	ZERO (4)
READ 239	/SLEWUD/(e)	13-15	ZERO (4)
READ 240	/SLEWRL/(e)	13-15	ZERO (4)
READ 229	SINS(l)	0-12	SINS (2)
READ 229	SINS(l)	13-15	ZERO (4)
READ 230	SINS(l)	0-12	SINS (2)
READ 230	SINS(l)	13-15	ZERO (4)
READ 231	SINS(l)	0-12	SINS (2)
READ 231	SINS(l)	13-15	ZERO (4)
READ 238	SPARE(m)	0-12	
READ 238	SPARE(m)	13-15	ZERO (4)
READ 241	SPARE(m)	0-12	
READ 241	SPARE(m)	13-15	ZERO (4)
READ 242	SPARE(m)	0-12	
READ 242	SPARE(m)	13-15	ZERO (4)
READ 243	SPARE(m)	0-12	
READ 243	SPARE(m)	13-15	ZERO (4)
READ 244	SPARE(m)	0-12	
READ 244	SPARE(m)	13-15	ZERO (4)
READ 245	SPARE(m)	0-12	
READ 245	SPARE(m)	13-15	ZERO (4)
READ 246	SPARE(m)	0-12	
READ 246	SPARE(m)	13-15	ZERO (4)
READ 255	SIGNAL CONVERTER(n)	13-15	ZERO (4)

Instruction	I/O ITEM	Bit(s)	Description
WRITE 224	//RNGUNIT//(e)	8-12	
WRITE 224	//RNGUNIT//(e)	13-15	ZERO (4)
WRITE 225	//RNGTEN//(e)	8-12	
WRITE 225	//RNGTEN//(e)	13-15	ZERO (4)
WRITE 226	//RNGHND//(e)	8-12	
WRITE 226	//RNGHND//(e)	13-15	ZERO (4)
WRITE 227	//GNDTRVEL//(e)	1-2	
WRITE 227	//GNDTRVEL//(e)	13-15	ZERO (4)
WRITE 228	//FPANGL//(e)	1-2	
WRITE 228	//FPANGL//(e)	13-15	ZERO (4)
WRITE 229	//STERROR//(e)	1-2	
WRITE 229	//STERROR//(e)	13-15	ZERO (4)
WRITE 230	SPARE(m)	0-12	
WRITE 230	SPARE(m)	13-15	ZERO (4)
WRITE 231	SPARE(m)	0-12	
WRITE 231	SPARE(m)	13-15	ZERO (4)
WRITE 232	//BRGDEST//(e)	13-15	ZERO (4)
WRITE 233	//GNDTRK//(e)	13-15	ZERO (4)
WRITE 234	//STEEREL//(e)	13-15	ZERO (4)
WRITE 235	//STEERAZ//(e)	13-15	ZERO (4)
WRITE 236	/SPARE1/(e)	13-15	ZERO (4)
WRITE 237	/SPARE2/(e)	13-15	ZERO (4)
WRITE 238	SPARE(m)	0-12	
WRITE 238	SPARE(m)	13-15	ZERO (4)
WRITE 239	SPARE(m)	0-12	
WRITE 239	SPARE(m)	13-15	ZERO (4)
WRITE 240	SPARE(m)	0-12	
WRITE 240	SPARE(m)	13-15	ZERO (4)

Channels 1 and 2 are not used for output.

Channel 3 output is not physically implemented.

CHAPTER 3

Modes of Operation

3.0. INTRODUCTION

3.0.1. Overview

We have grouped the possible states of the OFP into modes that correspond to A/C operating conditions. Because the functions performed by the OFP differ greatly in different modes, a description of the OFP requirements on a mode-by-mode basis is simpler than a general description.

We chose our modes to correspond as closely as possible to the modes mentioned in other A-7 documentation. However, none of the documents contain a definitive list of modes; nor do the documents agree precisely with each other. Therefore, to fill gaps and reconcile inconsistencies, we deviated occasionally from the current documentation.

Five classes of modes are described in this chapter: alignment, navigation, navigation update, weapon delivery, and test. The system can be in more than one mode at one time, provided the modes are in different mode classes. Exclusion relations among modes in different classes are described in Chapter 4.

The alignment modes correspond to different procedures for aligning the IMS platform X, Y, Z frame with Earth's east, north, vertical coordinate system. These modes are primarily distinguished by the reference data used to determine the amount of platform misalignment. Among the alignment modes are three calibration modes, which calculate the rate of drift of the axes of the particular IMS platform. The drift is compensated for during navigation. The seven alignment modes are listed below, with the shorter, mnemonic names that are used to refer to them in the rest of the document.

Land autocalibration	*Lautocal*	(calibration)
SINS autocalibration	*Sautocal*	(calibration)
01 update	*01Update*	(calibration)
Land alignment	*Landaln*	
SINS alignment	*SINSaln*	
IMS-HUD alignment	*HUDaln*	
Air alignment	*Airaln*	

The navigation modes correspond to different procedures for calculating position, velocity and wind data and for maintaining the IMS platform in alignment. The ten navigation modes are listed below, with their mnemonic names.

Doppler inertial gyrocompassing	*DIG*

Doppler inertial	*DI*
Inertial	*I*
Unaligned Doppler inertial	*UDI*
Open loop	*OLB*
Magnetic slave	*Mag sl*
Grid	*Grid*
Polar Doppler inertial	*PolarDI*
Polar inertial	*PolarI*
IMS failed	*IMS fail*

The navigation update modes correspond to different procedures for obtaining a correction for the A/C present position. Obtaining a navigation update is like setting a watch: an outside reference is used to get an initial correct value. The six navigation update modes are listed below, with their mnemonic names.

HUD or visual update	*HUDUpd*
Radar update	*RadarUpd*
Flyover update	*FlyUpd*
Automatic flyover update	*AflyUpd*
Map update	*MapUpd*
Tacan update	*TacUpd*

The weapon delivery modes correspond to different procedures for identifying and tracking targets and for determining the moment at which a weapon should be released. Many of the displays, especially on the HUD, vary considerably from one weapon delivery mode to another. The weapon delivery modes are listed below with their mnemonic names.

Air-to-air guns	*A/A Guns*
Air-to-ground guns/rockets	*A/G Guns*
Bomb on coordinates	*BOC*
Bomb on coordinates, Fly-to-0	*BOCFlyto0*
Bomb on coordinates, offset	*BOCoffset*
Continuously computed impact point	*CCIP*
Manual ripple	*Manrip*
Normal attack	*Nattack*
Normal offset	*Noffset*
Normal attack with HUD unreliable	*HUDdown1*
Normal offset with HUD unreliable	*HUDdown2*
Special bomb on coordinates	*SBOC*
Special BOC, Fly-to-0	*SBOCFlyto0*
Special BOC offset	*SBOCoffset*
Special normal attack	*Snattack*
Special normal offset	*Snoffset*
Special normal attack with HUD unreliable	*SHUDdown1*
Special normal offset with HUD unreliable	*SHUDdown2*
Walleye	*Walleye*

A sequence of tests is run in a single test mode—Ground Test (*Grtest*)— to make sure the computer and its interfaces to other hardware components are operating correctly.

3.0.2. Organization

Following the definition of legal mode combinations, the five classes of modes are described in the following order: alignment modes, navigation modes, navigation update modes, weapon delivery modes, and test modes. Each respective section has an overview of a mode. The mode overviews are not meant to be complete user-level descriptions of the mode characteristics. Instead, they summarize briefly and informally the characteristics that distinguish the modes in a given class from each other. *The overviews are meant to be introductory in nature and not necessarily authoritative. If there is a conflict between information in an overview and information presented elsewhere, the latter should be considered correct.* For more narrative descriptions, see Refs. 14, 15, 17, 24, 26, 27, and 28.

After the mode overviews for a class, we indicate the mode in that class that the system will be in when started up. We then indicate the events that will cause the system to change from one mode to another. This fully specifies the mode of the system, provided that we know the history of events.

There is a single transition table for alignment, navigation, and test modes because the transitions are so interrelated.

3.1. LEGAL MODE COMBINATIONS

This section defines the allowable mode combinations. There are no restrictions other than these.

(1) The system is always in one and only one of the following modes:

Lautocal	*DIG*	*Grtest*
Sautocal	*DI*	
Landaln	*I*	
SINSaln	*UDI*	
01Update	*OLB*	
HUDaln	*Mag sl*	
Airaln	*Grid*	
	IMS fail	
	PolarDI	
	PolarI	

(2) The system may be in at most one of the following modes at a time:

HUDUpd	*Nattack*	*Walleye*
RadarUpd	*Noffset*	*Snattack*
MapUpd	*BOC*	*Snoffset*
TacUpd	*BOCFlyto0*	*SBOC*
FlyUpd	*BOCoffset*	*SBOCFlyto0*
	CCIP	*SBOCoffset*
	A/G Guns	*SHUDdown1*
	HUDdown1	*SHUDdown2*
	HUDdown2	

(3) The system may only be in *AflyUpd* when it is in either *BOC* or *SBOC*.

(4) The system may be in *A/A Guns* and *Manrip* separately or together.

(5) The system may not be in any of the following modes if the navigation mode is *IMS fail*, *Mag sl*, or *Grid* and the condition !ADC Up! is false:

Nattack	*Noffset*	*BOC*
BOCFlyto0	*BOCoffset*	*CCIP*
HUDdown1	*HUDdown2*	*Walleye*
Snattack	*Snoffset*	*SBOC*
SBOCFlyto0	*SBOCoffset*	*SHUDdown1*
SHUDdown2		

3.2. ALIGNMENT MODES

3.2.0. Introduction

The alignment modes are primarily distinguished from each other by the reference data used to determine the amount of platform misalignment, and by the sequence and duration of alignment stages. Different alignment modes also affect pilot displays differently, especially the HSI ground track needle, the IMS nonaligned light, and the panel. These features are summarized in the alignment mode overviews.

The alignment stages, which are defined in Table 3.2-a, determine the kind of correction activity taken. For example, in some stages, errors are allowed to accumulate for a fixed amount of time and then calculated and removed. In other stages, errors are continuously calculated and removed. In some stages, errors are removed by slewing*; in other stages, errors are removed by torquing. The alignment stage most recently completed can affect the way functions are performed. Finally, if *Airaln* is entered after alignment is partially completed in another alignment mode, the earlier stages of *Airaln* are not performed.

In the mode overviews, the times given for the various stages are the times presented in pilot documentation, i.e., what pilots are told to expect. These times do not include time required to slew or torque out errors in the stages that allow errors to accumulate. If an alignment mode is exited (see Tables 3.4-b and 3.4-c) the current stage is also exited, whether the indicated time has elapsed or not.

Table 3.2-a: Alignment Stages

!CL stage!	Coarse level	Platform X and Y axes are roughly aligned to local horizontal—tilt errors are allowed to accumulate and are then slewed out. Heading corrections are not applied. The duration given for !CL stage! in the table for each mode is that required by the error accumulation phase. However, the total duration of !CL stage! is the sum of this time and the time needed to correct and remove the errors. Errors have been removed when !slewing complete! occurs.
!HL stage!	Hi-gain level	Refined alignment of X and Y axes to local horizontal occurs—tilt errors are continuously torqued out. Heading corrections are not applied.
!CA stage!	Coarse azimuth	Z axis is roughly aligned to the local meridian. Heading errors are allowed to accumulate and are slewed out if large or torqued out if smaller. X and Y axis errors are allowed to accumulate and are removed by slewing. The duration given for !CA stage! in this chapter for each mode is that required by the error accumulation phase. However, the total duration of !CA stage! is the sum of this time and the time needed to correct and remove the errors. Errors have been removed when !slewing complete! occurs.

Table 3.2-a: Alignment Stages

!HG stage!	Hi-gain gyrocompass	Z axis is roughly aligned to local meridian—airborne versions of !CA stage! X and Y axis errors are continuously torqued out.
!FG stage!	Fine gyrocompass	Z-axis is fine-aligned to local meridian. Fine alignment of X and Y axes continues. X and Y axis errors are allowed to accumulate and are removed by torquing at the end of the stage. Heading errors are allowed to accumulate and are slewed out if large or torqued out if smaller. The duration given for !FG stage! in this chapter for each mode is that required by the error accumulation phase. However, the total duration of !FG stage! is the sum of this time and the time needed to correct and remove the errors. Errors have been removed when !slewing complete! occurs.
!ED stage!	East drift	East gyro drift bias is calculated and Data 02 is updated; heading and level alignments are refined.
!ND stage!	North drift	North gyro drift bias is calculated and Data 01 is updated; heading and level alignments are refined.
!HS stage!	Heading slew	Z axis is slewed until heading equals a computed heading. (*SINSaln*: SINS heading + !Delta heading!; *HUDaln*: !azimuth reference heading! + //ASAZ//).
!FM stage!	Fast magnetic heading update	The platform is released from computer control and is allowed to align itself based on ML1 compass and magnetic variation; the computer samples heading rate of change to decide when it is finished.
!TS stage!	Alignment test	Errors are allowed to accumulate and are then compared to a threshold, to see if they are within acceptable limits. The duration given for !TS stage! in this chapter for each mode is that required by the error accumulation operation. However, the total duration of !TS stage! is the sum of this time and the time needed to correct and remove the errors. For *Landaln* mode, errors have been removed when !Land velocity test passed! OR !Land velocity test failed! occurs.

3.2.1. Land Autocalibration (*Lautocal*)

This mode is used to calculate and update the drift rates associated with the X and Y axes of the platform, when the aircraft is on the ground. Since the A/C is not moving, the reference velocities are zero: any nonzero /XVEL/ or /YVEL/ values are interpreted as signs of platform misalignment.

Reference data:

Horizontal velocities: 0 corrected by Earth's rate
Latitude and longitude: values most recently entered by pilot

Stages:

Coarse level	50 seconds	!CL stage!
Coarse azimuth	100 seconds	!CA stage!
Fine gyrocompassing	150 seconds	!FG stage!
Coarse azimuth 2	200 seconds	!CA stage!
East drift - 02 update	260 seconds	!ED stage!
Coarse azimuth 3	50 seconds	!CA stage!
North drift - 01 update	200 seconds	!ND stage!

Comments:

The first three stages allow the platform enough time to become thermally stabilized.

3.2.2. SINS Autocalibration (*Sautocal*)

This mode is used to calculate and update the drift rates for the X and Y axes of the platform, when the aircraft is on a carrier. SINS data are used for reference data; since the A/C movement is entirely due to ship movement, its actual velocities can be computed from the SINS velocities, taking into account the distance of the A/C from the SINS platform (!SINS offsets!) and !Delta heading!. /XVEL/ and /YVEL/ deviations from corrected SINS east and north velocities are interpreted as signs of platform misalignment.

Reference data:
Horizontal velocities: SINS velocities, with corrections for A/C displacement from SINS source (!SINS offsets!) and !Delta heading!.
Heading: Ship's heading, corrected by !Delta heading!
Latitude and longitude: ship's coordinates

Stages:

Coarse level	50 seconds	!CL stage!
Coarse azimuth	200 seconds	!CA stage!
Coarse azimuth 2	600 seconds	!CA stage!
East drift - 02 update	1860 seconds	!ED stage!
Coarse azimuth 3	50 seconds	!CA stage!
North drift - 01 update	1800 seconds	!ND stage!

Interruptions:
If SINS velocity and heading invalid for 2 seconds, the mode is exited and a full *SINSaln* mode must be executed before *Sautocal* may be restarted.

Accuracy test: None.

Comments: See Land Autocalibration overview.

3.2.3. 01 Parameter Update (*01Update*)

This mode is used to update the drift rate of the Y axis, when the aircraft is on the ground and a full *Landaln* mode has been executed. The new drift rate value is not used unless the accuracy tests are passed.

Reference data:

Horizontal velocities: 0, corrected by Earth's rate

Stages:

Fine gyrocompassing	200 seconds	!FG stage!
Alignment test	30 seconds	!TS stage!

The above sequence is repeated until the mode is exited.

Accuracy test:

Velocity test: north and east velocities < 1/8 fps for 30 seconds
Delta01 test: difference between old and new Y axis drift rate values <0.049.

3.2.4. Land Alignment (*Landaln*)

This mode is used to align the axes of the platform to north, east, and vertical when the aircraft is on the ground. Since the A/C is not moving, the reference velocities are zero: any nonzero /XVEL/ or /YVEL/ values are interpreted as signs of platform misalignment.

Reference data:

Horizontal velocities: 0 corrected by Earth's rate

Stages:

Coarse level	50 seconds	!CL stage!
Coarse azimuth	100 seconds	!CA stage!
Fine gyrocompassing	150 seconds	!FG stage!
Fine gyrocompassing	200 seconds	!FG stage!
Alignment test	30 seconds	!TS stage!

The last two stages are repeated until the mode is exited. The duration of the error accumulation phase of the !FG stage! that follows a !TS stage! depends upon the outcome of the Land velocity test at the end of the preceding !TS stage!. If !Land velocity test passed!, the duration is 200 seconds. If NOT !Land velocity test passed!, the duration is 170 seconds.

Accuracy test: North and east velocities: less than 1/8 fps after 30 seconds.

3.2.5. SINS alignment (*SINSaln*)

This mode is used to align the axes of the platform to east, north, and vertical when the aircraft is on a carrier. SINS data are used for reference data; since the A/C movement is entirely due to ship movement, its actual velocities can be computed from the SINS velocities, taking into account the distance of the A/C from the SINS platform and the !Delta heading!. /XVEL/ and /YVEL/ deviations from corrected SINS east and north velocities are interpreted as signs of platform misalignment.

Reference data:

Not all the reference data are required; alignment may proceed even if the optional data become not available.

Horizontal velocities: SINS velocities, with corrections for A/C displacement from SINS source (!SINS offsets!) (required) and !Delta heading!

Heading: Ship's heading, corrected by !Delta heading! (required)

Latitude and longitude: ship's coordinates (optional)

SINS heading, pitch and roll (required)

Stages:

Heading slew	varies	!HS stage!
Coarse level	50 seconds	!CL stage!
Coarse azimuth	200 seconds	!CA stage!
Fine gyrocompassing	600 seconds	!FG stage!
Alignment test	30 seconds	!TS stage!

The last two stages repeat until mode exited.

Interruptions: SINS data interrupt greater than 5 seconds—current stage restarted power interrupt less than 30 seconds—continues where left off otherwise stage restarted.

Accuracy test: difference between IMS and corrected SINS north and east velocities: < 1 fps after 30 seconds.

3.2.6. IMS-HUD Alignment (*HUDaln*)

This mode is primarily used to correct the platform heading quickly, when the aircraft is on the ground and the angle between the Ya axis and the line from the A/C nose to a visual reference point is known. Once the heading correction has been made, the mode will continue with a regular *Landaln* sequence, if /IMSMODE/=$Gndal$; otherwise the mode will be exited.

Reference data:

Azimuth of known reference point
HUD coordinates of known reference point
(For other reference data, see *Landaln* overview.)

Stages: Heading slew: !HS stage!

If /IMSMODE/ = $Iner$ OR $Norm$, the mode is exited at this point. Otherwise alignment continues with the sequence of stages given in *Landaln* overview.

Interruptions: If power interrupted: continues where left off.

Accuracy test: If /IMSMODE/=$Iner$ OR $Norm$: None. If /IMSMODE/=$Gndal$: north and east velocities: less than 1/8 fps after 30 seconds.

3.2.7. Airborne Alignment (*Airaln*)

This mode is used to align the axes of the platform to north, east, and vertical while the aircraft is airborne and navigating. Since the A/C is moving, the platform velocities must be compared to another measurement of A/C velocity. The Doppler groundspeed !DGNDSP! is resolved into north and east components and compared to the platform velocities to determine the amount of platform misalignment.

Reference data:
Horizontal velocities: !DGNDSP!, resolved into north and east components, using /DRFTANG/.

Stages:

Fast magnetic heading update	30 deg/min	!FM stage!
Coarse level	50 seconds	!CL stage!
High gain level	180 seconds	!HL stage!
High gain gyrocompassing	420 seconds	!HG stage!
Fine gyrocompassing and test	300 seconds	!FG stage!

If !CL stage! was completed in an earlier mode, *Airaln* starts with !HL stage!; if !CA stage! was completed, *Airaln* starts with !FG stage!. The last stage is repeated until the test is passed.

Interruptions:
!FM stage!:—interrupted when roll greater than 5°.
Power interrupts—extend alignment time by the time the power is down.
Doppler interrupts—

during !CL stage! - starts over (*OLB* during interruptions)
all other stages - extend alignment time by time Doppler is down (*I* during interruptions)

Accuracy test: East and north velocity differences from Doppler: less than 5 fps.

3.3. NAVIGATION MODES

3.3.0. Introduction

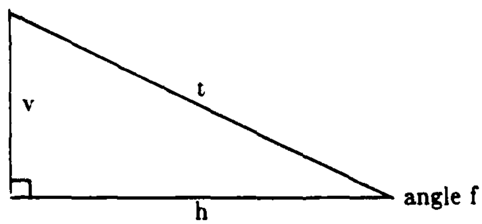
The two major aspects that distinguish navigation modes are (1) the data sources used in the velocity, heading, and attitude calculations, and (2) whether any adjustments are applied to the platform axes, and if so, how they are calculated. These two main areas are covered in the navigation mode overviews.

The modes are also grouped into two classes: *Primary* and *backup*. The primary purpose of the classification is continuity with existing documentation. Also the Data 98 display distinguishes between modes in this way.

In the overviews, vertical velocity is frequently calculated from AOA, IMS attitudes, and either horizontal velocity or true airspeed (total velocity). In these cases, the following steps are followed to calculate vertical velocity:

(1) The angle of the A/C velocity vector relative to horizontal is calculated from AOA, pitch, and roll.

(2) Side v of the triangle below is solved, given that angle f (see step 1) is known and either side h (horizontal velocity) or side t (total velocity) is known.



We distinguish between "IMS corrections" and "IMS adjustments." Both involve torquing the platform axes. However, the angle to be torqued is calculated differently in the two cases:

(1) Correction angles are calculated by comparing platform velocities to Doppler velocities to determine the magnitude of platform misalignment. For the Z axis, this is called *Doppler gyrocompassing*, since the IMS heading is corrected. For the X and Y axes, this is called *Doppler leveling*, since platform tilt errors are removed.

(2) Adjustment angles are calculated by applying fixed corrections: a reference velocity is not needed. Adjustment maintains the platform in alignment with Earth axes, accounting for Earth curvature and for the ongoing drift occurring in each axis.

3.3.1. Doppler Inertial Gyrocompassing (*DIG*)

Class: Primary

Horizontal velocities used: IMS north and east velocities damped by Doppler groundspeed

Vertical velocities used:

ADC reliable: IMS vertical velocity damped by ADC baroaltitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading, AOA, attitudes
ADC not reliable: last computed or inserted

True heading used: IMS true heading

Attitude used: IMS pitch and roll.

3.3.2. Doppler Inertial (*DI*)

Class: Primary

Horizontal velocities used: IMS north and east velocities damped by Doppler groundspeed

Vertical velocities used:

ADC reliable: IMS vertical velocity damped by ADC baroaltitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading, attitudes, AOA
ADC not reliable: last computed or inserted

True heading used: IMS true heading

Attitude used: IMS pitch and roll.

3.3.3. Inertial (*I*)

Class: Primary

Horizontal velocities used: IMS east and north velocities

Vertical velocities used:

ADC reliable: IMS vertical velocity damped by ADC baroaltitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading, attitudes, AOA
ADC not rel: last computed or inserted

True heading used: IMS true heading

Attitude used: IMS pitch and roll.

3.3.4. Magnetic Slave (*Mag sl*)

Class: Backup

Horizontal velocities used:

Not airborne: 0 fps
Airborne and Doppler reasonable: Doppler groundspeed
Airborne, Doppler not reasonable, ADC reasonable: ADC velocities and wind
Airborne, Doppler and ADC unreasonable: stale value

Vertical velocities used:

ADC reliable: ADC airspeed, AOA, attitudes
ADC not reliable: 0 fps

Wind computed from:

Doppler and ADC reliable: Doppler groundspeed, ADC airspeed, heading
Either unreliable: last computed or inserted

True heading used: IMS true heading

Attitude used: IMS pitch and roll.

3.3.5. Grid (*Grid*)

Class: Backup

Horizontal velocities used:

Not airborne: 0 fps
Airborne and Doppler reasonable: Doppler groundspeed
Airborne, Doppler not reasonable, ADC reasonable: ADC velocities and wind
Airborne, Doppler and ADC unreasonable: stale value

Vertical velocities used:

ADC reliable: ADC airspeed, AOA, attitudes
ADC not reliable: 0 fps

Wind computed from:

Doppler and ADC reliable: Doppler groundspeed, ADC airspeed, heading
Either unreliable: last computed or inserted

True heading used: IMS heading

Attitude used: IMS pitch and roll.

3.3.6. Unaligned Doppler Inertial (*UDI*)

Class: Primary

Horizontal velocities used: IMS east and north velocities damped by Doppler groundspeed

Vertical velocities used:

ADC reliable: IMS vertical velocity, ADC barometric altitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading
ADC not rel: last computed or inserted

True heading used: IMS heading

Attitude used: IMS pitch and roll.

3.3.7. Open Loop (*OLB*)

Class: Backup

Horizontal velocities used:

Doppler reasonable (decoupled): Doppler groundspeed
Doppler not reasonable: ADC true airspeed and wind

Vertical velocities used:

ADC reliable: AOA, attitudes, ADC airspeed
ADC not reliable: 0 fps

Wind computed from:

ADC and Doppler reliable: Doppler groundspeed, heading, ADC airspeed
Either not reliable: last computed or inserted

True heading used: IMS heading

Attitude used: IMS pitch and roll.

3.3.8. IMS failure (*IMS fail*)

Class: Backup

Horizontal velocities used:

Not airborne: 0 fps
Airborne and Doppler reasonable: Doppler groundspeed
Airborne, Doppler not reasonable, ADC reasonable: ADC velocities and wind
Airborne, Doppler and ADC unreasonable: stale value

Vertical velocities used: 0 fps

Wind computed from:

ADC and Doppler reliable: Doppler groundspeed, heading, ADC airspeed
Either not reliable: last computed or inserted

True heading used:

Partial IMS failure: magnetic heading + magnetic variation
Complete IMS failure: north

Attitude used: Pitch = !True AOA!, roll = 0°.

3.3.9. Polar Doppler Inertial (*PolarDI*)

In this mode, the platform is not maintained pointing to north because the magnitude of the corrections exceed the capacity of the torque motors. Instead, errors are calculated, and the errors are added together to be used as an estimate of wander angle (heading error).

Class: Primary

Horizontal velocities used: IMS velocities damped by Doppler groundspeed

Vertical velocities used:

ADC reliable: IMS vertical velocity, damped by baroaltitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading, AOA, attitudes
ADC not reliable: last computed or inserted

True heading used: IMS heading corrected by wander angle

Attitude used: IMS pitch and roll.

3.3.10. Polar Wander Azimuth, Inertial (*PolarI*)

In this mode, the platform is not maintained pointing to north because the magnitude of the corrections exceed the capacity of the torque motors. Instead, errors are calculated, and the errors are added together to be used as an estimate of wander angle (heading error).

Class: Primary

Horizontal velocities used: IMS north and east velocities

Vertical velocities used:

ADC reliable: IMS vertical velocity, damped by baroaltitude
ADC not reliable: horizontal velocity, AOA, attitudes

Wind computed from:

ADC reliable: horizontal velocity, ADC airspeed, heading, AOA, attitudes
ADC not rel: last computed or inserted

True heading used: IMS heading corrected by wander angle

Attitude used: IMS pitch and roll.

3.4. TRANSITIONS BETWEEN ALIGNMENT/NAVIGATION/TEST MODES

Table 3.4-a shows which alignment, navigation, or test mode the system will be in when initialized.

Subsequent behavior is determined by the transition events in Tables 3.4-b and 3.4-c. The mode transition events between the navigation, alignment, and test modes have been divided into two tables for improved readability. Table 3.4-b shows those events that cause transitions between the modes while the aircraft is on the ground (/ACAIRB/=No). Table 3.4-c gives those events that cause transitions whil- the aircraft is airborne (/ACAIRB/=Yes).

The system is always in one and only one of the 18 modes.

Table 3.4-a: Initial Modes

Modes	Conditions
Landaln	!IMS Up! AND /IMSMODE/=$Gndal$ AND !Data 23!=!Land!
OLB	!IMS Up! AND (/IMSMODE/=$Iner$ OR $Norm$ OR (/IMSMODE/=$Gndal$ AND !Data 23!=!Sea!))
Mag sl	!IMS Up! AND /IMSMODE/=$Mag sl$
Grid	!IMS Up! AND /IMSMODE/=$Grid$
IMS fail	NOT !IMS Up!

Table 3.4-b
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	!present position entered!	/ACAIRB/=Yes	/IMSAUTOC/=On	!Desig!	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!ND stage complete!	!HS stage complete!	/PNLTEST/=$TEST$	!IMS up!	!latitude! > 80 deg.	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!SINS up!	!SINS velocity test passed!	!Land velocity test passed!	!No intervening takeoff!	!ground tests finished!	New Mode
Lautocal	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	-	-	-	-	@T	-	f	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	@T	-	f	-	t	-	-	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*
Sautocal	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	*SINSaln*
	-	-	-	-	-	-	-	@T	-	f	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	f	-	-	-	-	-	-	f	-	f	-	-	-	-	-	-	-	@F	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	@T	-	f	-	t	-	-	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	!present position entered!	/ACAIRB/=Yes	/IMSAUTOC/=On	!Desig!	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!ND stage complete!	!HS stage complete!	/PNLTEST/=$TEST$	!IMS up!	!latitude!>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!SINS up!	!SINS velocity test passed!	!Land velocity test passed!	!No intervening takeoff!	!ground tests finished!	New Mode
Landaln																							
	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	*Lautocal*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*HUDaln*
	-	@T	-	-	-	-	t	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	@T	-	t	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*OLB*
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	-	-	-	-	@T	-	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	@T	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	@T	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	t	-	-	-	-	t	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	\present position entered\	/ACAIRB/=Yes	/IMSAUTOC/=On	\Desig\	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\ND stage complete\	\HS stage complete\	/PNLTEST/=$TEST$	\IMS up\	\latitude\>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\SINS up\	\SINS velocity test passed\	\Land velocity test passed\	\No intervening takeoff\	\ground tests finished\	New Mode
SINSaln	-	-	@T	-	t	-	-	-	-	f	-	-	-	-	-	-	-	-	t	-	-	-	*Sautocal*
	-	-	-	-	@F	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	*Landaln*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*SINSaln*
	-	@T	-	-	-	-	t	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	t	-	t	-	-	f	-	f	-	-	-	f	f	@F	-	-	-	-	
	-	-	-	-	-	-	t	-	-	-	-	f	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	t	-	-	-	-	f	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	f	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	f	-	-	f	-	-	-	-	-	f	f	@F	-	-	-	-	
	-	@T	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	@T	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	*Polarl*
	-	-	-	-	t	-	t	-	-	f	-	t	-	-	-	f	f	@F	-	-	-	-	
	-	-	-	-	-	-	t	-	-	-	-	t	-	-	@T	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	!present position entered!	/ACAIRB/=Yes	/IMSAUTOC/=On	!Desig!	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!ND stage complete!	!HS stage complete!	/PNLTEST/=$TEST$	!IMS up!	!latitude!>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!SINS up!	!SINS velocity test passed!	!Land velocity test passed!	!No intervening takeoff!	!ground tests finished!	New Mode
01Update																							
	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Lautocal*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*HUDaln*
	-	@T	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	f	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	@T	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	-	-	-	-	-	-	-	t	-	-	@T	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	\present position entered\	/ACAIRB/=Yes	/IMSAUTOC/=On	\Desig\	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\ND stage complete\	\HS stage complete\	/PNLTEST/=$TEST$	\IMS up\	\latitude\>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\SINS up\	\SINS velocity test passed\	\Land velocity test passed\	\No intervening takeoff\	\ground tests finished\	New Mode
HUDaln																							
	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	*Lautocal*
	-	@T	-	-	-	-	t	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	t	-	-	-	-	f	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	t	-	-	-	-	f	-	@T	-	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	*OLB*
	-	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	f	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	f	-	t	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	f	-	t	-	-	-	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	@T	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	*Polarl*
	-	-	-	-	-	-	t	-	-	-	-	t	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	t	-	-	-	-	t	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	\present position entered\	/ACAIRB/=Yes	/IMSAUTOC/=On	\Desig\	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\ND stage complete\	\HS stage complete\	/PNLTEST/=$TEST$	\IMS up\	\latitude\>80 deg.	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\SINS up\	\SINS velocity test passed\	\Land velocity test passed\	\No intervening takeoff\	\ground tests finished\	New Mode
I	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	f	-	-	*Landaln*
	@T	-	-	-	f	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	
	@T	-	-	-	t	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	*SINSaln*
	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	t	f	-	*01Update*
	-	-	-	@T	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*HUDaln*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	*OLB*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	
	@T	-	-	-	t	-	-	-	-	-	-	-	t	-	-	-	-	f	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	*Polarl*
	-	-	-	-	-	-	-	-	-	@T	-	-	-			-	-	-	-	-	-	-	*Grtest*
OLB	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	*Landaln*
	@T	-	-	-	t	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	*SINSaln*
	-	-	-	@T	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*HUDaln*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	\present position entered\	/ACAIRB/=Yes	/IMSAUTOC/=On	\Desig\	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\ND stage complete\	\HS stage complete\	/PNLTEST/=$TEST$	\IMS up\	\latitude\>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\SINS up\	\SINS velocity test passed\	\Land velocity test passed\	\No intervening takeoff\	\ground tests finished\	New Mode
Mag sl	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*
Grid	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*
IMS fail	-	-	-	-	f	-	-	-	-	-	@T	-	t	-	-	-	-	-	-	-	-	-	*Landaln*
	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	t	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	@T	-	-	t	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	-	-	-	-	@T	-	t	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	t	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	t	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*

Table 3.4-b (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Not Airborne (/ACAIRB/=No)

Current Mode	!present position entered!	/ACAIRB/=Yes	/IMSAUTOC/=On	!Desig!	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!ND stage complete!	!HS stage complete!	/PNLTEST/=$TEST$	!IMS up!	!latitude!>80 deg	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!SINS up!	!SINS velocity test passed!	!Land velocity test passed!	!No intervening takeoff!	!ground tests finished!	New Mode
Polarl	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	t	-	*Landaln*
	@T	-	-	-	f	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	
	@T	-	-	-	t	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	*SINSaln*
	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	t	f	-	*01Update*
	-	-	-	@T	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*HUDaln*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	*OLB*
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	
	@T	-	-	-	t	-	-	-	-	-	-	-	t	-	-	-	-	f	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	*Grid*
	-	-	-	-	-	-	-	-	-	f	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	*Grtest*
Grtest	-	-	-	-	f	-	-	-	-	-	t	-	t	-	-	-	-	-	-	-	-	@T	*Landaln*
	-	-	-	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	-	-	@T	*OLB*
	-	-	-	-	-	-	-	-	-	-	t	-	-	-	t	-	-	-	-	-	-	@T	
	-	-	-	-	t	-	-	-	-	-	t	-	t	-	-	-	-	-	-	-	-	@T	
	-	@T	-	-	-	-	-	-	-	-	t	-	-	-	t	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	-	-	-	
	-	@T	-	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	@T	*Mag sl*
	-	@T	-	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	t	-	-	-	-	@T	*Grid*
	-	@T	-	-	-	-	-	-	-	-	t	-	-	-	-	-	t	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	@T	*IMS fail*
	-	@T	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	

Table 3.4-c
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	\present position entered\	/ACAIRB/=Yes	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\IMS Up\	\latitude\ gt 70 deg	\latitude\ gt 80 deg	\Doppler up\	\Doppler coupled\	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMS ODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\Air velocity test passed\	\Pitch small\ AND \Roll small\	New Mode
Airaln	@T	-	-	-	-	-	f	-	t	-	-	-	-	-	-	-	-	*Airaln*
	f	-	-	-	-	-	f	-	t	-	-	-	f	-	-	@T	-	*DIG*
	-	-	-	-	-	-	t	f	-	t	-	-	-	-	-	@T	-	*DI*
	-	-	-	-	t	-	-	f	-	t	-	-	@T	-	-	-	-	
	-	@F	-	-	t	-	-	f	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	t	-	-	f	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	-	f	-	f	-	-	@T	-	-	-	-	
	-	-	-	-	f	-	-	-	-	t	-	-	@T	-	-	-	t	*UDI*
	-	@F	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	f	-	-	-	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	f	-	-	-	-	f	-	-	@T	-	-	-	-	
	-	-	-	-	f	-	-	-	-	-	-	-	@T	-	-	-	f	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	t	-	-	t	-	t	-	-	@T	-	-	-	-	*PolarDI*
	-	@F	-	-	t	-	-	t	-	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	t	-	-	t	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	t	-	-	t	-	f	-	-	@T	-	-	-	-	

Table 3.4-c (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	!present position entered!	/ACAIRB/=Yes	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!IMS Up!	!latitude! gt 70 deg	!latitude! gt 80 deg	!Doppler up!	!Doppler coupled!	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!Air velocity test passed!	!Pitch small! AND !Roll small!	New Mode
DIG	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*Airaln*
	-	-	-	-	-	-	-	-	t	t	-	-	@T	-	-	-	-	*DI*
	f	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	
	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	f	-	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
DI	-	-	-	f	-	-	-	f	-	-	-	@T	-	-	-	-	-	*Airaln*
	-	-	-	f	-	-	-	f	-	-	@T	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	-	
	-	-	-	t	-	-	f	-	-	-	-	@T	-	-	-	-	-	*DIG*
	-	-	-	t	-	-	f	-	-	-	@T	-	-	-	-	-	-	
	f	-	-	t	-	-	@F	-	t	-	-	t	-	-	-	-	-	
	f	-	-	t	-	-	@F	-	t	-	t	-	-	-	-	-	-	
	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*I*
	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	@F	-	-	t	-	-	-	-	
	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	t	*UDI*
	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	f	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	*PolarDI*

Table 3.4-c (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	\present position entered\	/ACAIRB/=Yes	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\IMS Up\	\latitude\ gt 70 deg	\latitude\ gt 80 deg	\Doppler up\	\Doppler coupled\	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\Air velocity test passed\	\Pitch small\ AND \Roll small\	New Mode
I	-	@F	f	-	-	-	-	-	-	-	t	-	-	-	-	-	-	*Landaln*
	-	-	-	f	-	-	-	-	@T	-	t	-	-	-	-	-	-	*Airaln*
	-	-	-	f	-	-	-	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	f	-	-	t	-	-	f	-	@T	-	t	-	-	-	-	-	-	*DIG*
	f	-	-	t	-	-	f	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	t	-	-	f	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	t	-	-	f	-	t	-	-	@T	-	-	-	-	-	
	-	-	-	t	-	-	t	f	t	-	@T	-	-	-	-	-	-	*DI*
	-	-	-	t	-	-	t	f	t	-	-	@T	-	-	-	-	-	
	f	-	-	-	-	-	t	f	@T	-	t	-	-	-	-	-	-	
	f	-	-	-	-	-	t	f	@T	-	-	t	-	-	-	-	-	
	f	-	-	-	-	-	-	f	@T	t	-	-	t	-	-	-	-	
	f	-	-	-	-	-	-	f	t	@T	-	-	t	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	*PolarI*
UDI	-	-	-	-	-	-	-	-	t	-	-	@T	-	-	-	-	-	*Airaln*
	-	-	-	-	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	@F	*OLB*
	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*

Table 3.4-c (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	\present position entered\	/ACAIRB/=Yes	\Data 23\=Sea	\CA stage complete\	\CL stage complete\	\IMS Up\	\latitude\ gt 70 deg	\latitude\ gt 80 deg	\Doppler up\	\Doppler coupled\	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	\Air velocity test passed\	\Pitch small\ AND \Roll small\	New Mode
OLB	-	-	-	-	-	-	-	-	@T	-	t	-	-	-	-	-	-	*Airaln*
	-	-	-	-	-	-	-	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	-	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	-	-	-	-	-	-	-	-	@T	t	-	-	t	-	-	-	t	*UDI*
	-	-	-	-	-	-	-	-	t	@T	-	-	t	-	-	-	t	
	-	-	-	-	-	-	-	-	t	t	-	-	-	-	-	-	@T	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
Mag sl	-	-	-	-	-	-	-	-	t	-	@T	-	-	-	-	-	-	*Airaln*
	-	-	-	-	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	-	-	-	-	-	-	-	-	t	t	-	-	@T	-	-	-	t	*UDI*
	-	-	-	-	-	-	-	-	f	-	-	-	@T	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	f	
	-	-	-	-	-	-	-	-	f	-	@T	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*

Table 3.4-c (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	/present position entered/	/ACAIRB/=Yes	/Data 23/=Sea	/CA stage complete/	/CL stage complete/	/IMS Up/	/latitude/ gt 70 deg	/latitude/ gt 80 deg	/Doppler up/	/Doppler coupled/	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	/Air velocity test passed/	/Pitch small/ AND /Roll small/	New Mode
Grid	-	-	-	-	-	-	-	-	t	-	@T	-	-	-	-	-	-	*Airaln*
	-	-	-	-	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	-	-	-	-	-	-	-	-	t	t		-	@T	-	-	-	t	*UDI*
	-	-	-	-	-	-	-	-	f	-	-	-	@T	-	-	-	-	*OLB*
	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	f	
	-	-	-	-	-	-	-	-	f	-	@T	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
IMS fail	-	-	-	-	-	@T	-	-	t	-	t	-	-	-	-	-	-	*Airaln*
	-	-	-	-	-	@T	-	-	t	-	-	t	-	-	-	-	-	
	-	-	-	-	-	@T	-	-	t	t	-	-	t	-	-	-	t	*UDI*
	-	-	-	-	-	@T	-	-	f	-	-	-	t	-	-	-	-	*OLB*
	-	-	-	-	-	@T	-	-	-	f	-	-	t	-	-	-	-	
	-	-	-	-	-	@T	-	-	-		-	-	t	-	-	-	f	
	-	-	-	-	-	@T	-	-	f	-	t	-	-	-	-	-	-	
	-	-	-	-	-	@T	-	-	f	-	-	t	-	-	-	-	-	
	-	-	-	-	-	@T	-	-	-	-	-	-	-	t	-	-	-	*Mag sl*
	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	t	-	-	*Grid*

Table 3.4-c (continued)
Transitions Between Alignment, Navigation, and Test Modes
While the Aircraft Is Airborne (/ACAIRB/=Yes)

Current Mode	!present position entered!	/ACAIRB/=Yes	!Data 23!=Sea	!CA stage complete!	!CL stage complete!	!IMS Up!	!latitude! gt 70 deg	!latitude! gt 80 deg	!Doppler up!	!Doppler coupled!	/IMSMODE/=$Gndal$	/IMSMODE/=$Norm$	/IMSMODE/=$Iner$	/IMSMODE/=$Mag sl$	/IMSMODE/=$Grid$	!Air velocity test passed!	!Pitch small! AND !Roll small!	New Mode
PolarDI	@T	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	*Airaln*
	@T	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	t	*UDI*
	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	f	*OLB*
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	*PolarI*
	-	-	-	-	-	-	-	-	-	@F	-	-	t	-	-	-	-	
	-	-	-	-	-	-	-	-	-	f	-	-	@T	-	-	-	-	
	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
PolarI	-	@F	f	-	-	-	-	-	-	-	t	-	-	-	-	-	-	*Landaln*
	-	-	-	f	-	-	-	-	@T	-	t	-	-	-	-	-	-	*Airaln*
	-	-	-	f	-	-	-	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	f	-	-	-	-	t	-	-	@T	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	t	-	-	t	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	*OLB*
	@T	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	*Mag sl*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*Grid*
	-	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	*IMS fail*
	-	-	-	-	-	-	-	-	@T	t	-	-	t	-	-	-	-	*PolarDI*
	-	-	-	t	-	-	-	-	@T	-	t	-	-	-	-	-	-	
	-	-	-	t	-	-	-	-	@T	-	-	t	-	-	-	-	-	
	-	-	-	-	-	-	-	-	t	@T	-	t	-	-	-	-	-	
	-	-	-	t	-	-	-	-	t	-	@T	-	-	-	-	-	-	
	-	-	-	t	-	-	-	-	t	-	-	@T	-	-	-	-	-	

3.5. NAVIGATION UPDATE MODES

3.5.0. Introduction

In a navigation update mode, data about a reference point near the aircraft are used to obtain an estimate of A/C position. The update is obtained by comparing the coordinates of two points: the OFP's estimate of the reference point (O) and the pilot's estimate (P). If O and P coincide, no correction is necessary; if they do not coincide, the pilot's claim is assumed to be valid and the OFP data are updated accordingly.

The navigation update modes differ in the reference point that is used (present position or destination) and in the way that the pilot and the OFP exchange information about the location of the reference point. The pilot communicates by (1) designating when the A/C is above the reference point; (2) slewing the aiming symbol on the HUD or the cursors on the radarscope; or (3) slewing the map. The OFP communicates by (1) placing the aiming symbol on the HUD or the cursors on the radarscope; (2) moving the map; or (3) displaying information on the panel. The OFP usually displays the error computed by comparing the two estimates, so that the pilot can decide whether or not to accept the new value.

In several update modes, the horizontal distance from the A/C to the reference point must be computed. This computation is called *ranging*. Assuming the OFP knows the angle "d" in Fig. 3.5a, the distance "h" may be computed if either the slant range "s" is known or the altitude "a" is known. Which one of these is known depends on the mode, !Data 24!, and the availability of the sensors.

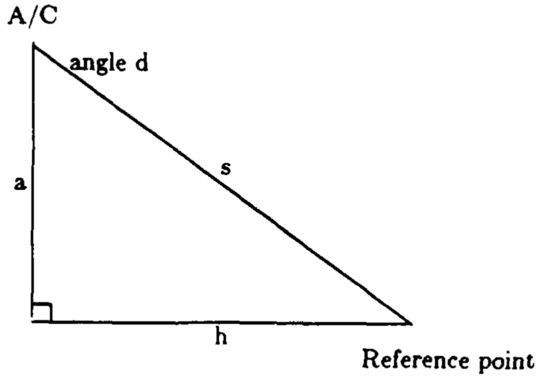


Figure 3.5-a: Ranging calculations

The mode variations are summarized in the overviews that follow.

3.5.1. HUD or Visual Update (*HUDUpd*)

Reference point: Called up destination (1-9)
OFP estimate shown: Position of aiming symbol, before slewing
OFP estimate derived: OFP compares destination coordinates to present position coordinates to compute aiming symbol position
Pilot estimate shown: Position of aiming symbol, at designation.
Pilot estimate derived: Pilot slews aiming symbol to overlay the observed location.
Ranging: Slant range if !Slant range reasonable! is between mode entry and first slew. Otherwise, the sensor is defined by !Data 24! (/RADALT/ or !Baro altitude above target!).

3.5.2. Flyover Update (*FlyUpd*)

Reference point: Called up destination (1-9)
OFP estimate derived: Present position coordinates at designation
Pilot estimate derived: Destination coordinates (pilot designates when the A/C is directly over the destination).

3.5.3. Automatic Flyover Update (*AflyUpd*)

Reference p int: Called up destination (1-9)
OFP estimate derived: Present position coordinates at designation
Pilot estimate derived: Destination coordinates (pilot designates when the A/C is directly over the destination).

3.5.4. Radar Update (*RadarUpd*)

Reference point: Called up destination (1-9)
OFP estimate shown: Position of radar cursors, before slewing
OFP estimate derived: OFP compares destination coordinates to present position coordinates to compute position of radar cursors
Pilot estimate shown: Position of radar cursors, at designation
Pilot estimate derived: Pilot slews radar cursors to overlay the location seen on the radarscope
Ranging: from sensor defined by !Data 24! (/RADALT/ or !Baro altitude above target!).

3.5.5. Map Update (*MapUpd*)

Reference point: Present position
OFP estimate shown: Map location under position marker before designation
OFP estimate derived: Present position coordinates before designation
Pilot estimate shown: Map location after designation
Pilot estimate derived: Pilot slews map to move position seen on the filmstrip under the position marker.

3.5.6. TACAN Update (*TacUpd*)

Reference point: Called up destination (1-9)

OFP estimate: present position coordinates at designation

TACAN estimate: position calculated from TACAN station coordinates, /RNGSTA/ and /BRGSTA/, as Fig. 3.5-b indicates. h is the horizontal distance from the a/c to the TACAN station, calculated from /RNGSTA/ and the angle d.

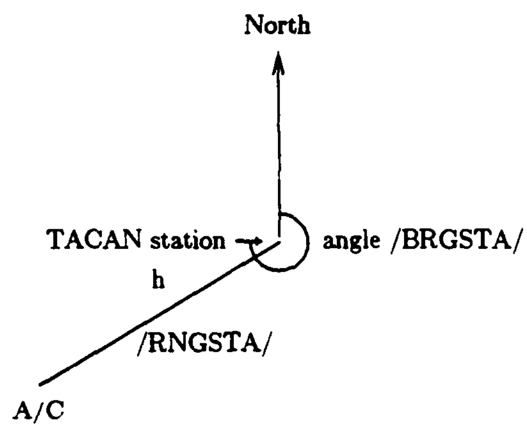


Figure 3.5-b

Update initiation: Target designation button - as long as depressed, TACAN sampling and filtering occurs.

Update accepted: ENTER key depressed
Ranging: From sensor defined by !Data 24! (/RADALT/ or !Baro altitude above target!

3.5.7. Transitions Between Update Modes

Table 3.5-a shows the transitions between the various navigation update modes. No other events will cause transitions between navigation update modes. Because the system is not always in one of the update modes, we have introduced a mode called *UNone* to represent all states of the system when it is not in an update mode. When the system starts, it is in the update mode *UNone*.

Table 3.5-a
Transitions between Navigation Update Modes

Current Mode	!Station selected!	/ACAIRB/=Yes	/MODEROT/=$PRESPOS$	/PRESPOS/=$UPDATE$	/UPDATTW/=$FLYOVER$	/UPDATTW/=HUD	/UPDATTW/=$RADAR$	/UPDATTW/=$TAC L-L$	!/UPDATTW/=Other!	/GUNSSEL/=Yes	!WD MFS!	!Data 23!=!Sea!	!Weapon mode!=*BOC*	/MFSW/=$None$	/MFSW/=TF	!Non-zero digit entered!	/ENTERSW/=On	!FLY-TO changed!	New Mode
UNone	f	t	t	t	-	t	-	-	-	f	-	-	-	t	-	@T	-	-	*HUDUpd*
	f	t	t	t	-	-	t	-	-	f	-	-	-	t	-	@T	-	-	*RadarUpd*
	f	f	t	t	-	-	t	-	-	f	-	f	-	t	-	@T	-	-	
	-	t	t	t	t	-	-	-	-	-	-	-	t	-	-	@T	-	-	*AflyUpd*
	@F	-	t	t	t	-	-	-	-	f	f	-	-	-	-	-	-	-	*MapUpd*
	f	-	@T	t	t	-	-	-	-	f	f	-	-	-	-	-	-	-	
	f	-	t	@T	t	-	-	-	-	f	f	-	-	-	-	-	-	-	
	f	-	t	t	@T	-	-	-	-	f	f	-	-	-	-	-	-	-	
	f	-	t	t	t	-	-	-	-	@F	f	-	-	-	-	-	-	-	
	f	-	t	t	t	-	-	-	-	f	@F	-	-	-	-	-	-	-	
	f	t	t	t	-	-	-	t	-	f	f	-	-	-	-	@T	-	-	*TacUpd*
	t	t	t	t	-	-	-	t	-	f	f	-	-	-	t	@T	-	-	
HUDUpd	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*UNone*
	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*HUDUpd*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	
	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	*MapUpd*

Table 3.5-a (continued)
Transitions between Navigation Update Modes

Current Mode	!Station selected!	/ACAIRB/=Yes	/MODEROT/=$PRESPOS$	/PRESPOS/=$UPDATE$	/UPDATTW/=$FLYOVER$	/UPDATTW/=HUD	/UPDATTW/=$RADAR$	/UPDATTW/=$TAC L-L$	!/UPDATTW/=Other!	/GUNSSEL/=Yes	!WD MFS!	!Data 23!=!Sea!	!Weapon mode!=*BOC*	/MFSW/=$None$	/MFSW/=TF	!Non-zero digit entered!	/ENTERSW/=On	!FLY-TO changed!	New Mode
RadarUpd	-	@F	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	*UNone*
	-	f	-	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*RadarUpd*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	
	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	*MapUpd*
FlyUpd	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*UNone*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*MapUpd*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	

Table 3.5-a (continued)
Transitions between Navigation Update Modes

Current Mode	!Station selected!	/ACAIRB/=Yes	/MODEROT/=$PRESPOS$	/PRESPOS/=$UPDATE$	/UPDATTW/=$FLYOVER$	/UPDATTW/=HUD	/UPDATTW/=$RADAR$	/UPDATTW/=$TAC L-L$	!/UPDATTW/=Other!	/GUNSSEL/=Yes	!WD MFS!	!Data 23!=!Sea!	!Weapon mode!=*BOC*	/MFSW/=$None$	/MFSW/=TF	!Non-zero digit entered!	/ENTERSW/=On	!FLY-TO changed!	New Mode
AflyUpd	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*UNone*
	-	-	-	-	-	-	-	-	-	-	-	-	@F	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	
MapUpd	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*UNone*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	-	*FlyUpd*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	*MapUpd*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
TacUpd	-	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	*UNone*
	-	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	
	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	@F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	@T	-	
	-	-	-	-	@T	-	-	-	-	-	-	-	-	-	-	-	-	-	*MapUpd*

3.6. WEAPON DELIVERY MODES

3.6.0. Introduction

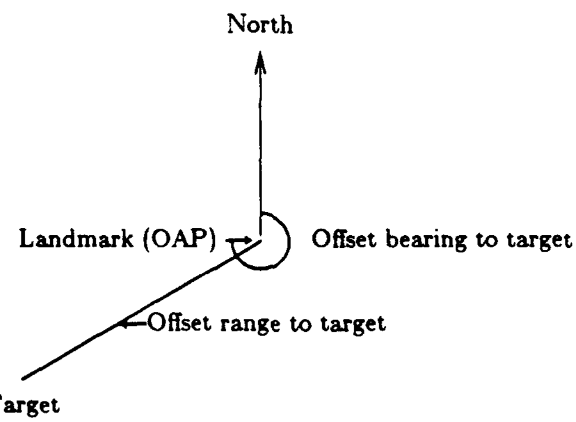
The weapon delivery modes differ primarily in the way the target location is identified to the OFP.

In normal modes (*Nattack*, *Noffset*, *BOCFlyto0*, *HUDdown1*, and *HUDdown2*), the pilot sees the target or a landmark near the target and identifies the point to the OFP by designating when the aiming symbol or standby reticle overlays the point.

In bomb-on-coordinates modes (*BOC*, *BOCoffset*), the OFP computes the location of the target or landmark by comparing Fly-to coordinates to present position coordinates.

In *CCIP* mode, the pilot may release a weapon at any time. The OFP displays HUD symbols to show the pilot the location that would be hit if a weapon were released now.

The offset modes (*Noffset*, *HUDdown2*, and *BOCoffset*) identify a target by its position relative to a landmark, as the following figure shows.



In *Manrip* and *Walleye*, the pilot may release the weapon at any time. In *Manrip*, the OFP calculates release time to space a stik correctly.

The weapon modes also differ in the pilot displays, especially HUD symbols, and the type of ranging used to calculate horizontal and vertical components of the distance to target. Ranging is discussed in the navigation update mode overview.

The special weapon modes operate essentially the same as the parent mode (e.g., *BOC* is the parent mode of *SBOC*).

These points are summarized in the overviews that follow.

3.6.1. Normal Attack (*Nattack*)

How target location identified: Visually by the pilot. The TC-2 is notified by the position of the aiming symbol at designation or after each slew.

Additional target information: Burst height. If baroaltimeter highest priority available sensor: altitude, MSLP.

Additional target information source: DEST 1-9, OR IF MARK 0-9 OR DEST 0: Altitude default (0 ft), burst height default (0 ft) and MSLP default (29.92)

Designation signaled by: Target designate button or release button or first slew or retained from *BOC*, *BOCFlyto0*, or *BOCoffset* modes

Undesignation by: Target designate button if already designated

Air to ground ranging used: Ranging is started on mode entry. There is no sampling until the first slew or until designation. Thereafter, the sampling is done when a target is designated and at the end of each slew.

Sources for Target ranging: Upon designation and after each slew, the priority sensor is used as the source. At other times, the target is dead reckoned.

3.6.2. Normal Offset (*Noffset*)

How target location identified: Offset from a landmark (offset aimpoint) that is identified visually by the pilot. The landmark is identified to TC-2 by the position of the aiming symbol at designation.

Additional target information: Burst height, delta height (difference in altitude between landmark and target), range (distance from offset aimpoint to target), bearing (direction from offset aimpoint to target); if baroaltimeter highest priority sensor: altitude, MSLP

Additional target information source: DEST 1-9

Designation signaled by: Target designate button or release button

Undesignation by: Target designate button if already designated

Air to ground ranging used: Started on mode entry no sampling until first slew sampling at designation and after each slew

Sources for Target ranging: Upon designation and after each slew, the priority sensor is used as the source. At other times, the target is dead reckoned.

3.6.3. Bomb on Coordinates (*BOC*)

How target location identified: Coordinates of DEST OR MARK (1-9)

Additional target information: Burst height if baroaltimeter highest priority available sensor: altitude, MSLP

Additional target information source: DEST 1-9, or IF MARK 1-9: Altitude default (0 ft), burst height default (0 ft) and MSLP default (29.92)

Designation signaled by: Mode entry (autodesignation): None

Air to ground ranging used: None

Sources for Target ranging:

> **Horizontal range:** coming within 30 nautical miles (nmi) and after each slew: measurements of priority sensor other times: dead reckoned
>
> **Vertical range:** continuous measurements of priority sensor.

3.6.4. Bomb on Coordinates, Fly-to 0 (*BOCFlyto0*)

How target location identified: Visually by pilot—location identified by TC-2 by location of HUD AS and radar cursors at designation and after each slew

Additional target information: Altitude default (0 ft), burst height default (0 ft) and MSLP default (29.92)

Designation signaled by: Target designate button or release button or first slew

Undesignation by: Target designate button if already designated

Sources for Target ranging:

> **Horizontal range:** coming within range and after each slew: measurements of priority sensor other times: dead reckoned
>
> **Vertical range:** continuous measurements of priority sensor.

3.6.5. Bomb on Coordinates Offset (*BOCoffset*)

How target location identified: Offset from coordinates stored for DEST (1-9) (the offset aimpoint is originally the DEST point: after slewing, it is the point displaced from the DEST by the slew corrections)

Additional target information: Burst height, delta height (difference in altitude between offset aimpoint and target), range (distance from offset aimpoint—to target), bearing (direction from offset aimpoint to target), if baroaltimeter highest priority sensor: altitude, MSLP

Additional target information source: DEST 1-9

Designation signaled by: Target designate button or release button

Undesignation by: Target designate button if already designated

Sources for Target ranging: After each slew, the priority sensor is used as the source. At other times, the target is dead reckoned.

3.6.6. Continuously Computed Impact Point (*CCIP*)

How target location identified: Impact point at the moment the release enable pressed; release is allowed any time in mode; HUD shows where bomb would hit if released now.

Additional target information: If baroaltimeter highest priority available sensor: altitude, MSLP; burst height always 0

Additional target information source: DEST 1-9, OR IF MARK 1-9 OR DEST 0: Altitude default (0 ft), MSLP default (29.92)

Designation signaled by: None.

Undesignation by: None.

Air to ground ranging used: On mode entry, antenna slaved to intersection of ASL and solution cue.

Sources for Target ranging: Continuous measurements of priority sensor

3.6.7. Air to Ground Guns/Rockets (*A/G Guns*)

How target location identified: Visually by pilot.

3.6.8. Air to Air Guns (*A/A Guns*)

How target location identified: Visually by pilot.

3.6.9. Manual Ripple (*Manrip*)

How target location identified: First weapon released when release enable pressed—TC-2 computes spacing of remaining weapons in the stik.

3.6.10. Normal Attack, HUD unreliable (*HUDdown1*)

How target location identified: Visually by the the pilot—TC-2 notified by the position of the standby reticle at designation, which it assumes at HUD ORA.

Additional target information: Burst height; if baroaltimeter highest priority available sensor: altitude, MSLP.

Additional target information source: DEST 1-9, OR IF MARK 1-9 OR DEST 0: Altitude default (0 ft), burst height default (0 ft), and MSLP default (29.92)

Designation signaled by: Target designate button or release enable button

Undesignation by: Target designate button, when designated

Air to ground ranging used: Started on mode entry; no sampling until designated; sampling at designation

Sources for Target ranging:

Designation: measurements of priority sensor
Other times: dead reckoned.

3.6.11. Backup HUD Mode for Normal Offset (*HUDdown2*)

How target location identified: Offset from a landmark that is identified visually by the pilot—landmark identified to TC-2 by the position of the standby reticle at designation, which it assumes is at HUD ORA.

Additional target information: Burst height, delta height (difference in altitude between landmark and target), range (distance from landmark—offset aimpoint—to target), bearing (direction from offset aimpoint to target), if baroaltimeter highest priority sensor: altitude, MSLP

Additional target information source: DEST 1-9

Designation signaled by: Target designate button or release button

Undesignation by: Target designate button, if already designated

Air to ground ranging used: Antenna slaved on mode entry sampling at designation

Sources for Target ranging:

Designation: measurements of priority sensor
Other times: dead reckoned.

3.6.12. Walleye (*Walleye*)

How target location identified: The A/C is flown to place the aiming reticle over the target, which should place the target within the Walleye seeker field of view, causing the target to appear on the radar scope television display. The A/C is then flown to place the target at the center of the television display.

Additional target information: Altitude. MSLP

Designation signaled by: Target designation button

Undesignation by: Target designation button, if already designated

Sources for Target ranging:

Horizontal range: computed from altitude and depression angle

Vertical range: baro or radar altimeter

3.6.13. Special mode overviews

Normal Attack (*Snattack*)
Special Normal Offset (*Snoffset*)
Special Bomb on Coordinates (*SBOC*)
Special BOC Fly-to 0 (*SBOCFlyto0*)
Special BOC Offset (*SBOCoffset*)

How target location identified: Same as parent mode

Additional target information:

!low-drag!: Same as parent mode
!high-drag!: Burst height entry has no effect, all others same as parent mode

Additional target information source: Same as parent mode

Designation signaled by: Same as parent mode, except release enable button will not designate

Undesignation by: Mode deselection

Air to ground ranging used: Same as parent mode

Sources for Target ranging: Same as parent mode

3.6.14. Backup HUD mode for Special Normal Attack (*SHUDdown1*)

How target location identified: Visually by the pilot—TC-2 notified by the position of standby reticle at designation, which it assumes at HUD ORA

Additional target information: Burst height; if baroaltimeter highest priority available sensor: altitude, MSLP

Additional target information source: DEST 1-9, OR IF MARK 1-9 OR DEST 0: Altitude default (0 ft), burst height default (0 ft), and MSLP default (29.92)

Designation signaled by: Target designate button

Undesignation by: Mode deselection

Air to ground ranging used: Same as *Snattack*

Sources for Target ranging: Same as *Snattack*

3.6.15. Backup HUD Mode for Special Normal Offset (*SHUDdown2*)

How target location identified: Offset from a landmark that is identified visually by the pilot - landmark identified to TC-2 by position of the standby reticle at designation, which it assumes is at HUD ORA

Additional target information: burst height, delta height (difference in altitude between landmark and target), range (distance from landmark—offset aimpoint—target), bearing (direction from offset aimpoint to target), if baroaltimeter highest priority sensor: altitude, MSLP

Additional target information source: DEST 1-9

Designation signaled by: Target designate button

Undesignation by: Mode deselection

Air to ground ranging used: Same as *Snoffset* ST Same as *Snoffset*

3.6.16. Extended Weapon Delivery Modes

A group of weapon delivery modes exist that are not the primitive modes listed in this section. These modes are indicated by one of the primitive modes and some other conditions. Table 3.6-a defines the extended modes.

Table 3.6-a: Extended Weapon Delivery Modes

Extended Mode	Conditions
NBShrike	(*Nattack* OR *Noffset* OR *BOC* OR *BOCoffset* OR*BOCFlyto0* OR *HUDdown1* OR *HUDdown2*) AND !Shrike!
NBnotShrike	(*Nattack* OR *Noffset* OR *BOC* OR *BOCoffset* OR *BOCFlyto0* OR *HUDdown1* OR *HUDdown2*) AND NOT !Shrike!
LoNuke	(*Snattack* OR *Snoffset* OR *SBOC* OR *SBOCoffset* OR *SBOCFlyto0* OR *SHUDdown1* OR *SHUDdown2*) AND !low drag!
HiNuke	(*Snattack* OR *Snoffset* OR *SBOC* OR *SBOCoffset* OR *SBOCFlyto0* OR *SHUDdown1* OR *SHUDdown2*) AND !high drag!

3.6.17. Transitions Between Weapon Delivery Modes

Table 3.6-b shows the transitions between the various weapon delivery modes that are described in this section. No other events will cause transitions between weapon modes. Because the system is not always in a weapon delivery mode, we have introduced a mode called ***WNone*** to represent all states of the system when it is not in a weapon delivery mode. When the system starts, it is in the weapon mode ***WNone***.

Table 3.6-b
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
WNone	-	-	-	-	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	T	-	-	OFF_MFS
	-	-	-	-	-	-	-	-	-	T	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
	-	-	-	T	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
	-	-	-	-	T	-	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
	-	-	-	-	-	T	-	-	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
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	-	-	-	-	-	-	-	T	-	-	-	-	-	f	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	
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Note: In this table, "T" and "F" are used to represent "@T" and "@F", respectively.

Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	\/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
WD_MFS	-	-	-	-	-	-	-	-	-	-	-	-	f	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	T	*WNone*
	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	T	
	-	-	-	-	-	-	-	-	-	-	-	-	f	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	T	
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	t	-	f	-	-	-	-	-	-	-	f	-	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	T	*BOC*
	t	-	f	-	-	-	-	-	-	-	t	-	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	-	T	*BOCFlyto0*
	t	-	f	-	-	-	-	-	-	-	t	-	t	-	-	t	-	-	-	-	-	-	-	-	-	-	-	-	T	*BOCoffset*
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	t	f	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	-	T	*HUDdown1*
	t	f	f	-	-	-	-	-	-	-	t	-	t	-	-	-	-	-	t	-	-	-	-	-	-	-	-	-	T	*HUDdown2*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
Nattack	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	T	-	-	-	*WNone*
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	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	OFF_MFS
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	WD_MFS
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Noffset	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD_MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
BOC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	T	-	-	-	
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
BOCoffset	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	'Ready station!	/HUDREL/=Yes	'Reserved weapon!	'Special!	'Rockets!	'Guns!	'Walleye!	'Shrike!	'Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	'WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	'Desig!	'Redesignate!	!Any dest. entered!	'high drag!	!low drag!	'Overflown exit!	'Overfln gt 42nmi!	/ACAIRB/=Yes	'In OFF_MFSW!	'In WD_MFSW!	New Mode
HUDdown1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	OFF_MFS
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	WD_MFS
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HUDdown2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
A/G Guns	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	OFF_MFS
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A/A Guns	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfin gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
A/A Manrip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	OFF_MFS
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/-Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/-No	/FLYTOTW/-0	!/FLYTOTW/ reset!	/FLYTOTOG/-$Dest$	!WD MFS!	/MFSW/-BOC	/MFSW/-$BOCOFF$	/MFSW/-$CCIP$	/MFSW/-$NATT$	/MFSW/-$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/-Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
Snoffset	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	T	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
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SBOC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfln gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
SBOCFlyto0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	t	-	-	-	-	-	T	-	-	-	
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SBOCoffset	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
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Table 3.6-b (continued)
Transitions Between Weapon Delivery Modes

Current Mode	!Ready station!	/HUDREL/=Yes	!Reserved weapon!	!Special!	!Rockets!	!Guns!	!Walleye!	!Shrike!	!Other weapon!	/GUNSSEL/=No	/FLYTOTW/=0	!/FLYTOTW/ reset!	/FLYTOTOG/=$Dest$	!WD MFS!	/MFSW/=BOC	/MFSW/=$BOCOFF$	/MFSW/=$CCIP$	/MFSW/=$NATT$	/MFSW/=$NATTOFF$	!Desig!	!Redesignate!	!Any dest. entered!	!high drag!	!low drag!	!Overflown exit!	!Overfin gt 42nmi!	/ACAIRB/=Yes	!In OFF_MFSW!	!In WD_MFSW!	New Mode
Walleye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	*WNone*
	-	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	OFF_MFS
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	WD_MFS
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3.7. TEST MODE

3.7.0. Introduction

This mode exercises the logic of the computer and its input/output interfaces in a specific sequence with selected data patterns in order to detect possible malfunctions. The sequence is defined by a series of stages, each described in Table 3.7-a. If any error occurs, the computer halts and the computer fail light comes on.

Table 3.7-a: Self-Test Stages

!CS Tstage!	Coresum	To detect memory errors, the storage-protected portion of main storage is summed up and compared to an expected value.
!TM Tstage!	Timer	The 10 and 16 bit counters are checked against the GO/NO-GO counter to make sure they generate interrupts at the proper time. If this test is correct, the 10 and 16 bit counters, as well as the GO/NO-GO counter, are assumed to be operating correctly.
!GA Tstage!	Gyro Accelerometer	Using the BITE command to wrap output signals to inputs, values are written to the gyro counters and read back from the accelerometers. The input values should match the output values.
!DIO Tstage!	Discrete I/O	Using the BITE command to wrap output signals to inputs, values are written to discrete output words 1 and 2 and read back from discrete input words 1 and 2, respectively. The input values should match the output values.
!SC Tstage!	Serial Channel	Using the BITE command to wrap output signals to inputs, values are written to the cycle steal channels and read back from the serial input channels. The input values should match the output values. The HUD attack test pattern is displayed at the end of this stage. The timing of the external control interrupt is also checked.

For each of the three Signal Converter test stages listed below, the following occurs: the associated output channels are loaded with specific values. An input value, hardware-generated as a function of the output values, is read in. An error occurs when this input value is not equivalent to an expected value (different in each stage). This test verifies the accuracy of conversions. The timing of the "Data Ready" interrupt is also checked.

!DC Tstage!	DC Signal Converter	
!AC1 Tstage!	AC Signal Converter 1	
!AC2 Tstage!	AC Signal Converter 2	
!PD Tstage!	Panel Display	If no errors have occurred in previous stages, all NAV/WD panel lights come on and the upper and lower windows display all 8's. If an error has been detected, the Computer Fail light on the Caution and Advisory panel will come on, the panel display will not change from what it was at mode entry, and this stage will not be entered. This stage lasts for 8 seconds.

3.7.1. Ground Test (*Grtest*) overview

Stage sequence:

Coresum	!CS Tstage!
Timer	!TM Tstage!
Gyro Accelerometer	!GA Tstage!
Discrete I/O	!DIO Tstage!
Serial Channel	!SC Tstage!
DC Signal Converter	!DC Tstage!
AC Signal Converter 1	!AC1 Tstage!
AC Signal Converter 2	!AC2 Tstage!
Panel Display	!PD Tstage!

HUD: attack test pattern displayed at the end of !SC Tstage!. The pattern displayed depends on the value of the master function switch (see Figure 3.7.1-a). The left pattern is displayed when no function is selected. The right pattern is displayed when any function is selected.

Figure 3.7.1-a: HUD test patterns

Special built-in test output 1:

set to 45° in !AC1 Tstage! and !AC2 Tstage!

Special built-in test output 2:

set to 225° in !AC1 Tstage! and !AC2 Tstage!

CHAPTER 4

Time-Independent Descriptions of A-7E Software Functions

4.0. INTRODUCTION

4.0.1. Overview

This section gives the values of the output data items as a function of A/C situation. In most cases, we do not specify how the output values are related to the input values; the requirements state that output values must bear a certain relationship to the actual flight conditions, and the input values are considered only a means for acquiring the correct values. However, in some situations, the pilot must have the ability to choose from alternative sources of similar information (e.g., a barometric altimeter or a radar altimeter) or the system must choose from alternative data sources on the basis of external conditions. In these cases, the requirements must be expressed by naming the sources of input data appropriate for different conditions. In short, where the system implementor is free to choose his input data sources, we do not name them. Where requirements dictate the input data sources, output values are expressed as functions of input values.

The services required of the OFP are described in terms of a set of **functions**. Each function determines the value for one or more output data items. For example, the values of //FPMAZ// and //FPMEL// are both determined by the function called "Update Flight Path Marker Coordinates."

The display windows on the TC-2 panel are used to display so many different values that we have described the computation of each value as a separate function. In effect, we have described each function as if it had its own continuously available display window and its own set of output data items. We are then able to describe separately the rules that determine which information is actually displayed and the rules that determine the various values.

4.0.2. Organization

Each function is described in a section that (a) lists the modes in which the function must be performed, (b) names the output data items affected, (c) describes the conditions under which the function must be performed, and (d) includes one or more tables giving a detailed description of the output values in terms of aircraft situations or input values. The functions are described without the timing requirements, which are given in Chapter 5.

Every function is classified as either **periodic** or **demand**. A periodic function will be performed repeatedly at regular intervals. If it is not required all the time, the section lists the events that initiate and terminate performance. A demand function is initiated by a specific event, such as a button being pushed. For a demand function, we describe the events that cause it to be executed and the action required after each event.

Each function is also classified by the hardware device associated with its output data items. For example, there are IMS functions to provide values to IMS output data items. Chapter 4 is organized by hardware devices, with all the functions for one device in the same subsection. The subsections are given in the order that the devices are described in chapter 2. Within each subsection, the functions are given in the same order as in Chapter 2. However, even if an output data item is transmitted to more than one hardware device, the function associated with it is only described in one place in Chapter 4.

4.1. INERTIAL MEASUREMENT SET FUNCTIONS

4.1.1. Switch AUTOCAL Light On/Off
(Demand function)

Output data item(s) affected: //AUTOCAL//

Output description:

Event Table 4.1-a: When AUTOCAL Light Switched On/Off		
MODES	EVENTS	
Lautocal *Sautocal*	@T(In mode)	@F(In mode)
ACTION	//AUTOCAL//:=On	//AUTOCAL//:=Off

4.1.2. Switch Computer Control of IMS On/Off
(Demand function)

Output data item(s) affected: //COMPCTR//

Output description:

Event Table 4.1-b: When IMS Controlled by the Computer

MODES	EVENTS	
Airaln	@T(!roll large!) WHEN (!FM stage!) OR @T(!FM stage complete!) OR @T(In mode) WHEN(NOT !FM stage! AND //COMPCTR//=Off)	@F(!roll large!) WHEN (!FM stage! AND //COMPCTR//=On) OR @T(!FM stage!) WHEN (NOT !roll large! AND //COMPCTR//=On) OR @T(!CL stage complete! AND !IMS total velocity! > 1440 fps) WHEN(/ACAIRB/=Yes AND //COMPCTR//=On)
All alignment except *Airaln*	@T(In mode) WHEN (//COMPCTR//=Off)	@T(!CL stage complete! AND !IMS total velocity! > 1440 fps) WHEN(/ACAIRB/ = Yes AND //COMPCTR//=On)
DIG *DI* *I* *UDI* *OLB* *PolarDI* *PolarI*	@T(In mode) WHEN(//COMPCTR//=Off)	X
Mag Sl *Grid* *IMS fail*	X	@T(In mode) WHEN (//COMPCTR//=On)
ACTION	Computer controlled //COMPCTR//:=On	Not computer controlled //COMPCTR//:=Off

4.1.3. Issue Computer Failure
(Demand function)

Output data item(s) affected: //COMPFAIL//

Output description:

Event Table 4.1-c: When Computer System Fails		
MODES	EVENTS	
All modes except *Grtest*	X	@T(!power up!)
Grtest	@T(!Checksum test failed! OR !Interface test failed!)	X
ACTION	//COMPFAIL//:=Yes	//COMPFAIL//:=No

4.1.4. Torque Platform X, Y, and Z Axes
(Periodic function)

Initiation and termination:

Initiation: @T(//COMPCTR//= On) (see Section 4.1.2)

Termination: @T(//COMPCTR//= Off) (see Section 4.1.2)

Output data item(s) affected: //XGYCOM//, //YGYCOM//,

Output description:

The TC-2 calculates the number of degrees that the platform axes need to be turned to keep each axis in alignment with the appropriate Earth axis (Xp: east, Yp: north, Zp: away from Earth center).

Whether X and Y axis errors are slewed or torqued during alignment depends entirely on the alignment stage, as shown in Table 4.1-d below.

Selector Table 4.1-d:
Alignment Stages in Which X and Y Errors are Corrected by Torquing

Modes	Alignment Stages
Lautocal	!FG stage! or !ED stage! or !ND stage!
Sautocal	!ED stage! or !ND stage!
Landaln, *SINSaln* *HUDaln*, *01Update*	at end of !FG stage!
Airaln	!HL stage! or !HG stage! or !FG stage!

Table 4.1-e shows the alignment stages in which Z axis errors are removed by slewing or torquing. Z axis errors larger than the !slew-torque cutoff! are slewed out (see Section 4.1.6), and smaller adjustments are made by torquing.

Selector Table 4.1-e:

Alignment Stages in Which Z Axis Misalignment Errors are Removed by Slewing or Torquing

MODES	Alignment Stages
Lautocal, *Sautocal*	At the end of !CA stage!, at end of !ND stage! at end of !ED stage! or during !FG stage!
Landaln, *SINSaln* *HUDaln*	At the end of !CA stage! or at end of !FG stage!

In some modes, the platform axes are only maintained in alignment, that is, compensations are made for Earth's rotation, A/C movement, and the known drift bias for the particular gyros in the particular A/C (see Sections 4.6.19 through 4.6.21).

In other modes, the TC-2 corrects the axes for misalignment by comparing the IMS velocities to reference velocities, and using the differences to calculate the platform misalignment. The reference velocities used in different modes are shown in Table 4.1-g. Table 4.1-f shows when the axes are only maintained and when they are also corrected.

Selector Table 4.1-f: Platform Torquing

MODES	X AXIS ACTION	Y AXIS ACTION	Z AXIS ACTION
Lautocal *Landaln* *Sautocal* *SINSaln* *01Update* *HUDaln* *Airaln*	Maintained and Corrected	Maintained and Corrected	Maintained and Corrected
DIG	Maintained and Corrected	Maintained and Corrected	Maintained and Corrected
DI	Maintained and Corrected	Maintained and Corrected	Maintained
I *UDI*, OLB*	Maintained	Maintained	!latitude! $\leq 80^\circ$: Maintained !latitude! $> 80^\circ$: None
PolarDI	Maintained and Corrected	Maintained and Corrected	None
PolarI	Maintained	Maintained	None

Selector Table 4.1-g: Reference Velocities for Platform Corrections

MODES	SOURCES OF REFERENCE VELOCITIES
Lautocal, *Landaln* *01Update*, *HUDaln*	Constant value (0)
SINSaln, *Sautocal*	SINS X, Y, Z offsets and SINS data
Airaln, *DIG*, *DI*, *PolarDI*	!DGNDSP!, /DRFTANG/

4.1.5. Change IMS Scale Factor
(Demand function)

Output data item(s) affected: //IMSSCAL//

Output description:

Event Table 4.1-h: When the Scale Factor Is Changed

MODES	EVENTS	
Lautocal *Landaln* *01Update*	@T(In mode) WHEN (//IMSSCAL//=$Coarse$)	X
HUDaln	@T(In mode) WHEN (/IMSMODE/ = $Gndal$ AND //IMSSCAL//=$Coarse$)	@T(In mode) WHEN (/IMSMODE/ = ($Norm$ OR $Iner$) AND //IMSSCAL// = $Fine$)
Sautocal, *SINSaln* *Airaln*, *DIG*, *I*, *DI*, *UDI*, *OLB*, *PolarDI*, *PolarI*	X	@T(In mode) WHEN (//IMSSCAL//=$Fine$)
ACTION	//IMSSCAL//:=$Fine$	//IMSSCAL//:=$Coarse$

4.1.6. Switch X,Y,Z Slewing On/Off
(Demand function)

Output data item(s) affected: //XSLEW// //XSLSEN// //YSLSEN// //ZSLEW// //ZSLSEN//

Output description: The commands

//XSLEW//:=On
//YSLEW//:=On
//ZSLEW//:=On

start the corresponding axis slewing in the direction given by the value of the associated //*SLSEN// output (CW or CCW). Slewing is stopped by setting the //*SLEW// outputs to Off when the slewing has been on the time required to move the * axis the desired amount at the rates given in Section 2.1.1.14.

Table 4.1-i shows the alignment modes and stages when platform tilt errors are removed by slewing the X and Y axes. These errors are removed by slewing whether they are small or large.

Selector Table 4.1-i:
Alignment Stages in Which X and Y Errors are Corrected by S[illegible]ing

MODES	Alignment Stages
Lautocal, *Sautocal* *Landaln*, *SINSaln* *HUDaln*	At the end of the !CL stage! OR At the end of the !CA stage!
Airaln	At the end of the !CL stage!

Note: Platform slewing can only occur when //COMPCTR// = On; (Section 4.1.2).

Z axis slewing occurs (a) when Z axis errors are to be removed during the alignment stages shown in Table 4.1-e if the velocity error calculations show that the Z axis is out of alignment by more than the !slew-torque cutoff! (b) in *Lautocal* and *Sautocal*, to rotate the north-pointing axis so that it points east, and later to move it back, and (c) to remove heading errors in *SINSaln* and *HUDaln* modes. The second two kinds of slewing are summarized in Table 4.1.j.

Event Table 4.1-j: Z Axis Slews

MODES	EVENTS			
Lautocal *Sautocal*	@T(!ED stage!)	@F(!ED stage!)	X	X
SINSaln	X	X	@T(In mode)	X
HUDaln	X	X	X	@T(/TD/=On) WHEN (NOT !during platform slewing!)
AMOUNT OF SLEWING PERFORMED	90° CCW	90° CW + error in !ED stage! (see Table 4.1-e)	!SINS-error![1]	!Az-reference error![2]

[1]!SINS error! is the error calculated by comparing !IMS heading! to !SINS heading! corrected by !Delta heading!

[2]!Az-reference error! is the error calculated by comparing the !IMS heading! to the heading calculated from the !azimuth reference heading! corrected by the Aiming Symbol azimuth displacement at designation.

4.1.7. Change Latitude-greater-than-70-degrees
(Demand function)

Output data item(s) affected: //LATGT70//

Output description:

Event Table 4.1-k: Latitude $> 70^\circ$

MODES	EVENTS	
All Alignment and Navigation Modes	@T(In mode AND !latitude! $> 70^\circ$)	@T(In mode AND !latitude! $< 70^\circ$)
ACTION	//LATGT70//:=Yes	//LATGT70//:=No

4.1.8. IMS Non-Aligned Light Functions

4.1.8.1. Switch IMS Non-Aligned Light On/Off
(Demand function)

Output data item(s) affected: //IMSNA//

Output description:

Event Table 4.1-l: When IMS Non-Aligned Light Switched On and Off

MODES		
Lautocal *Sautocal*	@T(In mode)	
Landaln	@T(In mode)	@T(!Land velocity test passed!)
SINSaln	@T(In mode)	@T(!SINS velocity test passed!) OR @F(In mode)
Airaln	@T(!CL stage complete!) OR @T(In mode) WHEN (!CL stage complete!)	@T(In mode) WHEN (NOT !CL stage complete!) OR @T(!Air velocity test passed!)
01Update	@F(!Land velocity test passed!) OR @F(!New 01 test passed!)	@T(!Land velocity test passed! AND !New 01 test passed!)
HUDaln	@T(!HS stage complete!) WHEN (/IMSMODE/=$Gndal$)	@T(In mode) OR @F(In mode) OR @T(!CL stage complete!)
DIG, *DI* *PolarDI*	@T(!Nav velocity test failed!)	X
Mag sl, *Grid* *IMS fail*	X	@T(In mode)
ACTION	//IMSNA//:=On	//IMSNA//:=Off

Note: Blinking takes precedence (see Table 4.1-m). At the termination of blinking, the light goes to the state for which the condition has most recently been met. (The state may have changed several times while the light was blinking.)

4.1.8.2. Flash the IMS Non-aligned Light
(Periodic function)

Output description:

Event Table 4.1-m:
When IMS Non-Aligned Light Flashed

MODES	EVENTS	
SINSaln	@T(In mode AND !SINS down!)	@F(!SINS down!)
Airaln *DIG* *DI* *UDI* *PolarDI* *I* *PolarI*	@T(In mode AND (NOT !IMS-DOP Reasonable! OR NOT !IMS-ADC Reasonable! OR NOT !IMS Reasonable!))	@T(!IMS-Dop Reasonable! AND !IMS-ADC Reasonable! AND !IMS Reasonable!)
ACTION	Initiation //IMSNA// alternated between On and Off	Termination //IMSNA// returned to state specified by tbl 4.1-l set by other INA function (Section 4.1.8.1)

4.2. FORWARD-LOOKING RADAR FUNCTIONS

4.2.1 Enable Radar Cursors
(Demand function)

Output data item(s) affected: //CURENABL//

Output description:

Event Table 4.2-a:
When Radar Cursors Enabled

MODES	EVENTS	
RadarUpd	@T(In mode AND !ground range! to !fixpoint! ≤ 22nmi)	@T(None of listed modes) OR @T(/MFSW/=TF)
BOC *BOCoffset* *SBOC* *SBOCoffset*	@T(In mode AND !ground range! to !Fly-to point! ≤ 20 nmi)	@T(None of listed modes) OR @T(/MFSW/=TF)
BOCFlyto0 *SBOCFlyto0*	@T(In mode)	@T(None of listed modes) OR @T(/MFSW/=TF)
ACTIONS	//CURENABL// := On	//CURENABL/// := Off

4.2.2. Placement of Radar Cursors

4.2.2.0. Reference points indicated by radar cursors

The two radar cursors show the position of some reference point relative to the A/C present position. The reference point varies, depending on the mode and prevailing conditions, as shown in the tables below.

Condition Table 4.2-b:
Radar Cursor Reference Point in Weapons Delivery Modes

MODES	CONDITIONS			
BOC *SBOC*	NOT !Desig!	!Desig!	X	X
BOCFlyto0 *SBOCFlyto0*	X	!Desig!	X	NOT !Desig!
BOCoffset *SBOCoffset*	NOT !Desig! AND !Before slewing!	X	!Desig! OR !After slewing!	X
REFERENCE POINT:	!Fly-to point!	!target!	!OAP!	a point on the !ground track! 8 nmi in front of A/C

Condition Table 4.2-c:
Radar Cursor Reference Point in *RadarUpd* Mode

MODE	CONDITIONS	
RadarUpd	!Before slewing!	!After slewing!
REFERENCE POINT:	!Called-up point!	!fixpoint!

4.2.2.1. Update Azimuth-Cursor Position
(Periodic function)

Initiation and termination: This function is performed only when //CURENABL//=On.

Output data item(s) affected: //CURAZCOS// //CURAZSIN//

Output description:

The azimuth cursor shows the bearing to the reference point defined in Table 4.2-b or Table 4.2-c. The angle between the cursor and the display center line is equal to the angle between a line projected into the X-Y plane drawn from the A/C to the reference point and the A/C !ground track!. Thus, if the target is directly along the velocity vector of the A/C, the azimuth cursor is centered.

The radar azimuth shows a maximum of 45° in either direction from the center. The azimuth cursor is placed according to the following table, where

Condition Table 4.2-d: Azimuth Cursor Position

MODES	CONDITIONS			
RadarUpd *BOC* *BOCFlyto0* *BOCoffset* *SBOC* *SBOCFlyto0* *SBOCoffset*	90° < BRG < −90°	−90° ≤ BRG < −45°	−45° ≤ BRG ≤ 45°	45° < BRG ≤ 90°
CURSOR POSITION	out of view	left edge	BRG° from center	right edge

Whenever the cursor is displayed, the pilot can move it, using the slew control. Inputs from /SLEWRL/ affect the azimuth-cursor position changing it at the !Radar rate!. The slew control displacement from center indicates the rate and direction of movement.

4.2.2.2. Update Range-Cursor Position
(Periodic function)

Initiation and termination: This function is performed when and only when //CURENABL//=On.

Output data item(s) affected: //CURPOS//

Output description:

The output is required in the following modes: *RadarUpd*, *BOC*, *BOCFlyto0*, *BOCoffset*, *SBOC*, *SBOCFlyto0* and *SBOCoffset*

The value output for //CURPOS// is the !slant range! from the A/C to the reference point defined in Tables 4.2-b and 4.2-c. The //CURPOS// output value is limited in the following way:

//CURPOS//:=MIN(!slant range!, 20 nmi)

If the azimuth cursor is out of view (see Section 4.2.2.1), //CURPOS//:= 0.

Whenever the cursor is displayed, the pilot can move it, using the slew control. Inputs from /SLEWUD/ affect the //CURPOS// value, changing it at the !Radar rate!. The slew control displacement from center indicates the rate and direction of movement.

Note: The value output by this function is !slant range! even though the cursor actually shows !ground range!. The conversion from !slant range! to !ground range! is performed by the FLR (see Section 2.1.3.7).

4.2.3. Slave or Release the FLR Antenna
(Demand function)

Output data item(s) affected: //ANTSLAVE//

Output description:

Event Table 4.2-e: When FLR Antenna Slaved or Released

MODES	EVENTS	
HUDUpd	@T(In mode)	@F(In mode) OR @T(/MFSW/=TF)
Nattack *Noffset* *CCIP* *HUDdown1* *HUDdown2* *Snattack* *Snoffset* *SHUDdown1* *SHUDdown2*	@T(In mode)	@F(In mode) OR @T(/MFSW/=TF)
A/G Guns	@T(/GUNSSEL/ = Yes) OR @T(In mode AND !Rockets!)	@F(In mode) OR @T(/MFSW/=TF)
Grtest	@T(!AC1 Tstage!) OR @T(!AC2 Tstage!)	@F(!AC2 Tstage!) OR @T(/MFSW/=TF)
ACTION	//ANTSLAVE//:=On	//ANTSLAVE//:=Off

Note: In the software, (//ANTSLAVE// = On AND //CURENABL// = On) does not occur.

4.2.4. Update Antenna Elevation
(Periodic function)

Initiation and termination: This function is performed when and only when //ANTSLAVE// = On

Output data item(s) affected: //STEEREL//

Output description:

Selector Table 4.2-f: Antenna Elevation Steering Commands	
MODES	ELEVATION COMMANDS
HUDUpd *Nattack* *Noffset* *A/G Guns* *HUDdown1* *HUDdown2* *Snattack* *Snoffset* *SHUDdown1* *SHUDdown2*	Antenna aimed at location indicated by Aiming Symbol (see Section 4.3.1)
CCIP	Antenna aimed at location indicated by intersection of ASL and lower solution cue. (see Section 4.3.11.1)
Grtest	//STEEREL//:= 15°

4.2.5. Update Antenna Azimuth/Drift Angle
(Periodic function)

Initiation and termination:

Event Table 4.2-g: When Azimuth Steering Must be Output

MODES	EVENTS	
All Alignment and Navigation *HUDUpd* *RadarUpd* *Nattack *Noffset* *CCIP* *Snattack* *Snoffset* *A/G Guns* *HUDdown1* *HUDdown2* *SHUDdown1* *SHUDdown2*	@T(In mode)	@T(No listed mode)
Grtest	@F(In mode) OR @T(//ANTSLAVE//= On)	@T(In mode) OR @T(//ANTSLAVE//= Off)
ACTION	Initiation Must be output	Termination

Output data item(s) affected: //STEERAZ//

Output description:

This function has two different purposes: when //ANTSLAVE// = On, //STEERAZ// is used to steer the antenna in azimuth. At other times, the value is the !drift angle!, which the FLR uses to calculate !ground track! so that the center of the FLR display represents !ground track!

Condition Table 4.2-h
Azimuth Steering Commands

MODES	CONDITIONS				
Alignment Navigation with no modes listed below	/ACAIRB/ =No	/ACAIRB/ =Yes	X	X	X
HUDUpd *Nattack* *Noffset* *A/G Guns* *HUDdown1* *HUDdown2* *SHUDdown1* *SHUDdown2* *Snattack* *Snoffset*	X	//ANTSLAVE// =Off	//ANTSLAVE// =On	X	X
CCIP	X	X	X	Always	X
Grtest	X	X	X	X	!AC1 Tstage! !AC2 Tstage!
//STEERAZ// VALUE	0°	!limited drift angle![1]	!aiming symbol![2]	!lower solution cue![3]	45°

[1]!limited drift angle! = SIGN(!drift angle!) × MIN(10°, ABS(!drift angle!))

[2]!aiming symbol! is the //STEERAZ// value such that the antenna is pointed in the same direction as the Aiming Symbol.

[3]!lower solution cue! is the //STEERAZ// value such that the antenna is pointed in same direction indicated by the intersection of ASL and the Lower Solution Cue.

4.2.6. Update Ground Track Velocity
(Periodic function)

Initiation and termination:

Event Table 4.2-i: When Ground Track Velocity Must Be Output		
MODES	EVENTS	
All Alignment and Navigation modes	@T(/MFSW/=TF)	@F(/MFSW/=TF)
Grtest	@T(!DC Tstage!)	@F(!DC Tstage!)
ACTION	Initiation Must be output	Termination Output is ignored by FLR[1]

[1]This function can operate continuously without doing harm.

Output data item(s) affected: //GNDTRVEL//

Output description:

The value assigned to //GNDTRVEL// is the most recently calculated A/C velocity relative to the ground, that is, !System horizontal velocity!.

//GNDTRVEL// is set to !Test Value 1! in *Grtest* when !DC Tstage!.

4.2.7. Update Flight Path Angle (ADI and FLR)
(Periodic function)

Initiation and termination:

Event Table 4.2-j: When //FPANGL// Must Be Output

MODES	EVENTS	
All Alignment and Navigation modes *Nattack*, *Noffset* *BOC*, *BOCFlyto0* *BOCoffset*, *Snattack* *Snoffset*, *SBOC* *SBOCFlyto0* *SBOCoffset* *HUDdown1*, *HUDdown2* *SHUDdown1* *SHUDdown2*	@T(In mode)	X
Grtest	@T(!DC Tstage!)	@T(In mode) OR @F(!DC Tstage!)
ACTION	Initiation Must be output	Termination

Output data item(s) affected: //FPANGL//

Output description:

When required by the FLR (see note below), the //FPANGL// value is the A/C flight path angle; that is, the angle between the A/C velocity vector and its projection into the horizontal plane. However, when the FLR does not require the value, it is sometimes used to give a special display to the pilot via the ADI horizontal needle. The different values assumed by //FPANGL// are shown in Tables 4.2-k and 4.2-l.

Note: This output data item goes to both the ADI horizontal needle and the FLR. The FLR only requires it when /MFSW/ = TF; at other times, the value has no effect on the FLR. See Sections 2.1.3.8 and 2.3.2.2.

Condition Table 4.2-k: //FPANGL// Value in Navigation, Alignment, and Test Modes

MODES	CONDITIONS		
Airaln, *DIG*, *DI* *I*, *UDI*, *PolarDI*,*PolarI* No applicable weapon modes[1]	/MFSW/=TF AND /ACAIRB/=Yes	(NOT /MFSW/=TF) OR /ACAIRB/=No	X
Mag sl, *Grid* *OLB*, No applicable weapon modes[1]	/MFSW/=TF AND !ADC Up! AND !Doppler Up! AND /ACAIRB/=Yes	(NOT /MFSW/=TF) OR NOT !ADC Up! OR NOT !Doppler Up! OR /ACAIRB/=No	X
IMS fail All alignment modes except *Airaln* No listed weapons modes	X	Always	X
Grtest	X	X	!DC Tstage!
VALUE	!limited flight path angle![2]	ADI needle out of view	!Test Value 2!

[1]The applicable weapons modes are: *Nattack*, *Noffset*, *BOC*, *BOCFlyto0*, *BOCoffset*, *Snattack*, *Snoffset*, *SBOC*, *SBOCFlyto0*, *SBOCoffset*, *HUDdown1*, *HUDdown2*, *SHUDdown1*, *SHUDdown2*.

[2]!limited flight path angle! = SIGN (!flight path angle!) $\times$ MIN(ABS(!flight path angle!), 21.6°)

Condition Table 4.2-l //FPANGL// in Weapon Delivery Modes

MODES	CONDITIONS			
LoNuke	ABS (//PUACEL//) > 4°	ABS(//PUACEL//) ≤4° AND NOT !A/C inverted!	ABS(//PUACEL//) ≤4° AND !A/C inverted!	X
HiNuke **NBnotShrike** *Walleye*	ABS(//LSOL-CUEL//) > 4°	X	X	ABS(//LSOL-CUEL//)≤4°
NBShrike	Always	X	X	X
ACTION	ADI needle out of view	//PUACEL//	−//PUACEL//	//LSOLCUEL//

4.3. HEAD UP DISPLAY FUNCTIONS

4.3.1. Update Aiming Symbol Coordinates
(Periodic function)

Initiation and termination: In Table 4.3.1-a, !Range! refers to the ground range from the A/C present position to the reference point defined in Tables 4.3.1-b and 4.3.1-c.

Event Table 4.3.1-a: When Aiming Symbol Switched On/Off

MODES	EVENTS	
A/A Guns *A/G Guns* *BOCFlyto0* *HUDdown1* *HUDdown2* *Nattack* *Noffset* *SBOCFlyto0* *SHUDdown1* *SHUDdown2* *Snattack* *Snoffset* *Grtest*	@T(In mode)	X
BOC *BOCoffset*	@T(In mode AND !Range! ≤ 30 nmi)	@T(In mode AND !Range! > 30 nmi)
SBOC *SBOCoffset*	@T(In mode AND !Range! ≤ 30 nmi)	@T(In mode AND !Range! > 42 nmi)
RadarUpd	@T(In mode AND !Range! ≤ 20 nmi)	@T(In mode AND !Range! > 20 nmi)
HUDUpd	@T(In mode AND !Range! ≤ 22 nmi)	@T(In mode AND !Range! > 22 nmi)
Walleye	@T(In mode)	@T(/RE/=On)
Landaln *01Update* *I*, *OLB* *PolarI*	@T(!aiming switches set!)	X
!*None*!	X	@T(In mode)
ACTION	//HUDAS//:=On	//HUDAS//:=Off or AS moved out of view

Output data item(s) affected: //ASAZ// //ASEL//

Output description:

The Aiming Symbol is usually placed on the HUD to overlay a reference point. The type of reference point varies according to the prevailing mode and conditions, as shown in Tables 4.3.1-b and

4.3.1-c. In some cases, the original position of the symbol is determined by comparing the known coordinates of the reference point to the A/C present positions. In other cases, the pilot moves the symbol by slewing to overlay a point that he sees. When the Aiming Symbol is "ground stabilized," that is, it overlays a fixed point on the ground, the symbol is moved on the HUD to compensate for A/C movement.

At other times, rather than following a fixed point, the Aiming Symbol shows a point that bears a particular relationship to the A/C position, such as being a fixed distance away from it. In this case, the point changes as the A/C moves. The main example is given in Table 4.3.1-d; when the Aiming Symbol overlays !impact point!, it shows the location that would be hit if the gun were fired now.

In most modes, the pilot can change the AS placement by slewing. The slewing rate depends on the chosen mode - either the !HUD rate!, or the faster !Radar rate!. !During slewing!, the AS symbol placement is derived from its previous placement and inputs from the slew controls (/SLEWRL/ and /SLEWUD/), which give a rate and direction of movement. Table 4.3.1-f shows when slewing is allowed and at which of the two rates.

Condition Table 4.3.1-b: AS Reference Point in Non-Weapon Modes

MODES	CONDITIONS			
HUDaln *Landaln* *01Update* *I* *OLB* *PolarI*	X	X	!Before slewing!	!After slewing!
HUDUpd *RadarUpd*	!Before slewing!	!After slewing!	X	X
Grtest	X	X	Always	X
REFERENCE POINT	!Called-up[1] point! (ground stabilized)	!fixpoint![1] (ground stabilized)	HUD center	!adjusted point!

[1]In *HUDUpd* mode the following limiting occurs, where !ASAZ! and !ASEL! are the values before limiting:

//ASAZ// := SIGN(!ASAZ!) × MIN(ABS(!ASAZ!), 5.5°)

//ASEL// := MIN(!ASEL!, 4.3°) (if !ASEL! positive)
//ASEL// := MAX(!ASEL!, −11.7°) (if !ASEL! negative)

Condition Table 4.3.1-c:
AS Reference Point in Designated Weapon Delivery Modes

MODES	CONDITIONS				
Nattack *Snattack* *HUDdown1* *SHUDdown1*	NOT !Desig!	X	X	!Desig!	X
Noffset *Snoffset* *HUDdown2* *SHUDdown2*	NOT !Desig! AND !Before slewing!	X	NOT !Desig! AND !After slewing!	!Desig!	X
BOC *SBOC*	X	!Before slewing!	X	!After slewing!	X
BOCFlyto0 *SBOCFlyto0*	X	X	X	!Desig!	NOT !Desig!
BOCoffset *SBOCoffset*	X	NOT !Desig! AND !Before slewing!	NOT !Desig! AND !After slewing!	!Desig!	X
Walleye	Always	X	X	X	X
REFERENCE POINT	HUD Aimsight (see below)	!Fly-to point! (ground stabilized)	!OAP! (ground stabilized)	!target! (ground stabilized)	point on !ground track! 8 nmi in front of A/C

Condition Table 4.3.1-d:
Definition of HUD Aimsight Position

MODES	CONDITIONS	
Nattack *HUDdown1*	!Shrike!	NOT !Shrike!
Noffset *Snattack* *Snoffset* *HUDdown2* *SHUDdown1* *SHUDdown2*	X	Always
Walleye	Always	X
HUD Aimsight	!weapon boresight!	Point overlaid by FPM

Selector Table 4.3.1-e AS Position in Guns Modes	
MODE	Aiming Symbol Position
A/G Guns *A/A Guns*	Overlaying !impact point!

Condition Table 4.3.1-f: Aiming Symbol Slewing			
MODES	CONDITIONS		
Nattack	(NOT !release possible! AND NOT !Shrike!) OR (!designation retention! AND !Shrike!)	X	(!release possible! AND NOT !Shrike!) OR (NOT !designation retention! AND !Shrike!)
Noffset	NOT !release possible!	X	!release possible!
BOC *BOCFlyto0* *BOCoffset*	X	NOT !release possible! AND !Range! < 20 nmi	!release possible! OR !Range! > 20 nmi
A/A Guns *A/G Guns* *HUDdown1* *HUDdown2* *Walleye* *SHUDdown1* *SHUDdown2* *Grtest*	X	X	Always
Snattack *Snoffset*	NOT !Special release possible!	X	!Special release possible!
SBOC *SBOCFlyto0* *SBOCoffset*	X	NOT !Special release possible! AND !Range! < 20 nmi	!Special release possible! OR !Range! > 20 nmi
RadarUpd	X	Always	X
HUDUpd *HUDaln* *Landaln* *01Update* *I* *OLB* *PolarI*	Always	X	X
SLEWING	at !HUD rate!	at !Radar rate!	None allowed

!Range! represents the !ground range! to the HUD reference point.

4.3.2. Azimuth Steering Line Functions

4.3.2.1. Update Azimuth Steering Line Coordinates
(Periodic function)

Initiation and termination:

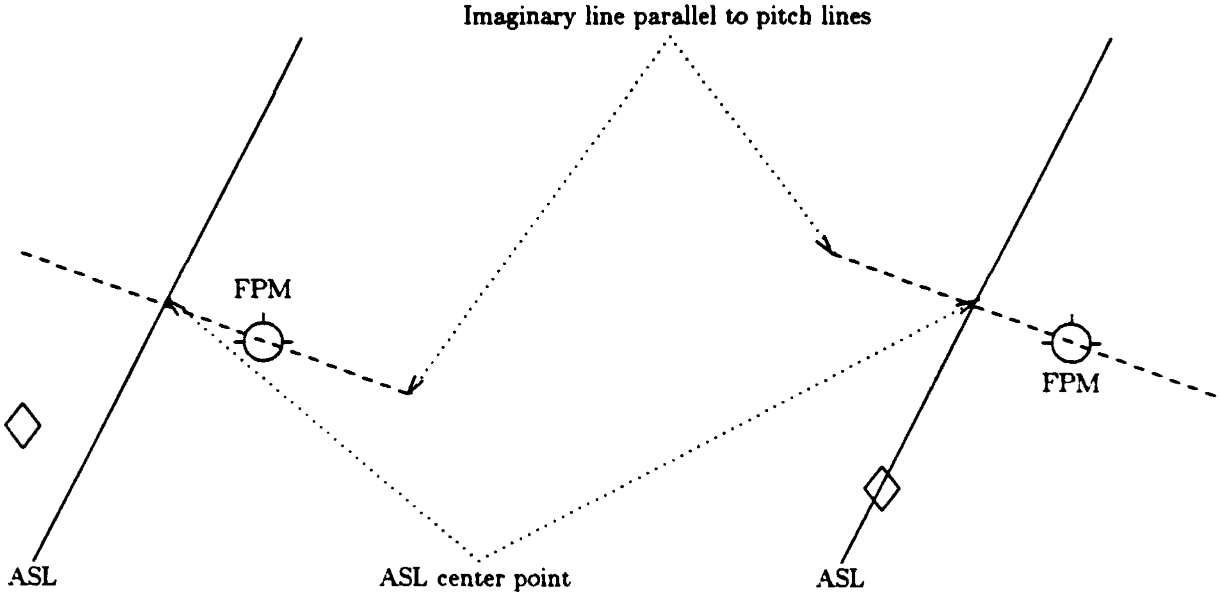
Event Table 4.3.2-a: When ASL Switched On/Off

MODES	EVENTS	
Nattack, *Noffset* *BOC*, *BOCFlyto0* *BOCoffset*, *CCIP* *HUDdown1*, *HUDdown2* *Snattack*, *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	@T(In mode)	@F(In mode)
Grtest	@T(!WD MFS! AND end of !SC Tstage!)	@T(In mode) OR @F(!WD MFS!) OR @F(In mode)
ACTIONS	//HUDASL//:=On	//HUDASL//:=Off OR placed out of view

Output data item(s) affected: //ASLAZ// //ASLEL//

Output description:

The ASL usually shows the pilot the direction and sometimes the amount of steering error to his target or release point. Steering error is the angle between (1) the projection into the horizontal plane of the A/C !ground track! and (2) the projection into the horizontal plane of the line from the A/C to the target or release point. In all modes except *CCIP*, the ASL center is placed on the line that is parallel to the pitch lines, and that passes through the FPM, as shown in Fig. 4.3-a. In some cases, we describe the ASL position as a displacement from the FPM along this line. This displacement affects the values of both //ASLAZ// and //ASLEL//. In other cases, we describe the ASL position by stating that it intersects another HUD symbol, such as the aiming symbol. This does not mean that the ASL center point is placed within the other symbol. Instead, it means that the ASL center point is placed on the line going through the FPM, such that, given the angle of the ASL (see Section 4.3.2.2), the line will intersect the symbol.



Placement of ASL showing half steering error

Placement of ASL intersecting aiming symbol

Figure 4.3-a

The ASL position is limited by the software in the following way, where !ASLEL! and !ASLAZ! are the values before limiting:

//ASLAZ// := SIGN(!ASLAZ!) x MIN(ABS(!ASLAZ!), 6.7°))

//ASLEL// := MIN(!ASLEL!, 4.3°) (if !ASLEL! positive)
//ASLEL// := MAX(!ASLEL!, −11.7°) (if !ASLEL! negative)

Condition Table 4.3.2-b:
ASL Placement in Designated Weapons Delivery Modes

MODES	CONDITIONS				
Nattack *Snattack* *HUDdown1* *HUDdown2* *Noffset* *BOCFlyto0* *Snoffset* *SBOCFlyto0* *SHUDdown1* *SHUDdown2*	X	NOT !Desig!	!steering to target!	!OTS!	!GAS!
BOC *SBOC*	!Range![1] > 30 nmi	X	!Range! ≤ 30 nmi AND !steering to target!	!OTS!	!GAS!
BOCoffset *SBOCoffset*	!Range! > 30 nmi	NOT !Desig! AND !Range! ≤ 30 nmi	!Range! ≤ 30 nmi AND !steering to target!	!OTS!	!GAS!
ASL PLACEMENT	!steering error! from FPM (same as //FLTDIRAZ//	ASL Line Intersects AS[2]	!alternate steering! display[3]	-(half of !steering error!) from FPM	edge of HUD to closest return

[1]!Range! means ground distance from A/C present position to the aiming symbol reference point.

[2]In *Nattack* and *Snattack*, the AS is centered in the FPM, so the ASL center would also be centered in the FPM; in *BOCFlyto0*, *SBOCFlyto0*, *Noffset*, and *Snoffset*, the AS may be displaced from the FPM, causing the ASL center also to be moved.

[3]!Alternate steering! has two substages. When the horizontal range to the target is > 48,000 feet, the steering error is calculated to cause the A/C to fly over the target. Within 48,000 feet, the steering error is calculated to take the A/C to the proper place to release the weapon, which may not be directly over the target.

When the A/C pitch gets large, the steering error is multiplied by the weighting factor shown below, because otherwise the error grows too large to display.

Table 4.3.2-c: Steering Error Weighting Factors	
!system pitch! $\leq 0^\circ$:	1
$0^\circ <$!system pitch! $\leq 60^\circ$:	$1 - 1.5 \times$!system pitch!/360°
$60^\circ <$!system pitch! $\leq 80^\circ$:	3 − 13.5 x !system pitch!/360°
$80^\circ <$!system pitch! $\leq 90^\circ$	0

In other modes, the ASL placement depends on other conditions, shown in the table below.

Condition Table 4.3.2-d: ASL Coordinates in Other Modes

MODES	CONDITIONS	
CCIP	!impact angle elevation! $> 20^\circ$ below A/C boresight	!impact angle elevation! $< 20^\circ$ below A/C boresight
Grtest	Always	X
ASL PLACEMENT	ASL center in FPM	ASL center 4° below FPM, ASL intersecting the FPM

Condition Table 4.3.2-e: !Alternate Steering! Display

MODES	CONDITIONS	
Nattack *Noffset* *BOCFlyto0* *BOC* *BOCoffset* *HUDdown1* *HUDdown2*	NOT !Shrike!	!Shrike!
SHUDdown1 *SHUDdown2* *Snattack* *Snoffset* *SBOCFlyto0* *SBOC* *SBOCoffset*	Always	X
ASL PLACEMENT	half of !steering error! from FPM	displaced from AS by !drift angle!

4.3.2.2. Update Azimuth Steering Line Angle
(Periodic function)

Initiation and termination: This function is performed whenever the ASL is in view (see Section 4.3.2.1)

Output data item(s) affected: //ASLCOS// //ASLSIN//

Output description:

Condition Table 4.3.2-f: ASL Angle

MODES	CONDITIONS		
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *HUDdown1* *HUDdown2* *SHUDdown1* *SHUDdown2*	X	Always	X
CCIP	X	!impact angle elevation! > 20° below A/C boresight	!impact angle elevation! ≤ 20° below A/C boresight
Grtest	Always	X	X
ASL ANGLE	0° (vertical)	perpendicular to pitch lines, showing real world vertical	angle of !Bomb fall line!

4.3.3. Update HUD Barometric Altitude
(Periodic function)

Initiation and termination: None: always done

Output data item(s) affected: //BAROHUD//

Output description:

Condition Table 4.3.3-a: Barometric Altitude Display Values

MODES	CONDITIONS		
All modes except *Grtest*[1]	!ADC Up! AND !Dest 1-9!	!ADC Up! AND (!Mark! OR !Dest 0!)	NOT !ADC Up!
BAROMETRIC ALTITUDE	/BAROADC/ corrected for !FLY-TO mslp!	/BAROADC/ corrected for 29.92 MSLP	4500

[1]In *Grtest* mode, the HUD displays a fixed value, the value of //BAROHUD// at mode entry time.

4.3.4. Update Flight Director Coordinates
(Periodic function)

Initiation and termination:

Event Table 4.3.4-a: When Flight Director Coordinates Updated		
MODES	EVENTS	
All modes	@T(!power up!) OR @F(!WD MFS!)	@T(!WD MFS!)
ACTION	Initiation FD moved in view	Termination FD out of view

Output data item(s) affected: //FLTDIRAZ//

Output description:

The Flight Director output is an azimuth displacement from the HUD ORA showing the **azimuth steering error**, that is, the angle between the projections into the horizontal plane of the A/C Ya axis (A/C heading) and the line drawn from the A/C to the !Fly-to point!. (As a result, the distance between the FPM and the Flight Director shows the angular difference between the A/C !ground track angle! and the bearing to the !Fly-to point!).

Condition Table 4.3.4-b: Flight Director Azimuth Value		
MODES	CONDITIONS	
NOT *Grtest*	/FLYTOTW/≠0	/FLYTOTW/=0
Grtest	X	Always
//FLTDIRAZ//	SIGN(azimuth steering error) × MIN(ABS(azimuth steering error),5°)	0

4.3.5. Flight Path Marker Functions

4.3.5.1. Update Flight Path Marker Coordinates
(Periodic function)

Initiation and termination: This function must be performed whenever //HUDVEL// = \$On\$ (see Section 4.3.12).

Output data item(s) affected: //FPMAZ// //FPMEL//

Output description:

The Flight Path Marker shows the direction of the A/C velocity vector. If the A/C is moving straight ahead from the nose of the A/C, the FPM is optically centered on the HUD. The azimuth displacement from HUD center shows the lateral velocity component and elevation displacement shows the vertical velocity component.

Although the means for deriving Flight Path Marker position varies as shown in Table 4.3.5-a, the position is usually derived from the current !System velocities!. The velocities are first resolved into lateral, forward and vertical components, that is, velocities along Xa, Ya, and Za axes respectively. Then FPM coordinates are derived in the following manner:

//FPMAZ// := 57.29 × Lateral_velocity / forward velocity

//FPMEL// := 57.29 × Vertical velocity / forward velocity

57.29 converts from radians to degrees. The Flight Path Marker is limited by the software in the following way, where !FPMAZ! and !FPMEL! are the values before limiting:

//FPMAZ// := SIGN(!FPMAZ!) × MIN((ABS(!FPMAZ!), 6°)

//FPMEL// := MIN(!FPMEL!, 4.3°) (if !FPMEL! positive)
//FPMEL// := MAX(!FPMEL!, −11.7°) (if !FPMEL! negative)

Condition Table 4.3.5-a: Coordinates of the Flight Path Marker			
MODES	CONDITIONS		
Airaln	X	!FM stage complete! OR !ADC Up!	NOT !FM stage complete! AND NOT !ADC Up!
Alignment modes except *Airaln* *Grtest*	Always	X	X
DIG, *DI*, *UDI*, *PolarDI*	X	Always	X
I, *PolarI*	/ACAIRB/ = No	/ACAIRB/ = Yes	X
OLB *Mag sl*, *Grid*	/ACAIRB/=No	!ADC Up! AND /ACAIRB/=Yes	NOT !ADC Up! AND /ACAIRB/=Yes
IMS fail	/ACAIRB/=No	X	/ACAIRB/=Yes
FPM COORDINATES	//FPMAZ//:=0° //FPMEL//:=0°	based on !System velocities!	//FPMAZ//:=0° //FPMEL//:=!True AOA!

4.3.5.2. Start FPM Flashing
(Demand function)

Output data item(s) affected: //HUDFPM//

Output description:

Event Table 4.3.5-b: When FPM Flashed		
MODES	EVENTS	
Nattack, *Noffset* *BOC*, *BOCFlyto0* *BOCoffset*, *CCIP* *Walleye*, *Snattack* *Snoffset*, *SBOC* *SBOCFlyto0*, *SBOCoffset* *Manrip*	@T(!rls pts passed! = !stik quantity!)	@T(sufficient time elapsed[1] after @T(//HUDFPM// = $Blink$))
ACTION	//HUDFPM//:=$Blink$	//HUDFPM//:=$Constant$

[1]The value of //HUDFPM// should be reset to $Constant$ as soon as the OFP can be sure the HUD received the $Blink$ value. See Section 2.1.4.6 for timing characteristics relative to this function.

4.3.6. Update HUD Magnetic Heading
(Periodic function)

Initiation and termination: None; always performed

Output data item(s) affected: //MAGHDGH//

Output description:

Condition Table 4.3.6-a: Magnetic Heading		
MODES	CONDITIONS	
All alignment and navigation modes except *IMS fail*	Always	X
IMS Fail	/IMSMODE/ $\neq$ \$Offnone\$	/IMSMODE/=\$Offnone\$
Grtest	X	Always
//MAGHDGH//	!magnetic heading!	0° (North)

4.3.7. Update HUD Pitch Angle
(Periodic function)

Initiation and termination: None; always performed

Output data item(s) affected: //PTCHANG//

Output description: In all modes but *Grtest*, the HUD displays !system pitch!. In *Grtest* mode, the HUD displays a fixed value, the current value of !IMS pitch! at mode entry time.

4.3.8. Pullup Anticipation Cue Functions

4.3.8.1. Update Pullup Anticipation Cue Coordinates
(Periodic function)

Initiation and termination:

In the following table, !Range! refers to ground range to the !Fly-to point!.

Event Table 4.3.8-a: When PUAC Updated		
MODES	EVENTS	
Nattack, *Noffset*, *BOCFlyto0*, *CCIP*, *A/G Guns*, *Walleye*	@T(In mode)	X
Snattack *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset*	@T(!Rmax+6000!)	@T(!Rmin+6000! AND !rls pts passed! = 0) OR @T(!Range! > 10 nmi AND !rls pts passed! = !stik quantity!) OR @T(!IMS pitch! < −30° AND !rls pts passed! = !stik quantity!) OR @T(!high drag!)
BOC, *BOCoffset*	@T(In mode AND !Range! ≤ 30 nmi)	@T(!Range! > 30 nmi)
Grtest	@T(!WD MFS!)	@F(!WD MFS!)
None of the modes listed above	X	@F(!WD MFS!)
ACTION	Initiation PUAC in view	Termination PUAC out of view

Output data item(s) affected: //PUACAZ// //PUACEL//

Output description:

In most modes, the PUAC shows the pilot how far he is from the "pullup point": the point where he must execute a 4g pullup to avoid either the ground or the blast radius of a released weapon. In *Grtest*, the PUAC is centered on the display.

In Table 4.3.8-b, (*A/G Guns* AND !Rockets!) and (*A/G Guns* AND !Guns!) are treated as if they were two separate modes.

Condition Table 4.3.8-b: PUAC Elevation

MODES	CONDITIONS	
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *CCIP* *A/G Guns* (!Rockets!) *Walleye*	!slant range! to !ground pullup point! $>$ 5000 ft AND !slant range! to !blast pullup point! $>$ 5000 ft	!slant range! to !ground pullup point! $\leq$ 5000 ft OR !slant range! to !blast pullup point! $\leq$ 5000 ft
A/G Guns (!Guns!)	!slant range! to !ground pullup point! $>$ 5000 ft	!slant range! to !ground pullup point! $\leq$ 5000 ft
SBOC *SBOCFlyto0* *SBOCoffset* *Snattack* *Snoffset* *SHUDdown1* *SHUDdown2*	Always	X
PUAC ELEVATION	3.5° below FPM per 1000 ft to closest pullup point	0.7° below FPM

Selector Table 4.3.8-c: PUAC Azimuth

MODES	PUAC AZIMUTH
Nattack, *Noffset* *BOC*, *BOCFlyto0* *BOCoffset* *Snattack*, *Snoffset*, *SBOC*, *SBOCFlyto0*, *SBOCoffset*	Centered in azimuth on the ASL
CCIP *A/G Guns* *Walleye*	//FPMAZ//

Note: The ground avoidance calculations are based on the assumption that terrain around a target is flat.

The purpose of the ground avoidance calculations is to keep the A/C above the target altitude by at least a safety margin of 98 feet. It is assumed to be unnecessary to calculate ground avoidance unless the A/C is moving down with a vertical velocity of at least 3 fps.

The purpose of the blast avoidance calculations is to keep the A/C outside of a blast sphere of radius 1500 feet around each bomb burst point in a stik. It is unnecessary to calculate the blast avoidance if any of the following conditions holds:

(1) slant range to designated target greater than 16,400 ft

(2) NOT !Desig!, in one of the following modes: *Nattack*, *Noffset*, *BOCFlyto0*, *BOCoffset*

(3) *A/G Guns* AND NOT !Rockets!

(4) !rls pts passed! = !stik quantity!

(5) !overfln!

(6) *Snattack*, *Snoffset*, *SBOC*, *SBOCFlyto0*, and *SBOCoffset*

(7) A/C greater than 1500 feet past impact point at time of impact

The target altitude used in these calculations is given in Table 4.3.8-d below.

Condition Table 4.3.8-d: Target Altitude

MODES	CONDITIONS		
Nattack *BOC* *CCIP* *A/G Guns* *Walleye*	!Dest 1-9!	X	!Mark! OR !Dest 0!
BOCoffset *Noffset*	X	Always	X
BOCFlyto0	X	X	Always
Target altitude:	!Destaltitude!	!Destaltitude! + !Delta Height!	0

4.3.8.2. Flash PUAC

(Periodic function)

Output description:

Event Table 4.3.8-e: When PUAC Flashed		
MODES	EVENTS	
BOCoffset, *CCIP*, *Nattack*, *Noffset* *BOC*, *BOCFlyto0*, *Walleye*	@T(In mode AND /MA/ = \$Off\$)	@T(/MA/ = \$On\$) OR @F(In mode)
Snattack *Snoffset* *SBOC* *SBOCoffset* *SBOCFlyto0*	@T(In mode AND /MA/=\$Off\$) WHEN(!low drag!)	@T(/MA/=\$On\$ OR !high drag!) OR @F(In mode)
A/G Guns	@T(In mode AND /MA/ = \$Off\$) WHEN (!Guns! OR !Rockets!)	@T(/MA/ = \$On\$) OR @T(!Guns! OR !Rockets!)
None of above modes	X	@T(None of above modes)
ACTIONS	Initiation: PUAC moved in and out of view. When in view, PUAC positioned by Update PUAC function (see §4.3.8.1)	Termination: PUAC positioned by Update PUAC function (see §4.3.8.1)

4.3.9. Flash Pullup Cue
(Demand function)

Initiation and termination:

Initiation: The Pullup Cue is flashed (i.e., //HUDPUC//:=On) when the A/C reaches a !pullup point!, i.e., a point where the pilot must immediately execute a 4 g pullup to escape the ground or the blast radius of a weapon. In the weapons delivery modes *Nattack*, *Noffset*, *BOC*, *BOCFlyto0*, *BOCoffset*, *CCIP*, *A/G Guns*, *Walleye*, *Snattack*, *Snoffset*, *SBOC*, *SBOCFlyto0*, and *SBOCoffset* this point occurs when the PUAC reaches the FPM. In other modes, only ground avoidance is calculated.

For low-drag special weapons the Pullup Cue indicates a 4 g pullup is required for weapon release. Ground and blast avoidance is not calculated. The Pullup Cue appears for two seconds when used for this purpose.

Termination: The Pullup Cue stops flashing (i.e., //HUDPUC//:=Off) when the pilot pulls up sufficiently to remove the A/C from danger, or has been flashed for two seconds when !low drag! AND !Special!.

4.3.10. Update HUD Roll Angle
(Periodic function)

Initiation and termination: None - always performed

Output data item(s) affected: //ROLLCOSH// //ROLLSINH//

Output description: In all modes except *Grtest*, the roll angle transmitted to the HUD is !system roll!. In *Grtest* mode, the HUD displays a fixed value, the current value of !system roll! at mode entry time.

4.3.11. Solution Cue Functions

4.3.11.1. Display Solution Cues
(Demand function)

". sp 50u
">0 When".

Event Table 4.3.11-a: When Both Solution Cues Switched On/Off		
MODES	EVENTS	
NBnotShrike	@T(!target in range! AND !Desig! AND NOT !GAS! AND NOT !During slewing!) OR @T(!target in range! occurs in 1 second) WHEN (!IMS pitch! = 42°)	@F(!target in range!) OR @F(!Desig!) OR @T(!GAS!) OR @T(!During slewing!)
Snattack *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	@T(!Special in range! AND !Desig! AND NOT !GAS! AND NOT !During slewing!)	@F(!Special in range!) OR @F(In mode) OR @T(!GAS!) OR @T(!During slewing!)
NBShrike *Walleye*	@T(!target in range! AND !Desig!)	@F(!target in range!) OR @F(!Desig!)
CCIP	@T(ABS(!impact angle elevation!) ≤ 16° AND ABS(!impact angle azimuth!) ≤ 12°)	@T(ABS(!impact angle elevation!) > 16° OR ABS(!impact angle azimuth!) > 12°)
A/G Guns	@T(!target in range!)	@F(!target in range!)
Grtest	@T(!WD MFS!)	@F(! WD MFS!)
None of above modes	X	@T(In mode)
ACTIONS	//HUDSCUE//:= On	//HUDSCUE//:= Off or cues placed out of view

Note: If the pitch of the A/C is near 42° when the target is designated, the Solution Cue is displayed 1 second before the target comes within !maximum range! to give the pilot warning that a release point is imminent.

4.3.11.2. *Update Lower Solution Cue Coordinates*
(Periodic function)

Initiation and termination: Performed whenever //HUDSCUE//=On

Output data item(s) affected: //LSOLCUAZ// //LSOLCUEL//

Output description:

The Lower Solution Cue has three different uses: (1) as a warning that a release point is approaching; (2) as an impact point indicator; (3) as an in-range cue. In the first case, it is centered in azimuth on the ASL, moving toward or away from the ASL center point in elevation, as indicated in Table 4.3.11-b, c, & d. The other two cases are shown in Table 4.3.11-e.

Condition Table 4.3.11-b: Placement of Lower Solution Cue

MODES	CONDITIONS		
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *HUDdown1* *HUDdown2*	!OTS!	!low drag! AND NOT !OTS!	NOT !low drag! AND NOT !OTS!
LOWER SOLUTION CUE DISTANCE FROM ASL CENTER POINT	4°	SIGN(!dive pullup!) × MIN (4°, 1° x 1/8 × ABS(!dive pullup!))	SIGN(!distance-to-release!) × MIN(4°,1°×1/1000 × ABS(!distance-to-release!))

!distance-to-release! < 0 when the release point has been overflown.

Condition Table 4.3.11-c: Placement of Lower Solution Cue for !low drag! Special Weapons

MODES	CONDITIONS	
LoNuke	!OTS! OR !range to Rmax! < 0 OR NOT !A/C facing target!	!Range! to !target! ≤ 10 nmi AND !A/C facing target!
LSC DISPLACEMENT FROM FPM	out of view	MIN(4°.1° × 1/1000 × ABS(!range to Rmax!))

Condition Table 4.3.11-d: Placement of Lower Solution Cue for !high drag! Special Weapons			
MODES	CONDITIONS		
HiNuke	!TOS!	NOT !TOS! AND !distance to release! ≥ 0	NOT !TOS! AND AND !distance to release! < 0
LSC DISPLACEMENT FROM FPM	4°	SIGN(!distance-to-release!) ×MIN(4°,.1°×1/1000 ×ABS(!distance-to-release!))	−(MIN(3.5°,.1°×1/1000× ABS(!distance-to-release!)))

Selector Table 4.3.11-e: Other Positions for the Lower Solution Cue	
MODES	SOLUTION CUE PLACEMENT
A/G Guns *Walleye*	Superimposed on the Aiming Symbol (which pilot interprets as !target in range! cue)
CCIP	Intersecting ASL showing the !impact point!
Grtest	Along the bottom of the Flight Path Marker

4.3.11.3. Update Upper Solution Cue Coordinates
(Periodic function)

Initiation and termination:

Event Table 4.3.11-f: When Upper Solution Cue Displayed

MODES	EVENTS	
NBnotShrike *Snattack*, *Snoffset* *SBOCoffset* *SBOC*, *SBOCFlyto0* *SHUDdown1*, *SHUDdown2*	@T(//HUDSCUE//=On) WHEN (!low drag!)	@T(//HUDSCUE//=Off OR NOT !low drag!)
None of the modes listed above and below	X	@T(In mode)
Grtest	@T(//HUDSCUE//=On)	@T(//HUDSCUE//=Off)
ACTION	Upper Cue in view, placed according to following table	Upper Cue out of view, placed in position where it is not visible

Output data item(s) affected: //USOLCUAZ// //USOLCUEL//

Output description:

The Upper Solution Cue is centered in azimuth on the ASL, moving toward or away from the ASL center point in elevation, as indicated in Table 4.3.11-g. In *Grtest*, the Upper Solution Cue is placed along the top of the FPM.

Condition Table 4.3.11-g: Placement of Upper Solution Cue

MODES	CONDITIONS	
NBnotShrike *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	!OTS!	NOT !OTS!
USC DISTANCE FROM ASL CENTER POINT	SIGN(!OTS pullup!) × MIN(4°,1°×1/8× ABS(!OTS pullup!))	SIGN(!loft pullup!)×MIN(4°, 1°×1/8×ABS(!loft pullup!))

4.3.11.4. Flash Solution Cues
(Periodic function)

Initiation and termination:

Event Table 4.3.11-h: When Solution Cues Started and Stopped Flashing		
MODES	EVENTS	
Nattack *Noffset* *HUDdown1* *HUDdown2* *SHUDdown1* *SHUDdown2* *Snattack* *Snoffset*	@T(FLR sampled[1] AND NOT !Slant range reasonable!)	@T(FLR sampled AND !Slant range reasonable!)
A/G Guns	@F(!Slant range reasonable!) WHEN (/GUNSSEL/=Yes)	@T(/GUNSSEL/ = No) OR @T(!Slant range reasonable!)
None of modes listed above	X	@T (None of above modes)
ACTION	Initiation of flashing: Solution Cues moved in and out of view	Termination of flashing Solution Cues left where placed by other functions (§4.3.11.1 and §4.3.11.2)

Note: Even though FLR is sampled constantly in *CCIP* mode, the Solution Cue is never flashed because it is used as an aiming indicator, so that the flashing would be confusing.

[1]@T(FLR sampled) occurs when @T(!Desig!) occurs, or when @T(!slewing finished!) WHEN(!Desig!) occurs.

4.3.12. Vertical Velocity and Acceleration Indicators

4.3.12.0. When the Velocity Indicators are Updated

Output data item(s) affected: //HUDVEL//

Output description:

Table 4.3.12-a shows when the program updates the values for the two vertical velocity indicators and the Flight Path Marker position (see Section 4.3.5).

Event Table 4.3.12-a: When Velocity Indicators Switched On/Off

MODES	EVENTS	
Airaln	@T(!FM stage complete!) OR @T(!AOA reasonable!)	@F(!AOA reasonable!) WHEN (NOT !FM stage complete!)
Mag Sl *Grid* *IMS fail* *OLB*	@T (!AOA reasonable!) OR @T(/ACAIRB/=No)	@F(!AOA reasonable! AND /ACAIRB/=Yes)
All other modes	@T(None of above modes)	X
ACTIONS	Initiation //HUDVEL//:=On	Termination //HUDVEL//:= Off

Comment: Hardware constraints cause both the vertical derivative and the Flight Path Marker functions to be initiated and terminated by the value of //HUDVEL//. See the description of //HUDVEL// in Chapter 2.

4.3.12.1. Update HUD Vertical Velocity
(Periodic function)

Initiation and termination:

Termination: This function is performed whenever //HUDVEL//=On

Output data item(s) affected: //VERTVEL//

Output description:

The HUD Vertical Velocity Indicator usually shows !System vertical velocity!, i.e., the vertical velocity calculated from the highest priority, reliable sensors (see Table D-c in the Dictionary.)

Condition Table 4.3.12-b: Vertical Velocity Value

MODES	CONDITIONS	
NOT *Grtest*	Always	X
Grtest	X	Always
OUTPUT	!System vertical velocity! in feet per second	0

4.3.12.2. Update HUD Vertical Derivative
(Periodic function)

Initiation and termination:

Termination: This function is performed whenever //HUDVEL//=On

Output data item(s) affected: //VTVELAC//

Output description:

The HUD Vertical Derivative Indicator shows either vertical velocity or vertical acceleration, depending on the active modes. If it shows vertical velocity, the same value is output that goes to //VERTVEL//.

Condition Table 4.3.12-c: Vertical Derivative Value		
MODES	CONDITIONS	
All modes except those below	Always	X
Snattack *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	NOT !low drag!	!low drag!
OUTPUT	//VERTVEL// value (see Table 4.3.12-b)	!normal acceleration!, from 0 to 6 g[1]

[1] //VERTVEL// and //VTVELAC// govern the position of a pointer on a scale (see Chapter 2). When reading an acceleration, the pilot interprets the bottom of the scale as 0 g's and the top of the scale as +8 g's. Thus, the actual value to be sent to the data item is $-1000 + 250 \times$ the acceleration in g's.

4.4. BOMB RELEASE FUNCTIONS

4.4.1. Switch Bomb Release On/Off
(Demand function)

Output data item(s) affected: //BMBREL//

Output description:

Event Table 4.4-a: When Bomb Release is Issued

MODES	EVENTS	
NBShrike	@T(/RE/=On AND !time elapsed! since //FIRRDY//=On > 2.31 s AND !Shrike solution!)	@T(!fire pulse width elapsed!)
CCIP **NBnotShrike** *Walleye* *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	@T(//FIRRDY//=On)	@T(!fire pulse width elapsed!)
Manrip	@T(//FIRRDY//=On) WHEN(NOT !Shrike!) OR @T(//FIRRDY//=On AND !time elapsed! since //FIRRDY//=On > 2.31 s) WHEN(!Shrike!)	@T(!fire pulse width elapsed!)
ACTION	//BMBREL//:=On	//BMBREL//:=Off

4.4.2. Switch Fire Ready On/Off
(Demand function)

Output data item(s) affected: //FIRRDY//

Output description:

Event Table 4.4-b
When First Fire Ready in a Stik Is Issued

MODES	EVENTS	
NBnotShrike	@T(/RE/=On AND !Special solution!)	@T(//BMBREL//=Off)
Manrip	@T(/RE/=On)	@T(//BMBREL//=Off) OR @T(/RE/=Off) WHEN (//FIRRDY//=On AND !Shrike!)
CCIP *Walleye*	@T(/RE/=On)	@T(//BMBREL//=Off)
HiNuke	@T(/RE/ = On) WHEN (!time elapsed! since @T(!Special solution!)≤2 s)	@T(//BMBREL//=Off)
LoNuke	@T(/RE/=On AND !flight path angle!=!Amax!) WHEN (!eligible release! AND NOT !Special solution occurred!) OR @T(/RE/=On AND !flight path angle!=!Amin!) WHEN (!eligible release! AND !Special solution occurred!) OR @T(/RE/=On AND !Special solution!) WHEN (!eligible release! AND !Amin! ≤!flight path angle!≤!Amax!) OR @T(/RE/=On) WHEN (!eligible release! AND time since @T(!Special solution!)≤2 s)	@T(//BMBREL//=Off)
NBShrike	@T(!time to solution! ≤ 2.5 seconds AND /RE/=On)	@T(//BMBREL//=Off) OR @T(/RE/=Off) WHEN(//FIRRDY//=On)
ACTION	//FIRRDY//:=On	//FIRRDY//:=Off

Event Table 4.4-c:
When Subsequent Fire Ready Pulses in a Stik Are Issued

MODES	EVENTS	
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *CCIP* *Manrip* *HUDdown1* *HUDdown2*	@T(!ground range! from !impact point! of last release to !impact point! of present = !bomb spacing!) WHEN (!rls pts passed! < !stik quantity! AND /RE/=On)	@T(//BMBREL//=Off) OR @T(/RE/=Off) WHEN(!Shrike! AND //FIRRDY//=On)
ACTION	//FIRRDY//:=On	//FIRRDY//:=Off

4.4.3. Switch Bomb Tone On/Off
(Demand function)

Output data item(s) affected: //BMBTON//

Output description:

Event Table 4.4-d: When Bomb Tone Turned On and Off

MODES	EVENTS	
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *HUDdown1* *HUDdown2*	@T(/RE/=On) WHEN (!Desig!)	@T(//FIRRDY//=On) WHEN(//BMBTON//=On) OR @T(/RE/=Off) WHEN(//BMBTON//=On)
Walleye	@T(/RE/=On)	@T(!time elapsed! since @T(//BMBTON//=On)=1 s)
Snattack *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	@T(!Rmax!) OR @T(!Rmin!) OR @T(/RE/=On) WHEN (!Desig!)	@T(!time elapsed! since @T(!Rmax!)=1 s) OR @T(!Rmin+6000!) WHEN(//BMBTON//=On) OR @T(//BMBREL//=On) WHEN(//BMBTON//=On) OR @T(!IMS pitch!>15° AND /RE/=Off) WHEN(!low drag!) OR @T(/RE/ = Off) WHEN(//BMBTON//=On AND !high drag!)
CCIP *Manrip*	@T(/RE/=On)	@T(/RE/ = Off) WHEN(//BMBTON//=On)
A/G Guns	@T(/RE/=On) WHEN (!Rockets!)	@T(//BMBREL//=On) WHEN(//BMBTON//=On) OR @T(/RE/ = Off) WHEN(//BMBTON//=On)
ACTION	//BMBTON//:=On	//BMBTON//:=Off

4.4.4. Beep Bomb Tone
(Demand function)

Output data item(s) affected: //BMBTON//

Output description: The bomb tone is beeped by turning it on and off a specified number of times per second. The rate is given by the dictionary entry !beep rate!.

Event Table 4.4-e: When Bomb Tone Beeped

MODES	EVENTS	
Snattack *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	@T(!R65!)	@T(!elapsed time! since beeping started > 2 seconds)
ACTION	//BMBTON// cycled at !beep rate!	//BMBTON//:=Off

4.5. PROJECTED MAP DISPLAY SET FUNCTIONS

4.5.1. Update Map Azimuth Ring Angle
(Periodic function)

Initiation and termination: None: always done

Output data item(s) affected: //AZRING//

Output description: This function positions the azimuth ring so that the N marker shows the direction of north on the filmstrip. Thus, if the map is oriented with !ground track! up (see Section 4.5.3), the marker at the top of the display shows the horizontal direction of the A/C velocity vector. //AZRING// is not affected by the value of /PMHOLD/.

//AZRING// := !magnetic heading! + !ground track angle! – true heading

This function is not performed in *Grtest*.

Initiation and termination: None: always done

Output data item(s) affected: //DESTPNT//

Output description: The destination pointer shows the bearing to the !Fly-to point! from the A/C present position. The //DESTPNT// value is the angle measured clockwise from the A/C !ground track! to the line drawn from the the A/C present position to the !Fly-to point!. If /FLYTOTW/=0 then //DESTPNT//:=0

This function is not performed in *Grtest*.

4.5.2. Update Map Orientation Angle
(Periodic function)

Initiation and termination: None: always done

Output data item(s) affected: //MAPOR//

Output description: The filmstrip is oriented so that either the map north or the horizontal direction of the A/C velocity vector (!ground track!) is pointed up in the map display.

Condition Table 4.5-b: Map Orientation

MODES	CONDITIONS		
NOT *Grtest*	/PMNORUP/ = Yes AND /PMHOLD/ = No	/PMNORUP/ = No AND /PMHOLD/ = No	/PMHOLD/ = Yes
//MAPOR// VALUE	0	!ground track angle!	last value of //MAPOR// before @T(/PMHOLD/ = Yes)

4.5.3. Update Filmstrip Position
(Periodic function)

Initiation and termination: None: always done

Output data item(s) affected: //XCOMMC//, //XCOMMF//,

Output description:

This function positions the filmstrip so that a reference point on the map is shown in a specified position of the display. The reference point on the filmstrip is defined in Table 4.5-c, and the display face position is defined in Table 4.5-d.

The filmstrip that contains the maps is divided into two areas, A and B. They may overlap in coverage, but B covers a larger area. The software must select a map in the area specified by Table 4.5-e. Parameters describing the filmstrip must be input by the pilot. (See Sections 4.6.27 through 4.6.29). These specify the location and orientation of the areas shown in A and B. Area A is covered in two scales, area B in only one scale. Filmstrips are considered part of the hardware and are discussed in references (33h, 33i, 33j).

During slewing, the map reference point is changed from the pre-slew reference point by slewing. Slewing inputs /SLEWUD/ and /SLEWRL/ indicate a direction and rate of movement. The rates are in terms of the !Map rate!.

Condition Table 4.5-c: Map Reference Points

MODES	CONDITIONS		
Align modes Nav modes NOT *MapUpd*	NOT !During slewing! AND NOT (!DEST displayed! OR !MARK displayed!) AND /PMHOLD/=No	NOT !During slewing! AND (!DEST displayed! OR !MARK displayed!) AND /PMHOLD/=No	/PMHOLD/ =Yes OR !During slewing!
MapUpd	NOT !Desig! AND NOT !During slewing!	X	!Desig! OR !During slewing!
MAP REFERENCE POINTS	present position of the A/C	!Called-up point! or !Mark location![a]	!slewed-to point!

[a]!Called-up point! if !DEST displayed!; !Mark location! if !MARK displayed!.

Condition Table 4.5-d: Map Display Position		
MODES	CONDITIONS	
All Navigation and Alignment *MapUpd*	/PMNORUP/ = Yes OR /PMDCTR/ = No	/PMNORUP/ = No AND /PMDCTR/ = Yes
DISPLAY POSITION:	center reference circle	bottom center of display

Table 4.5-e: Map Area Selected					
Area Now Displayed	**/PMSCAL/**	**!IN A!**	**!IN B!**	**Note**	**Next Area**
A or undefined	20	No	No		Error - Undefined
		No	Yes	2	Error - Undefined
		Yes	No	1	A
		Yes	Yes	2	A
	80	No	No		Error - Undefined
		No	Yes		B
		Yes	No	1	A
		Yes	Yes		A
B	20	No	No		Error - Undefined
		No	Yes	2	Error - Undefined
		Yes	No	1	A
		Yes	Yes	2	A
	80	No	No		Error - Undefined
		No	Yes		B
		Yes	No	1	Error - Undefined
		Yes	Yes		B

Legend

!IN A!: reference position within Area A of the map
!IN B!: reference position within Area B
Error - Undefined: indicates an error (Undesired Event), but a display from area B at scale 80 would be a useful response.

Notes

(1) With current maps, this cannot happen since the A area is included in the B area. However, this is not required by the NAVAIR filmstrip specification.

(2) With current maps, this cannot happen, since area B is only in scale 80. However, this is not required by the NAVAIR filmstrip specification.

Panel Service Functions

4.6. PANEL SERVICE FUNCTIONS

4.6.0. Description Approach

Unlike most of the TC-2 outputs, the panel outputs are relatively unconstrained: neither the format nor the contents of the outputs are completely constrained by the hardware device. For each of the 13 windows there are 2^7 possible outputs, which can be combined with 2^{10} combinations of format lights turned on and off. Of this huge number of possible outputs, only a small subset is used. Since this set can be added to easily, the panel is one of the more flexible devices controlled by the TC-2.

Because the panel is relatively free-form, we have had to make more artificial distinctions in this section than in other parts of Section 4. The Panel Display Functions do not correspond directly to output data items. Instead, they correspond to semantic entities, such as present position or wind speed and direction, that can be displayed using the panel output data items. These entities are determined by the OFP rather than by the hardware interfaces.

Each Panel Display Function is described as if it were always performed, that is, as if it had its own separate display windows. The rules for determining which of the Panel Display Functions actually controls the panel output data items are given in section 4.6.1.

The values of many of the Panel Displays may be changed by the pilot entering information through the keyboard. The rules for successful data entry are given in Section 4.6.2.

During data entry, the OFP changes the panel display. For example, it echoes the characters keyed in by the pilot. We found it most convenient to describe these requirements along with the rules for entering data in Section 4.6.2. Since the actual requirement is to change the data item values in response to pilot actions, Section 4.6.2 completes the partial description of the panel display given in Section 4.6.1.

Section 4.6.3 describes the display in the separate, mark window. This window is completely controlled by this function.

Section 4.6.4 specifies when the enter light (//ENTLIT//) is turned on and off. This is not included under the Panel Display Functions with the other format lights because it does not depend on which Panel Display function is currently in control.

The descriptions of the Panel Display Functions in Sections 4.6.5 through 4.6.54 resemble both the descriptions of hardware data items and the descriptions of other functions. Thus they give information about the possible values (range, resolution, format) as well as showing how and when the values are changed in response to different events. These functions control the list of output data items shown below. In the list, the format lights are starred. The format section of each description shows which format lights the function turns on, as well as how the displayed value should be interpreted by the pilot (where the decimal point is assumed to be, etc.) The set of possible formats are defined in Table 4.6-a.

*//LLITDEC//	*//LLITE//	*//LLITW//	*//LLIT322//	//LWDIG1//
//LWDIG2//	//LWDIG3//	//LWDIG4//	//LWDIG5//	//LWDIG6//
//LWDIG7//	*//ULITN//	*//ULITS//	*//ULIT222//	*//ULIT321//
//UWDIG1//	//UWDIG2//	//UWDIG3//	//UWDIG4//	//UWDIG5//
//UWDIG6//	//KELIT//			

The panel data that can be entered by the pilot also play the role of input data items. Both the panel data name and the mnemonic names for the possible values can be !items! appearing in the dictionary, if they are referred to in other parts of the document. For example, !Data 23! = !Sea! refers to the condition that the most recent value entered for the Update Data 23 function was -000000, which signifies that the A/C is based on a ship.

Table 4.6-a: Panel Formats

Format Name	Format Description	Example
!angle - Lwindow!	//LLIT322//=On; seconds digits are blank	360°59' "
!angle - Uwindow!	//ULIT321//=On; seconds digits are blank	360°59'
!blank!	No format lights on and all windows blank	
!decimal point!	//LLITDEC//=On; zero fill to left	00056.01
!label!	No format lights on; blank fill to left	23
!lat!	Either //ULITN//=On OR //ULITS//=On //ULIT222//=On	S65°45'23"
!long!	Either //LLITE//=On OR //LLITW//=On //LLIT322//=On	E125°23'45"
!no lights!	No format lights on	
!north light!	//ULITN//=On and //ULIT222//=On; and all windows = $Blank$	N ° ' "
!sign!	No format lights on two values: !positive! !negative!	 0000000 -000000
!signed fraction!	No format lights on; zero fill to right Leftmost window indicates sign: either 0 or - Assumed decimal point after sign	-123000
!signed integer!	No format lights on; zero fill to left Assumed decimal point after right digit Leftmost window indicates sign: either 0 or -	-02456 -034567
!signed 2-digit!	No format lights on: zero fill to right Leftmost window indicates sign: either 0 or - Decimal point assumed after 3rd window from left	-350000
!unsigned fraction!	No format lights on: zero fill to right Assumed decimal point before left digit	012300
!unsigned integer!	No format lights on; zero fill to left Assumed decimal point after right digit	000021

4.6.1. Rules for Changing the Panel Display

Tables 4.6-b and 4.6-c specify which Panel Display Function should control the panel outputs, given the current state of the panel inputs and the current mode and program conditions.

Event Table 4.6-b
Panel Display Functions in Update Modes

MODES	EVENTS		
HUDUpd *FlyUpd* *RadarUpd* *TacUpd*	@T(In mode) OR @T(/ENTERSW/=On)	@T(!Dest called up!)	@T(/TD/=On)
MapUpd	@T(In mode) OR @T(/ENTERSW/=On)	X	@T(/TD/=On)
AflyUpd	@T(In mode) OR @T(/ENTERSW/=On)	@T(!Dest called up!)	X
PANEL DISPLAY FUNCTION	Present position section 4.6.5	Destination Coordinates section 4.6.11	Position Error section 4.6.17

Table 4.6-c shows what is displayed in other modes when switches on the panel are changed The /UPDATTW/, /MODEROT/, /PMHOLD/, and /PRESPOS/ switches may be set in any order, but the keyed-in value must be entered after the other switches are set. It is not necessary to reset the switches before another keyed-in value is entered if a different display is desired in the same mode.

In Table 4.6-c, the number in parentheses gives the subsection where the Panel Display Function is described. Thus, Present Position (5) indicates that the Present Position Panel Display Function is described in Section 4.6.5.

Table 4.6-c
Panel Display Functions in Non-Update Modes

PANEL FUNCTION	/PMHOLD/	/UPDATTW/	/MODE_ROT/	/PRESPOS/	/KBDINT/
Present Position (5)	No	X	$PRES POS$	$LAT LONG$	None
Wind (6)	No	X	$PRES POS$	$WINDS$	None
SINS X and Y Offsets (7)	No	$SINS X-Y$	$PRES POS$	$UPDATE$	None
SINS Z offset Delta Heading (8)	No	$SINS Z-DHDG$	$PRES POS$	$UPDATE$	None
Tacan Magnetic Variation (9)	No	$TAC-MV$	$PRES POS$	$UPDATE$	1-digit (Not 0)
Platform Heading (10)	No	$IMS-HUD$	$PRES POS$	$UPDATE$	None
Destination Coordinates (11)	No	X	$DEST$	X	1-digit (Not 0)
Destination ALTITUDE-MSLP (12)	No	X	$ALT-MSLP$	X	1-digit (Not 0)
Offset Range, Bearing (13)	No	X	$RNG-BRG$	X	1-digit (Not 0)
Offset Delta and Burst Height (14)	No	X	$D-BHT$	X	1-digit (Not 0)
Mark Coordinates (15)	No	X	$MARK$	X	1-digit (Not 0)
Map Coordinates (16)	Yes	X	X	X	None
Numbered Data (00-26, 70-73, 80-85, 88-99) (18-54)	No	$DATA$	$PRES POS$	$UPDATE$	2-digits

Special Cases:

In the special cases listed below, the Panel Display Functions are interrupted and the panel is temporarily set to a fixed display.

(1) Most of the Panel Display Function are identified by the setting of the switches /UPDATTW/, /PRESPOS/ and /MODEROT/. For some displays, a number must be keyed in by the pilot to complete the identification. During the time between when the switches are set and the number

is entered, the panel is blank.

(2) In *Grtest* mode, no Panel Display Functions control the panel. Instead, the panel displays the data it was showing at mode entry. When !PD Tstage! is entered (indicating that all tests have passed), all lights are turned on - the windows display 8 and !format lights on!. When the mode is exited the Panel Display Function defined by the switch settings resumes.

(3) @T(//COMPFAIL//=Yes), all panel lights are turned on.

(4) If the pilot makes an error during data entry, an error display (described in Section 4.6.2) is shown momentarily before the Panel Display Function defined by the switch settings resumes.

(5) If an update mode is exited without the update being accepted (i.e., the exit is caused by changes in one of the following inputs: /UPDATTW/, /PRESPOS/, /MODEROT/, /FLYTOTW/ or /FLYTOTOG/), the panel is blank momentarily before the panel display function defined by the switch settings resumes.

(6) @T(/PMHOLD/=Off) the panel is blank momentarily before the Panel Display Function defined by the switch settings resumes.

(7) During the stages of data entry, the panel display is described in Section 4.6.2.

(8) All 9's are displayed if any of the following conditions occurs during *TacUpd*: NOT !TACAN valid! OR /RNGSTA/ < /BAROADC/ OR /IMSMODE/ = $Grid$

(9) In an update mode, all 9's are displayed if the number keyed in for !Dest called up! is 0.

4.6.2. Rules for Entering Data

The data entry process includes the following five steps:

(1) !Alterable data displayed! must be true. *Only the value controlled by that function may be changed.*

(2) /KBDENBL/ = On

//KELIT// := On

Panel Display: blank

(3) Data keyed in using /KBDINT/ inputs

Panel Display: !echo!

(4) IF error in format or range, GO TO 1. See associated Panel Display Function for restrictions on the values.

Panel Display: All 9's, south, west, and all format lights flashed. Then display of step 1 resumed.

(5) IF /KBDENBL/ = On GOTO 1

(6) /ENTERSW/ = On

//KELIT// := Off

Panel Display: blank

Special case: To enter Present Position or SINS Z Offset/Delta heading, steps 3 and 4 may be omitted. Then the stale value is reentered. This is only important in alignment mode entry (see Table 3.6-a).

Entry or display errors:

(1) /KBDENBL/ depressed twice with no intervening /KBDINT/ or /ENTERSW/

(2) /ENTERSW/ depressed when NOT //ENTLIT//=On (See Section 4.6.4).

(3) Update modes, /KBDENBL/ depressed.

(4) In Update modes, any /KBDINT/ input after @T(!Dest called up!).

(5) In other modes, after panel switches are changed, if more /KBDINT/ buttons are pressed than specified in the /KBDINT/ column of Table 4.6-c.

(6) Attempt to display non-existent data (27-69, 74-79, 86-87)

(7) Error in data format or range (see Sections 4.6.5 through 4.6.54)

(8) When trying to enter Present Position, /ACAIRB/=Yes

(9) When trying to enter Wind, /ACAIRB/=No OR !ADC Up!

4.6.3. Change Panel MARK Display
(Demand function)

Output data item(s) affected: //MARKWIN//

Output description:

Event Table 4.6-d: Mark Window Display

MODES	EVENTS			
All modes	@T(!Power Up!)	@T(/MARKSW/=On) WHEN (NOT !Data 98 displayed!)	@T(!Data 98 displayed!) WHEN (NOT !ADC reasonable!)	@T(!Data 98 displayed!) WHEN (!ADC reasonable!)
MARK WINDOW	$Blank$	!Mark number!	1	0

4.6.4. Switch Panel ENTER Light On/Off
(Demand function)

Output data item(s) affected: //ENTLIT//

Output description:

Event Table 4.6-e: When Panel ENTER light switched on and off		
MODES	EVENTS	
Any mode except those modes listed below	@T(/KBDENBL/=On) WHEN (!Alterable data displayed! AND //ENTLIT// = Off)	@T(!Panel switch changed! OR !Panel error!) WHEN (//ENTLIT//=On) OR @T(!power up!)
HUDUpd *RadarUpd* *TacUpd* *FlyUpd* *MapUpd*	@T(/TD/ = On) WHEN (//ENTLIT//=Off)	@T(!Panel switch changed! OR !Keyboard input! OR !FLY-TO changed!) WHEN (//ENTLIT//=On)
ACTION	Switched on //ENTLIT//:= On	Switched off //ENTLIT//:= Off

4.6.5. Update Present Position Coordinates Display (Periodic function)

UPPER WINDOW: Present position latitude

When value initialized: OFP loaded

Initial value: 0°

Units: degrees, minutes, seconds

Range: N 89° 59' 59" to S89° 59' 59"

Display resolution: 1 second

Characterization of value: latitude of A/C position

Display format: !lat!

LOWER WINDOW: Present position longitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E 180 to W 180

Display resolution: 1 second

Characterization of value: longitude of A/C position

Display format: !long!

BOTH WINDOWS:

When value changed:

Event Table 4.6.5-a
When Panel Present Position Coordinates Changed

MODES	EVENTS
Sautocal *SINSaln*	@T(!pilot entry!) OR @T(!New SINS coordinates!)
Lautocal *Landaln* *01Update* *HUDaln*	@T(!pilot entry!)
Airaln *DIG*, *DI* *UDI*, *PolarDI*	@T(!Displayable difference!)
I, *OLB*	@T(!pilot entry!) WHEN (/ACAIRB/=No) OR @T(!Displayable difference!) WHEN (/ACAIRB/=Yes)
Mag sl, *Grid*	@T(!pilot entry!) WHEN (/ACAIRB/=No) OR @T(!Displayable difference!) WHEN (/ACAIRB/=Yes AND (!ADC Up! OR !Doppler Up!))

4.6.6. Update Wind Display
(Periodic function)

UPPER WINDOW: Wind velocity

When value initialized: OFP loaded

Initial value: 0

Units: knots

Range: 0 to 255 (If value > 255 entered, output undefined)

Display resolution: 1 knot

Display format: !unsigned integer!

LOWER WINDOW: Wind direction

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: 0 to 360

Display resolution: 1 second

Display format: !angle - Lwindow!

BOTH WINDOWS:

When value changed:

Event Table 4.6.6-a: When Panel Wind Display Changed

MODES	EVENTS
All alignment except *Airaln*	@T(!Displayable difference!) WHEN (!ADC Up!)
Airaln *DIG*, *DI* *UDI*, *PolarDI*	@T(!Displayable difference!) WHEN (!ADC Up!) OR @T(!pilot entry!) WHEN (NOT !ADC Up!)
I, *PolarI*	@T(!Displayable difference!) WHEN (!ADC Up!) OR @T(!pilot entry!) WHEN (/ACAIRB/=Yes AND NOT !ADC Up!)
Mag sl, *Grid* *OLB*, *IMS fail*	@T(!Displayable difference!) WHEN (!Doppler Up! AND !ADC Up!) OR @T(!pilot entry!) WHEN (/ACAIRB/=Yes AND (NOT !ADC Up! OR NOT !Doppler Up!))

4.6.7. Update SINS X and Y Offsets Display
(Periodic function)

UPPER WINDOW: SINS X offset

LOWER WINDOW: SINS Y offset

BOTH WINDOWS:

When value initialised: OFP loaded

Initial value: 0

Units: feet

Range: −2047 to +2047

Display resolution: 1 ft

Display format: !signed integer!

Characterisation of value: X offset and Y offset are the X and Y coordinates of the A/C in the SINS coordinate system. See Addendum for discussion of the SINS coordinate system. The pilot enters these values and they are never calculated by the OFP.

When value changed: @T(!pilot entry!)

4.6.8. Update SINS Z Offset and Delta Heading (Periodic function)

UPPER WINDOW: SINS Z offset

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: −2047 to +2047

Display resolution: 1 ft

Characterization of value: Z offset is the A/C Z coordinate in the SINS coordinate system. See Addendum for discussion of the SINS coordinate system. The pilot enters the value, and it is never calculated by the OFP.

Display format: !signed integer!

When value changed: @T(!pilot entry!)

LOWER WINDOW: SINS delta heading

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes

Range: 0 to 360

Display resolution: 1 minute

Characterization of value: Angle between the Ys axis of the SINS coordinate system and the Ya axis projected into the Xs-Ys plane. The angle is measured clockwise, looking down, from the Ya axis. The pilot enters the value, and it is never calculated by the OFP.

Display format: !angle - Lwindow!

When value changed: @T(!pilot entry!)

4.6.9. Update Magnetic Variation Display
(Periodic function)

UPPER WINDOW: Blank

Display format: !north light!

LOWER WINDOW: Magnetic variation

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E180 to W180

Display resolution: 1 second

Characterization of value: magnetic variation associated with a particular location, usually a TACAN station. Note: Nine magnetic variations may be stored at one time. The particular magnetic variation to be displayed or altered is identified by the single non-zero digit entered by the pilot (see Table 4.6-c).

Display format: !long!

When value changed: @T(!pilot entry!)

4.6.10. Update Platform Heading and Reference Heading Display
(Periodic function)

UPPER WINDOW: Platform heading

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes

Range: 0 to 360

Display resolution: 1 minute

Characterisation of value: !IMS heading!

Display format: !angle - Uwindow!

When value changed: @T(!Displayable difference!)

LOWER WINDOW: Azimuth Reference Heading

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes

Range: 0 to 360

Display resolution: 1 minute

Characterisation of value: Azimuth of a known reference point, that is, the angle from the Ya axis to the projection into the Xa-Ya plane of a line drawn from the A/C to the reference point. The angle is measured clockwise from the reference point to A/C heading.

Display format: !angle - Lwindow!

When value changed: @T(!pilot entry!)

4.6.11. Update Destination Coordinates Display (Periodic function)

UPPER WINDOW: Destination Latitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: N89 59 59 to S89 59 59

Display resolution: 1 second

Display format: !lat!

LOWER WINDOW: Destination Longitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E 180 to W 180

Display resolution: 1 second

Display format: !long!

BOTH WINDOWS:

Characterization of value: Coordinates of a location that the pilot wants either to fly toward, to use as a navigation update reference point, to use as a target or to use as an offset aimpoint to locate a target.

When value changed: @T(!pilot entry!) OR @T(!map destination entry!) OR @T(!data link waypoint coordinates! received) (see also Addendum).

Rules for !map destination entry!

1. /MODEROT/ = $DEST$
2. /PMHOLD = Yes
3. Slewing may occur (/SLEWUD/ and /SLEWRL/ inputs)
4. Destination number keyed in (/KBDINT/ = 1, 2... OR 9)
5. /KBDENBL/ = On
6. /ENTERSW/ = On

After the last step, the coordinates of the filmstrip location under the reference point becomes the coordinates of the destination identified in step 4.

Note: Nine sets of coordinates can be stored as destinations at one time. The particular set to be displayed or altered is identified by the single non-zero digit keyed in by the pilot (see Table 4.6-c).

4.6.12. Update Destination Altitude and MSLP Display
(Periodic function)

UPPER WINDOW: Altitude

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: ±65535

Display resolution: 2 feet (!rounded down!)

Characterization of value: altitude of associated location above or below sea level; positive: above sea level

Display format: !signed integer!

LOWER WINDOW: MSLP

When value initialized: OFP loaded

Initial value: 29.92

Units: inches of Hg

Range: 0 to 40.95

Display resolution: 0.01 inches

Characterization of value: mean sea level pressure at associated location

Display format: !decimal point!

BOTH WINDOWS:

When value changed: @T(!pilot entry!)

Note: Nine sets of altitude-MSLP may be stored at one time. The particular set to be displayed or altered is identified by the single non-zero digit keyed in by the pilot (see Table 4.6-c).

4.6.13. Update Offset Range and Bearing Display
(Periodic function)

UPPER WINDOW: Range

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 to 131.070

Display resolution: 4 feet (!rounded down!)

Characterization of value: distance from Offset Aimpoint (!OAP!) to actual target

Display format: !unsigned integer!

LOWER WINDOW: Bearing

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: 0 to 360

Display resolution: 1 second

Characterization of value: angle between line from Offset Aimpoint (!OAP!) to north and line from Offset Aimpoint to target, measured clockwise from the north line looking down

Display format: !angle - Lwindow!

BOTH WINDOWS:

When value changed: @T(!pilot entry!)

Note: Nine offset range-bearing sets may be stored at one time. The particular set to be displayed or altered is identified by the single non-zero digit keyed in by the pilot (see Table 4.6-c).

4.6.14. Update Offset Delta Height and Burst Height
(Periodic function)

UPPER WINDOW: Delta height

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: ±65535

Display resolution: 2 feet (!rounded down!)

Characterization of value: difference in altitude between Offset aimpoint (!OAP!) and !target!; positive value means !OAP! below !target!, negative value means !OAP! above !target!.

Display format: !signed integer!

When value changed: @T(!pilot entry!)

LOWER WINDOW: Burst height

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 - 65535

Display resolution: 2 feet (!rounded down!)

Characterization of value: height above ground where bomb to burst for that destination

Display format: !unsigned integer!

When value changed: @T(!pilot entry!)

Note: Nine delta-height/burst-height sets may be stored at one time. The particular set to be displayed or altered is identified by the single non-zero digit keyed in by the pilot (see Table 4.6-c).

4.6.15. Update Mark Coordinates Display
(Periodic function)

UPPER WINDOW: !Mark location! latitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: N89 59 59 to S89 59 59

Display resolution: 1 second

Display format: !lat!

LOWER WINDOW: !Mark location! longitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E180 to W180

Display resolution: 1 second

Display format: !long!

BOTH WINDOWS:

Characterization of value: !Mark location! coordinates.

4.6.16. Update Map Coordinates Display
(Periodic function)

UPPER WINDOW: Map latitude

Units: degrees, minutes, seconds

Range: N89 59 59 to S89 59 59

Display resolution: 1 second

Display format: !lat!

LOWER WINDOW: Map longitude

Units: degrees, minutes, seconds

Range: E 180 to W 180

Display resolution: 1 second

Display format: !long!

BOTH WINDOWS:

Characterization of value: coordinates of position under reference point of PMDS (see Section 4.5.4)

When value changed: @T(/PMHOLD/ = \$Yes\$) OR @T(!Displayable difference!) WHEN (/PMHOLD/=\$Yes\$)

Note: The differences will be caused by slew control inputs (/SLEWUD/ and /SLEWRL/ at !Map rate!. Because the values are only changed when (/PMHOLD/ = \$Yes\$), the A/C movement does not change the values.

4.6.17. Update Position Error Display
(Periodic function)

UPPER WINDOW: error in latitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: N90 to S90

Display resolution: 1 second

Display format: !lat!

LOWER WINDOW: Error in longitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E180 to W180

Display resolution: 1 second

Display format: !long!

BOTH WINDOWS:

Characterization of value: The position error is the difference between the coordinates of the two reference points given in Table 4.6.17-a. The position error is measured from the first reference point to the second. The direction of the error is shown by the format lights. For example, //ULITN// = On and //LLITE// = On means the error is north east, that is, the second point is northeast of the first.

Selector Table 4.6.17-a: Update Mode Reference Points

MODES	FIRST REFERENCE POINT	
HUDUpd	!Called-up point!	!fixpoint! (indicated by AS)
RadarUpd	!Called-up point!	!fixpoint! (indicated by Radar cursors)
FlyUpd	!Called-up point!	A/C present position
TacUpd	A/C present position	position calculated from !Called-up point! coordinates, /RNGSTA/ and /BRGSTA/
MapUpd	A/C present position	!fixpoint! (indicated by map display position)

When value changed:

Event Table 4.6-17-b: When Panel Position Error Changed

MODES	EVENTS
HUDUpd *FlyUpd* *RadarUpd*	@T(/TD/ = On)
TacUpd	@T(/TD/ = On) OR @T(!Displayable difference!) WHEN (/TD/ = On)
MapUpd	@T(/TD/ = On) OR @T(!Displayable difference!) WHEN (!Desig! AND !During slewing!)

4.6.18. Update DATA 00
(Periodic function)

UPPER WINDOW: 00

Display format: !label!

LOWER WINDOW: north gyro drift delta

When value initialized: *Landaln*: @T(!CL stage!)

Initial value: 0

Units: deg/hour

Range: ±0.99

Display resolution: 0.001

Characterization of value: Difference between newly calculated !north gyro drift! and the value previously stored under Data 01. This value is changed whether or not @T(!New 01 test passed!) occurs.

Display format: !signed fraction!

When value changed:

01Update: @T(!TS stage complete!)
Landaln: @T(In mode), set to 0.

4.6.19. Update DATA 01
(Periodic function)

UPPER WINDOW: 01

Display format: !label!

LOWER WINDOW: !north gyro drift!

When value initialized: OFP loaded

Initial value: 0

Units: deg/hour

Range: −1 to +1

Display resolution: 0.001

Characterization of value: Rate of drift of the gyro associated with the Y axis. Positive is CW looking along the Y axis from the origin in the positive direction.

Display format: !signed fraction!

When value changed:

Event Table 4.6.19-a: When Panel Data 01 Changed

MODES	EVENTS
Lautocal *Sautocal*	@T(!ND stage complete!) OR @T(!pilot entry!)
01Update	@T(!TS stage complete!) WHEN (!New 01 test passed!) OR @T(!pilot entry!)
Other alignment and navigation modes	@T(!pilot entry!)

4.6.20. Update DATA 02
(Periodic function)

UPPER WINDOW: 02

Display format: !label!

LOWER WINDOW: east gyro drift

When value initialized: OFP loaded

Initial value: 0

Units: deg/hour

Range: −1 to +1

Display resolution: .001

Characterization of value: Rate of drift of the gyro associated with the X axis. Positive is CW looking along the X axis from the origin in the positive direction.

Display format: !signed fraction!

When value changed:

Event Table 4.6.20-a: When Panel Data 02 Changed

MODES	EVENTS
Lautocal *Sautocal*	@T(!ED stage complete!) OR @T(!pilot entry!)
Other navigation or alignment modes	@T(!pilot entry!)

4.6.21. Update DATA 03
(Periodic function)

UPPER WINDOW: 03

Display format: !label!

LOWER WINDOW: vertical gyro drift

When value initialized: OFP loaded

Initial value: 0

Units: deg/hour

Range: −1 to +1

Display resolution: .001

Characterization of value: Rate of drift of gyro associated with Z axis. Positive is CW, looking along the Z axis from the origin in the positive direction. This value is specific to an individual IMU and is never calculated by the OFP.

Display format: !signed fraction!

When value changed: @T(!pilot entry!)

4.6.22. Update DATA 04-06 (north, east, vertical)
(Periodic function)

UPPER WINDOW: 04, 05, 06

Display format: !label!

LOWER WINDOW: gyro scale

When value initialized: OFP loaded

Initial value: Depends on IMU

Units: second/pulse

Range: .32 to .48

Display resolution: .0004

Characterization of value: Amount of rotation represented by each //*GYCOM// pulse. where * is Y for north (04), X for east (05) and Z for vertical (06). These values are specific to an individual IMU and never calculated by OFP

Display format: !unsigned fraction!

When value changed: @T(!pilot entry!)

4.6.23. Update DATA 07-09 (North, East, Vertical)
(Periodic function)

UPPER WINDOW: 07, 08, 09

Display format: !label!

LOWER WINDOW: delta velocity scale (low gain)

When value initialized: OFP loaded

Initial value: 0

Units: feet/second/pulse

Range: .026 to .038

Display resolution: .00003

Characterization of value:

Data 07, 08: The increment in velocity represented by each /*VEL/ count when /IMSSCAL/ = $Coarse$. * is Y for north (07) and X for east (08).

Data 09: The increment in velocity represented by each /ZVEL/ count.

These numbers are specific to an individual IMU and are never calculated by the OFP.

Display format: !unsigned fraction!

When value changed: @T(!pilot entry!)

Note: Although 0 is displayed as the initial value, the value loaded is a large number to prevent the platform from operating almost normally before the maintenance personnel load the correct parameters.

4.6.24. Update DATA 10-11 (north, east)
(Periodic function)

UPPER WINDOW: 10, 11

Display format: !label!

LOWER WINDOW: delta velocity scale (high gain)

When value initialized: OFP l. aded

Initial value: 0

Units: feet/second/pulse

Range: .00026 to .00038

Display resolution: .000001

Characterization of value: The increment in velocity represented by each /*VEL/ count when /IMSSCAL/ = $Fine$. * is Y for north (10) and X for east (11). This value is specific to an individual IMU and is never calculated by the OFP.

Display format: !unsigned fraction!

When value changed: @T(!pilot entry!)

Note: Although 0 is displayed as the initial value, the value loaded is a large number to prevent the platform from operating almost normally before the maintenance personnel load the correct parameters.

4.6.25. Update DATA 12-14 (north, east, vertical)
(Periodic function)

UPPER WINDOW: 12, 13, 14

Display format: !label!

LOWER WINDOW: delta velocity bias (low gain)

When value initialized: OFP loaded

Initial value: 0

Units: feet/s^2

Range: horizontal: −.02 to +.02; vertical: −.1 to +.1

Display resolution: .0003

Characterization of value: Each incremental velocity measurement contains an error caused by gyro-accelerometer misalignment. These are corrections to be applied for the Y axis (12) and X axis (13) when /IMSSCAL/ = $Coarse$ and for the Z axis (14) always. These numbers are specific to an individual IMU and are never calculated by OFP.

Display format: !signed fraction!

When value changed: @T(!pilot entry!)

4.6.26. Update DATA 15-16 (north, east)
(Periodic function)

UPPER WINDOW: 15, 16

Display format: !label!

LOWER WINDOW: delta velocity bias (high gain)

When value initialized: OFP loaded

Initial value: 0

Units: feet/s^2

Range: −.01 to +.01

Display resolution: .0003

Characterization of value: Each incremental velocity measurement contains an error caused by gyro-accelerometer misalignment. These are corrections to be applied for the Y axis (15) and X axis (16) when /IMSSCAL/ = $Fine$. These numbers are specific to an individual IMU and never calculated by the OFP.

Display format: !signed fraction!

When value changed: @T(!pilot entry!)

4.6.27. Update DATA 17-18 (area A, area B)
(Periodic function)

UPPER WINDOW: 17, 18

Display format: !label!

LOWER WINDOW: map control longitude

When value initialised: OFP loaded

Initial value: 0

Units: deg/min/s

Range: +180

Display resolution: 1 second

Characterization of value: Longitude of center line on map, area A (17) and area B (18). These numbers are specific to an individual filmstrip and are never calculated by the OFP.

Display format: !long!

When value changed: @T(!pilot entry!)

4.6.28. Update DATA 19-20 (area A, area B)
(Periodic function)

UPPER WINDOW: 19, 20

Display format: !label!

LOWER WINDOW: map control latitude

When value initialized: OFP loaded

Initial value: 0

Units: integer counts

Range: −90 to +90 (N80 to S80 degrees)

Display resolution: 10 seconds

Characterization of value: Latitude of southernmost part of map in area A (19) and area B (20). The indicated value entered is in integer counts. To get a standard value in degrees, minutes and seconds, use the following equation:

standard value = indicated value × (53' 20")

These values are specific to an individual filmstrip and are never calculated by the OFP.

Display format: !signed integer!

When value changed: @T(!pilot entry!)

4.6.29. Update DATA 21-22 (area A, area B)
(Periodic function)

UPPER WINDOW: 21, 22

Display format: !label!

LOWER WINDOW: orientation

When value initialized: OFP loaded

Initial value: !positive!

Characterization of value: Orientation of the long axis of filmstrip of area A (21) and area B (22).

!positive!: !NS!: map oriented north-south
!negative!: !EW!: map oriented east-west

Display format: !sign!

When value changed: @T(!pilot entry!)

4.6.30. Update DATA 23
(Periodic function)

UPPER WINDOW: 23

Display format: !label!

LOWER WINDOW: land or sea based

When value initialised: OFP loaded

Initial value: !positive!

Characterization of value: Whether the A/C is operating on land or at sea on a carrier. A display or !pilot entry! of !positive! (!negative!) indicates !Land! (!Sea!).

Display format: !sign!

When value changed: @T(!pilot entry!)

4.6.31. Update DATA 24
(Periodic function)

UPPER WINDOW: 24

Display format: !label!

LOWER WINDOW: vertical ranging priority

When value initialized: @T(!power up!) WHEN (/IMSREDY/= No AND /ACAIRB/ = No) OR @T(!present position entered!)

Initial value: !negative!

Display format: !sign!

Characterization of value: Which sensor is used for ranging when the FLR not available. A display or !pilot entry! of !positive! (!negative!) indicates radar (baro) altimeter has priority over baro (radar) altimeter.

When value changed: @T(!pilot entry!)

4.6.32. Update DATA 25
(Periodic function)

UPPER WINDOW: 25

Display format: !label!

LOWER WINDOW: Doppler use

When value initialized: @T(!power up!) WHEN (/IMSREDY/= No AND /ACAIRB/ = No) OR @T(!present position entered!)

Initial value: !negative!

Display format: !sign!

Characterization of value: Whether Doppler velocities should be used to damp system velocities and to calculate platform corrections when /IMSMODE/ = $Iner$. A display or !pilot entry! of !positive! (!negative!) indicates that Doppler should (should not) be used.

When value changed: @T(!pilot entry!)

4.6.33. Update DATA 26
(Periodic function)

UPPER WINDOW: 26

Display format: !label!

LOWER WINDOW: ADC equation

When value initialized: OFP loaded

Initial value: !negative!

Display format: !sign!

Characterization of value: Which equations should be used for true airspeed calculations.

!positive!: !L-probe! - L-probe equations used.
!negative!: !Non L-probe! - non L-probe equations used

When value changed: @T(!pilot entry!)

4.6.34. Update DATA 70
(Periodic function)

Characterization of value: Data 70 shows the state of the following input discretes, in the pattern shown below the list. Given after each input data item is the value that causes the corresponding panel window to show a \$1\$; the other value causes the window to show a \$0\$. A '-' in a diagram means the window is always \$Blank\$.

1	/STA1RDY/	\$Yes\$
2	/STA2RDY/	\$Yes\$
3	/STA3RDY/	\$Yes\$
4	/STA6RDY/	\$Yes\$
5	/STA7RDY/	\$Yes\$
6	/STA8RDY/	\$Yes\$
7	/GUNSSEL/	\$Yes\$
8	/RE/	\$On\$
9	/MULTRACK/	\$Yes\$
10	/TD/	\$On\$

	1	2	3	4	5	6	UPPER WINDOW
7	8	9	10	-	-	-	LOWER WINDOW

Display format: !no lights!

When value changed: Whenever one of the represented conditions changes value

4.6.35. Update DATA 71
(Periodic function)

Characterization of value: Data 71 shows the state of the following input discretes, in the pattern shown below the list. Given after the input data item is the value that causes the corresponding panel window to show a 1; the other value causes the window to show a 0. A '-' in a diagram means the window is always $Blank$.

1	/BMBDRAG/	$High$
2	/MFSW/	$NATT$ OR $NATTOFF$
3	/MFSW/	$NATTOFF$ OR $BOCOFF$
4	/MFSW/	BOC OR $BOCOFF$
5	/MFSW/	$CCIP$
6	/MFSW/	TF
7	/PMSCAL/	80
8	/PMHOLD/	Yes
9	/PMDCTR/	Yes
10	/PMNORUP/	Yes
11	/PMSLAND/	Yes
12	/HUDREL/	Yes

	1	2	3	4	5	6	UPPER WINDOW
7	8	9	10	11	12	-	LOWER WINDOW

Display format: !no lights!

When value changed: Whenever one of the represented conditions changes value

4.6.36. Update DATA 72
(Periodic function)

Characterization of value: Data 72 shows the state of the following input discretes, in the pattern shown below the list. Given after each input data item is the value that causes the corresponding panel window to show 1; other values cause the window to show a 0. A '-' in a diagram means the window is always $Blank$.

1	/IMSREL/	\$Yes\$
2	/ACAIRB/	\$Yes\$
3	/MA/	\$On\$
4	/IMSMODE/	\$Gndal\$
5	/IMSMODE/	\$Norm\$
6	/IMSMODE/	\$Iner\$
7	/IMSMODE/	\$Grid\$
8	/IMSMODE/	\$Magsl\$
9	/IMSREDY/	\$No\$
10	/IMSAUTOC/	\$On\$
11	/ADCFAIL/	\$Yes\$
12	/ARPPAIRS/	\$Yes\$

	1	2	3	4	5	6	UPPER WINDOW
7	8	9	10	11	12	-	LOWER WINDOW

Display format: !no lights!

When value changed: Whenever one of the represented conditions changes value

4.6.37. Update DATA 73
(Periodic function)

UPPER WINDOW: IMS true heading

Units: degrees, minutes

Range: 0° to 360°

Display resolution: ±1 minute

Characterization of value: !IMS heading!

Display format: !angle - Uwindow!

When value changed: @T(!Displayable difference!)

LOWER WINDOW: IMS magnetic heading

Units: degrees, minutes

Range: 0° to 360°

Display resolution: ±1 minute

Characterization of value: !magnetic heading!

Display format: !angle - Lwindow!

When value changed: @T(!Displayable difference!)

4.6.38. Update DATA 80
(Periodic function)

UPPER WINDOW: Baro above ground level altitude

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 to 65535

Display resolution: 1 foot

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.38-a: Data 80 Upper Window Values

MODES	EVENTS	
AflyUpd	X	@T(!Dest called up!) OR @T(/TD/=On)
Nattack,*Noffset* *BOCFlyto0* *SBOCFlyto0* *Snattack*,*Snoffset* *HUDdown1* *SHUDdown1*	@F(!Desig!) OR @T(In mode)	@T(!Desig!) OR @T(!slewing finished!) WHEN (!rls pts passed! = 0)
BOC *SBOC*	@T(In mode AND !Range! > 30 nmi)	@T(!Range! ≤ 30 nmi) OR @T(!slewing finished!) WHEN (!Range! ≤ 20 nmi AND !rls pts passed! = 0)
BOCoffset *SBOCoffset* *HUDdown2* *SHUDdown2*	@T(In mode) OR @F(!Desig!) OR @T(!Range! > 30 nmi)	@T(!Desig!) OR @T(!slewing finished!) WHEN (!Range! ≤ 20 nmi AND !rls pts passed! = 0) OR @T(!Range! ≤ 30 nmi)
CCIP	@T(In mode)	@T(!Displayable difference!) WHEN ((!impact angle elevation!≤16° AND !rls pts passed! = 0) OR !target return to view!) OR @T(!impact angle elevation!≤16°) WHEN (!Displayed difference! AND !rls pts passed!=0)
BARO AGL VALUE	0	!Baro altitude above target!

In Event Table 4.6.38-a. !Range! is defined as follows: In *BOC* or *SBOC* modes, or if !Desig!, it means !Range! to !target!. Otherwise, it means !Range! to !OAP!.

LOWER WINDOW: Priority altitude ranging

When value initialized: OFP loaded

Units: feet

Initial value: 0

Range: 0 to 65535 feet

Display resolution: 1 foot

Display format: !unsigned integer! preceded by a letter showing which sensor is being used (see Table 4.6.38-c): F for FLR, A for radar altimeter, and H for ADC baroaltimeter.

Value description and when value changed:

Event Table 4.6.38-b: Data 80 Lower Window Values

MODES	EVENTS	
Nattack *Noffset* *Snattack* *Snoffset* *HUDdown1* *SHUDdown1* *HUDdown2* *SHUDdown2*	@T(In mode) OR @F(!Desig!)	@T(!Desig!) OR @T(!slewing finished!) WHEN (!rls pts passed! = 0) OR @T(!Slant range reasonable!) WHEN (!Desig! AND !rls pts passed! = 0)
BOCFlyto0 *SBOCFlyto0*	@T(In mode) OR @F(!Desig!)	@T(!Desig!) OR @T(!slewing finished!) WHEN (!rls pts passed! = 0)
BOC *SBOC*	@T(In mode AND !Range! > 30 nmi)	@T(!Range! ≤ 30 nmi) OR @T(!slewing finished!) WHEN (!Range! to !target! ≤ 20 nmi AND !rls pts passed! = 0)
BOCoffset *SBOCoffset*	@T(In mode) OR @F(!Desig!) OR @T(!Range! > 30 nmi)	@T(!Desig!) OR @T(!slewing finished!) WHEN (!Range! ≤ 20 nmi AND !rls pts passed! = 0) OR @T(!Range! to !OAP! ≤ 30 nmi) WHEN(NOT !Desig!) OR @T(!Range! to !target! ≤ 30 nmi) WHEN(!Desig!)
CCIP	@T(In mode)	@T(!Displayable difference! AND !impact angle elevation!≤16°) WHEN(!rls pts passed! = 0 OR !target return to view!)
No listed weapon mode	@T(In mode)	X
PRIORITY ALTITUDE	0 feet	Altitude from priority sensor (See table 4.6.38-c)

The altitude shown in the lower window of Data 80 is either above ground level or above sea level, as shown in Table 4.6.38-c. The table also shows the actual value used under different conditions.

Condition Table 4.6.38-c: Altitude from Priority Sensor			
MODES	CONDITIONS		
Nattack *Noffset* *CCIP* *Snattack* *Snoffset* *HUDdown1* *SHUDdown1*	!Slant range reasonable!	NOT !Slant range reasonable! AND !Data 24!=!Radalt!	NOT !Slant range reasonable! AND !Data 24!=!Baro!
BOC *BOCFlyto0* *BOCoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *HUDdown2* *SHUDdown2*	X	!Data 24!=!Radalt!	!Data 24!=!Baro!
ALTITUDE	Above ground: !Altitude from slant range!	Above ground: /RADALT/	Above sea level /BAROADC/

Selector Table: 4.6.38-d: When Data 80 Displayed	
MODES	DATA 80 DISPLAY
A/A Guns *A/G Guns* *Walleye* *Manrip*	!blank!
All other weapon modes	Display given by Table 4.6.38-a and Table 4.6.38-b.

4.6.39. Update DATA 81
(Periodic function)"

UPPER WINDOW: Slant range at moment of release

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 to 262141

Display resolution: 8 feet

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.39-a: Data 81 Upper Window Value

MODES	EVENTS		
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *HUDdown1* *HUDdown2* *SHUDdown1* *SHUDdown2*	X	@T(!rls pts passed!=1)	X
CCIP	X	X	@T(!rls pts passed!=1)
Manrip	@T(In mode)	X	X
VALUE	0	!slant range! to !target!	!slant range! to !impact point!

LOWER WINDOW: Above ground level altitude at release

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 to 65535

Display resolution: 1 foot

Display format: !unsigned integer!

Characterization of value: Above ground level altitude, from highest priority available sensor:

Condition Table 4.6.39-b: Data 81 Lower Window Value			
MODES	CONDITIONS		
Nattack *Noffset* *CCIP* *Snattack* *Snoffset* *HUDdown1* *SHUDdown1*	!Slant range reasonable!	(NOT !Slant range reasonable!) AND !Data 24!=!Radalt!	(NOT !Slant range reasonable!) AND !Data 24!=!Baro!
BOC *BOCFlyto0* *BOCoffset* *Manrip* *SBOC* *SBOCFlyto0* *SBOCoffset* *HUDdown2* *SHUDdown2*	X	!Data 24!=!Radalt!	!Data 24!=!Baro!
ALTITUDE	!Altitude from slant range!	/RADALT/	!Baro altitude above target!

When value changed: @T(!rls pts passed! = 1) WHEN(*Nattack*, *Noffset*, *BOC*, *BOCFlyto0*, *BOCoffset*, *CCIP*, *Manrip*, *Snattack*, *Snoffset*, *SBOC*, *SBOCFlyto0*, *SBOCoffset* *HUDdown1*, *HUDdown2*, *SHUDdown1*, OR *SHUDdown2*)

4.6.40. Update DATA 82
(Periodic function)

UPPER WINDOW: !azimuth miss distance!

When value initialized: OFP loaded

Initial value: 0

Units: feet

Range: 0 to 65535

Display resolution: 1 foot

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.40-a: Data 82 Upper Window Value

MODES	EVENTS	
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset* *HUDdown1* *HUDdown2* *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	X	@T(!rls pts passed! = 1)
CCIP, *Manrip*	@T(In mode)	X
VALUE	0	!azimuth miss distance!

LOWER WINDOW: Weapon release angle

When value initialized: OFP loaded.

Initial value: 0

Units: degrees

Range: −180 to +180 (special); −90 to +90 (conventional)

Display resolution: 0.01 degree

Characterization of value: !weapon release angle!

Display format: !decimal point!

When value changed:

Nattack
Noffset
BOC @T(!rls pts passed! = 1)
BOCFlyto0
BOCoffset
CCIP
Manrip
HUDdown1
HUDdown2
Snattack
Snoffset
SBOC
SBOCFlyto0
SBOCoffset
SHUDdown1
SHUDdown2

4.6.41. Update DATA 83
(Periodic function)

UPPER WINDOW: True airspeed at release

When value initialized: OFP loaded

Initial value: 0

Units: knots

Range: 0 to 32767

Display resolution: 1 knot

Characterization of value: /TAS/

Display format: !unsigned integer!

LOWER WINDOW: G's at release

When value initialized: OFP loaded

Initial value: 0

Units: g's

Range: 0 to 32767

Display resolution: 0.1 g

Characterization of value: !normal acceleration!

Display format: !decimal point!

BOTH WINDOWS:

When value changed:

Nattack, *Noffset*	
BOC, *BOCFlyto0*	@T(!rls pts passed! = 1)
BOCoffset	
CCIP, *Manrip*	
Snattack, *Snoffset*	
SBOC, *SBOCFlyto0*	
SBOCoffset	
HUDdown1, *HUDdown2*,	
SHUDdown1, *SHUDdown2*	

4.6.42. Update DATA 84
(Periodic function)

UPPER WINDOW: Weapon quantity

Range: 0 to 99

Display resolution: 1

Characterization of value: /ARPQUANT/

Display format: !unsigned integer!

When value changed: @T(/ARPQUANT/ changed) WHEN(!rls pts passed!=0)

LOWER WINDOW: Weapon interval

Units: feet

Range: 10 to 990

Display resolution: 10 feet

Characterization of value: /ARPINT/

Display format: !unsigned integer!

When value changed: @T(/ARPINT/ changed) WHEN (!rls pts passed!=0)

4.6.43. Update DATA 85
(Periodic function)

UPPER WINDOW: Blank

LOWER WINDOW: ASCU code

Range: 00-99

Display resolution: 1

Characterization of value: /WEAPTYP/

Display format: !unsigned integer!

When value changed: @T(/WEAPTYP/ changed)

4.6.44. Update DATA 88
(Periodic function)

UPPER WINDOW: Alignment stage

When value initialized: power up

Initial value: blank

Characterization of value: two-letter code identifying the current alignment stage:

CL	!CL stage!
CA	!CA stage!
HL	!HL stage!
FG	!FG stage!
HG	!HG stage!
ND	!ND stage!
ED	!ED stage!
FG	!TS stage!
-	!FM stage!
-	!HS stage!

Display format: - - L L - -, where the -'s indicate blanks

When value changed: @T(!New stage!)

LOWER WINDOW: Elapsed time in alignment or navigation

When value initialized:

@T(!power up!) OR
@T(!CL stage!) OR
@T(//IMSNA//=Off) WHEN(In an alignment mode) OR
@T(!FG stage!) WHEN (//IMSNA//=Off) OR
@T(*01Update*) OR
@F(/IMSMODE/ = $Gndal$) OR
@T(!time elapsed! = 6 hr 45 min)

Initial value: 0

Units: hours, minutes, seconds

Range: 0 to 6 hr 45 min

Display resolution: 1 second

Characterization of value: !time elapsed!

Display format: !angle - Lwindow!

When value changed: @T(!Displayable difference!)

4.6.45. Update DATA 89
(Periodic function)

UPPER WINDOW: Blank

LOWER WINDOW: time-to-go to reach destination

Units: hours, minutes, seconds

Range: 0 to 6 hr 45 min

Display resolution: 1 second

Characterization of value: time-to-go before !Fly-to point! reached, assuming direct flight:
(!Range! to !Fly-to point!)/(!System horizontal velocity!)

If (time-to-go > 6 hr 45 min), zero is displayed

Display format: !angle - Lwindow!

When value changed: @T(!Displayable difference!)

4.6.46. Update DATA 90
(Periodic function)

UPPER WINDOW: SINS latitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: N 90 to S 90

Display resolution: 1 second

Display format: !lat!

LOWER WINDOW: SINS longitude

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes, seconds

Range: E 180 to W 180

Display resolution: 1 second

Display format: !long!

BOTH WINDOWS:

Characterization of value: ship's coordinates received over SINS data link

When value changed: *Sautocal*, *SINSaln*: @T(!New SINS coordinates!)

4.6.47. Update DATA 91
(Periodic function)

UPPER WINDOW: IMS heading

Units: degrees, minutes

Range: 0 to 360 degrees

Display resolution: 1 minute

Characterization of value:

Condition Table 4.6.47-a: Data 91 Upper Window Display

MODES	CONDITIONS	
All modes	!IMS Up!	NOT !IMS Up!
HEADING VALUE	!IMS heading!	!magnetic heading! + !IMS magnetic variation!

Display format: !angle - Uwindow!

When value changed: @T(!Displayable difference!)

LOWER WINDOW: SINS heading

When value initialized: OFP loaded

Initial value: 0

Units: degrees, minutes

Range: 0 to 360

Display resolution: 1 minute

Characterization of value: !SINS heading! (ship's heading)

Display format: !angle - Lwindow!

When value changed: *Sautocal* OR *SINSaln*: @T(!New SINS heading!)

4.6.48. Update DATA 92 (north) and 93 (east)
(Periodic function)

UPPER WINDOW: IMS velocity (north, east)

When value initialized: OFP loaded

Initial value: 0

Units: knots

Range: –2047 to +2047

Display resolution: 1 knot

Display format: !signed integer!

Value description and when value changed:

Event Table: 4.6.48-a: Data 92/93 Upper Window Value

MODES	EVENTS	
SINSaln *Sautocal*	@T(!New stage!)	@T(!Displayable difference!)
All other navigation or alignment modes	X	@T(!Displayable difference!)
DATA 92 VALUE DATA 93 VALUE	!SINS NVel! !SINS EVel!	!IMS NVel! !IMS EVel!

LOWER WINDOW: SINS velocity (north, east)

When value initialized: OFP loaded

Initial value: 0

Units: knots

Range: –2047 to 2047

Display resolution: 1 knot

Display format: !signed integer!

Characterization of value: !SINS NVel! (92) and !SINS EVel! (93)

When value changed:

Sautocal *SINSaln*	@T(!New SINS velocities!)

4.6.49. Update DATA 94
(Periodic function)

BOTH WINDOWS: SINS status

When value initialized: OFP loaded

Initial value: all zeros

Units: discrete

Characterization of value: During *Sautocal* and *SINSaln*. Data 94 shows the validity of the various data received over the SINS data link. The classified addendum explains how the validity of each datum is determined. The display is arranged in the pattern shown below; a 1 in the window indicates the datum is invalid while a 0 indicates that it is valid. A '-' indicates that the window is always blank.

1	!SINS heading!
2	!SINS NVel!
3	!SINS roll!
4	!SINS EVel!
5	!SINS pitch!
6	!SINS latitude!
7	!SINS longitude!

	1	-	2	-	3	-		UPPER WINDOW
4	-	5	-	6	-	7		LOWER WINDOW

During all other modes, the non-blank windows above are all set to 1.

Display format: !no lights!

When value changed: *Sautocal*, *SINSaln*: @T(one of the conditions changes) OR @F(In mode)

4.6.50. Update DATA 95
(Periodic function)

UPPER WINDOW: IMS ground speed

When value initialized:

power up
Landaln, *SINSaln*: @F(In mode) WHEN (/ACAIRB/=No)

Initial value: 0

Units: knots

Range: 0 to 1214

Display resolution: 1 knot

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.50-a: Data 95 Upper Window Values

MODES	EVENTS	
All navigation or alignment modes except *IMS fail*	@T(!Displayable difference!)	X
IMS fail	X	@T(In mode)
GROUNDSPEED VALUE	magnitude of vector sum of !IMS NVel! and !IMS EVel! (see §4.6.48)	0

LOWER WINDOW: Doppler ground speed

When value initialized: power up

Initial value: 0

Units: knots

Range: 0 to 1214

Display resolution: 1 knot

Characterization of value:

!Doppler Up!: smoothed !DGNDSP!
NOT !Doppler Up!: 0

Display format: !unsigned integer!

When value changed: @T(!Displayable difference!) WHEN(!Doppler Up!) OR @F(!Doppler Up!)

4.6.51. Update DATA 96
(Periodic function)

UPPER WINDOW: IMS drift angle

Value description and when value changed:

Event Table 4.6.51-a: Data 96 Upper Window Values		
MODES	EVENTS	
All navigation or alignment modes except *IMS fail*	@T(!Displayable difference!)	X
IMS fail	X	@T(In mode)
DRIFT ANGLE VALUE	!IMS drift angle!	0

LOWER WINDOW: Doppler drift angle

Characterization of value:

!Doppler Up! : /DRFTANG/ averaged over 3 seconds
NOT !Doppler Up! : 0

When value changed: @F(!Doppler Up!) OR @T(!Displayable difference!) WHEN(!Doppler Up!)

BOTH WINDOWS:

Units: degrees

Range: +180 degrees

Display resolution: 1 degree

Display format: !signed integer!

4.6.52. Update DATA 97
(Periodic function)

UPPER WINDOW: IMS total velocity

When value initialised: OFP loaded

Initial value: 0

Units: knots

Range: 0 to 1214

Display resolution: 1 knot

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.52-a: Data 97 Upper Window Values

MODES	EVENTS	
All navigation or alignment modes except *IMS fail*	@T(!Displayable difference!)	X
IMS fail	X	@T(In mode)
TOTAL SPEED VALUE	magnitude of vector sum of !IMS NVel!, !IMS EVel!, !IMS Vvel! (see §4.6.48)	0

LOWER WINDOW: ADC true airspeed

When value initialized: OFP loaded

Initial value: 0

Units: knots

Range: 0 to 1214

Display resolution: 1 knot

Display format: !unsigned integer!

Value description and when value changed:

Event Table 4.6.52-b: Data 97 Lower Window Value

MODES	EVENTS	
All modes	@T(/ACAIRB/=No) OR @F(!ADC Up!)	@T(!Displayable difference!) WHEN (/ACAIRB/=Yes AND !ADC Up!)
VALUE	0	/TAS/

4.6.53. Update DATA 98
(Periodic function)

Both windows and Mark window: Navigation status

Characterization of value: Data 98 shows the operating status of the 3 main sensors used for navigation: the ADC, the IMS and the Doppler. It shows whether the following conditions are true or false. The pattern below shows how the conditions are indicated in the windows. If a condition is true, the corresponding window is 1, otherwise it is 0. The windows shown with '-' are always $Blank$.

1 /ACAIRB/=No
2 *Magsl* OR *Grid* OR *IMSfail* OR (*Airaln* AND !FM stage!)
3 /IMSREDY/=No
4 /IMSREDY/=No OR /IMSREL/=No
5 NOT !IMS Reasonable!
6 /DRSREL/=No
7 NOT !Doppler Reasonable!
8 NOT !ADC Reasonable!

	1	-	2	-	3	-		UPPER WINDOW
4	-	5	-	6	-	7		LOWER WINDOW
						8		MARK WINDOW

Display format: !no lights!

When value changed: any one of the conditions changes

Note: The value of the mark window is given here for completeness, though Section 4.6.3 completely defines the value shown in the mark window.

4.6.54. Update DATA 99
(Periodic function)

BOTH WINDOWS: OFP Identification

When value initialized: OFP loaded

Characterization of value: character string identifying version of program; current string:

Upper Window:	OFP-A7
Lower Window:	NWC-2

Display format: !no lights!

4.7. HORIZONTAL SITUATION INDICATOR FUNCTIONS

4.7.0. Reference Points for HSI Functions

Both HSI range and HSI bearing are defined relative to some outside reference point that varies according to mode and conditions as shown in the table below:

Condition Table 4.7-a: Reference Point for HSI Displays

MODES	CONDITIONS			
All alignment and nav modes, none of the modes below; *Walleye* *A/G Guns*	/FLYTOTW/=0	/FLYTOTW/≠0)	X	X
Nattack *HUDdown1* *Snattack* *SHUDdown1*	NOT !Desig! AND /FLYTOTW/=0	NOT !Desig! AND /FLYTOTW/≠0)	X	!Desig!
Noffset *HUDdown2* *Snoffset* *SHUDdown2*	X	NOT !Desig! AND !Before slewing!	NOT !Desig! AND !After slewing!	!Desig!
BOC *SBOC*	X	!Before slewing! OR !Range! > 30	X	!After slewing! AND !Range!≤30
BOCFlyto0 *SBOCFlyto0*	NOT !Desig!	X	X	!Desig!
BOCoffset *SBOCoffset*	X	!Range! > 30 AND NOT !Desig!	!Range!≤30 AND NOT !Desig!	!Desig!
REFERENCE POINT	none	!Fly-to point!	!OAP!	!target!

!Range! means !ground range! to !Fly-to point!, in nmi

4.7.1. Update HSI Bearing Indicator
(Periodic function)

Initiation and termination:

Event Table 4.7-b: When //BRGDEST// Must Be Output		
MODES	EVENTS	
NOT *Grtest*	@T(In mode)	X
Grtest	@F(In mode) OR @T(!AC1 Tstage!) OR @T(!AC2 Tstage!)	@T(In mode) OR @F(!AC2 Tstage!)
ACTION	Initiation Must be output	Termination

Output data item(s) affected: //BRGDEST//

Output description:

Condition Table 4.7-c: Update HSI Bearing Indicator			
MODES	CONDITIONS		
NOT *Grtest*	No reference point defined	X	Reference point defined
Grtest	!AC1 Tstage!	!AC2 Tstage!	X
VALUE	0°	225°	!bearing angle!

Table 4.7-a shows when a reference point is defined.

4.7.2. Update HSI Ground Track
(Periodic function)

Initiation and termination:

Event Table 4.7-d: When HSI Ground Track Updated		
MODES	EVENTS	
SINSaln	@T(In mode)	@F(!CA stage!) OR @F(In mode)
Grtest	@T(!AC1 Tstage!)	@T(In mode) OR @F(!AC2 Tstage!)
All other modes	@T(/ACAIRB/ = Yes)	@T(/ACAIRB/=No)
ACTION	Initiation	Termination: needle set to 0°

Output data item(s) affected: //GNDTRK//

Output description:

Selector Table 4.7-e: HSI Ground Track Needle Placement	
MODES	NEEDLE POSITION
SINSaln	Oscillated between 0° and 11.3° Shows 11.3° for 0.6 s Shows 0° for 0.4 s
Grtest	225°
All other modes	!ground track angle!

4.7.3. Update Range Indicator (Map and HSI)
(Periodic function)

Initiation and termination: None. Always performed.

Output data item(s) affected: //RNGUNIT//, //RNGTEN//, //LFTDIG//

Output description:

The range indicator value is the geographical distance (ground range) from the A/C present position to the outside reference point defined in Table 4.7-a.

If no reference point is defined, the range value is 0.

The range is calculated either by great circle or rhumb line (flat earth) methods, depending on the great circle ground range to the reference point:

!Range! $\geq$ 32 nmi - great circle
!Range! $<$ 32 nmi - rhumb line

The values displayed are given either in nmi or in thousands of feet according to the table below. The table also shows the setting of the //LFTDIG// indicator.

Condition Table 4.7-f: HSI Range Units

MODES	CONDITIONS		
All modes except when overridden by modes below	!Range! $\geq$ 1000 nmi	!Range! $<$ 1000 nmi	X
NBShrike **NBnotShrike** *Snattack* *Snoffset* *SBOC* *SBOCFlyto0* *SBOCoffset* *SHUDdown1* *SHUDdown2*	X	NOT !Desig! OR (!Desig! AND !Range! $\geq$ 10 nmi)	!Desig! AND !Range! $<$ 10 nmi
Grtest	X	Always	X
RANGE UNITS: ACTION:	nmi //LFTDIG//:=One	nmi //LFTDIG//:=$Blank$	1000 ft //LFTDIG//:=One

Condition Table 4.7-g: Range Indicator Value			
MODES	CONDITIONS		
All modes except *Grtest*	X	X	Always
Grtest	!AC1 Tstage!	!AC2 Tstage!	X
VALUE	555	553	!limited range!

Note: The range indicator value must be set to 555 actually in !DC Tstage! to allow the servos to settle in time for !AC1 Tstage!.

4.8. ATTITUDE DIRECTION INDICATOR FUNCTIONS

4.8.1. Update ADI Azimuth Steering Needle Position
(Periodic function)

Initiation and termination: None. Always performed.

Output data item(s) affected: //STERROR//

Output description: The ADI steering needle shows either !steering error! to the !Fly-to point! or !target!. Table 4.8-a shows when the different values are displayed.

!steering error! to the !Fly-to point! is the angle measured from the A/C !ground track! to the line from the A/C to the !Fly-to point!. When this line is to the left of the !ground track!, the !steering error! value is negative; to the right, the value is positive.

The //STERROR// output value is limited between $\pm 2.5^\circ$, thus:

//STERROR// := SIGN(!steering error!) $\times$ MIN(2.5°, ABS(!steering error!))

Condition Table 4.8-a: ADI Steering Error

MODES	CONDITIONS			
Airaln *Walleye* Any Nav mode; None of modes below;	/ACAIRB/=No OR /FLYTOTW/ = 0	/ACAIRB/=Yes AND /FLYTOTW/$\neq$0	X	X
Nattack *HUDdown1* *Snattack* *SHUDdown1*	NOT !Desig! AND /FLYTOTW/ = 0	NOT !Desig! AND /FLYTOTW/$\neq$0	!Desig!	X
Noffset *HUDdown2* *Snoffset* *SHUDdown2* *BOCoffset* *SBOCoffset*	X	NOT !Desig!	!Desig!	X
BOC *SBOC*	X	X	Always	X
BOCFlyto0 *SBOCFlyto0*	NOT !Desig!	X	!Desig!	X
Grtest	NOT !DC Tstage!	X	X	!DC Tstage!
STEERING ERROR	0	!steering error! to !Fly-to point!	!steering error! to !target!	!Test Value 3!

4.9. GO/NO-GO COUNTER FUNCTIONS

4.9.1. Resetting the GO/NO-GO Counter
(Periodic function)

Initiation and termination: None. Always performed.

Output description: The GO/NO-GO counter must not be allowed to overflow. It must periodically be assigned a new value. How often this must occur depends on the value assigned; the maximum period of 1.3 seconds is obtained by setting the counter to zero.

CHAPTER 5

Timing Requirements

Periodic and demand functions are separated because the relevant timing information is different. Otherwise, the functions appear in the same order as in Chapter 4.

5.1. TIMING REQUIREMENTS FOR PERIODIC FUNCTIONS

In the following table, the entry "current" means the same value that appears in the "Current Rate" column for that function.

Function Name	Current Rate	Minimum Allowable Rate	Maximum Useful or Allowable Rate
IMS:			
Torque platform X axis	20 ms	40 ms	current
Torque platform Y axis	20 ms	40 ms	current
Torque platform Z axis	20 ms	40 ms	current
Flash INA light	not significant		
FLR:			
Update azimuth-cursor position[1]	80 ms	current	40 ms
Update range-cursor position	80 ms	current	40 ms
Update antenna azimuth	40 ms	current	current
Update antenna elevation	40 ms	current	current
Output ground track velocity	200 ms	current	current
Update flight path angle	200 ms	current	current
HUD:			
Update AS coordinates[1]	40 ms	40 ms	40 ms
Update ASL coordinates	67 ms	80 ms	40 ms
Update ASL angle	67 ms	80 ms	40 ms
Update barometric altitude	40 ms	80 ms	current
Update flight director coordinates	67 ms	80 ms	40 ms
Update FPM coordinates	67 ms	80 ms	40 ms
Update HUD magnetic heading	200 ms	current	40 ms
Update HUD pitch angle	40 ms	current	current
Update PUAC coordinates	200 ms	current	40 ms
Flash PUAC	40 ms		
Update HUD roll angle	40 ms	80 ms	current
Update lower solution cue coordinates	200 ms	current	40 ms
Update upper solution cue coordinates	200 ms	current	40 ms
Flash solution cues	200 ms		

Function Name	Current Rate	Minimum Allowable Rate	Maximum Useful or Allowable Rate
Update HUD vertical velocity	40 ms	current	current
Update HUD vertical derivative	40 ms	current	current
Map:			
Output azimuth ring angle	200 ms	current	40 ms
Output destination pointer angle	200 ms	current	40 ms
Output orientation angle	200 ms	current	40 ms
Update filmstrip position[1]	200 ms	current	40 ms
Panel:			
Panel display functions	1000 ms	1000 ms	100 ms
HSI:			
Update bearing indicator	200 ms	current	current
Update ground track angle	200 ms	current	current
Update range indicator	200 ms	current	current
ADI:			
Update azimuth steering needle position	67 ms	80 ms	current

5.2. TIMING REQUIREMENTS FOR DEMAND FUNCTIONS

For all the demand functions, the rate of demand is so low that it will not constitute a significant CPU-load.

For the starred entries the desired maximum delay is not known; the entry is the maximum delay in the current OFP, which we will use as an approximation. In one case, both the current and desired values are given. The current value would be good enough to satisfy requirements, but the desired rate would be preferred.

Function name	Maximum delay to completion
IMS:	
Switch AUTOCAL light on/off	*200 ms
Switch computer control on/off	*200 ms
Issue computer failure	not significant
Change scale factor	*200 ms
Switch X slewing on/off	*200 ms
Switch Y slewing on/off	*200 ms
Switch Z slewing on/off	*200 ms
Change latitude-greater-than-70 degrees	*200 ms
Switch INA light on/off	*200 ms

[1]When these display items are slewed, the only timing requirement is that their movement appear to a human to be continuous.

Function name	Maximum delay to completion
FLR:	
Enable radar cursor	200 ms
Slave or release slave	40 ms
HUD:	
Switch AS on/off	*200 ms
Switch ASL on/off	200 ms
Flash FPM	40 ms
Switch pullup cue on/off	40 ms
Switch both solution cues on/off	*40 ms
Switch velocity indicators on/off	*1000 ms
ASCU:	
Switch bomb release on/off	2 ms
Switch fire ready on/off	2 ms
Switch bomb tone on/off	concurrent with release enable
Panel:	
Change window display	300 ms (desired); 1000 ms (current)
Accept pilot data entry	40 ms
Change panel MARK display	200 ms
Switch panel ENTER light on/off	40 ms

CHAPTER 6

Accuracy Constraints on Software Functions

The purpose of Chapter 6 is to state the acceptable errors or tolerances for each of the functions described in Chapter 4. Accuracy requirements vary with A/C situation, weapon type, mode of operation and other factors.

Our original intention was to have Chapter 6 contain tables defining the tolerances in a way analogous to the tables defining the output values in Chapter 4. Unfortunately, the data necessary to complete such tables are not available to us. In a development of a totally new weapon system, the mission analysis necessary to determine these requirements would have been justified. Knowledge of the tolerances would be necessary to make rational choices of computation methods, data representation and resource allocation. In the present system, we have available a model with acceptable performance, and we know that the methods and representations used in that model are adequate to the task. For that reason, we have omitted Chapter 6 from this document and take as our requirement that we must meet or exceed the accuracy of the present system.

CHAPTER 7

Undesired Event (UE) Responses

7.0. INTRODUCTION

This chapter describes system responses to undesired events, such as hardware malfunctioning. It includes both responses made by the current OFP and hypothetical responses considered reasonable by system engineers. If our only purpose were to duplicate the current OFP, this chapter would be redundant, since the current responses are described in Chapter 4. However, we are also concerned with making the system easy to change. One very common change to a system is an improved response to an undesired event. To anticipate these changes, we have sketched the kinds of responses that might be considered useful.

For each response, we have indicated in the two columns to the right a) whether it is performed in the current OFP, and b) the system engineers' judgment of its usefulness. Responses are classified "'Y'" (Yes), "'N'" (no) and "'M'" (maybe). We included some responses judged not useful in order to keep a record of their consideration.

Although the responses are organized by means of detection, we do not describe how each of the UEs is detected. We organized them in this way because it gave us a systematic approach, so that we could be reasonably sure of completeness. We continue to use it because we believe gaps will show up more clearly.

UEs detected by periodic self checks	**Current**	**Desired**
a. IMS not functioning		
1) Inform pilot (currently !DATA 98! display).	Y	Y
2) Go to backup NAV mode (*IMS fail*).	Y	Y
b. Doppler not functioning		
1) Inform pilot (currently !Data 98! display).	Y	Y
2) Switch navigation modes. (From *DIG* or *DI* to *I*; from *UDI* to *OLB*).	Y	Y
3) If it starts functioning again, wait five seconds before using data.	Y	Y
c. ADC not functioning		
1) Set barometric altitude to nominal value: 4500 ft.	Y	Y
2) Inform pilot (Mark window when !Data 98! displayed).	Y	Y

	Current	Desired
3) Use other sources of velocity and altitude.	Y	Y
4) Do not do baroaltitude damping of vertical velocity.	Y	Y
5) Allow pilot to enter winds in keyboard.	Y	Y
d. FLR not functioning		
1) Flash solution cues to inform pilot if FLR not functioning when slant range sampled.	Y	Y
2) Revert to radar altimeter ranging or barometric altimeter ranging, depending on value of !Data 24!.	Y	Y
e. Radar Altimeter not reasonable.		
1) Inform pilot.	N	M
2) Revert to barometric altimeter ranging.	Y	Y
f. Memory checksum incorrect		
1) Stop - Force failsafe and switch computer fail light on.	Y	M
2) Run in a "restricted state." Navigate, no computed weapon release, warn pilot. If function performed by faulty memory area can be identified, leave out that function.	N	M
g. SINS data bad		
1) Inform pilot by wiggling HSI #2 needle.	Y	Y
UE's detected by software demand self checks		
a. Memory checksum fails (on ground)		
1) Stop - Force failsafe and switch computer fail light on.	Y	M
b. Computer instruction self test fails (not currently tested)		
1) Inform pilot by switching computer fail light on.	N	Y
2) Run in a "restricted state." Navigate, no computed weapon release, warn pilot. If function performed by facility memory area can be identified, leave out that function.	N	M
c. Signal Converter Self-test fails (currently only on ground)		
1) Turn fail light on: enter wait state.	Y	M
2) Record which test failed for later analysis.	N	M
d. HUD test pattern fails test (detected with help of pilot)		
1) Possible symbol substitution.	N	M

	Current	Desired
(Training and human factors problems.)		
UEs detected by pilot		
a. Pilot puts in incorrect data then notices it		
1) Rejection acknowledged.	Y	Y
2) Pilot may start over.	Y	Y
b. ASCU code incorrect (Rarely occurs; always part of pilot preflight check).		
1) Allow pilot to override hardware supplied data.	N	N
c. IMS producing bad data		
1) Pilot selects backup mode (*Grid* or *Mag Sl*).	Y	Y
d. ADC producing bad data		
1) Pilot should be able to declare ADC data failure.	N	Y
2) Behavior same as hardware detected failure.	N	Y
e. FLR not functioning		
1) Pilot turns it off.	Y	Y
f. HUD not functioning		
1) Pilot turns HUD off. HUD down weapon delivery modes may be entered.	Y	M
2) Pilot should be able to indicate nature of failure.	N	Y
3) Symbol substitution should be done on request.	N	M
g. ASCU not functioning		
1) Weapon delivery functions stopped. Software should not interfere.	N	Y
h. PMDS not functioning		
1) System ignores PMDS. PMDS indicates failure.	N	Y
i. TC-2 panel control not functioning		
1) Use armament panel to inform computer. Considered too complex for pilots.	N	N
2) Perform most frequently needed services with system aware that the panel is not functioning.	N	M
j. Radar altimeter not functioning		

	Current	Desired
1) Pilot turns it off.	Y	Y
2) Revert to baroaltimeter ranging.	Y	Y
k. Slew Control not functioning		
1) Pilot can inform computer.	N	Y
2) OFP ignores slew control.	N	Y
3) Alternate input source used to indicate slew.	N	N
l. Doppler not functioning		
1) Pilot switches it off.	Y	Y
2) Behaves as if the computer detected the failure.	Y	Y
m. TACAN not functioning		
1) Pilot won't use it.	Y	Y
2) System should ignore it.	Y	Y
n. AOA data bad		
1) Pilot can inform computer.	N	Y
2) Computer ignores input and uses a constant.	N	N
3) Pilot can change the constant.	N	N
o. SINS communication not functioning (ground only)		
1) No action.	Y	Y
p. Weight on wheel switch not functioning		
1) Possible Action: Override (might not be permitted).	N	N
q. Release enable switch not functioning		
1) Pilot informs computer to ignore setting of switch.	N	Y
2) Alternate input designated.	N	M
r. Designate switch not functioning		
1) Pilot informs computer.	N	M
2) Pilot can use release enable switch as alternate input.	Y	M
s. HSI not functioning		
1) Pilot informs computer.	N	Y
2) Display "distance to target" on HUD at pilot option.	N	M
3) Make other items available on panel.	N	M
t. ADI not functioning		
1) No action.	Y	M

	Current	Desired
u. Flight recorder not functioning		
1) Pilot informs computer.	N	Y
2) Don't ship data to flight recorder.	N	Y
v. Bomb tone not functioning		
1) Computer need not perform bomb tone functions.	N	Y
2) Possible use of light or HUD display symbol.	Y	Y
UEs detected by timeouts		
a. GO/NO-GO counter hits zero		
1) Save data.	N	Y
2) Pilot informed by 8's in window.	Y	Y
UEs detected by computer hardware		
a. DIAGNOSE instruction (not used in flight)		
1) None.	Y	M
b. Power interruption		
1) Perform a restart if airborne and IMS ready. Otherwise, perform a complete reinitialization.	Y	M

CHAPTER 8

Required Subsets

8.0. INTRODUCTION

Chapter 4 characterizes the functions of the A-7 OFP. The primary requirement is that the OFP be able to perform all of these functions. In addition, we require that the program be structured to facilitate the development of a set of *function subsets* that will:

(a) perform only a subset of the services performed by the whole OFP;

(b) be obtained by the removal of clearly identified sections of code and data structures without modification* of the remaining programs.

(c) use an amount of memory space and execution time roughly comparable to that which would have been used if the program had been originally developed to perform only that subset of the functions.

Note that these requirements cannot be satisfied by simply "turning off" the unneeded functions. The space and time consumed by the implementation of those functions would not be made available for other purposes.

These requirements can be reformulated by saying that when the subset systems are needed, they should use time and space in proportion to the complexity of the services, and the bigger subsets and the OFP itself should be obtained by adding code to the smaller subsets without modifying the code of the smaller subsets.

8.1. POTENTIAL SUBSETS

This section describes the potentially required OFP subsets in more detail.

8.1.1. Output Subsets

We consider a set of output data items to be a *user package* if it would not be useful to output just one of these items. For example, the Aiming Symbol azimuth (//ASAZ// and Aiming Symbol elevation (//ASEL//) form a user package because the HUD is not able to display the Aiming Symbol unless both of these items are provided.

There must be a subset available to transmit each user package. For example, there should be a subset available to perform the function

Display Azimuth Steering Line (AZIMUTH, ELEVATION, ANGLE)

A subset is required for each HUD symbol, for IMS-slew for each axis, for IMS-torque for each axis, for FLR antenna control, for FLR cursor display, for bomb release and fire ready, for PMDS display positioning, for panel display, for HSI bearing to destination, ground track, range to destination, for bomb

* It may be necessary to reassemble, using new assembly-time constants.

tone, for ADI and for the miscellaneous discrete items.

8.1.2. Input Subsets

We consider input data items to form a ***user package*** if one must know the value of one to make use of the value of the others. For example, we consider True Heading Cosine and True Heading Sine a user package because one must know both cosine and sine to determine the quadrant. There must be a subset capable of reading in any of these input user packages. These will include magnetic heading, pitch, role, true heading, X, Y, and Z accelerations, barometric altitude, mach number, true airspeed, FLR lockon and slant range to target, ASCU status, PMDS status, each of the panel switches and thumbwheels, radar altitude, slew control position and movement, the various MFS and ARP input switches, Doppler drift angle, Doppler ground speed, TACAN range and bearing to destination, AOA, and SINS inputs. The SINS subset is not needed when airborne. The memory allocated to it may be used for other purposes while airborne provided that it can be regenerated when a SINS input is available.

8.1.3. Hardware Test Subsets

There should be a subset capable of executing the hardware test sequences for any of the hardware units. Since these tests are not conducted when airborne, the remarks made about the SINS input subset apply here as well.

8.1.4. Scheduling Subset

There will be a subset of the system that provides for the synchronization and scheduling of a fixed number of concurrent activities with real-time deadlines. By means of reassembly it will be possible to adjust the space to take advantage of a decrease in the number of such activities or to allow for an increase in the number of such activities.

8.1.5. Real-time Input Data Base

The system will include a subset that makes current values of the input data items available to the rest of the OFP. This subset will use the input subsets and the scheduling subset. The data base subset will be so constructed that if certain data items are not needed, the memory space and cpu time devoted to maintaining those items can be saved at the cost of a reassembly operation.

8.1.6. Periodic Output Data Base

For those data items that must be output periodically, there will be a subset that maintains a record of the most recent values and sends them to the appropriate devices at the necessary intervals. This subset will use the output subsets and scheduling subset. It will be so constructed that if certain items are not being transmitted, the memory space and CPU time devoted to maintaining those items can be saved by means of a reassembly operation. This subset makes pseudo-output commands available to the rest of the OFP which then acts as if there was continuous output of the items in the data base.

8.1.7. Navigation Subsets

The system shall be capable of performing navigation functions without the presence of any of the weapons delivery software. In particular, the software required to maintain an estimate of current position and heading shall function without the presence of any weapons delivery software. It shall be possible to provide navigation information to the pilot through either the HUD, the HSI, the PMDS, or the panel even if the software used to display information on the other three devices is not available. Similarly, there shall be subsets available to perform navigation services using only a subset of the normal input devices wherever alternate means of obtaining the necessary input are available.

8.1.8. Weapons Delivery Subsets

There shall be functional subsets available for each of the possible subsets of the weapons carried on the aircraft. In the event that a weapon is not available or used, it shall be possible to generate a subset of the system in which the table space and code used for that weapon is made available for other uses.

8.1.9. Pilot Display Subsets

It shall be possible to produce a subset that eliminates some of the information displayed to the pilot. For example, a subset that does not include PMDS display functions should be available.

8.1.10. Alignment and Calibration Subsets

Subsets shall be available that can only perform land-based alignment or only perform ship-based alignment. Subsets without air alignment capabilities shall be available. All systems should be able to perform functions without the presence of the land or ship alignment code when airborne.

8.2. REQUIRED SUBSETS

This section describes all subsets that shall actually be delivered. Each is specified by describing the differences between it and the full OFP specified elsewhere in this document.

8.2.1. The Useful Subset

8.2.1.1. Data items

Data items belonging to the following devices shall not be included:

Bomb Tone (see Section 2.3.4)
Projected Map Display Set (see Section 2.1.6)
Shipboard Inertial Navigation System (see Section 2.2.8)
TACAN (see Section 2.2.6)
Waypoint Information System (see Section 2.2.11)

The following additional data items shall not be included:

//AUTOCAL//
//CURAZCOS//
//CURAZSIN//
//CURPOS//
//IMSNA//
/PNLTEST/

Only the following !Weapon Class! members shall be included: GN, HD, MD, SL, SH, SM, UN. All others shall be returned as UN.

8.2.1.2. Modes

Only the following modes shall be included. Actions which would cause an entry into one of the deleted modes shall cause no transition:

Alignment:	*Landaln*
Navigation:	*I*, *DIG*
Nav Update:	*HUDUpd*, *UNone*
Weapon:	*Nattack*, *Noffset*, *Manrip*, **NBnotShrike**, *WNone*
Test:	none

8.2.1.3. Functions

The following functions are not included:

A function to drive a deleted output item;
Update SINS X and Y Offsets Display;
Update SINS Z Offset and Delta Heading Display;
Update Map Coordinates Display;
Update DATA 03 through Update DATA 22;
Update DATA 26; !Land! shall always be true;
Update DATA 71 (lower window);
Update DATA 90;
Update DATA 91 (lower window);
Update DATA 92/93 (lower window);
Update DATA 94.

CHAPTER 9

Expected Types of Changes

9.0. INTRODUCTION

This chapter characterizes the requirement changes that can be expected in the future. It is impossible to give specific details of any particular change, but we wish to point out the aspects of this document that cannot be considered fundamental when designing the system. However, there are a few fundamental assumptions about the system that are not expected to change whatever enhancements are made. These are listed in Section 9.1.

9.1. FUNDAMENTAL ASSUMPTIONS

9.1.1 The flight characteristics and weapon characteristics are adequately characterized by the mathematical models documented in Refs. 6,7,10,11,12, 13,25. The flight conditions and mission conditions are such that the approximations made in deriving the equations will remain sufficiently accurate. All parameters that can vary from aircraft to aircraft, location to location, or weapon to weapon, are adequately identified in the referenced documents.

9.1.2 Point of impact (weapon delivery) calculation can not be accurately performed if alignment or location data are not accurate.

9.1.3 The computer will not be assigned "background" functions with non-real-time computation such as map-making, digital picture processing, etc.

9.1.4 When writing the programs, realistic (worst-case) upper bounds on memory requirements and cpu cycle requirements for each function can be predicted and will be independent of flight conditions.

9.2. COMPUTER CHANGES

9.2.1 The computer might be replaced by a TC-2A.

9.2.2 Additional channel hardware might be added to the TC-2.

9.2.3 Additional interlocks or improvements might be added to the present TC-2 channels.

9.2.4 A completely different computer might be substituted (very unlikely).

9.2.5 A register other than the A register might be used as an I/O buffer.

9.2.6 TC-2 Panel may be used for other parameters or pilot selectable switches.

9.3. INTERFACE CHANGES

9.3.1. General

(a) Assignment of devices to channels may be changed.

(b) Assignment of bits to discrete words may be changed.

(c) All data representations may be changed.

9.3.2. FLR

(a) Display symbology may be changed.

(b) Range characteristics could be improved.

9.3.3. HUD

(a) Data Item Identity codes could be changed.

(b) Symbols could be added.

(c) Computer controlled intensity or color could be added with a new HUD.

9.3.4. Other Uses of Flight Recorder

(a) Flight recorder might be used as a serial output channel.

9.3.5. ASCU

(a) ASCU might be replaced by computer controllable unit.

9.3.6. PMDS

(a) Map might be replaced by a unit that can be positioned more quickly (unlikely).

(b) Other film-strip formats and scaling might be used.

9.3.7. TC-2 Panel

(a) Additional switches or positions may be added (very likely).

9.3.8. Slew Control

(a) An extension dimension might be added (in A-6, but not likely for A-7).

9.3.9. Doppler Radar Set

(a) Precision might be increased (very unlikely).

9.3.10. Weapon Characteristic Parameters Are Subject to Change (Frequently)

9.4. FUNCTION CHANGES

9.4.1. General

(a) Improved processing algorithms might be added (e.g., Kalman filters).

(b) Performance rates and time limits are considered subject to change.

(c) New display information might be added (includes all pilot displays).

(d) More accuracy might be required.

(e) Comparison of redundant inputs (e.g., barometric vs. FLR slant range) may be added to detect major errors.

(f) New sensors (e.g., Forward Looking Infra-Red (FLIR)) may be added.

9.4.2. HUD

(a) Additional information might be provided by flashing, intensity (unlikely), color (unlikely), or new symbols.

(b) Meaning associated with symbols could be changed (Flight Path Marker, PUC are not allowed to change).

9.4.3. Panel

(a) Data entered by pilot could be displayed after ENTER pushed, so that he can verify (likely).

(b) Display before entering could be omitted.

9.4.4. New Weapons Functions

(a) Some weapons might require computer control after release (not likely).

(b) Some new weapons might require programming just before release (already planned).

(c) Some weapons might transmit data to computer after release.

(d) Some weapons might be tracked by A/C sensors after release and their positions displayed to pilot (not likely).

9.4.5. RECON Functions

(a) Camera and similar equipment might be added with computer control performing such functions as camera control after pilot does target designate (considered but unlikely).

9.4.6. In-flight A/C Monitoring Functions

(a) The computer might be provided with sensors monitoring A/C systems and required to warn the pilot of abnormal conditions by means of HUD display (not likely for A-7 but planned for other aircraft).

9.4.7. SYSGEN Capability Shipboard

(a) It may be necessary to remove portions of the OFP and add others when a special pod is changed (missionized software).

9.4.8. Suspension of Low Priority Activities to Allow Special Functions

(a) It may be necessary to cease certain functions (e.g., displays, monitoring functions) in order to free computing resources for some demand function (example: map driving during bomb run).

9.4.9. Internal A/C Communications Functions

(a) Software might have to serve as data link between other devices by getting data from one device and sending data to some other (not likely).

9.4.10. Accept Information Over Data Link While Airborne

(a) Updates in the air with the aid of ground stations might be required.

(b) Airborne A/C may accept destination data over data link.

9.4.11. Lateral Control of Aircraft

9.4.12. Parallel Processing of Release/Impact Points, Etc. for Several Weapons

9.4.13. Calculations for Two Destinations (One a Target) (Already Planned)

9.4.14. More Support for Moving Targets

9.4.15. Multi-step Flight Path Navigation

9.4.16. Electronic Warfare Counter Measures

(a) Example: checks on reasonableness.

9.4.17. Computer Self-test During Flight

CHAPTER 10

Glossary of Abbreviations, Acronyms, and Technical Terms

These acronyms and terms are used in the A-7 community to describe various aspects of the Navigation Weapon Delivery System (NWDS), that is, the complete system including the computer, software and all the hardware displays and sensors used for navigation and weapon delivery.

-A-

AAM	Air-to-air missile
ABH	Above burst height
above ground level	Vertical distance of A/C above target or ground
AC	Alternating current
a/c	Aircraft
A/C	Aircraft
ACL	Automatic carrier landing
ACLS	Automatic carrier landing system (not connected to the TC-2)
ADC	Air data computer - hardware component of the NWDS
A/D CONV	Analog-to-digital converter
ADI	Attitude direction indicator - hardware component of the NWDS
ADL	Aircraft datum line: the longitudinal center reference line of the a/c weapons system (3 degrees down from water line 100)
AFCS	Automatic flight control system (not connected to the TC-2)
AGE	Aerospace ground equipment
AGL	See ***above ground level***
AGM	Air-to-ground missile
AGR	Air-to-ground ranging - radar mode providing target slant range to the TC-2
aiming symbol	Diamond-shaped HUD symbol

alignment	Causing the IMS platform axes to point toward the Earth's local east, the projection in the local horizontal plane of the north vector, and the perpendicular to the local horizontal plane away from the Earth's center.
ALT	Altitude (also altimeter)
angle of attack	Angle of wing (or other reference horizontal) to air flow
ANT	Antenna
AN/ASN91	Another name for the TC-2 computer
AOA	See *angle of attack*
AOA transducer	Angle of attack transducer - a hardware component of the NWDS
AR	Aiming reticle - see *aiming symbol*
ARDA	Aiming reticle depression angle
ARL	Aiming reticle location
ARL	Armament reference line
ARP	Armament release panel - a hardware component of the NWDS
ARS	Armament release switch - also called *Release Enable*
AS	See Aiming symbol
ASCU	Armament station control unit - a hardware component of the NWDS
ASL	See *azimuth steering line*
AUTO	Automatic
AUTOCAL	Automatic calibration - calculation of IMS-axis drift biases
AZ	See *azimuth*
azimuth	Horizontal direction; for example, angle between a/c heading and the line projected into the horizontal plane from the a/c to a destination
azimuth steering error	Angular difference between actual ground track and desired ground track
azimuth steering line	Straight-line HUD symbol; also called *bomb fall line* (BFL)

-B-

Backup reticle	Also called *standby reticle* - symbol displayed by the HUD when the HUD not reliable
BARO	Barometric (altimeter/altitude)

BCN	Beacon integration - radar mode
Bearing	Angle between projection of Y_a axis onto the horizontal plane and projection onto the horizontal plane of the line from the A/C to a destination or target
BDU	Bomb dummy unit
BFL	Bombfall line - see ***azimuth steering line***
BHT	See ***burst height***
BIT	Built-in test
BITE	Built-in test equipment
BOC	Bomb on coordinates - an OFP weapon delivery mode
Bottom	Latitude below which PMDS map does not extend
BPC	Bullpup control set (see ***slew control***)
BRG	See ***bearing***
BRIL	Brilliance
BRL	Boresight reference line
Bullpup control	See ***slew control***
BUR	See ***backup reticle***
Burst height	distance above ground that a bomb is set to explode
B0, B15, etc.	Scale indicators. B0 means the binary point follows bit 0 of a 16-bit number, i.e., that the entire number is a fraction. B15 means the binary point follows bit 15, i.e., that the number is an integer

-C-

CA	Coarse azimuth - an OFP alignment stage; same as ***coarse gyrocompass***
CADU	Control and display unit; used to debug programs on the TC-2
CAL	Calibration
callup	Selection of a numbered destination
CBU	Cluster bomb unit
CCIP	Continuously computed impact point - an OFP weapon delivery mode
CCW	Counterclockwise

CDCE	Computer-driven cursor enable; when the OFP enables the cursors on the radarscope
CEP	Circular error probable - radius of circle in which 50% of bombs fall; measured in feet
CG	Center of gravity
CHAN	Channel
CIP	Computed impact point
CIR	Circular
CL	Coarse level - an OFP alignment stage
coarse	Platform self-contained alignment to true north
crab	Difference between ground track angle and the heading as measured by IMS; see also *drift angle*
CRT	Cathode-ray tube
CSGMP	Cross scan ground map, pencil - a radar mode
CSTA	Cross scan terrain avoidance - a radar mode
CW	Clockwise

-D-

DA	See *drift angle*
D/A CONV	Digital-to-analog converter
DC	Direct current
DDC	Digital data converter
delta heading	Angular difference between a/c heading and ship heading
DEOB	Deck edge outlet box - used to connect A/C to source of SINS data; each DEOB is marked with its offsets from the SINS source on the ship
designate	A pilot action that ground stablizes the HUD aiming symbol or radar cursors on the selected aiming point and records the aiming point location in the Tactical Computer. Used in update modes and weapons delivery modes
DEST	See *destination*
destination	A location whose coordinates are entered in the Tactical Computer by the pilot

DF	Direction-finding
DI	Doppler inertial - an OFP navigation mode
DIG	Doppler inertial gyrocompassing - an OFP Navigation mode
DIR	Direction
DIW	Discrete input word
DL	Data link
DLV	Delivery
DME	Distance measuring equipment
DOP	Doppler
DOW	Discrete output word
DR	Dead reckoning
drift angle	Angle between the projections into the horizontal plane of the Y_a axis and the A/C velocity vector. The angle is usually measured from the Y_a axis, — positive in the CW direction, looking down, and negative in the CCW direction
DRS	Doppler radar set
DU	Display unit

-E-

E	East
EAS	Electronic altitude sensor
EAS	Equivalent airspeed
ECM	Electronic countermeasures
ELA	Effective launch angle
ELEC	Electric
Enter	Inserting information (pilot selected or update) into the TC-2 via the Enter pushbutton
ET	Elapsed time
EULERANG	Geometry-related reference angles

-F-

FG	Fine gyro compassing - an OFP alignment stage
flight path angle	Angle between aircraft velocity vector and its projection into the horizontal plane: pitch corrected for angle of attack. The angle is usually measured from the horizontal line, positive in the up direction, negative in the down direction
flight path marker	HUD symbol showing direction of A/C velocity vector
FLIR	Forward-looking infrared
FLR	Forward-looking radar - a hardware component of NWDS
flux valve	ML1 magnetic compass - part of the IMS
FOV	Field of view
FPA	See *flight path angle*
FPM	See *flight path marker*
fps	Feet per second
FREEFALL	Low drag weapon
FREQ	Frequency
FRL	Fuselage Reference Line
FWD	Forward

-G-

g	Force of gravity or load factor
GAS	Go-around steering
GM	Ground mapping - radar m
GMP	Ground map, pencil - radar mode
GMPB	Ground mapping, pencil (beam) - radar mode
GMS	Ground map, spoiled - radar mode
GMSB	Ground mapping, shaped (beam) - radar mode
GND	Ground
GND ALIGN	Ground alignment - an IMS mode
grazing angle	Angle between the line defined by the direction that the FLR antenna points and its projection into the horizontal plane

Grid	Grid mode - an IMS mode; also an OFP navigatior mode
ground track	Line defined by projection of the A/C velocity vector onto the ground
ground track angle	Angle between ground track and the line from the A/C to true north (true heading + drift angle). The angle is usually measured CW from north looking down
GS	Ground speed
GTA	See ***ground track angle***
GYPTO	Gyro pulse torque
Gyrocompassing	Method used to align the IMS platform to true north

-H-

HDG	See ***heading***
HDGP	High drag general purpose
HD/LD	High drag/low drag - weapon types
heading	Line defined by the projection of the Y_a axis into the horizontal plane; or the angle between this line and the line from the A/C to north. See also ***true heading*** and ***magnetic heading***
Hg	Mercury
HG	High-gain gyro compassing - an OFP airborne alignment stage
HL	High-gain level - an OFP airborne alignment stage
HSI	Horizontal situation indicator - a hardware component of NWDS
HUD	Head-up display - a hardware component of NWDS
HW	Head wind
Hz	Hertz (cycle per second)

-I-

I	Inertial - IMS mode; also OFP navigation mode
IAS	Indicated air speed; not corrected for temperature and air pressure
IBFL	Instantaneous bombfall
IBS	Interbomb spacing
IMN	Indicated Mach number: not corrected for temperature and air pressure

IMS	Inertial measurement set - hardware component of NWDS
IMU	Inertial measurement unit - platform component of IMS
impact angles	Angles measured from the a/c Y_a axis to the line from the A/C to the impact point projected into the X_a-Y_a plane (azimuth) or into the Y_a-Z_a plane (elevation)
impact point	Point where bomb would hit the ground if released now
INA	IMS non-align light
incremental velocity	Change in velocity or Delta velocity. The IMS measures acceleration and by applying the variable of time provides incremental velocity to the TC-2 for aircraft speed and distance solutions
I N PANEL	Tactical Computer Control Panel (TCCP). Also called NWDS Panel
IP	Identification point (also initial point; also impact point). See *offset aim-point*
IR	Infrared
IWS	Integrated weapons system

-K-

KCAS	Knots calibrated airspeed - same as *KIAS*
KEAS	Knots equivalent airspeed
KEYBD	Keyboard
KIAS	Knots indicated airspeed; not corrected for temperature and air pressure
KN	Knots (nautical miles per hour)
Kt	Knots
KTAS	Knots true airspeed: corrected for temperature and air pressure

-L-

LAT	Latitude
Lateral steering error	See *azimuth steering error*
LB	Pounds
LBA	Limits of basic aircraft
LD	Low drag

LDG	Landing
LDGP	Low drag general purpose
LGB	Laser-guided bomb
LH	Left hand
LIN	Linear
LONG	Longitude
LOS	Line of sight angle
LRU	Line-replaceable unit
LSE	See *lateral steering error*
LTV	Ling-Temco-Vought; also referred to as Vought; the manufacturer of the A-7
LW	Lower window of the TC-2 panel

-M-

MA	Master arm - cockpit switch
MAG	Magnetic
Magnetic heading	Angle between the projection of the Y_a axis into the horizontal plane and the line from the a/c to magnetic north. The angle is usually measured CW from north looking down
MAG SL	Magnetic slave - IMS mode; also OFP Navigation mode
MAG VAR	Magnetic variation
Mark	Location visually identified by the pilot during a flight; mark coordinates are automatically saved by the TC-2
MAX	Maximum
MEA	Minimum enroute altitude
MER	Multiple ejector rack
MFS	Master function switches - cockpit switches
MHz	Megahertz
Mil	Milliradian
MIN	Minimum

Mk	Mark, Navy designation for model
MLV	Memory loader verifier
MN	Mach number
Mod	Navy designation for modification
Mode	Particular working status of the system
MRE	Mean radial error
MRI	Minimum release interval
MRT	Military rated thrust
MPI	Mean point of impact
ms	Milliseconds
MSL	Mean sea level
MSL ALT	Height of A/C above sea level: AGL + target altitude
MSLP	Mean sea level pressure
MV	Magnetic variation

-N-

N	North
NAL	Non align light (also called INA)
NATOPS	Naval Air Training and Operating Procedures Standardization - pilot manual
NAV	Navigation
NAV/WD	Navigation/weapon delivery
nm	Nautical miles
nmi	Nautical miles
NORM	Normal - IMS mode; also used as another name for DIG
NRL	Naval Research Laboratory, Washington, DC 20375-5000
NWC	Naval Weapons Center, China Lake, CA 93555
NWDC	Navigation weapon delivery computer (see TC-2)

NWDS	Navigation/weapon-delivery system
NWDS/NAVWD	Navigation weapons delivery system

-O-

OAP	See *offset aimpoint*
offset aimpoint	Landmark used to identify a target in an offset weapon delivery mode
offset bombing	Delivery of weapons to an obscured target identified in relation to a prominent landmark
OFP	Operational flight program
ORA	Optical Reference Axis; see introduction to the HUD data items (see Section 2.1.4)
OTP	Operational test program
OTS	Over-the-shoulder steering

-P-

PGS	Pilot's grip stick
pitch angle	Flight path angle above local horizontal
PMDS	Projected map display set
PNL	Panel
POS	Position
POT	Potentiometer
PPI	Plan position indicator; another name for the radarscope cursors
PRC	Program reloadable counter
PRES	Present
PRES POS	Present position
PSEUDO	Pseudo-ground-stabilized
PUAC	See *pullup anticipation cue*
PUC	See *pullup cue*
pullup anticipation cue	A HUD symbol
pullup cue	X-shaped HUD symbol

PUP	Pullup point
PWR	Power

-Q-

QTY	Quantity

-R-

RAD	Radar
RADALT	Radar altimeter - a hardware component of NWDS
Radar pencil beam	A tightly focused radar beam
Radar range cursor	An internal electronic radar signal recurringly generated at some specific time after each radar pulse transmission, appearing on the scope as a solid arc representing a specific range
Radar range sweep	The motion of the electron beam in a cathode ray tube that permits target blips and range cursors to be distributed across the face of the tube in proportion to their slant ranges
Range	Distance
Ranging	Measuring distance
RCVR	Receiver
RDR	Radar
RE	See *release enable*
reasonable	Component passes computer tests
reflective target	An area that presents prominent returns for radarscope interpretation
REL	Release
release enable	Switch on the pilot grip stick
reliable	Component passes its own self-test
RET	See *retarded weapon*
retarded weapon	High drag weapon
RET WPN	See *retarded weapon*
RF	Radio frequency
RH	Right hand

RKTS	Rockets
RMAX	Maximum range
RMIN	Minimum range
RNG	Range
rpm	Revolutions per minute

-S-

s	Seconds
S	South
SAM	Surface-to-air missile
SAR	Storage address register
SBR	Storage buffer register
Schuler tuned	A stable platform maintained in an orientation that is perpendicular to the earth's gravity
SDC	CV-2622/ASN-99 signal data converter
SDP	Signal data processor
SIAR	Serial Input Address Register
SIDS	Shrike Improved Display System
SIDR	Serial Input Data Register
SINS	Shipboard Inertial Navigation System
SF	Scale factor
SIMULT	Simultaneous
SING	Single
SL	Sea level
slant range	Line-of-sight distance from the aircraft to the target
slew control	Pilot joystick, used to control up-down and right-left movement of a display symbol. Also called Bullpup control
solution cue	HUD symbol providing pilot with release anticipation and appearing on screen when a/c within range of a target. Weapons delivery can occur when either cue crosses the flight path marker.

solution cue, upper	Solution cue used for loft deliveries
solution cue, lower	Solution cue used for level, dive and dive-toss deliveries
SRT	Standard rate turn
SSE	Special support equipment
STA	Station
STAB	Ground stabilized
STBY	Standby
STC	Self-test command
STCN	Sensitivity time control
STEER	Steering to target
steering command	A fly-to indication to center the vertical and horizontal command pointers or the flight director symbol on the HUD to achieve proper pitch and azimuth flight corrections
STIK	Set of bombs when more than one selected
STIK length	Distance between first and last weapon release in a stik delivery.

-T-

TA	Terrain avoidance - radar mode
TAC	Tactical
TACAN	Tactical air navigation
target altitude	Height of target above sea level
target designate	Switch on pilot grip stick
TAS	True airspeed
TC-2	Tactical computer-2; digital computer component of the NWDS; also called AN/ASN91, NWDC, 4PI
TCCP	Tactical computer control panel
TD	See *target designate*
TECHEVAL	Technical evaluation
TER	Triple ejector rack

TF	Terrain following - radar mode
TGT	Target
TM	Telemetry
TOF	Time of fall
TOL	Time of launch
torquing	Changing the orientation of an axis of inertial platform
toss delivery	Pulling up from a dive to launch
TOT	Time on target
transducer	An electromechanical device that converts motion or force into electrical signals; e.g., AOA transducer
transformer-rectifier	An electrical device for converting master-generator produced AC power to DC power
true heading	Angle between the projection of the Y_a axis into the horizontal plane and the line from the a/c to true north. The angle is usually measured CW from north looking down
TWE	Thumbwheel encoder (no longer used)

-U-

UDI	Unaligned Doppler inertial - an OFP Navigation mode
undesignate	Pilot action in weapons delivery modes. The HUD aiming symbol or radar cursors are released from ground stablization
uphill bombing	Lofting a bomb up to a burst height set above a/c AGL altitude
UTM	Universal transverse Mercator
UW	Upper window of the TC-2 panel

-V-

Vac	Volts alternating current
VAD	Vought Aerospace Division, LTV
valid	Indication or information that is reasonable and reliable
VAR	Variation
vdc	Volts direct current

VEL	Velocity
VERT	Vertical
VSD	Vought Systems Division, LTV

-W-

W	West
Water line 100	A standard reference line on the A-7 a/c
WD	Weapon delivery
WPN	Weapon
WPNS	Weapons
WT	Weight

-X-

X offset	Fore/aft distance of A/C from SINS source on a ship
XRI	Maximum release interval

-Y-

Y offset	Sideways distance of a/c from SINS source on a ship

-Z-

Z - DHDG	See *Z offset* and *delta heading*
Z offset	Vertical offset of A/C from SINS source on a ship

-Other-

Δ	Delta
4PI	Computer family name to which the TC-2 computer belongs

CHAPTER 11

References and Sources of Further Information

11.1. DOCUMENTATION

This section contains an annotated list of documents germane to the A-7 Operational Flight Program (OFP). The references are listed in order of accession. Each document is assigned to one of the subject categories given in Table 11-a. The subject abbreviation comes below the reference number in the document description. Table 11-a also gives the reference numbers of the documents that belong to each category.

Table 11-a: Subject Classification for A-7 Documentation

Subject abbreviation	Subject	Document numbers
PILOT	Pilot-oriented A-7 documentation	14, 15, 17, 26, 29
NWDS	Entire NWDS system, including but not limited to the OFP	1, 3, 4, 5
OFP-1	OFP Technical Descriptions and Documentation (for NWC-1)	8, 27a
OFP-2	OFP Technical Descriptions, Listing and Documentation (for NWC-2)	9, 10, 11, 12, 13, 16, 27b, 28
TC-2	TC-2 Reference Manuals	18, 19, 20
MATH	Analysis of Algorithms and Mathematical Subroutines	6, 7, 25, 40, 41
SIM	Simulation Facilities	21, 22, 30, 31, 32
VAL	Validation	23, 24
HARD	Hardware Specifications and Descriptions	2, 33, 34, 35, 36, 37, 38
SINS	SINS protocol description	39

(1) NWDS: Conf document *System Specification for A-7E Navigation/Weapon Delivery System (NWDS)*, AS-4195, 1 Feb. 1975

Functional requirements of the entire NWDS system (not just the software requirements).

Requirements for each of the following components: Digital Computer and panel, ASCU, HUD, PMDS, Doppler, ADI, IMS, HSI, ADC, and FLR

Description of NWC-1 modes and functions, including the following information for each of the attack modes: how initiated, aiming, designation, delivery, backup operation, and pictures of HUD symbology

Over 100 pages of tables and figures, including the following: Equipment used in different modes, signals between components broken down by navigation and attack modes, pictures and explanations of cockpit controls (over 90 pages)

A very brief performance requirements section.

(2) HARD: Conf document *Procurement Specification for Navigation/Weapon Delivery Digital Computer System for A-7D/E Airplane*, 204-16-29g, Nov. 1968

Primarily covers the computer and panel. Many hardware details. Function description mostly superseded by Refs. 1 and 4 Computer interface descriptions superseded by Ref. 3 except the following charts:

Computer-weapons management interface (p. 57)
Miscellaneous controls (p. 59)
Wing Station Stores Capability (p. 63) – probably out-of-date
Computer-TACAN interface (p. 67)
Computer-AR panel interface (p. 71)
Computer-SINS interface (p. 72)

(3) NWDS: Conf document *A-7 Navigation and Weapon Delivery System and Subsystem Characteristics: Accuracies and Tolerances, VSD #2-54150/5R-5790, 8 May 1975*

Computer-device tables, with the following information: signal names, types, ranges, accuracies, scales, modes, etc. for each of the following devices: Doppler, FLR, HSI, ADI, HUD, ADC, PMDS, AOA, IMS.

Subsystem Characteristics and vital statistics

IMS (especially operational limits)
FLR (especially mode descriptions, range rates)
HUD
ADC (especially resolution and rate of response)
Doppler (especially operational limits, probable error rates)
PMDS
Radar Altimeter (especially tracking rates)

(4) NWDS: Conf document *A-7 Navigation and Weapon Delivery System*, VSD #2-14000/5R-5 1 May 1975

Narrative presentation of system specified in Ref. 1. Table summarizing tactical computer characteristics. Table showing memory space allocation of OFP to 5 major modules. Radar mode descriptions with pictures of associated displays. HUD displays with explanatory captions for navigation and weapon delivery.

(5) NWDS: *Performance Specifications for the Weapon Delivery Function of the OFP* (U), IBM # 68-L68-012, 3 Dec. 1968

Out-of-date, but it contains useful tables:

Program discrete inputs
Program discrete outputs
Signal inputs
Display generation commands
Legal weapon mode selection (MSF X weapon type)
Annotated HUD displays for all weapon modes
Weapon delivery requirements (velocity, altitude, attitude)
Weapon delivery sensor priority for horizontal velocity,
vertical velocity, and attitude calculations

(6) MATH: *A-7D/E Aircraft Navigation Functions* (U), by L. Crews and Carl Hall, NWC, TN 404-176, Mar. 1975

Derivation and explanation of navigation equations, including justification for selected methods. Each section includes (a) a brief description of the calculation, relating it to the whole navigation process and (b) a list of input and output quantities.

(7) MATH: *A-7E Aircraft Weapon Delivery Equations* (U), by R. George, NWC TM 2926, Sept. 1976

Similar to Ref. 6 for weapon delivery functions.

(8) OFP-1: *WS8506 Documentation for OFP NWC-1* (U), by SCI (5 volumes and reference guide), NWC TN 404-223, Dec. 1975

These volumes contain a great deal of information, but the organization and size make it difficult to find answers to specific questions. Since they cover NWC-1, some of the software function is out-of-date.

(9) OFP-2: *OFP NWC-2 Glossary of Terms for A-7E Navigation and Weapon Delivery OFP* (U), for Tape 7, revision B, 1 Feb. 1977

Alphabetical list of program variables and constants, each described by some of the following:

value type (logical, single precision, double precision)
explanation of use
range, units, meaning of value
value (constant) or initial value (variable)
timing (how often updated/referenced)
scaling

(10) OFP-2: *A-7E OFP Math Flow Description - NWC-2* (U), for Tape 7, revision C, 1977

Prose to accompany flowcharts (Refs. 12 and 13) Algorithms described in terms of program variables, constants and labels. Sections: Navigation, Weapons delivery, Interrupt processor and control, NAV/WD Panel Processor, Self Test

(11) OFP-2: Conf document *A-7E Math Flow Description - NWC-2 Special Weapons, SHRIKE and WALLEYE* (C), for tape 7, revision C, 1977

Similar to Ref. 10

(12a) OFP-2: *OFP NWC-2 Math Flow* (U), for Tape 7, revision C, 1977

Low-level flowcharts, with a close correspondence to the code.

(12b) OFP-2: *System Flow for the TA-7C Navigation and Weapon Delivery OFP* (U), Mar. 1977

Higher level flowcharts, expressing in English the information that Ref. 12a expresses in program terms.

Warning: these flowcharts were written for the two-seater (TA-7C) version of the OFP, so that there are some differences (e.g., the one-seater does not include the digital scan converter functions.) See Ref. 12c. for a list of differences.

(12c) OFP-2: *TA-7C Operational Flight Program Math Flow Description Deltas* (U), 1977

Describes changes made to Ref. 10 for the two-seater version of the OFP. Use with Ref. 12b.

(13) OFP-2: Conf document *OFP NWC-2 Math Flow - Special Weapons, SHRIKE and WALLEYE* (U), for Tape 7, revision C, 1977

Low-level flowcharts, with a close correspondence to the code.

(14a) PILOT: *NATOPS Flight Manual A-7C, A-7E Aircraft* (U), NAVAIR 01-45AAAE-1, 15 March 1975; change 4, 1 Sept. 1976

Pilot's manual containing information about all aspects of the aircraft, except details of weapons delivery, which are contained in Ref. 15. Warning: this source describes NWC-1. See Ref. 14b. for an update. Important sections:

pp. 1-158 thru 1-222	Avionics Subsystems pictures and descriptions of principle components and their operating modes
pp. 1-236 thru 1-237	Avionics System Integration table showing functions of components
pp. 1-251 thru 1-253	TACAN system
8-1 thru 8-22	Navigation/Weapon Delivery System (NWC-1 OFP) User's manual for navigation, alignment, position updating.
8-23 thru 8-58	component descriptions and pictures for weapons delivery subsystem

(14b) PILOT: NATOPS Flight Manual Interim Change No. 65 (U) NAVAIR 01-45AAAE-1, 1 May 1977

Update to Ref. 14a, Section 8, reflecting NWC-2 navigation and diagnostic aid changes.

(15a) PILOT: Conf document *A-7C, A-7E Tactical Manual* (C), NAVAIR 01-45AAE-1T, Oct. 1974

Pilot's manual, containing weapons' delivery details. Warning: NWC-1.

(15b) PILOT: Sec document Secret supplement to Tactical Manual (S), NAVAIR 01-45AAE-1TA

Specific information about special weapons.

(15c) PILOT: Conf document *NWC-2 OFP Characteristics: Temporary Addendum No. TBD to Ref. 15a* (C), (preliminary)

Update to Tactical Manual reflecting NWC-2 weapons delivery changes. Moding, control, display changes and diagnostic aids for weapons delivery monitoring. Ballistics calculation changes for special weapons.

(16) OFP-2: *OFP NWC-2 Program Listing and Cross References* (U), NWC-2 Tape 7 Revision C, 3 Oct. 1977

Secret parts encoded.

(17) PILOT: *OFP A7 NWC-2 Viewgraph Presentation* (U), 22 April 1977

Presentation prepared for pilots, showing the differences between NWC-1 and NWC-2, particularly weapon's delivery: moding, display, diagnostics

(18) TC-2: *Introduction to TC-2 Assembly Language Programming for A-7D/E Programmers* (U), SCI, by G. Abels, Feb. 1976

Compilation of Refs. 19, 20, and Assembler Language manuals, written by a tech writer. (NOT RELIABLE). Confuses TC-2 and TC-2A in places.

(19) TC-2: *A-7D/E Programmers Guide to Input/Output for the TC-2* (U), IBM #6870158-3, 25 May 1970

For each input and output channel, it gives: information items, associated devices, data format. Explanation of cycle-stealing I/O and the BITE instruction. Some corrections have been made in our copy based on Lee Thomson's marginal notes.

(20) TC-2: *A-7 D/E Programmer's Reference Manual* (U), IBM #67-506-001, 14 Sept. 1967

Data and instruction formats, registers, interrupt processing, addressing. For each instruction: opcode and mnemonic, operands, timing, formats, affected indicators

(21) SIM: *A-7C/E Simulation Computer Program Documentation* (U), Parts 1-6, NWC TM 3105, Feb. 1977

Documentation for the V & V simulation laboratory (Sigma 5, VG, etc.). Pts. 1 and 2 provide an indirect description of the OFP, since they contain models of most of the interfaces – they show what assumptions had to be made about the OFP and other components to simulate the Avionics system.

(22) SIM: *A-7E Simulator Software Capabilities* (U), NWC TN 404-186, May 1974

Simulator description superseded by Ref. 21. Brief description of other software support on the SIGMA 5 and PDP 11, including the assembler and Tape merge, punch and verify program

(23) VAL: *A-7 Simulation Facility - Cursory Validation Plan for OFP NWC-2* (U), NWC TM 3159, Jan. 1977

Description of the short, 40-hour version of formal validation. Mostly derived from Ref. 24.

(24) VAL: *A-7 OFP Validation Plan and Procedures for Simulation Facilities* (U), OFP NWC-2, Parts 1 and 2, NWC TM 3204, Mar. 1977

Part 1 gives background and justification for the test approach. Part 1 appendix: user's manual for entering and displaying data on the NWDC panel, including units, accuracy and meaning of various panel quantities. Part 2 shows how the OFP should behave in a large number of test cases.

(25) MATH: *A-7D/E Mathematical Subroutine Description* (U), IBM #6870156-3, 25 May 1970

For each of the 16 subroutines:

flowchart
interfaces (in parameters, calling routines, called routines, etc.)
data organization
limitations (e.g. register contents destroyed, max size of input)
storage required
execution time

The descriptions should be checked against the code, but they should still be substantially correct.

(26) PILOT: *A Pilot's Guide to the Use and Understanding of the A-7E Avionics System* (U), VA-122, 29 Jan. 1973 Update

This manual should not be trusted for facts – it covers an earlier version of the OFP, and it was never formally released. However, it does provide background information and explanation which may aid understanding.

(27a) OFP-1: *Technical Description of NWC First A7E Operational Flight Program (OFP)* (U) by R. R. Bruckman, NWC Reg Memo 40408, 31 Aug. 1973, Rev. A

Describes changes to be made to an earlier version of the OFP. Mostly focuses on weapons delivery changes.

(27b) OFP-2: Technical Description of NWC-2 Operation Flight Program (U), Preliminary, rev. F, 21 Apr. 1976

Describes changes between NWC-1 and NWC-2. Mostly focuses on weapons delivery changes.

(28) OFP-2: *Advanced Organizational Maintenance Data* to be incorporated into NAVAIR 01-45AAE-2-17.2 (U), 15 Aug. 1977

Update to maintenance manual, reflecting NWC-2 changes. More complete description of diagnostic panel displays than Ref. 29. Discussions of alignment, updating, and weapons delivery.

(29) PILOT: *In Panel Display Card (U)*

Reference card showing NWDC panel displays for data locations 00-99, used for navigation, weapons delivery and maintenance diagnostics. Page 8 summarizes the pilot procedures for navigation updates. Page 9 explains when the INA should be steady or flashing.

(30) SIM: *CADU Reference Card (U)*

Informal list of instructions for the Control and Display Unit (CADU) used to load and debug OFPs in the laboratory TC-2 computers. The CADU allows limited tracing and breakpoint setting.

(31) SIM: *Weapons Station Simulator* (U), by Jack Williams, NWC 2706, Sept. 1976

Physical characteristics, components and operation of the Weapons Station Simulator laboratory (downstairs in hangar 3). Includes wiring diagrams and detailed signal descriptions.

(32) SIM: *Weapons Management Simulation and Control* (U), by Jack Williams, NWC 3029, Dec. 1976

Description of the weapons simulation laboratory focusing on the weapons delivery controls and components (ASCU, ARP, etc.). Wiring diagrams, decoder logic, and signal descriptions. Some prose which explains the use of the controls.

(33a-h)
HARD: Procurement Specifications for NWDS components.

a. *Inertial Measurement Set AN/ASN-90(V)* (U)

b. *Navigation Set, Radar AN/APN-190(V)* (U) (Doppler) Includes:

One paragraph description of operation
Operational limits
Electrical outputs: range, probable error form
Data transmission and word format
Resolution and timing

c. *Air Data Computer* (U)

d. *Transducer, Angle of Attack* (U)

e. *Forward Looking Radar System (AN/APQ-126)* (U)

f. *Projected Map Display Set* (U)

g. *Head Up Display* (U) Includes:

3.3.29 Discussion of symbology functions
Paragraphs per symbol, showing meaning, scale, limits, etc.

3.3.40 Digital Data Channel Description
List of data with identity codes

3.4.1 Symbol positioning accuracies

h. *Projected Map Display Set for A-7E Airplane, Film-strip for* (U)

i. *Specification for Multicolor 35MM Film-strips for the Projected Map Display System* (U) draft, 18 Nov. 1968

j. *DoD Procurement Specifications for Projected Map Display Set for the A-7 Aircraft* (U), June 1974

(34) HARD: *A/7D/E Head Up Display* (U), by W. N. Carroll, IBM 68-L88-099, 8 Apr. 1968

(35) HARD: *General Description of the Head Up Display (An/AVQ-7) for the A-7D/E Airplane* (U), by I. S. Glickstein, IBM 69-M93-001, 14 Feb. 1969

(36) HARD: *General Description of the Projected Map Display Set for the A-7E Airplane* (U), by Ira S. Glickstein, IBM 69-M93-003, 10 June 1969

(37) HARD: *Addendum No. 6, Projected-Map Display Set Functional and Performance Requirements for A-7E Airplane Navigation/Weapon Delivery System (NWDS)* (U), IBM 209-18-67b, 9 July 1968

(38) HARD: NAVAIR Maintenance Manuals

a. Inertial Measurement Set AN/ASN-90 (V): NAVAIR 05-35EAB-1, 15 Nov. 1971, Change 8 - 1 Nov. 1977

b. Head-Up Display Set AN/AVQ-7 (V): NAVAIR 05-35FAB-1, 15 Apr. 1972, Change 7 - 15 Oct. 1977

c. Projected Map Display Set AN/ASN-99 (V): NAVAIR 05-35FAC-1, 15 Aug. 1971, Change 4 - 15 Jan. 1977

(39) SINS: Conf document *Shipboard Data Link System Requirements for Aircraft Inertial Navigation System Alignment and Waypoint Insertion* Naval Air Systems Command, AR-57A, 3 May 1971

(49) MATH: *A Ballistic Trajectory Algorithm for Digital Airborne Fire Control* (U) by Duke, Brown, Burke, and Seeley, NWC TP 5416, 17 Aug. 1972

(41) MATH: *Coordinate Systems Analyst Manual (BLSIM5)* (U) by Kobaly (Systems Consultants, Inc.), Renta and Breisch (NWC A-7D Project Office), July 1979.

11.2. PEOPLE TO CONTACT FOR MORE INFORMATION

This section used to contain an annotated list of the people who could answer questions about various aspects of the A-7E, as well as the people who worked on the A-7E software engineering project. This information is very outdated, and those individuals have long since moved to various other projects, so it has been deleted.

The information which used to be here gave the name of each individual, the naval facility and address where he/she worked, phone numbers, and how the individual contributed to the project (e.g., "A-7 project member", "weapons delivery equations", etc.).

Dictionary of Terms Defined in this Document

!A/C facing target! — True if the angle between the line from the A/C to the target and the A/C Y axis (both projected into horizontal plane) is less than 90°.

!A/C inverted! — 270° > !system roll! > 90°

!AC test angle! — Angle determined by /ACTESTCOS/ and /ACTESTSIN/ (angular range: 0° to 360°).

!AC Test 1 failed! — Setup: None
Test steps:

//RNGUNIT//:=	5	(see also Section 4.7.3),
//RNGTEN//:=	5	(see also Section 4.7.3),
//RNGHND//:=	5	(see also Section 4.7.3),
//ANTSLAVE//:=	On	(see also Section 4.2.3),
//STEERAZ//:=	45°	(see also Section 4.2.5),
//GNDTRK//:=	225°	(see also Section 4.7.2),
//STEEREL//:=	15°	(see also Section 4.2.4),
//BRGDEST//:=	0°	(see also Section 4.7.1),
//SPARE1//:=	45	
//SPARE2//:=	225	

Failure criteria: (a) a hardware error occurred during the instruction sequence for any of the outputs (refer to Section 2.0.6). (b) any interrupt occurs before CONVERSION COMPLETE besides IN PANEL; (c) a hardware error occurred during the instruction sequence for /ACTESTCOS/ and /ACTESTSIN/ (refer to AC Self-Test, Section 2.1.8.6); (d) !AC test angle! < 44.7 or > 47.5.
Clean-up: None

!AC Test 2 failed! — Setup: None
Test steps:

//BRGDEST//:= 225° (see also Section 4.7.1),
//RNGUNIT//:= 3 (see also Section 4.7.3),
and the values set in !AC Test 1 failed! do not change.

Failure criteria: (a) a hardware error occurred during the instruction sequence for any of the outputs (refer to Section 2.0.6); (b) any interrupt occurs before CONVERSION COMPLETE besides

	IN PANEL; (c) a hardware error occurred during the instruction sequence for /ACTESTCOS/ and /ACTESTSIN/ (refer to AC Self-Test, Section 2.1.8.6); (d) !AC test angle! < 49.14° or > 52.0°. Clean-up: None
!AC1 Tstage!	Stage of *Grtest*. See Section 3.7.0.
!AC2 Tstage!	Stage of *Grtest*. See Section 3.7.0.
!acc bias!	Part of each incremental velocity measurement is an error caused by the misalignment of an accelerometer with its associated gyro. The biases caused by gyro-accelerometer misalignment are measured for each axis and can be entered in the TC-2 by the maintenance personnel (see Sections 4.6.25 and 4.6.26).
!ADC Reasonable!	150 fps < /TAS/ < 1024 fps
!ADC Up!	/ADCFAIL/=No AND !ADC Reasonable!
!adjusted point!	The position of the aiming symbol after the pilot moves it with the slew control.
!After slewing!	@T(ABS(/SLEWUD/) < 0.148 AND ABS(/SLEWRL/) < 0.148)
!Aiming switches set!	/MODEROT/=$PRESPOS$ AND /PRESPOS/=$UPDATE$ AND /UPDATTW/=$IMS-HUD$
!Air velocity test passed!	Difference between !IMS NVel! and !Doppler NVel!, and between !IMS EVel! and !Doppler EVel! ≤ 5 fps
!Alterable data displayed!	One of the following Panel Display Functions is controlling the panel output data items: Update Present Position Coordinates Display Update Wind Display Update SINS X and Y Offsets Display Update SINS Z Offset and Delta Heading Display Update Magnetic Variation Display (1-9) Update Platform Heading and Reference Hdg Display Update Destination Coordinates Display (1-9) Update Destination Altitude and MSLP Display (1-9) Update Offset Range and Bearing Display (1-9) Update Offset Delta Ht. and Burst Ht. Display (1-9) Update Data 01 Through Data 26 Display The rules for determining which function controls the panel are given in Section 4.6.1.
!alternate steering!	See Section 4.3.2
!Altitude from slant range!	Above ground altitude can be calculated from /SLTRNG/ and the depression angle from horizontal to the point on the ground that the FLR is aimed at since they provide the length of a side and an

angle of the right-angle triangle from the A/C to the ground underneath it to the target.

!Amax!
Maximum release angle for low drag special weapons (weapon dependent. associated with ASCU code)

!Amin!
Minimum release angle for low drag special weapons (weapon dependent, associated with ASCU code)

!angle - Lwindow!
Panel format — See Table 4.6-a

!angle - Uwindow!
Panel format — See Table 4.6-a

!Any destination entered!
Pilot enters the coordinates for any one of the 9 destinations through the panel. See Section 4.6.2 for panel entry rules.

!AOA reasonable!
!True AOA! > -5.6°.

!ASAZ!
!ASEL!
Values for Aiming Symbol coordinates, before limiting. See Section 4.3.1.

!ASLAZ!
!ASLEL!
Values for Azimuth Steering Line Center Point coordinates before limiting. See Section 4.3.2.

!axis aligned!
True when the alignment error value given in the table below is no longer exceeded for a particular axis in the specified stage:

	X-axis	Y-axis	Z-axis
!CA stage!	*	*	*
!CL stage!	*	*	n/a
!FG stage!	*	*	*

Values denoted with * were not available at the time of printing, but can be derived from the current implementation.

!azimuth miss distance!
The perpendicular distance between the !target! and the imaginary line drawn from the a/c through the !impact point!.

!azimuth reference heading!
The heading entered by the pilot of a known reference point. See Section 4.6.10 for more information.

!Az-reference error!
Defined in Section 4.1.6

!Baro!
One of the values of !Data 24!, indicating the pilot has chosen the baroaltimeter of the ADC as the priority backup ranging sensor. Panel value — See Section 4.6.31.

!BAROADC!
adjusted /BAROADC/
IF !Data 26! = !L-probe! THEN /BAROADC/ × [1 − /MACH/^{2} × (.02032 − 7.5148 × 10^{-7} ft × /BAROADC/)] + [!system vertical

velocity! × .4375 s] – 1056 ft
ELSE /BAROADC/ + 560 ft × (/MACH/ – 0.2)
This definition is device-dependent and likely to change if the current ADC is replaced.

!Baro altitude above target!	In *Noffset*, *BOCoffset*, *Snoffset*, *SBOCoffset*, *HUDdown2*, and *SHUDdown2* modes: /BAROADC/ – (!Destaltitude! + !Delta height!) All other modes: /BAROADC/ – !Destaltitude!
!Beep rate!	0.5 seconds
!Before slewing!	The stage in a weapons delivery or update mode after mode entry but before !During slewing!. In modes *Landaln*, *01Update*, *I*, *OLB*, and *PolarI*, becomes true when the event @T(!aiming switches set!) occurs and false when !During slewing!.
!blank!	Panel format — See Table 4.6-a
!blast pullup point!	The point where the A/C must immediately begin a 4 G pullup to keep out of the blast radius of an exploding weapon. This pullup includes 1.3 seconds aircraft/pilot reaction time before the 4 G portion of the maneuver. The blast radius is assumed to be 1500 ft around the blast point of the weapon.
!bomb fall line!	Imaginary line on the ground along which a ballistic weapon would travel if released now.

!bomb-spacing!	The distance between !impact points! for the bombs in a stik:
	IF !Shrike! THEN 1 nmi;
	IF !Mines! then
	MAX(Minimum-release-distance-for-mines,
	MRI-for-mines, /ARPINT/ × 10);
	IF NOT !Shrike! AND NOT !Mines! THEN
	MAX(Minimum release distance-for-weapon-type,
	/ARPINT/).
	Minimum release distances are figured from Minimum Release Intervals (MRI), given in Section 2.4. During a multiple release a change in /ARPINT/ is not accepted when /RE/=On.

!Called-up point!	Nine sets of coordinates can be stored as destinations. Each of these has a single-digit number associated with it. The location defined by the coordinates of the destination selected by the pilot when @T(!Dest called up!) occurs is called the Called-up point.
!CA stage!	Coarse azimuth. Alignment stage — See Section 3.2.0.
!CA stage complete!	Initially false. Becomes false on entry to *Lautocal*, *Sautocal*, *Landaln*, *SINSaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when (!X-axis corrected! AND !Y-axis corrected! AND !Z-axis corrected!).

!Checksum test failed!	The OFP periodically performs a check on the portions of memory that store program and fixed data by computing a checksum. The test is failed if a sum other than the expected sum results.
!CL stage!	Coarse level. Alignment stage — See Section 3.2.0.
!CL stage complete!	Initially false. Because false on entry to *Lautocal*, *Sautocal*, *Landaln*, *SINSaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid, *IMS fail*, *Grtest*. Becomes true when (!X-axis corrected! AND !Y-axis corrected!).
!coarse scale factor!	A value of Data 07, Data 08, or Data 09. See Section 4.6.23.
!Coord entered!	Coordinates have been entered for the called up destination. See also !Dest called up!.
!CS Tstage!	Stage of *Grtest*. See Section 3.7.0.
!data link waypoint coordinates!	Coordinates have been received from the Waypoint System.
!Data 01!	!north gyro drift!. Panel value — See Section 4.6.19.
!Data 23!	Whether a/c is land or carrier based. Panel value — See Section 4.6.30.
!Data 24!	Priority sensor for vertical ranging. Panel value — See Section 4.6.31.
!Data 25!	Whether Doppler coupled. Panel value — See Section 4.6.32.
!Data 26!	Which equations to use to calculate true airspeed. Panel value — See Section 4.6.33.
!Data 98 displayed!	Update Data 98 is the Panel Display Function currently controlling the panel output data items.

!DC Test failed!	Setup:
	//STERROR//:= !Test Value 3! (see also Section 4.8.1),
	//FPANGL//:= !Test Value 2! (see also Section 4.2.7),
	//GNDTRVEL//:= !Test Value 1! (see also Section 4.2.6).
	Test Steps: None
	Failure criteria: (a) any hardware error occurred during the instruction sequence for any of the outputs (refer to Section 2.0.6); (b) a hardware error occurred during the instruction sequence for /DCTEST/ (Refer to DC Self-Test, Section 2.1.8.7); (c) /DCTEST/ < -1.24 or > -1.16.
	Clean-up: None

!DC Tstage!	Stage of *Grtest*. See Section 3.7.0.
!decimal point!	Panel format — See Table 4.6-a.

!Delta heading!

Angle entered by pilot indicating difference between A/C heading and ship heading. Panel value — See Section 4.6.8.

!Delta height!

Difference in altitude between the OAP and the target. Panel value — See Section 4.6.14.

!Desig!

The pilot has identified a target to the computer. Initial value: false. Table D-d shows when !Desig! changes value.

!Designation-retention!

!Desig! AND !Desig! last became true in *BOC*, *BOCFlyto0* or *BOCoffset*.

!Destaltitude!

An altitude entered by the pilot associated with a particular destination. Panel value — See Section 4.6.12.

!Dest called up!

During update modes, the pilot keys in the single non-zero digit that identifies the destination to be used as the update reference point. !Dest called up! becomes true when @T(!Non-zero digit entered!) occurs while in an update mode. It becomes false upon exit from the current update mode.

!DEST displayed!

Update Destination Coordinates Display (see Section 4.6.11) is the Panel Display Function currently controlling the panel output data items.

!Dest 0!

/FLYTOTOG/ = $Dest$ AND /FLYTCTW/ = 0

!Dest 1-9!

/FLYTOTOG/ = $Dest$ AND /FLYTOTW/ ≠ 0

!DGNDSP!

if !BAROADC! is available /DGNDSP/ - [/DGNDSP/ × !BAROADC! / 4000000 feet] otherwise /DGNDSP/ - [/DGNDSP/ × 9 / 8000]

This definition is device-dependent and likely to change if the current Doppler is replaced.

!DIO Tstage!

Stage of *Grtest*. See Section 3.7.0.

!Discrete I/O Test failed!

Setup: //BITE1//:= $WRAPDISCR$, //BITE2//:= $None$.

Subtest 1 — Step: //DOW1//:= 00A4$_{16}$. Failure criteria: /DIW1/ ≠ 00A4$_{16}$.

Subtest 2 — Step: //DOW2//:= A5A4$_{16}$. Failure criteria: /DIW2/)!= A5A4$_{16}$.

Subtest 3 — Step: //DOW2//:= 5A5A$_{16}$. Failure criteria: /DIW2/ ≠ 5A5A$_{16}$.

Clean-up:

//DOW1//:= 0000$_{16}$,
//DOW2//:= 0000$_{16}$,
//BITE1//:= $None$,

//BITE2//:= $None$.

!Displayable difference!	Some of the Update Panel Functions are concerned with values that change continuously, such as the A/C position when it is airborne. The functions update the values to be displayed on the panel at discrete intervals. !Displayable difference! occurs when the difference between the most recent update value and the current value is greater than the resolution for that function.
!distance to release!	With !high drag! weapons, the !ground range! the A/C must travel to reach the point where it should release the first weapon in the stik. Measured in feet.
!dive pullup!	If the A/C is close enough to the target, there exist two pitch angles (one greater than the pitch for maximum range, one less than this pitch) from which the aircraft, at present position and airspeed, would release a !low drag! weapon, and the weapon would reach burst height at the target. If the aircraft is close enough for these two angles to be calculated, !dive pullup! is the lower of the two pitch angles minus the !system pitch!. Otherwise, !dive pullup! is 42° minus !system pitch!.
!Doppler coupled!	One of the values of !Data 25!, used by the pilot to select or deselect the use of the Doppler radar when in an inertial navigation mode. This value indicates Doppler should be used. Panel value — See Section 4.6.32.
!Doppler EVel!	East component of !DGNDSP!
!Doppler NVel!	North component of !DGNDSP!
!Doppler Reasonable!	True iff /DRSREL/ = Yes for last 5 seconds AND 256 fps ≤ !DGNDSP! ≤ 1456 fps AND !DGNDSP! change from .2 s ago ≤ 79 fps AND /DRFTANG/ ≤ 29.5° AND /DRFTANG/ change from .2 s ago ≤ 4° AND at least 1 bit change in either /DGNDSP/ or /DRFTANG/ in last 2 seconds
!Doppler Up!	/DRSREL/ = Yes AND /DRSMEM/ = No AND !Doppler Reasonable!
!drift angle!	IF !Doppler Up! THEN /DRFTANG/ ELSE !IMS drift angle!
!during platform slewing!	//XSLEW// = On OR //YSLEW// = On OR //ZSLEW// = On.
!During slewing!	At least one of /SLEWUD/ or /SLEWRL/ indicates slew control displayed from center. If the slew control were a perfect device, the meaning of this term would be (NOT /SLEWUD/ = 0 OR

NOT /SLEWRL/ = 0). Since the slew control is not perfect, see Section 2.2.2 for reliable indications of displacement.

!echo! — The characters typed in by the pilot are echoed in the panel window. Exactly what is displayed depends on the format of the display that he is entering. For example, when a display of format !lat! is displayed, the first /KBDINT/ must be either S or N, or else an error has been made. If the first input is correct, either //ULITN//:=On or //ULITS//:=On. Subsequent /KBDINT/ values are shown in panel windows.

!ED stage! — East drift. Alignment stage — See Section 3.2.0.

!ED stage complete! — Initially false. Becomes false on entry to *Lautocal*, *Sautocal*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when !Data 02! has been calculated and (!X-axis corrected! AND !Y-axis corrected! AND !Z-axis corrected!).

!eligible release! — !Desig! AND PUAC in view

!EW! — One of two values of Data 19 and Data 20, indicating that the associated map area is oriented East-West. See Section 4.6.28.

!FG stage! — Fine gyrocompass. Alignment stage — See Section 3.2.0

!fine scale factor! — A value of Data 10 or Data 11. See Section 4.6.24.

!fire pulse width! — Length of time that //BMBREL//=On should be true to cause the ASCU to release a particular weapon. The fire pulse widths vary from weapon to weapon and are given in Table 2.4-a.

!fixpoint! — In Update modes after @T(!Dest called up!) occurs, the reference point is one of the nine destinations, until the pilot slews the aiming symbol or radar cursors to show his idea of the reference point location. After he slews, the aiming symbol or cursors track the point the pilot left them over when he finished slewing. This refined point is the fixpoint.

!flight path angle! — !system pitch! - [!True AOA! X Cosine(!system roll!)]

!FLY-TO changed! — Value of either /FLYTOTOG/ or /FLYTOTW/ changed.

!FLY-TO MSLP! — See Section 4.3.3 The MSLP associated with the location indicated by /FLYTOTOG/ and /FLYTOTW/.

!Fly-to point! — Destination or Mark indicated by settings of /FLYTOTOG/ and /FLYTOTW/.

!/FLYTOTW/ reset! — /FLYTOTW/ changes value from x to y, where $x \neq y \neq$ 0.

!FM stage! — Fast magnetic heading update. Alignment stage — See Section 3.2.0.

!FM stage complete! — Initially false. Becomes false on entry to *Airaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when the difference between 2 averages of 3 readings each is less than 10 deg per minute.

!format lights on! — The following data items are set to On: //ULITN//, //ULITS//, //ULIT222//, //ULIT321//, //ENTLIT//, //KELIT//, //LLITE//, //LLITW//, //LLIT322//, //LLIT-DEC//.

!FPMAZ!
!FPMEL! — Values for Flight Path Marker coordinates before limiting. See Section 4.3.5.

!GA Tstage! — Stage of *Grtest*. See Section 3.7.0.

!GAS! — Go-around steering. See Table D-e to see when Go-around steering is in progress. The purpose of GAS is to show the pilot cues for the quickest return to a target that he has overflown by more than 13000 ft.

!Grazing angle! — The elevation angle that the FLR antenna is pointed down from local horizontal. This angle is positive when the antenna is aimed below horizontal.

!ground pullup point! — The point where the A/C must execute a 4 g pullup to avoid hitting the ground, assuming a safety margin of ... This pullup includes 1.3 seconds of aircraft/pilot reaction time before the 4 g portion of the maneuver.

!ground range! — Horizontal distance to some point.

!ground tests finished! — Initialized to false. Becomes true after 4 seconds elapsed in !PD Tstage! of *Grtest* mode. Becomes false when *Grtest* exited.

!ground track! — Line defined by projection of A/C velocity vector into horizontal plane.

!ground track angle! — Angle (clockwise from North looking down) between !ground track! and the line from the A/C to true north.

!Guns! — True when !weapon class!=GN. Otherwise, false.

!Gyro Accel Test failed! — Setup: //BITE1//:= $None$; //BITE2//:= $WRAPGYACC$
Test Steps: For each axis, in sequence, * = X, Y, then Z.

a. When /DIMWC/ = $Ready$, /*GYCNT/ is read and tval:= /*GYCNT/.
b. If tval ≥ 0 then oval:= −8 else oval:= 8.
c. //*TORTEST//:= oval.
d. Delay 40 ms.
e. ival:= /*VELTEST/.

Failure criteria: oval ≠ ival.

Clean-up: //BITE2//:= $None$.

!HG stage! — Hi-gain gyrocompass. Alignment stage — See Section 3.2.0.

!high drag! — True iff:

!weapon class! = SH OR
!weapon class! = SSH OR
!weapon class! = HD OR
(!weapon class! = OD AND /BMBDRAG/ = $High$) OR
(!weapon class! = OR AND /BMBDRAG/ = $High$) OR
(!weapon class! = SOD AND /BMBDRAG/ = $High$)

!HL stage! — Hi-gain level. Alignment stage — See Section 3.2.0.

!HS stage! — Heading slew. Alignment stage — See Section 3.2.0.

!HS stage complete! — Initially false. Becomes false on entry to *SINSaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when !Z-axis corrected!.

!HUD rate! — Azimuth displacement, in degrees per second:
$(25/256) \times /SLEWRL/ \times (/SLEWRL/^2 - .148^2 + 9)$

elevation displacement, in degrees per second:
$(25/256) \times /SLEWUD/ \times (/SLEWUD/^2 - .148^2 + 9)$

!impact angle azimuth! — The angle between the A/C Ya axis and the line projected into the Xa-Ya plane from the a/c nose to the !impact point!. Looking in the -Za direction, it is positive clockwise from Ya.

!impact angle elevation! — The angle between the A/C Ya axis and the line projected into the Ya-Za plane from the A/C nose to the !impact point!. Measured from the Ya axis in the positive Za direction (up).

!impact point! — The point on the ground that would be hit by a weapon released now or a gun fired now, in any weapon delivery mode. At different times, different compensations are made in impact point calculations. (a) *A/G Guns* with !Guns!: wind, parallax, gravity drop, and AOA. (b) *A/G Guns* with !Rockets!: wind and gravity. (c) *A/A Guns*: A/C acceleration and platform angles.

!IMS-ADC Reasonable! — ABS(!IMS total velocity! - /TAS/) $\leq$ 191 kt OR !ADC down!.

!IMS-Dop Reasonable! — ABS(!IMS groundspeed! - !DGNDSP!) $\leq$ 62 kt OR !Doppler down!.

!IMS drift angle! — Drift angle calculated by subtracting !IMS heading! from the ground track angle derived from !IMS NVel! and !IMS EVel!.

!IMS EVel! — Velocity calculated from /XVEL/ history - speed of A/C in the east direction (assuming platform aligned). It is set to 0 when @T(in mode) for *IMS fail* and when @F(in mode) for

	SINSaln, *Sautocal*, *Landaln*, and *Lautocal*.
!IMS ground speed!	Magnitude of the horizontal component of the velocity vector, calculated from !IMS NVel! and !IMS EVel! - length of vector g in figure D-a.
!IMS heading!	Angle determined by /THDGCOS/ and /THDGSIN/ (angular range: 0° to 360°); above 80° latitude corrected by addition of !wander angle!.
!IMS magnetic variation!	Magnetic variation received through the IMS true heading inputs, /THDGCOS/ and /THDGSIN/ (angular range: 0° to 360°), when !IMS down! See Section 2.1.1.8.
!IMS NVel!	Velocity calculated from /YVEL/ history — speed of the A/C in the north direction (assuming platform aligned). It is set to 0 when @T(in mode) for *IMS fail* and when @F(in mode) for *SINSaln*, *Sautocal*, *Landaln*, and *Lautocal*.
!IMS pitch!	Angle determined by /PCHCOS/ and /PCHSIN/ (angular range: ±180°). (see !system pitch!)
!IMS Reasonable!	Magnitude of !IMS total velocity! ≤ 1440 fps AND !IMS total velocity! 0.2 s ago ≤ 50 fps.
!IMS roll!	Angle determined by /ROLLCOSI/ and /ROLLSINI/ (angular range: ±180°). (see !system roll!)
!IMS total velocity!	3-dimensional vector sum of !IMS NVel!, !IMS EVel! and !IMS VVel!
!IMS Up!	/IMSREDY/ = Yes AND /IMSREL/ = Yes
!IMS VVel!	Velocity calculated from /ZVEL/ history - speed of the A/C moving towards or away from the ground (assuming IMS aligned).
!IN A! !IN B!	See Section 4.5.3.
!In-time test failed!	The OFP is required to reset the TC-2 GO/NO GO counter every 1.3 seconds. This test is failed if the OFP fails to do this.
!In OFF_MFSW!	True iff current weapons mode is OFF_MFSW.
!In WD_MFSW!	True iff current weapons mode is WD_MFSW.
!inc vel scale!	X and Y axes: IF //IMSSCAL// = $Coarse$ THEN !coarse scale factor! ELSE !fine scale factor! Z axis: !coarse scale factor!
!Interface test failed!	!Timer Test failed! OR !Gyro Accel Test failed! OR !Discrete I/O Test failed! OR !DC Test failed! OR !Serial Channel Test failed! OR !AC Test 1 failed! OR !AC Test 2 failed!

!Keyboard input!	Any /KBDINT/ button pushed
!label!	Panel format — See Table 4.6-a.
!Land!	One of the values of !Data 23!, indicating A/C based on land. Panel value — See Section 4.6.30.
!Land velocity test passed!	Initial value: false. Becomes false on entry into one of the following modes: *Lautocal*, *Sautocal*, *Landaln*, SINSaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when land test passed, i.e. when !IMS NVel! and !IMS EVel! both less than 1/8 fps at the end of the TS alignment stage.
!lat!	Panel format — See Table 4.6-a.
!latitude!	Latitude coordinate of present position (see Section 4.6.5).
!limited drift angle!	See Section 4.2.5.
!limited flight path angle!	See Section 4.2.7.
!limited range!	!range! MOD 1000.
!loft pullup!	The difference between the upper release angle for !low drag! weapons defined in !dive pullup! and the !system pitch!. If the aircraft is close enough for these two angles to be calculated, !loft pullup! is the upper of the two pitch angles minus the !system pitch!. Otherwise, !loft pullup! is 42° minus the !system pitch!.
!long!	Panel format — See Table 4.6-a.
!longitude!	Longitude coordinate of present position (see Section 4.6.5).
!low drag!	True iff: !weapon class! = \$SL\$ OR (!weapon class! = \$OD\$ AND /BMBDRAG/ = \$Low\$) OR (!weapon class! = \$OR\$ AND /BMBDRAG/ = \$Low\$) OR (!weapon class! = \$SOD\$ AND /BMBDRAG/ = \$Low\$)
!L-probe!	One of the values of !Data 26!, indicating that L-probe equations should be used to calculate true airspeed. Panel value — See Section 4.6.33.
!Mach Unreasonable!	/MACH/ more than .0195 different from last value read
!mag var entered!	Magnetic variation has been entered for the destination to be used for reference data during a TACAN update. Panel value — See Section 4.6.9.
!magnetic heading!	Angle determined by /MAGHCOS/ and /MAGHSIN/ (angular range: 0° to 360°).

!magnetic variation!	Magnetic variation associated with a particular destination. See Section 4.6.9.
!map destination entry!	Defined in Section 4.6.11.
!Map rate!	azimuth displacement, in earth arcseconds per second: $(25/4) \times /SLEWRL/ \times (/SLEWRL/^2 - .148^2 + 9)$ elevation displacement, in earth arcseconds per second: $(25/4) \times /SLEWUD/ \times (/SLEWUD/^2 - .148^2 + 9)$
!Mark!	/FLYTOTOG/=$Mark$
!MARK displayed!	Update Mark Coordinates Display (see Section 4.6.15) is the Panel Display Function currently controlling the panel output data items.
!Mark location!	The coordinates of a location that the aircraft has flown over, and that the pilot has chosen to be stored for later recall. Nine sets of coordinates can be stored as mark locations at one time. A new set is stored whenever @T(/MARKSW/ = On occurs. Each set is identified by the !Mark number! assigned to it when it is stored. The set of coordinates to be displayed as the !Mark location! is determined by the single non-zero digit keyed in by the pilot (see Table 4.6-c).
!Mark number!	Number associated with each set of Mark coordinates as they are stored. The number is initialized to 0 when the OFP is loaded and incremented by 1 whenever @T(/MARKSW/=On) occurs. The successor of 9 is 1.
!maximum range!	If the aircraft continues with its present pitch and velocity for 1.3 seconds. then goes through a 4 g pullup trajectory (measured in the plane of a/c velocity and Zp) until the plane has a pitch of 42 degrees, then release a !low drag! weapon, the bomb will be at a !ground range! from the aircraft equal to the !maximum range! when it falls to its burst height.
!Mines!	True when !weapon class!=MF. Otherwise, false.
!miss-distance!	IF !Mines!: Distance to designated !target! from !impact point! of first weapon in the stik if /WEAPTYP/ = 24, 30, 31, 32, 33 Other weapons: Distance to designated !target! from center of stik. Center of stik is defined in the following way: if /ARPQUANT/ is odd: !impact point! of center weapon; else: half distance between !impact points! of center two weapons.
!Nav velocity test failed!	Difference between !IMS NVel! and !Doppler NVel! > 10 fps OR difference between !IMS EVel! and !Doppler EVel! > 10 fps in *DI*, *DIG*, or *PolarDI* modes.
!ND stage!	North drift. Alignment stage - See Section 3.2.0.

!ND stage complete!	Initially false. Becomes false on entry to *Lautocal*, *Sautocal*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Crtest*. Becomes true when !Data 01! has been calculated and (!X-axis corrected! AND !Y-axis corrected! AND !Z-axis corrected!).
!negative!	Panel value: Upper window: - 0 0 0 0 0 Lower window: - 0 0 0 0 0 0
!New SINS coordinates!	SINS coordinates received, valid, and more than 1 second different from previous SINS coordinates.
!New SINS heading!	SINS heading received, valid, and more than 1 minute different from previous SINS heading.
!New SINS velocities!	SINS velocities received, valid, and more than 1 knot different from previous SINS velocities.
!New stage!	True when alignment stage changes.
!New 01 test passed!	Difference between old !Data 01! value and new !Data 01! value $\leq$ 0.049. See Section 4.6.19.
!No intervening takeoff!	@T(/ACAIRB/=Yes) has not occurred since latest exit from *Landaln* mode.
!no lights!	Panel format — See Table 4.6-a.
!Non L-probe!	One of the values of !Data 26!, indicating that L-probe equations should not be used for true airspeed calculations. Panel value — See Section 4.6.33.
!Non-zero digit entered!	Any single /KBDINT/ value is entered, except 0.
!normal acceleration!	Acceleration along the Za axis. Positive in the positive Za direction.
!north gyro drift!	Defined in Section 4.6.19.
!north light!	Panel format — See Table 4.6-a.
!NS!	One of two values of Data 19 and Data 20, indicating that the associated map area is oriented North-South. See Section 4.6.28.
!OAP!	Offset aimpoint - used in *BOCoffset*, *Noffset*, *HUDdown2*, *SBOCoffset*, *Snoffset*, and *SHUDdown2* modes. The OAP is a landmark close to a target, and the target is defined by its position relative to the OAP. In these modes, the !Fly-to point! is the original OAP, which may be changed by slewing.
!offset bearing!	Panel value - see Section 4.6.13.

!offset range!	Panel value - see Section 4.6.13.
!OF-range!	!ground range! past last !impact point!.
!Other weapon!	!Ready station! AND NOT (!Reserved weapon! OR !Shrike!).
!OTS!	Over the shoulder steering, used for loft and over-the-shoulder maneuvers. See Table D-e to see when Over the shoulder steering is in progress.
!OTS pullup!	With !low drag! weapons and !OTS!, the angle the A/C must pullup to reach the correct release angle in an OTS maneuver. In the first portion of the pullup !A/C facing target! is not true. During this time interval the !loft pullup! is calculated for a !low drag! weapon to an imaginary target that is the same !ground range! as the !target! from the aircraft, but at a bearing from the aircraft that is 180° from the bearing of the !target!. The !OTS pullup! is 180° minus this !loft pullup! minus (2 × !system pitch!). When !A/C facing target! and !OTS!, !OTS pullup! is equal to !loft pullup!.
!overflown exit!	True if last weapon mode was exited because the target was overflown without a release.
!Overfln!	The A/C has passed the last release point in a stik. If the !stik quantity! is 1, the last release point is the target. If the !stik quantity! is 2, the last release point is one-half the stik interval past the target. If the !stik quantity! is 3, the last release point is one stik interval past the target, and so forth.
!Overfln gt 42 nmi!	!Overfln! by more than 42 nmi.
!Panel error!	See Section 4.6.2 for a list.
!Panel switch changed!	/MODEROT/, /UPDATTW/, or /PRESPOS/ change value. OR /KBDENBL/ = ON OR /ENTERSW/ = ON
!PD Tstage!	Stage of *Grtest*. See Section 3.7.0.
!pilot entry!	The pilot goes through the procedure outlined in Section 4.6.2 to enter data. The only data that can be affected by this procedure are the ones associated with the Update Panel Display function currently controlling the panel output data items.
!pitch small!	ABS(!system pitch!)≤20°. (Only relevant for determining whether system in *OLB* or *UDI* modes).
!positive!	Panel value: Upper window: 0 0 0 0 0 0 Lower window: 0 0 0 0 0 0 0
!power up!	OFP started and initialized.

Dictionary ALSPAUGH, FAULK, BRITTON, PARKER, PARNAS, AND SHORE

!present position entered!

Pilot enters coordinates for A/C present position. For rules of data entry, see Section 4.6.2.

!pullup point!

Either !ground pullup point! or !blast pullup point!, whichever is closer.

!R65!

!Desig! AND !low drag! AND !Special! AND !A/C facing target! at optimum pullup range for a 65-degree !flight path angle! at release.

!Radalt!

One of the values of !Data 24!, indicating the pilot has chosen the radar altimeter as the priority backup ranging sensor. Panel value — See Section 4.6.31.

!RADALT reasonable!

50 ft $\leq$ /RADALT/ $\leq$ 4990 ft AND -30° $\leq$!system roll! $\leq$ 30°

!Radar rate!

Azimuth displacement, in degrees per second:
(25/16) × /SLEWRL/ × (/SLEWRL/^{2} -.148^2 + 9)

Elevation displacement, in feet per second:
1600 × /SLEWUD/ × (/SLEWUD/^{2} -.148^2 + 9)

!Range!

Horizontal distance from A/C position to a reference point. For specific definitions, see Sections 4.3.1, 4.3.2, 4.3.8, 4.6.38, 4.7.0, 4.7.3.

!range to Rmax!

The !Range! to the point where !Rmax! will be true.

!Ready station!

!Station selected! AND /WEAPTYP/≠00 AND !weapon class!≠UN

!Redesignate!

(/TD/=On OR !Non-zero digit entered!) AND *AflyUpd*

!release possible!

Within 40 seconds of a possible release, i.e., ABS(//*SOLCUEL//-//FPMEL//)$\leq$.59° AND //*SOLCUEL// > //FPMEL//, where * is 'L' or 'U' (see Sections 4.3.5 and 4.3.11). When this condition is true, a solution cue is between the top and center of the Flight Path Marker.

!Reserved weapon!

!Walleye! OR !Special! OR !Rockets! OR !Guns!

!rls pts passed!

Number of computed release points for latest stik that have already been passed. Initial value: 0. Initialized:

@T(!Desig!) OR
@T(*CCIP*) OR
@T(*Manrip*) OR
@T(/RE/=On) WHEN (!rls pts passed! = !stik quantity!)

Incremented:

@T(//BMBREL//=On) OR
@T(!rls pts passed! > 0 AND all other
conditions for bomb release are satisfied except
/RE/=Off). (see Section 4.4.1)

!Rmax!	!Desig! AND !low drag! AND !Special! AND !A/C facing target! AND !ground range! to target is !maximum range!.
!Rmax+6000!	!Desig! AND !low drag! AND !Special! AND !A/C facing target! AND !ground range! to target is equal to !maximum range! plus 6000 feet.
!Rmin!	!Desig! AND !low drag! AND !Special! AND !A/C facing target! AND a/c at minimum pullup range that would result in weapon impact on target.
!Rmin+6000!	!Desig! AND !low drag! AND !Special! AND !A/C facing target! AND a/c at pullup range that would result in weapon impact 6000 feet long of target.
!Rockets!	True when !weapon class! = RK. Otherwise, false.
!roll large!	ABS(!system roll!) > 5°.
!roll small!	ABS(!system roll!) ≤ 30° (only relevant for determining whether system in *OLB* or *UDI* modes)
!rounded down!	If the resolution for a panel function is greater than 1, the pilot can enter a value between the values the panel can display, but when it is displayed back to him, it will be rounded down to the closest value the function can maintain.
!SC Tstage!	Stage of *Grtest*. See Section 3.7.0.
!Sea!	One of the values of !Data 23!, indicating that A/C based on sea. Panel value — See Section 4.6.30.

!Serial Channel Test failed!

Setup:

//BITE1//:= $WRAP23$, //BITE2//:= $None$,
//CSADATA1//:= $0055AA_{16}$, //CSBDATA1//:= $1555AA_{16}$,
//CSADATA2//:= $1555AA_{16}$, //CSBDATA2//:= $2AAA55_{16}$,
//CSADATA3//:= $2AAA55_{16}$, //CSBDATA3//:= $2AAA55_{16}$,
//CSADATA1//:= $2AAA55_{16}$.

Subtest 1 — Steps: Wait until latest Channel A output is //CSADATA2//. /SERIAL1/ is read. Failure criteria:

a. a hardware error occurs in the instruction sequence for /SERIAL1/.
b. /SERIAL1/ ≠ $1555AA_{16}$ (same as //CSADATA2//).

Subtest 2 — Steps: Wait until latest Channel B output is //CSBDATA1//. /SERIAL2/ is read. Failure criteria:

a. a hardware error occurs in the instruction sequence for /SERIAL2/
b. /SERIAL2/ ≠ $1555AA_{16}$ (same as //CSBDATA1//).

Subtest 3 — Steps: Wait until latest Channel A output is

//CSADATA3//. /SERIAL1/ is read. Failure criteria:

a. a hardware error occurs in the instruction sequence for /SERIAL1/.
b. /SERIAL1/ ≠ $2AAA55_{16}$ (same as //CSADATA3//).

Subtest 4 — Steps: Wait until latest Channel B output is //CSBDATA2//. /SERIAL2/ is read. Failure criteria:

a. a hardware error occurs in the instruction sequence for /SERIAL2/
b. /SERIAL2/ ≠ $2AAA55_{16}$ (same as //CSBDATA2//).

Clean-up: //BITE2// := $RESETCYCS$, //BITE1// := $None$, and //BITE2// := $None$.

!Serial Input OK!	Validity = 1 AND Parity = 1 AND Address Parity = 1 AND Serial Input in Progress = 0
!Shrike!	True if !weapon class!=SK; false otherwise.
!Shrike solution!	A/C within 40 mils (2.29°) of the desired launch angle
!sign!	Panel format — See Table 4.6-a.
!signed fraction!	Panel format — See Table 4.6-a.
!signed integer!	Panel format — See Table 4.6-a.
!signed 2-digit!	Panel format — See Table 4.6-a.
!SINS down!	No SINS received OR All SINS invalid OR SINS velocity invalid for more than 1 second OR SINS attitude and heading invalid for more than 3 seconds.
!SINS error!	Heading error calculated for !HS Stage! — Defined in Section 4.1.6
!SINS EVel!	/SINEVEL/
!SINS heading!	/SINHDG/
!SINS heading received!	Valid SINS heading received — See Addendum.
!SINS latitude!	/SINLAT/
!SINS longitude!	/SINLON/
!SINS NVel!	/SINNVEL/
!SINS offsets!	The X, Y, and Z coordinates of the a/c in the SINS coordinate system. Panel values — see 4.6.7 and 4.6.8.
!SINS pitch!	/SINPTH/

!SINS roll!	/SINROL/
!SINS velocity test passed!	Initial value: false. Becomes false on entry into one of the following modes: *Lautocal*, *Sautocal*, *Landaln*, SINSaln*, *HUDaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when SINS test passed, i.e. when difference between !IMS NVel! and !SINS NVel! $\leq$ 1 fps after 30 s AND difference between !IMS EVel! and !SINS EVel! $\leq$ 1 fps at the end of the TS alignment stage.
!slant range!	Total line-of-sight distance to some point.
!Slant range reasonable!	!Grazing angle! $> 4^\circ$ AND $-40^\circ \leq$!system roll! $\leq 40^\circ$ AND FLR Antenna Azimuth and Elevation within 16° of Ya axis AND 1700 ft $\leq$ /SLTRNG/ $\leq$ 54000 ft
!slewed-to point!	If /PMHOLD/ = Yes, this is the filmstrip point under the display marker of the map when @T(!slewing finished!) occurs. The display marker varies, as shown in Section 4.5.4.
!slewing complete!	No further change in //XSLEW//, //YSLEW//, and/or //ZSLEW// will occur in the current stage.
!slewing finished!	@T(/SLEWUD/:=:0 AND /SLEWRL/:=:0) (this indicates that the slew inputs fall below the minimum that indicates that the control has returned to center. See Section 2.2.2).
!slew-torque cutoff!	20 arcminutes, which is the minimum platform Z axis error worth slewing out — Z axis errors smaller than this are torqued out.
!Special!	True when (!weapon class!=SOD OR !weapon class!=SSH; false otherwise.
!Special in range!	IF !low drag! THEN !Range to target! $\leq$ 10 nmi; IF !high drag! THEN !target in range!.
!Special release possible!	ABS(//LSOLCUEL// − //FPMEL//) $\leq .59^\circ$ AND //LSOLCUEL// > //FPMEL// (see Sections 4.3.5 and 4.3.11). When this condition is true, the Lower Solution Cue is between the top and center of the Flight Path Marker.
!Special solution!	!miss-distance! $\leq$ 10 ft AND ABS(!steering error!) $\leq 20^\circ$
!Special solution occurred!	@T(!Special solution!) since last target designation
!Station selected!	/STA*n*RDY/ = Yes for any $n \in \{1\ 2\ 3\ 6\ 7\ 8\}$.
!steering error!	Angle measured from !ground track! to the line from the A/C to the destination; positive value show destination line to left of !ground track!, looking down.
!steering to target!	See Table D-e.

!stik quantity!	IF !Shrike! AND *Manrip* THEN 1; IF !Shrike! AND NOT *Manrip* THEN MAX(1, MIN(/ARPQUANT/,4)); IF !Special! THEN 1; IF !Mines! THEN MAX(1, MIN(/ARPQUANT/,20)); IF none of above weapons THEN MAX(/ARPQUANT/,1) During a multiple release a change in /ARPQUANT/ is not accepted when /RE/=On.
!System horizontal velocity!	Total velocity along the ground. See !System velocities! and Tables D-a and D-b.
!system pitch!	IF !IMS up! THEN !IMS pitch! ELSE !True AOA!
!system roll!	IF !IMS up! THEN !IMS roll! ELSE 0.
!System velocities!	System velocities are the most recently calculated velocities from the most reliable available sensors. Tables D-a through D-c show the input data items are used at different times to compute the velocities.
!System vertical velocity!	Total velocity away from or toward the ground. See !System velocities! and Table D-c.
!TACAN valid!	Section 2.2.6 indicates how the validity of TACAN data is determined.
!target!	See Table D-f.
!target in range!	Target-in-range criteria for different modes are defined in Table D-g. For the definition of !target in range! for *Walleye*, see Reference 11.
!target return to view!	False initially. Becomes true when @T(!impact angle elevation! ≤ 16 deg) WHEN(!target view lost!) occurs. Becomes false when @T(!impact angle elevation! > 16 deg) OR @T(*CCIP*) OR @F(*CCIP*) occurs.
!target view lost!	False initially. Becomes true when @T(!impact angle elevation! > 16°) WHEN(in *CCIP*) occurs. Becomes false when @T(*CCIP*) OR @F(*CCIP*) occurs.
!Test Value 1!	Indicated: 512. Standard: 450°. The indicated value is the most useful to the Self-Test use of the data item. The standard value is given for compatibility with the respective data item table and is obtained by applying the scale and offset to the indicated value.
!Test Value 2!	Indicated: 512. Standard: 15° (see !Test Value 1!)
!Test Value 3!	Indicated: 320. Standard: 1.25° (see !Test Value 1!)
!time elapsed!	Clock time from some moment

!time to solution!	Estimated time remaining to solution
!Timer test failed!	Setup: None Subtest 1 — Step: the 10 bit counter is loaded with 10.24 ms. Failure criteria: an interrupt occurs before 10.22 ms or after 10.26 ms, as timed by the GO/NO-GO counter Subtest 2 — Step: the 16 bit counter is loaded with 0.65 s. Failure criteria: an interrupt occurs before 0.65536 s or after 0.65540 s, as timed by the GO/NO-GO counter. Clean-up: None
!TM Tstage!	Stage of *Grtest*. See Section 3.7.0.
!TOS!	Tail on steering, used to steer the A/C away from a weapon blast with the tail of the A/C pointing at the blast.
!TS stage!	Alignment test. Alignment stage — See Section 3.2.0.
!TS stage complete!	Initially false. Becomes false on entry to *HUDaln*, *Landaln*, *SINSaln*, *UDI*, *OLB*, *Mag sl*, *Grid*, *IMS fail*, *Grtest*. Becomes true when (TBD).
!True AOA!	The smoothed value of .76 X /AOA/ - 8.68. The smoothing is a simple lag filter with time constant 3.125 seconds. The device is read every 0.025 seconds. This definition is device-dependent and likely to change if the current AOA sensor is replaced.
!unsigned fraction!	Panel format — See Table 4.6-a.
!/UPDATTW/=Other!	/UPDATTW/≠$FLYOVER$ AND /UPDATTW/≠HUD AND /UPDATTW/≠$RADAR$ AND /UPDATTW/≠$TAC L-L$
!Walleye!	True when !weapon class!=WL. Otherwise, false.
!wander angle!	Accumulated corrections to alignment of the IMS Zp axis which are not actually applied when the A/C is above 80° latitude. The angle is measured from between the line from the A/C to north and the Yp axis.
!WD MFS!	True iff: /MFSW/ = $Natt$ OR /MFSW/ = BOC OR /MFSW/ = $CCIP$ OR /MFSW/ = $NATTOFF OR /MFSW/ = $BOCOFF$
!weapon boresight!	IF !Shrike! OR !Walleye! THEN 0 mils on HUD vertical axis;
!weapon class!	Weapons are classified by drag and other characteristics in Table 2.4-a.

!weapons released! — Number of weapons in the latest stik that have actually been released. Angle of weapon velocity vector to earth horizontal, down negative.

!weapon release angle! — Angle between weapon velocity vector and earth horizontal, down negative.

!within grace period! — Less than 1.6 seconds elapsed since one of the following modes exited: *BOC*, *BOCFlyto0*, *BOCoffset*

!X-axis corrected! — Initially false. Becomes false on entry to !CL stage!, !CA stage!, !HL stage!, !HC stage!, !FC stage!, !ND stage! or !HS stage!. Becomes true when the IMS X axis has been torqued or slewed (see Tables 4.1-d and 4.1-i) such that the condition !axis aligned! holds.

!Y-axis corrected! — Initially false. Becomes false on entry to !CL stage!, !CA stage!, !HL stage!, !HC stage!, !FC stage!, !ND stage! or !HS stage!. Becomes true when the IMS Y axis has been torqued or slewed (see Tables 4.1-d and 4.1-i) such that the condition !axis aligned! holds.

!Z-axis corrected! — Initially false. Becomes false on entry to !CA stage!, !HC stage!, !FC stage!, !ED stage!, !ND stage!, and !HS stage!. Becomes true when the IMS-Z axis has been torqued or slewed (see Tables 4.1-e and 4.1-j) such that the condition !axis aligned! holds.

Condition Table D-a: System Horizontal Velocities in Navigation Modes

MODES	CONDITIONS				
DI *DIG* *UDI* *PolarDI*	Always	X	X	X	X
I *PolarI*	X	Always	X	X	X
Magsl *Grid* *OLB* *IMS fail*	X	X	!Doppler Up!	!Doppler Down! AND !ADC Up!	!Doppler Down! AND !ADC Down!
VELOCITY SOURCES	!IMS NVel! !IMS EVel! damped by !DGNDSP!	!IMS NVel! !IMS EVel!	!DGNDSP! drift angle heading	/TAS/ !True AOA! !system pitch! wind	stale /TAS/ !True AOA! stale wind !system pitch!

Selector Table D-b : System Horizontal Velocities in Alignment Modes	
Lautocal *Landaln* *01Update* *HUDaln*	Constant (0)
Sautocal *SINSaln*	SINS velocities, adjusted by by !SINS offsets!
Airaln	!IMS NVel!, !IMS EVel! damped by !DGNDSP!

Condition Table D-c: System Vertical Velocity				
MODES	CONDITIONS			
Alignment *DIG*, *DI* *I*, *UDI* *PolarDI*, *PolarI*	/ADCFAIL/=No	/ADCFAIL/=Yes	X	X
Mag sl, *Grid*, *OLB*	X	X	!ADC Up!	NOT !ADC Up!
IMS fail	X	X	X	Always
	!IMS VVel! damped by /BAROADC/	!System horizontal velocities! !flight path angle!	/TAS/, !flight path angle!	0

Event Table D-d: When Designated and Undesignated		
MODES	EVENTS	
All nav update modes	@T(/TD/=On)	@T(In mode) OR @F(In mode)
Landaln *01Update* *I*, *OLB*	@T(/TD/=On) WHEN(!aiming switches set!)	X
HUDaln	X	@F(!aiming switches set!) OR @F(In mode)
Nattack (Not !Shrike!)	@T(/TD/=On OR /RE/=On OR !After slewing!) WHEN(NOT !Desig!)	@F(In mode) OR @T(/TD/ = On) WHEN (!Desig!) @T(In mode) WHEN (Not !within grace period!)
Noffset (Not !Shrike!)	@T(/TD/=On OR /RE/= On) WHEN (NOT !Desig!)	@T(In mode) OR @F(In mode) OR @T(/TD/ =On) WHEN(!Desig!) @T(In mode) WHEN (Not !within grace period!)
BOC *SBOC* (Not !Shrike!)	@T(In mode)	X
BOCFlyto0 (Not !Shrike!)	@T(/TD/=On OR /RE/ =On OR !After slewing!) WHEN (NOT !Desig!)	@T(In mode) OR @T(/TD/=On) WHEN(!Desig!)
BOCoffset (Not !Shrike!)	@T(/TD/=On OR /RE/ = On) WHEN(NOT !Desig!)	@T(In mode) OR @T(/TD/=On) WHEN(!Desig!)
Snattack	@T(/TD/=On OR !After slewing!) WHEN (NOT !Desig!)	@F(In mode)
Snoffset	@T(/TD/=On) WHEN (NOT !Desig!)	@T(In mode) OR @F(In mode)
SBOCFlyto0	@T(/TD/=On OR !After slewing!) WHEN (NOT !Desig!)	@T(In mode)
SBOCoffset	@T(/TD/=On) WHEN (NOT !Desig!)	@T(In mode)
NBShrike	@T(/TD/=On OR /RE/=On) WHEN (NOT !Desig!)	@F(In mode) OR @T(/TD/=On) WHEN (!Desig!)
Walleye	@T(/TD/=On) WHEN (NOT !Desig!)	@F(In mode) OR @T(/TD/=On) WHEN (!Desig!)
!Desig!:	true	false

Event Table D-e: Steering Stages				
MODES	EVENTS			
LoNuke	@T(!Desig!) OR @T(!Range! to !target! ≤ 5000 ft OR !steering error! ≤ 20 deg) WHEN(!GAS!)	@T(!Overfln!) WHEN(!Desig! AND !weapons released!=0)	@T(!weapons released!=1)	@T(!A/C facing target!) WHEN(!OF-range! ≤ 42 nmi)
HiNuke	@T(!Desig!) OR @T(!Range! to !target! ≤ 5000 ft OR !steering error! ≤ 20 deg) WHEN(!GAS!)	X	@T(!Overfln!) WHEN(!Desig!) OR @T(!weapons released!=1)	@T(!OF-range! > 13000 ft) WHEN(!Desig! AND !Overfln! AND !weapons released! = 0) OR @T(!A/C facing target!) WHEN(!OF-range! ≤ 42 nmi)
NBnot- Shrike	@T(!Desig!) OR @T(!Range! to !target! ≤ 5000 ft OR !steering error! ≤ 20 deg) WHEN(!GAS!)	@T(!Overfln!) WHEN(!Desig!)	X	@T(!OF-range! > 13000 ft) WHEN(!Desig! AND !Overfln!)
NBShrike	@T(!Desig!) OR @T(!Range! to !target! ≤ 5000 ft OR !steering error! ≤ 20 deg) WHEN(!GAS!)	X	X	@T(!Overfln!) WHEN(!Desig!)
STEERING STAGES	!steering to target!	!OTS!	!TOS!	!GAS!

Table D-f: Target in Weapon Delivery Modes

MODES	!target!
Nattack *BOCFlyto0* *Snattack* *SBOCFlyto0*	location on ground overlaid by AS at designation and after each slew
HUDdown1 *SHUDdown1*	location on ground intersecting the HUD ORA at designation
HUDdown2 *SHUDdown2*	OAP is the point on the ground intersecting the HUD ORA at designation; target is a point on the line drawn from the OAP in the direction defined by !Offset bearing!; the target is !Offset range! nmi from the OAP.
Noffset *Snoffset*	OAP is the point on the ground overlaid by AS at designation and after each slew; target is a point on the line drawn from the OAP in the direction defined by !Offset bearing!; the target is !Offset range! nmi from the OAP.
BOC *SBOC*	Before slewing, the target is the !Fly-to point!; after slewing, it is the point defined by the radar cursors when @T(!slewing finished!) occurs.
BOCoffset *SBOCoffset*	OAP is defined in the same way the target is defined in *BOC* (*SBOC*); target position relative to OAP is defined in *Noffset* (*Snoffset*)
Walleye	location on ground overlaid by AS at designation

Condition Table D-g: Target-in-range criteria

MODES	CONDITIONS			
Nattack *Noffset* *BOC* *BOCFlyto0* *BOCoffset*	!high drag!	!low drag!	X	X
A/G Guns	X	X	!Guns!	!Rockets!
!target in range!	!distance-to release! ≤ 6000 ft	!dive pullup! ≤ 42 deg	!slant range! to !impact point! ≤ 8192 ft	!slant range! to !impact point! ≤ 14366 ft

Data Item Index

Mode Index

Index of Output Items Affected by Functions