NASA/CR-2017-219646

FIM Avionics Technical Reference Manual

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July 2017

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Rev	Date	Revision Summary
—	1-Dec-16	Initial version
A	7 Mar 17	Updates per customer comments - Updated diagrams and text to match SDD updates - Text and formatting corrections - Attached latest Speed Control source code (may be delivered in separate zip file)
B	8 Mar 17	Removed title page footer

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1.0 INTRODUCTION

1.1 System Overview

The objective of this program is to design and develop two prototype FIM avionics systems that can be installed in the following aircraft: B737-NG, B757-200. The FIM avionics system shall host a FIM application based on NASA's ASTAR algorithm.

1.2 Document Overview

This document contains a summary of technical information relating to the Honeywell FIM software, TPU and system operation.

2.0 REFERENCED DOCUMENTS

The following documents apply to the extent to which they are referenced within this plan

2.1 Customer Documents

Document Number	Document Title
	Honeywell_SOW_ATD1_Phase2_REV B.docx
CR-2015-218794	NASA ASTAR 13 rev. 7 description document

2.2 Honeywell Documents

Document Number	Document Title
EG-003690-6.3.D	Software Design Description for the FIM software
EG-003690-6.3.C	FIM Software Requirements Specification
EG-003690-6.7	Honeywell Inputs for the System Requirements Definition Document
EG-003690-6.20	Ground Test Plan
EG-003690-6.22	Test Aircraft Installation Plan
XCRIBE	Honeywell XCRIBE Programming Manual
D201404000021	Maintenance Manual, TPA-100B TCAS Processor

2.3 Other Documents

Document Number	Document Title

ATD1_FIMSRD_2015-01-23	Flight Deck Interval Management (FIM) System Requirements Document (SRD)
D06412904 Rev. B	G700AB Software Design Guide
D06415030 Rev. B	ICD For the Smart Display Unit
8725G1	Specification Control Drawing for the Smart Display EFB
ARINC 834	Aircraft Data Interface Function (ADIF)

3.0 FIM AVIONICS TECHNICAL REFERENCE

The technical reference document provides an overview of the technical design, operation and performance of the FIM application and FIM avionics system

3.1 Theory of Operation

The EFB FIM software is comprised of the FIMHost.exe application and the CGD Server. The FIM Host implements the CDTI, FIM IO, Speed Control, Trajectory Generation, and Navigation Database Services. The CGD Server receives data from the FIM Host and transfers it to a web browser based application on the CGD hardware. Separate EFB and CGD are provided for the captain and first officer. The FIM Host software operates in a master-slave mode, with the captain's EFB typically being the master. User input and current FIM state is shared between the master and slave, but only the master EFB performs the FIM computation.

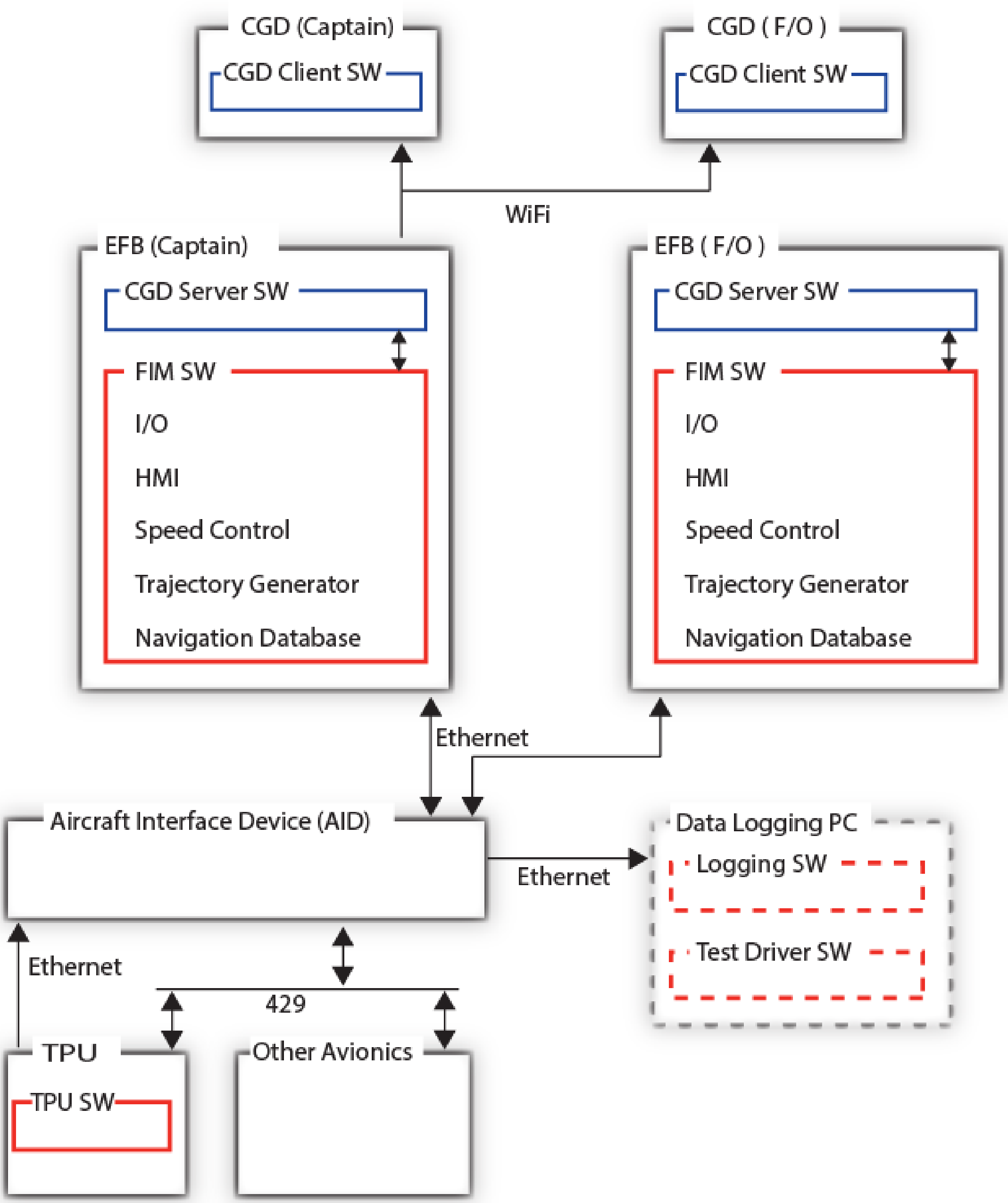


Figure 1 FIM Avionics Software Allocation

All aircraft bus data is transferred to the FIM Host via the Aircraft Interface Device (AID). The FIM Host provides a subscription list to the AID, which in turn collects the requested data off the aircraft busses and provides it to the FIM Host via an Ethernet connection.

The TPU IO process has been modified to provide additional, FIM specific data but otherwise uses the existing Honeywell TPA-100 B baseline software. Once the traffic to follow has been identified by the

FIM Host software, the TPU will ensure the target data is provided in the DTIF traffic, even if it would have been normally prioritized out.

Data logging is performed off board, on a separate data logging laptop PC. The data logging system is based on the existing Honeywell MonTPA (Monitor TPA) logging software. In the case of MonTPA, the traffic computer sends data logging packets over Ethernet to the MonTPA logging software running on the laptop. The FIM Host software uses the same approach and logging packet structure, but connects to the MonEFB (Monitor EFB) logging software on the PC. MonEFB is a variant of MonTPA modified to parse and display the FIM specific log messages. Both MonTPA and MonEFB capture all received data in log files for post event analysis.

3.1.1 FIM Application launch and initialization

While the FIM application, FIMHost.exe, can be run directly by double clicking the executable on the EFB, a batch file on the EFB desktop sets up the networking parameters, runs the CGD server and the FIM host software. To start the EFB FIM software, double click the *StartFIM.bat* batch file. The FIM software will initialize per the configuration files, with only one EFB taking on the master role.

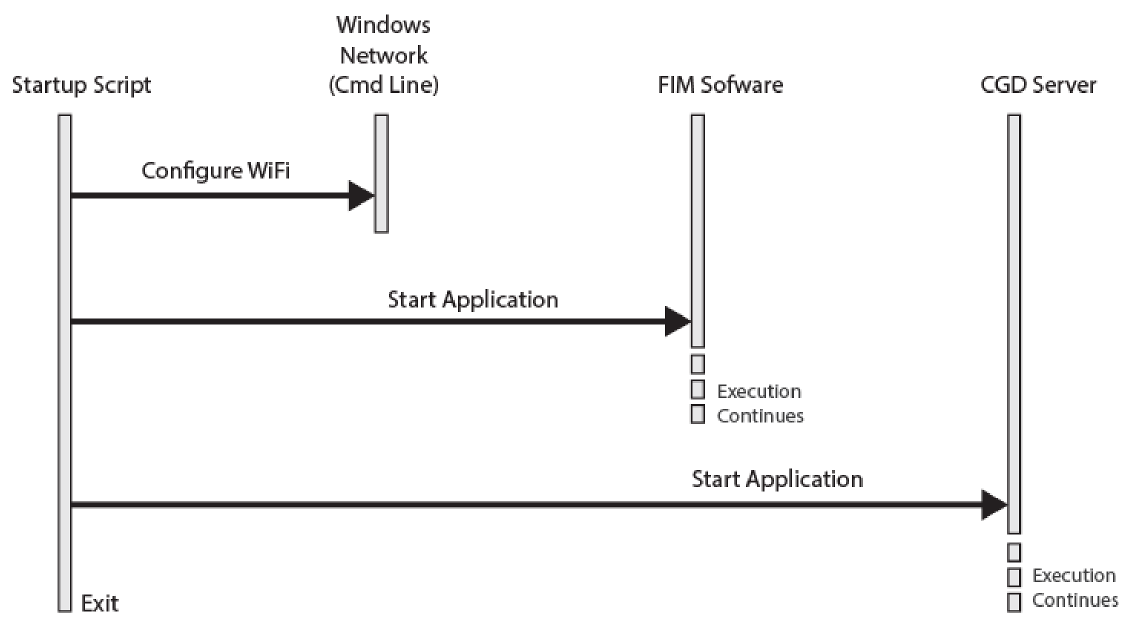
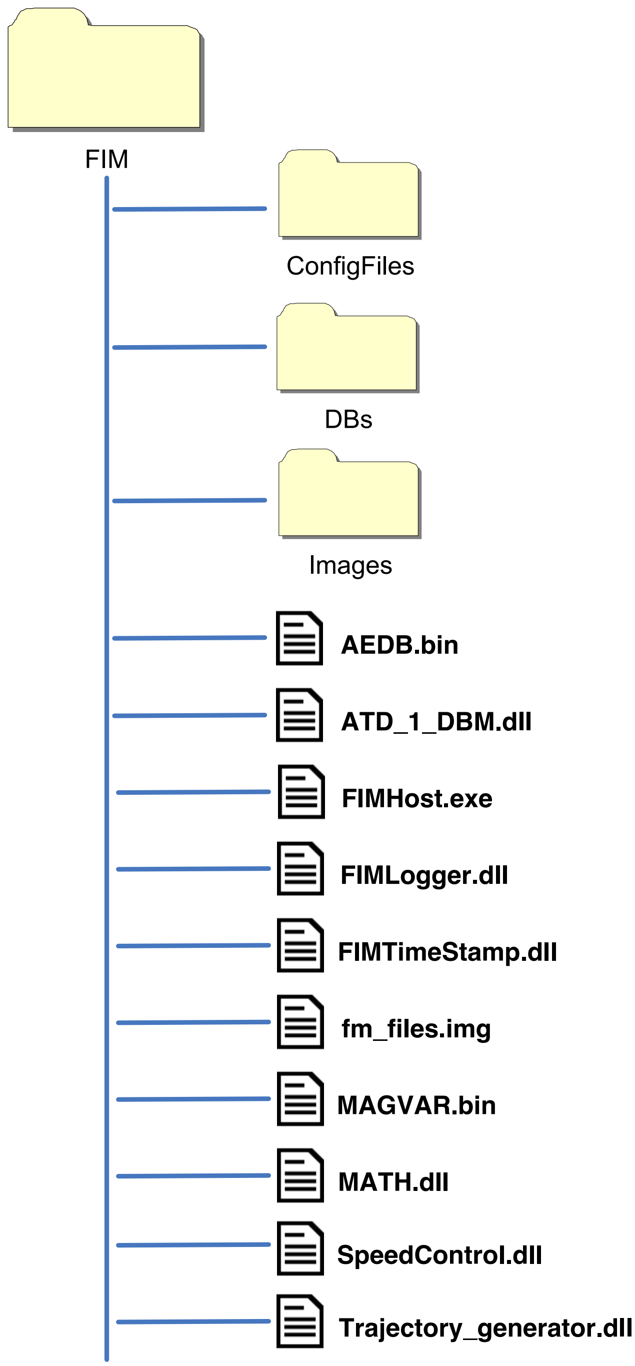


Figure 2 EFB Software Startup

The TPU is installed and starts up as in any other aircraft installation.

3.1.2 FIM Application Installation and Directories

The FIM Avionics EFB is a MS Windows based tablet. The FIM Application is installed in a subdirectory on the “C:” drive. The directory structure is shown:



The FIMHost.exe application and associated libraries are at the base 'FIM\' directory. The "ConfigFiles\" subdirectory contains the FIM Host configuration files (section 3.1.3). The "DBs\" subdirectory contains required navigation database files (standard and custom). The "Images\" subdirectory contains required image files used by the FIM Host application user interface.

FIM root directory files:

File Name	Description
FIMHost.exe	Main FIM avionics, EFB executable application
FIMLogger.dll	Library for logging FIM data to MonEFB
FIMTimeStamp.dll	Library for generating consistent timestamps
ATD_1_DBM.dll	Navigation database module library
Math.dll	Required library used by the Navigation database
SpeedControl.dll	Speed Control module library
AEDB.bin	Required file used by the Trajectory Generator
MAGVAR.bin	Required file used by the Trajectory Generator
Fm_files.bin	Required file used by the Trajectory Generator
Trajectory_generator.dll	Trajectory Generator module library

3.1.3 FIM Application Configuration

The FIMHost.exe application initialization is controlled by 3 "*.conf*" configuration files. These are located in the /ConfigFiles subdirectory of the FIM Application installation directory. The files are each read once on FIMHost.exe startup. Changes to the configuration require restarting the FIM Host software.

The configuration files are (sample files are provided in section 4.0):

ConfigIM.conf:

Defines the general IM and ownship parameters used by the EFB FIM Host software.

Each row contains <IM parameter Name> = <Parameter Value> where IM Parameter Name is a string name, without spaces. The Parameter Value is a numerical value. Comments start with a pound/hash '#' character.

Eg. AIRSPACE_RESTRICITON_ALTITUDE = 10000

The available fields are

Table 1 FIM Host Configuration Table 2 EFB Network Configuration

Parameter	Sample Value	Units	Description
MAX_IMSPEED_CHANGE_PERCENT	15	Percentage (%)	The Maximum speed change percentage should be within this limit
VMO	350	Knots (Kts)	
MMO	0.8	Mach (M)	
IMSPEED_UPPER_LIMIT_IN_MACH	0.77	Mach (M)	Upper Limit of the calculated IM Speed when using Mach for calculation
IMSPEED_UPPER_LIMIT_IN_CAS	540	Knots (Kts)	Upper Limit of the calculated IM Speed

			when using CAS for calculation
IMSPEED_LOWER_LIMIT_IN_CAS	120	Knots (Kts)	Lower Limit of the calculated IM Speed when using CAS / Mach for calculation
MIN_FINAL_APPROACH_SPEED	120	Knots (Kts)	Minimum Final Approach Speed of the Aircraft
HORIZONTAL_PATH_CONFORMANCE_LIMIT	3.0	Nautical Miles (NM)	Maximum Horizontal deviation from the Computed Trajectory
CRUISE_PROFILE_ALTITUDE_IN_FL	230	FL	Cruise Profile Altitude in terms of Flight Level
CRUISE_PROFILE_SPEED_IN_MACH	0.75	Mach (M)	Cruise Profile Speed
DESCENT_PROFILE_SPEED_IN_CAS	240	Knots (Kts)	Descend Profile Speed
AIRSPACE_RESTRICTION_SPEED_IN_CAS	250	Knots (Kts)	Airspace Speed Restriction
AIRSPACE_RESTRICTION_ALTITUDE	10000	Feet (ft)	Airspace Restriction Altitude
FINAL_APPROACH_DELTA_ANGLE	45	Degrees	Minimum Angle for the Ownship or the Target for Final Approach Clearance

EFBCom.conf:

Defines the EFB master, slave and observer IP communications addresses. Each configuration row contains <Label> _SPACE_ <IP Address>, where label provides the name of the remote connection. Comments start with a pound/hash '#' character.

The valid labels are:

Parameter Name	Example IP Address	Description
CAPTAINEFBIP	192.168.4.101	Master EFB
FIRSTOFFICEREFBIP	192.168.4.102	Slave EFB
TESTDIRECTOREFBIP	192.168.4.103	Test Director EFB
AIDUIP	192.168.4.254	Aircraft Interface Device

StapLableChannel.conf:

Defines which ARINC labels and channels that the AID will subscribe to, and transfer to the EFB using the STAP protocol. Each configuration row contains <Label> _SPACE_ <Channel #>. Comments start with a pound/hash '#' character.

Table 3 STAP Label Configuration

Label No	Channel No	Description
DTIF (Display of Traffic Information Files) Information		
367	0	DTIF STX and ETX Labels
366	0	DTIF Data Labels
Ownship Information		
110	0	GPS Latitude Coarse
111	0	GPS Longitude Coarse
120	0	GPS Latitude Fine
121	0	GPS Longitude Fine
203	0	Barometric Altitude
205	3	Mach
206	3	Calibrated Air Speed
213	3	Static Air Temperature
312	2	Ground Speed
313	2	True Track Angle
314	2	True Heading
315	2	Wind Speed
316	2	Wind Direction
Health Information		
13	0	TCAS Display Control
15	0	TCAS Altitude Selection Limit
125	0	UTC Time HH:MM.M
140	0	UTC Time Seconds Fine
150	0	UTC Time HH:MM:SS
163	0	Availability of different application
270	0	Advisory
274	0	TCAS mode
350	0	TCAS System Health

3.1.4 FIM Host

The FIMHost.exe application is the main FIM avionics software, comprised of the main application, along with libraries that implement the Speed Control, Trajectory Generator and Navigation Database functionality.

FIM Host main software contains the IO, CDTI, data logging and thread management. The design and implementation of the FIM Host and CDTI are based on previous IM programs, modified for the needs of ATD-1. The CDTI user interface appearance is defined in the Software Design Document.

The system includes 2 EFBs – captain and first officer. By default the captain's EFB is considered the master, and the F/O EFB the slave. User input may occur on either, but only the master will perform FIM calculations. While input to the system can be performed on either EFB, there is no input deconfliction. Should entry conflicts occur the most recent entry, from either EFB, will take precedence. Flight demonstration procedures will be structured to prevent conflicting simultaneous inputs.

There is no automatic failover of the EFBs. Should the master EFB fail, a restart of the FIM application is required to re-initialize the second EFB in the master role. The slave EFB can be modified via the configuration files, or simply restarted as it will self assign as the master if no other master is found.

The FIM host can also be run on a MS Windows laptop and provide information to the test director or other observer. The interaction with an observing FIM Host operates similar to the master-slave, except that the observer can not enter data.

3.1.4.1 FIM Host State Flow

The FIM Host manages the FIM state flow within the FIM Avionics. The following describes the state flow architecture implemented in the FIM Host.

Enabling ARM: The operator enters the Own-ship information and the Target information.

The Airport is assumed to be the same for both ownship and target. The below flow diagram explains the enabling of ARM button to activate FIM (Flight-deck Interval Management)

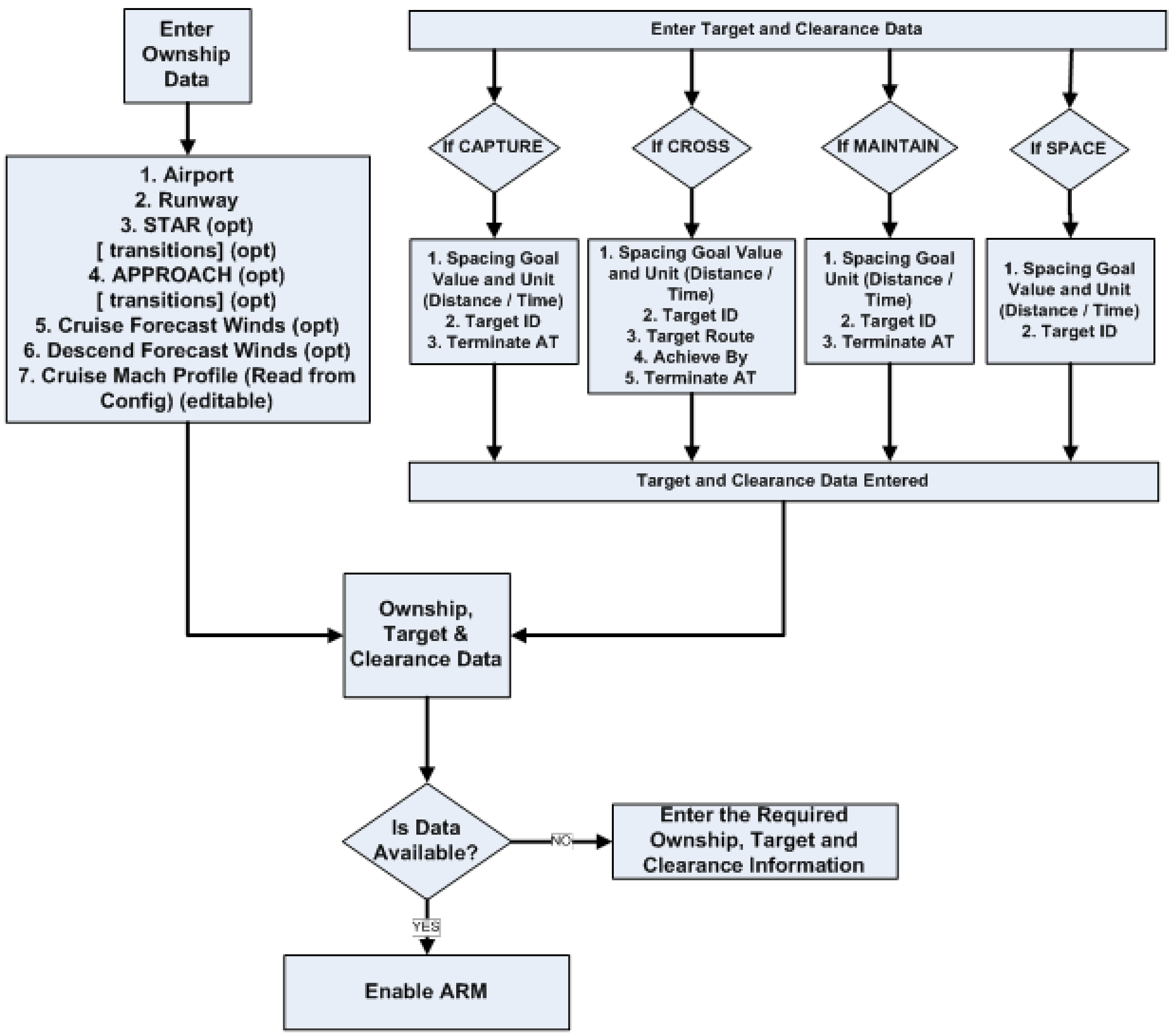


Figure 3 ARM State Flow

General State Machine Execution:

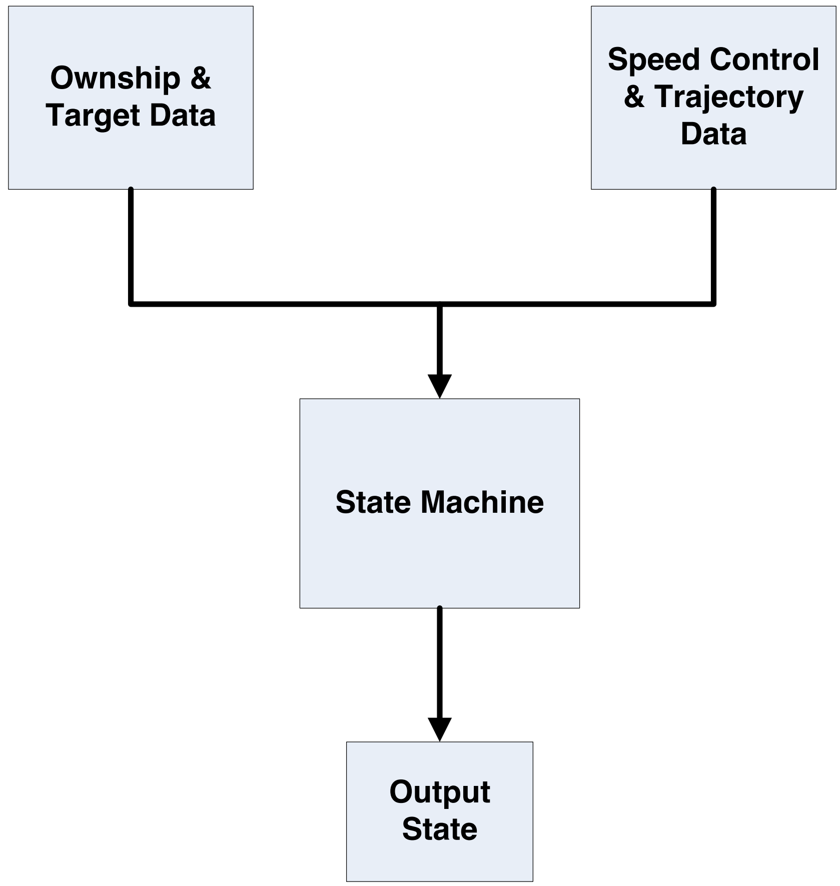


Figure 4 General State Machine Flow

The State machine consumes the user input, ownship and target information, speed control output and trajectory output, validates the states and provides the state as output. The following State Machine flow is the high level view of the state machine, with detailed state flows following.

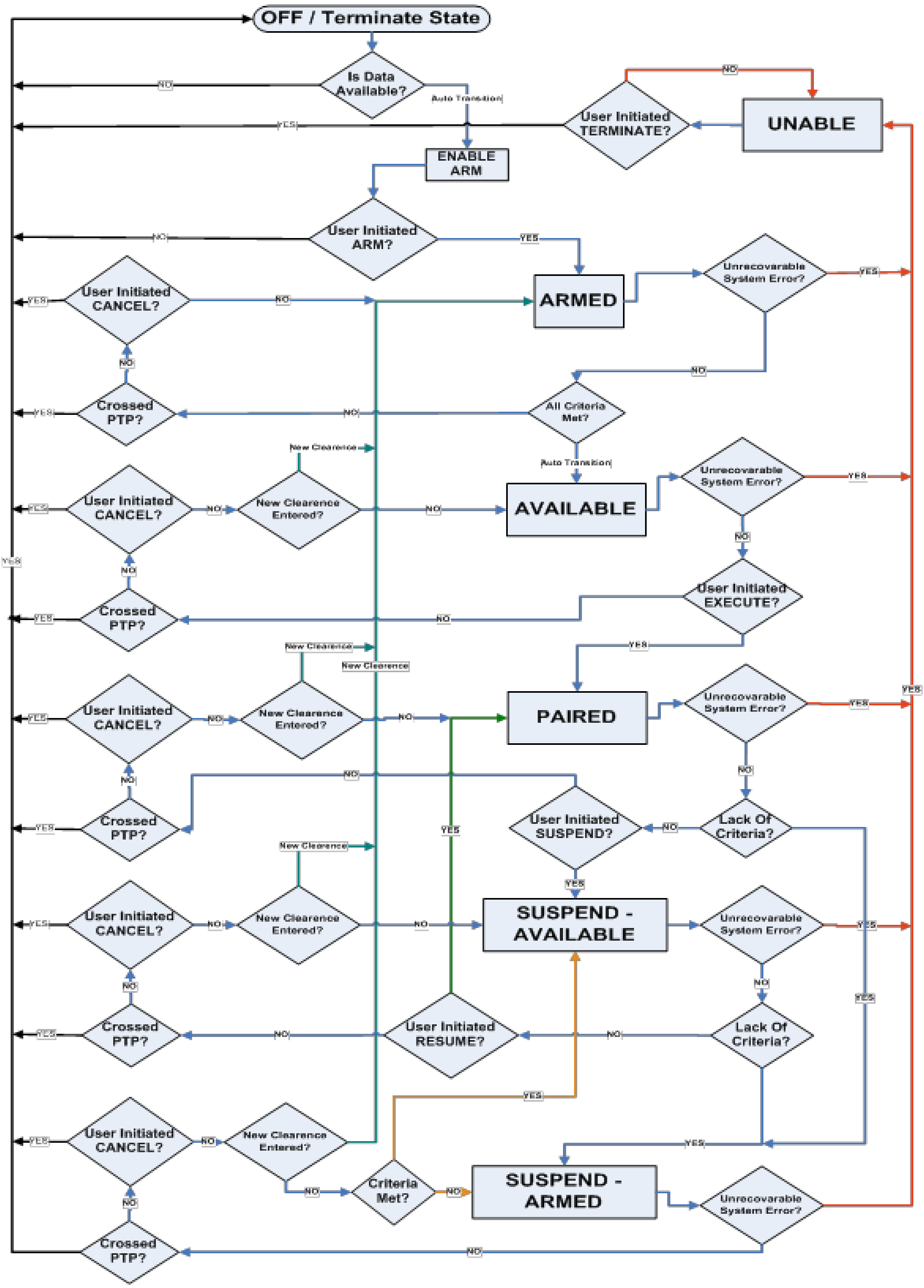


Figure 5 FIM State Machine Flow

Transition from ARMED to Other States: The flow diagram presents the possible transition from ARMED States.

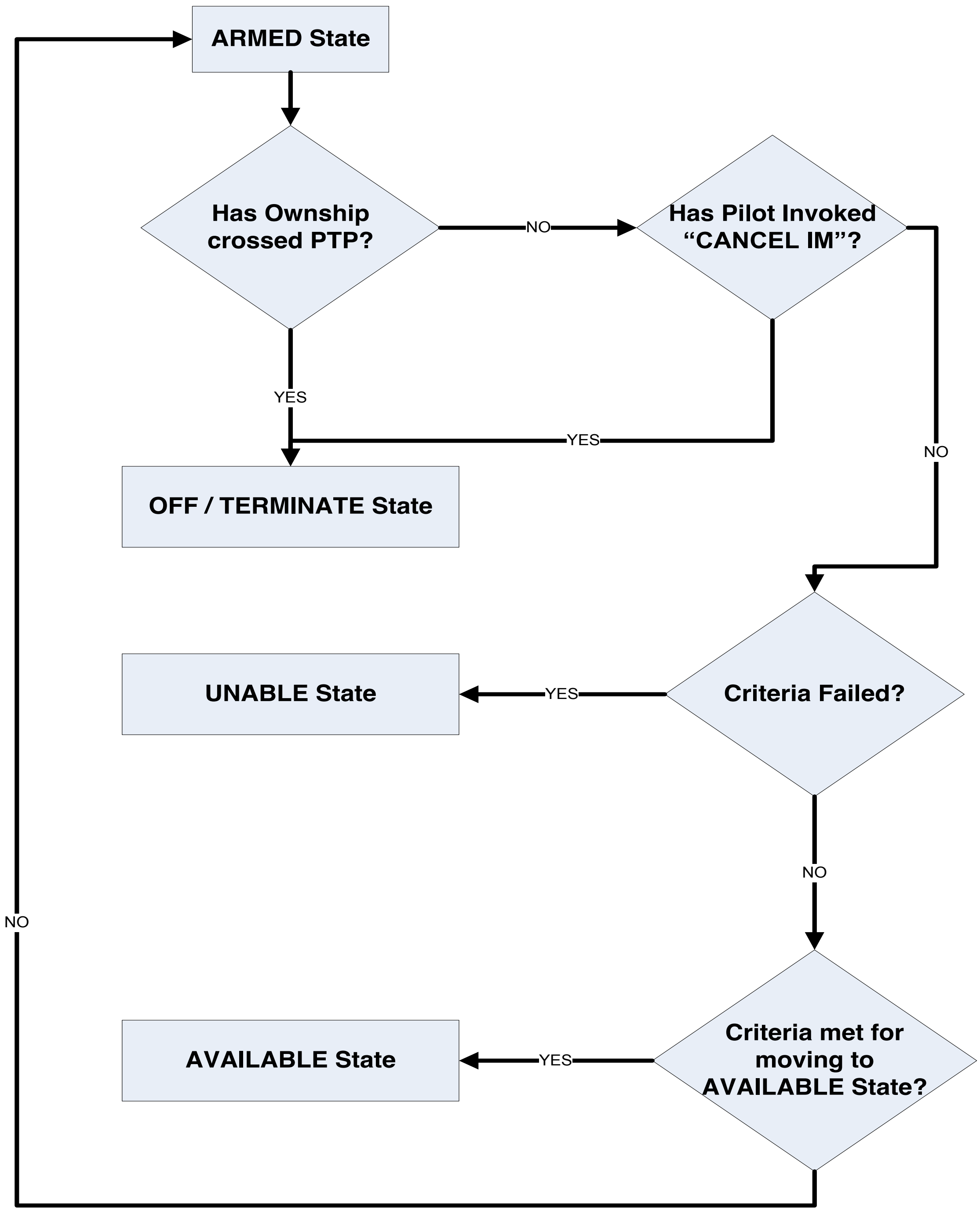


Figure 6 ARMED State Transition

Transition from AVAILABLE to Other States: The flow diagram illustrates the possible transition from AVAILABLE States.

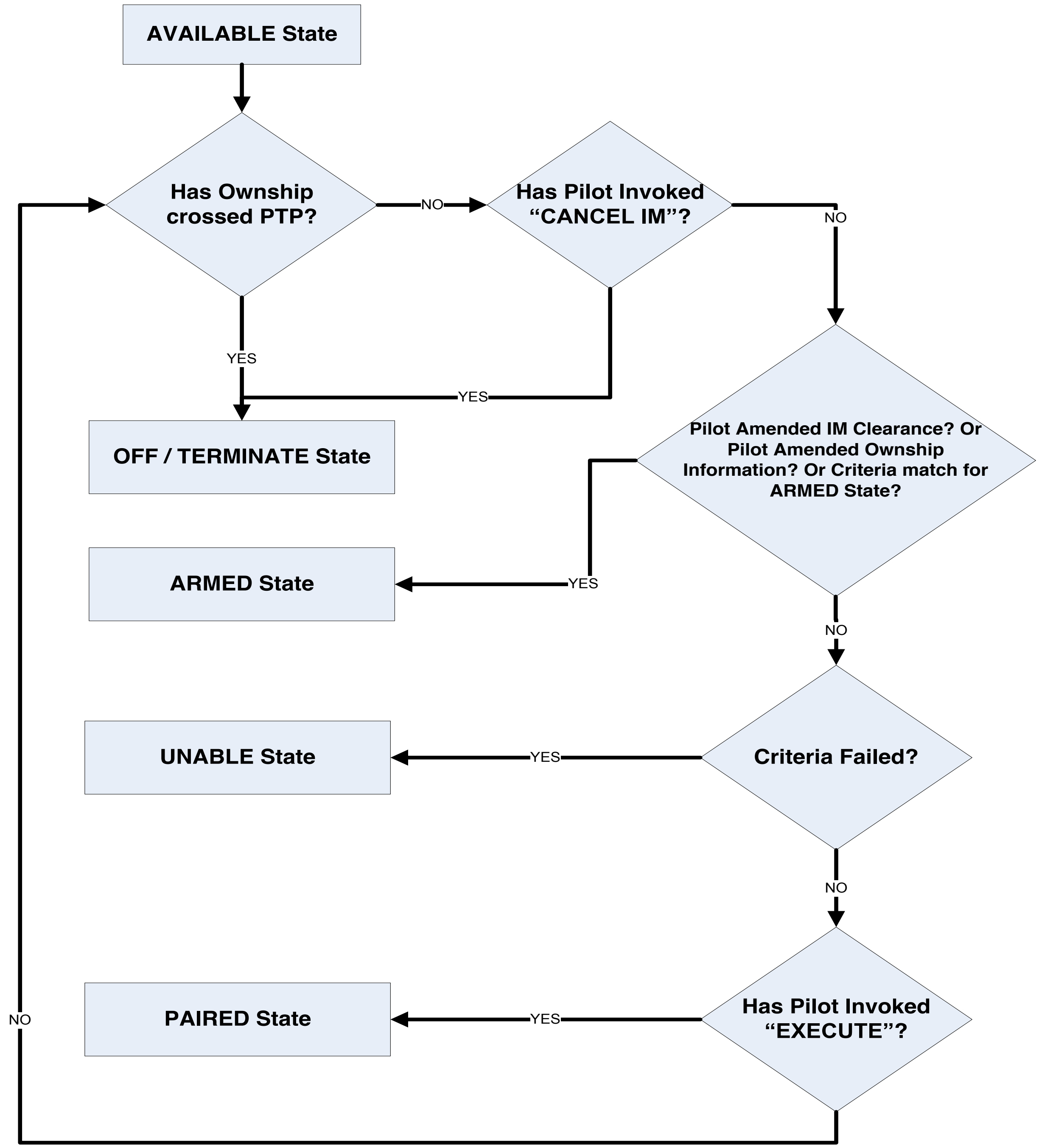


Figure 7 AVAILABLE State Transition

Transition from PAIRED to Other States: The flow diagram shows the possible transition from PAIRED States.

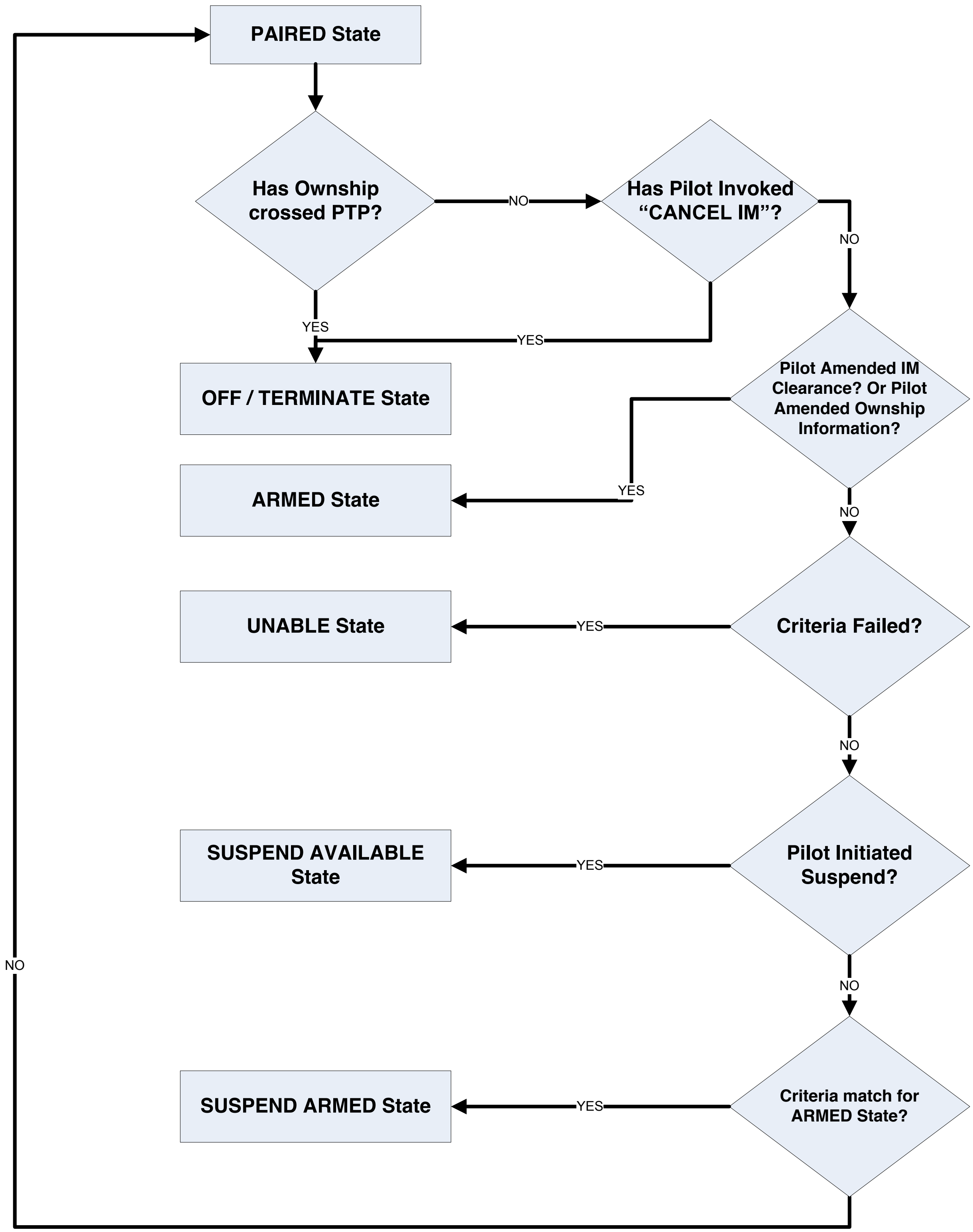


Figure 8 Paired State Transition

Transition from SUSPENDED AVAILABLE to Other States: The flow diagram shows the possible transition from SUSPENDED AVAILABLE States.

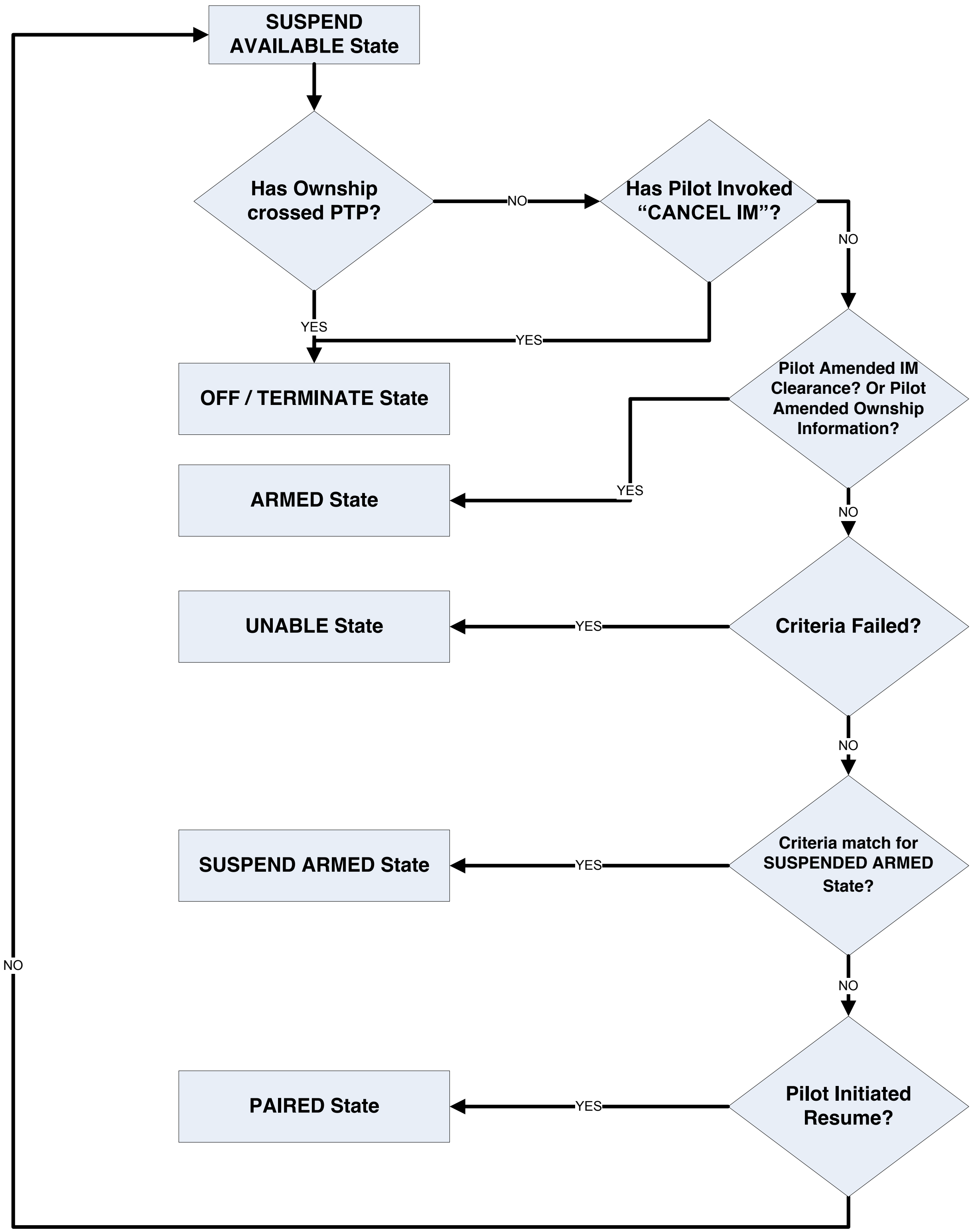


Figure 9 Suspend-Available State Transition

Transition from SUSPENDED ARMED to Other States: The flow diagram illustrates the possible transition from SUSPENDED ARMED States.

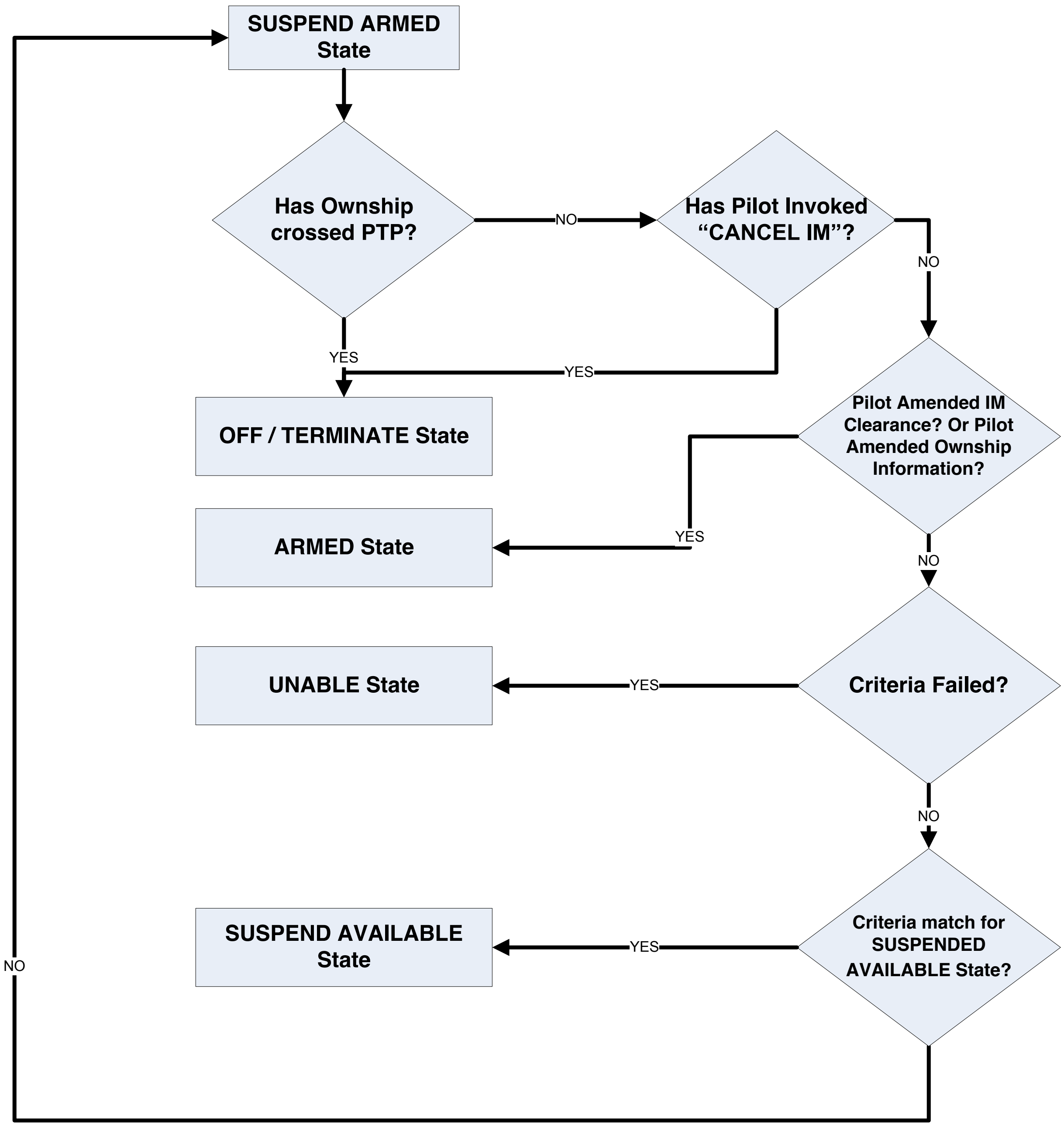


Figure 10 Suspend-Available State Transition

ARMED, AVAILABLE, PAIRED, SUSPENDED AVAILABLE, SUSPENDED ARMED transition to OFF / TERMINATE State

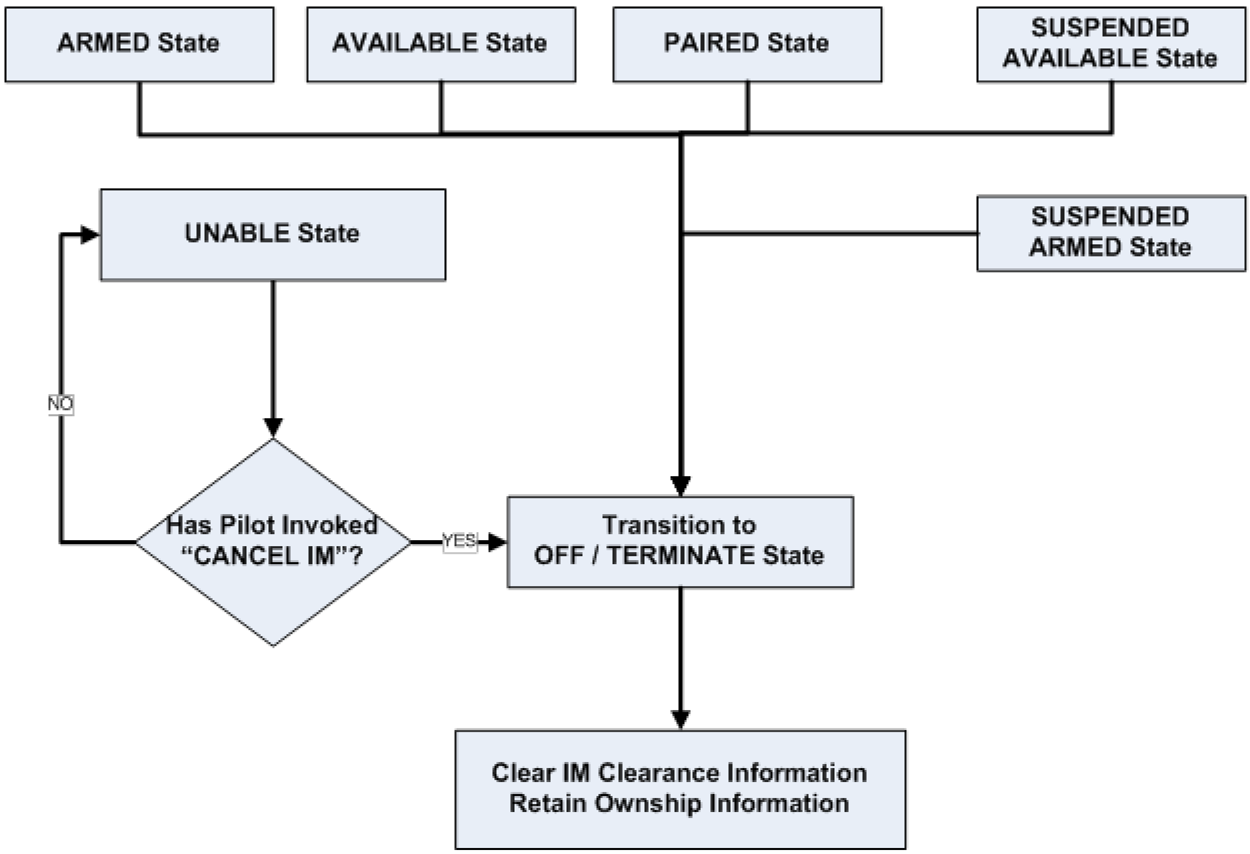


Figure 11 Transition to Terminate

UNABLE state transitioning to OFF / TERMINATE State:

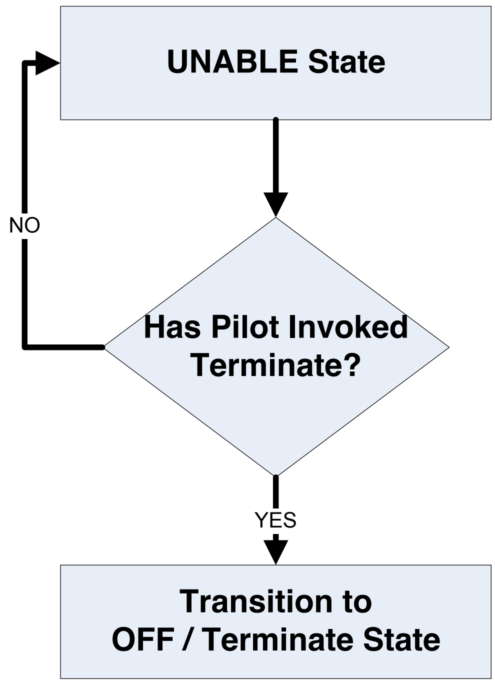


Figure 12 Unable State Transition

3.1.4.2 FIM Host Execution

Execution of the modules within the FIM Host is thread based. Though MS Windows is not a real time operating system, the FIM Host provides internal thread management to maintain some overall execution and timing control. This helps to ensure that individual modules do not starve other modules. Additionally, threading performance is captured in the FIM Host logging to allow evaluation of thread performance.

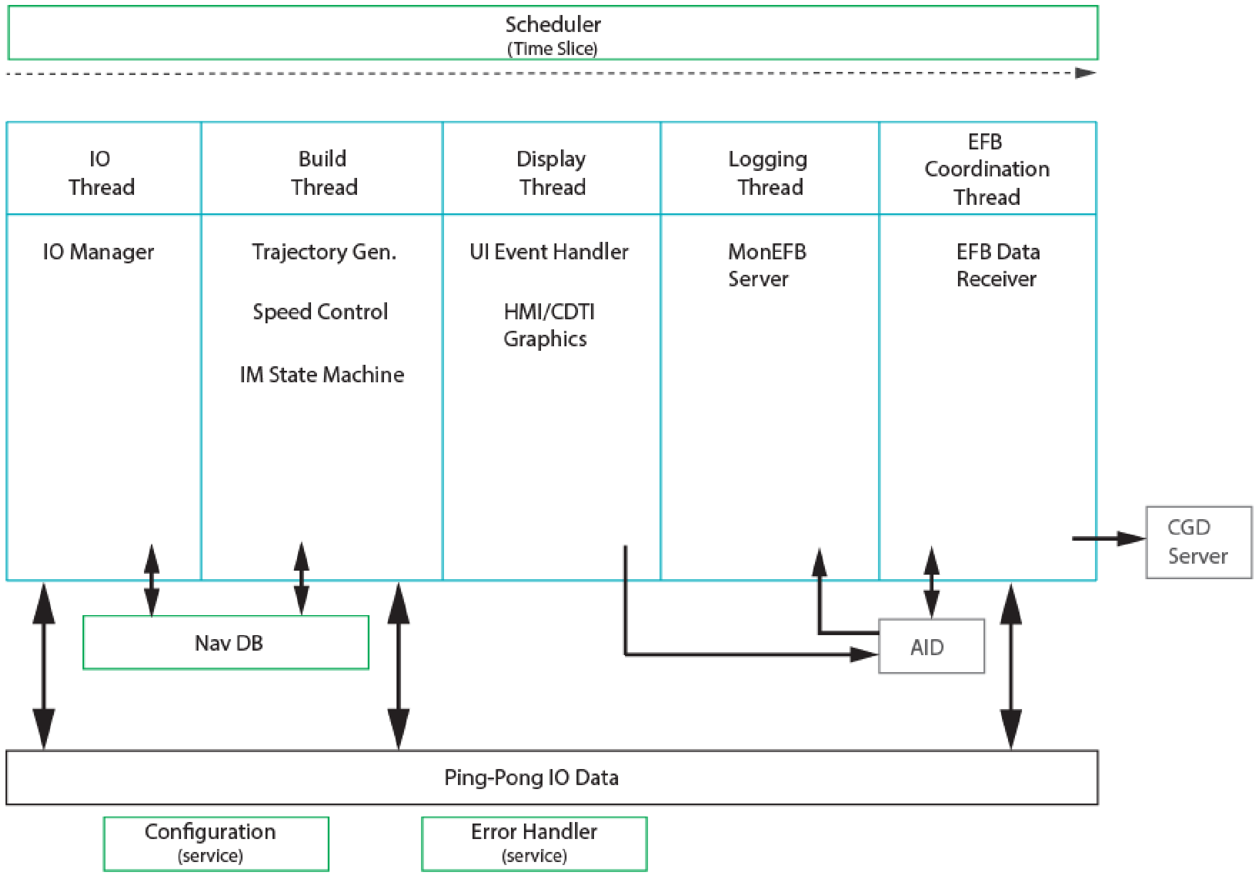


Figure 13 FIM Host Thread Flow

The IO Thread handles incoming data, storing the latest bus data (via the AID) in a ping-pong data buffer for use by the other modules. The Build Thread executes the Speed Control processing, which in turn invokes the TG, as well as managing the current IM state. The Display Thread updates the CDTI and processes any user input. The Logging Thread collects log data from the other modules and transmits log buffers to the external MonEFB logging application. Finally the Coordination thread manages the master-slave coordination between the EFBs and the CGD coordination.

3.1.5 Trajectory Generator

The Trajectory Generator (TG) module provides utilities to generate a 4D Trajectory for a given flight plan. The TG can produce 4D trajectories for the ownship as well as the designated aircraft the ownship is instructed to follow or Traffic-To-Follow (TTF).

The TG component also has the responsibility to store the Traffic History Database (THDB) which captures data (e.g. Position, Ground speed, Altitude etc.) for traffic in the vicinity, and making the history available once the designated traffic has been chosen

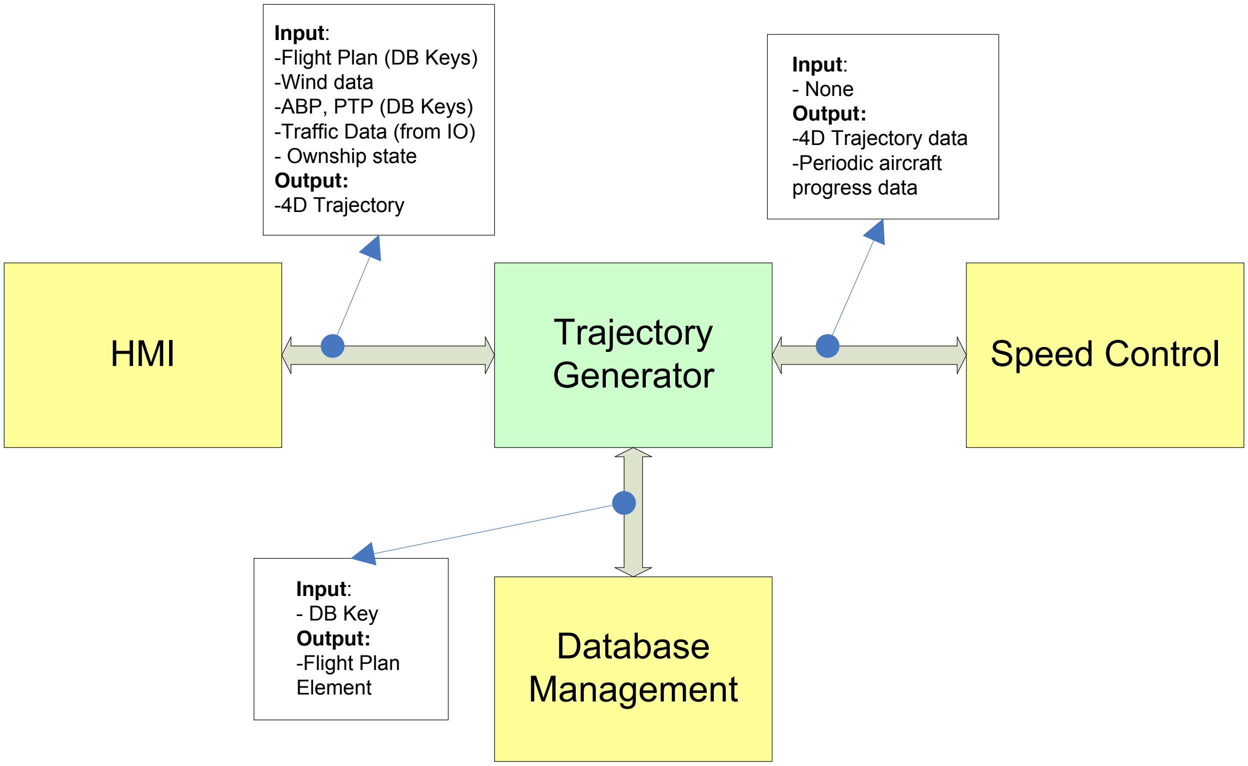


Figure 14 Trajectory Generator Architecture Relationship

The Trajectory Generator module is primarily invoked for computation by the Speed Control, although the CDTI/HMI retrieves data for the ownship and target for display. The TG retrieves data as needed from the navigation database module (NDB), and stores temporary waypoints in the NDB.

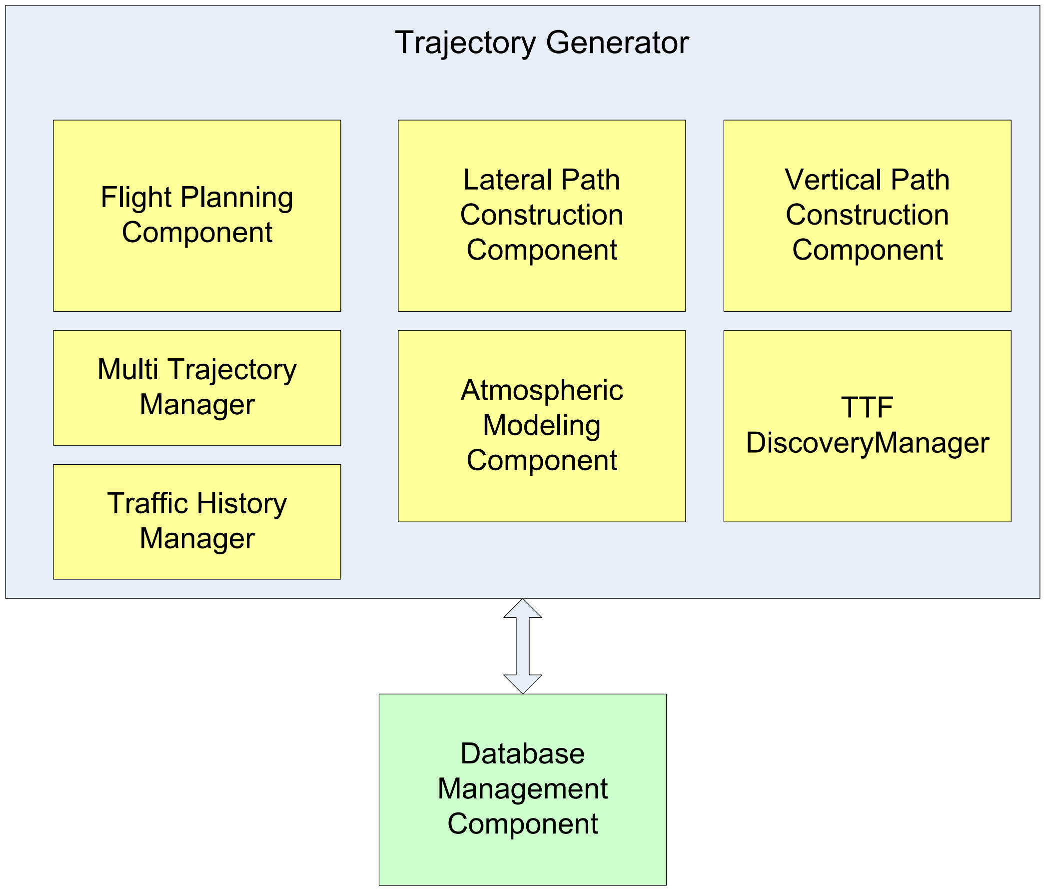


Figure 15 Trajectory Generator Architecture

The core of the Trajectory Generator architecture and code is based on existing Honeywell FMS strategic planning software. The strategic planning baseline provides lateral/vertical flight planning, trajectory computation, descent path construction and predictions. These capabilities are used by the HMI and Speed Control for path generation, and ownship & traffic path conformance monitoring.

The principal components of the Trajectory Generator FIM Avionics software are:

- **Flight Planning Component**: This component is responsible for inserting/deleting/modifying the flight plan information. This component converts IFPI elements into a string of waypoints with their applicable altitude and speed constraints as defined in the procedures. It contains the classes required to instantiate Static Flight Plan's (SFP). All information which can be entered to specify a Plan in the system will be contained and managed as part of a SFP. The use of the term Static is to convey that these Plans maintain no information which requires update based on aircraft or system state, they are static with respect to how and when they are created. Primarily the Plans are only manipulated by a user performing an aperiodic action which results in an event on the SFP of interest. No periodic processing based on aircraft or system state will result in a change or modification to a SFP.

- **Lateral Path Construction Component**: The objective of this component is to perform the transformation of ARINC 424 leg information (the Lateral Flight Plan) into a continuous series of Segments which represent both the path described by the leg information and the lateral transitions between these legs.

- **Vertical Path Construction Management Component**: This component takes the input flight plan, a starting Aircraft state and constructs the vertical Trajectory meeting all the constraints w.r.t Altitude, Speed, Time and Position.

- **Atmospheric Modeling Component**: This component blends the current sensed atmospheric conditions into the forecast model in order to provide a smoother transition of flight from current situations into the predicted situations.

- **Multi Trajectory Manager Component**: This component manages the trajectory generation of ownship and TTF.

- **TTF Discovery Manager Component**: The Designated Traffic's cruise altitude, cruise speed, and descent speed are not expected to be known by the ownship's crew, nor are there any UI interfaces for entering these. Therefore, an algorithm is implemented to discover what the Traffic's cruise conditions are based on its historic data. This component implements the discovery algorithm

- **Traffic History Manager Component**: This component manages the traffic history database, which provides up to 1000 seconds of track history for traffic DTIF data.

As some FIM operations require history of the traffic to follow, a traffic history database is maintained. This database contains a circular buffer for each of 600 individual flight IDs (configurable as needed). For each flight id, 1000 track seconds of DTIF information (flight ID, track ID, position, altitude, ground speed and track) of non coasted is maintained. While track history is only needed for the traffic to follow, until the TTF is known track history needs to be maintained for all possible candidates.

3.1.6 Speed Control

The Speed Control module (SC) implements the ASTAR 13, revision 7 speed control law as described in the NASA CR-2015-218794 document. It provides both trajectory and state based spacing mechanisms and produces speed commands to the aircraft crew to achieve and maintain desired spacing goals. The Speed Control module relies on the TG module for trajectory and path generation.

The module also performs conformance monitoring to determine aircraft conformance to the commanded speed. The commanded speed is presented to the crew via the FIM Host HMI and the CGD. As there is no linkage between the FMS and FIM avionics, the crew must respond and act on the speed commands. Conformance monitoring will observe the aircraft response and provide alerts if conformance is not maintained.

The SC module is divided into a number of sub components as shown below.

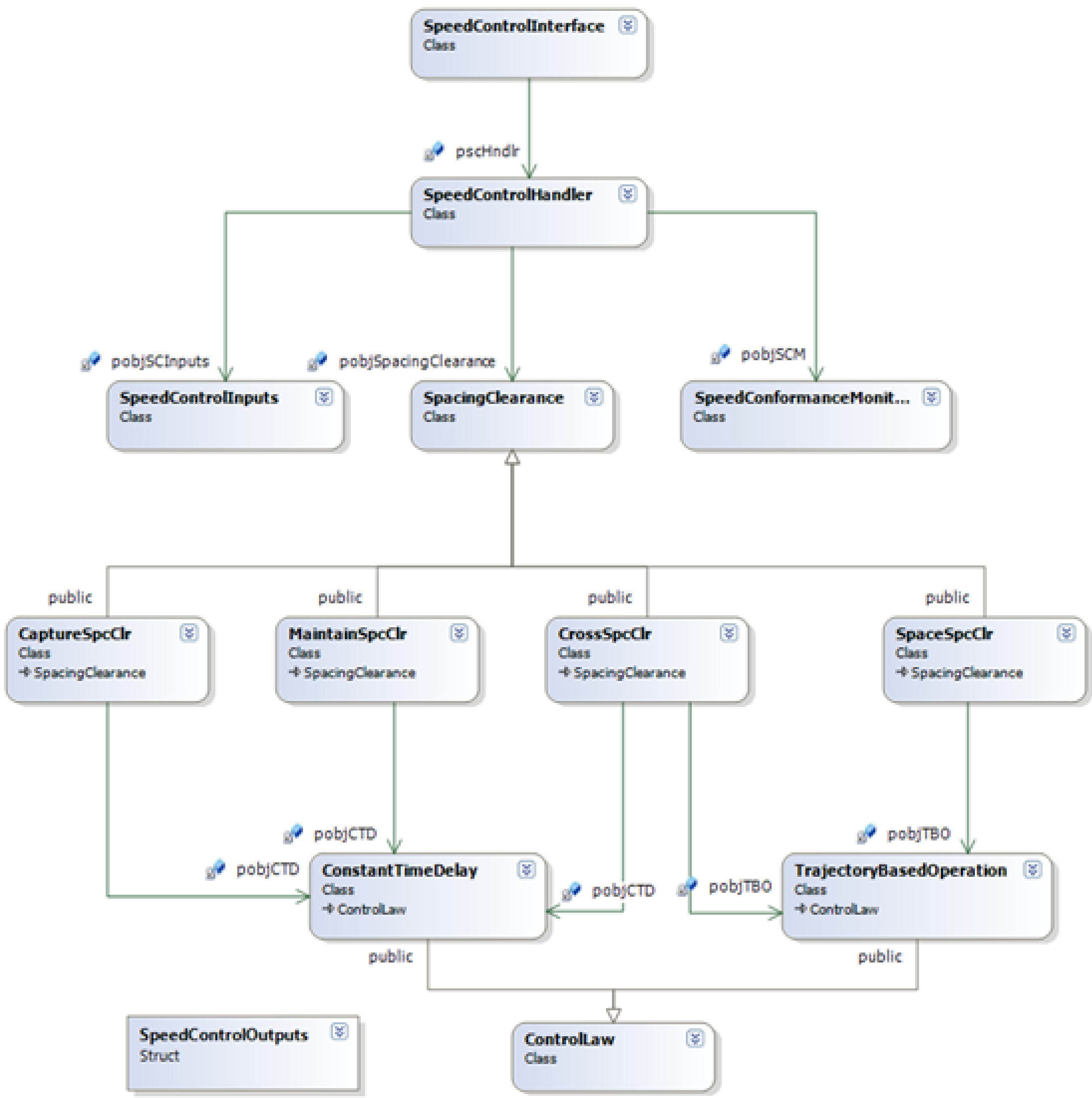


Figure 16 Speed Control Sub Components

The speed control sub-elements are:

- **Speed Control Interface**: Provides the SC interface to the FIM system. The FIM Host application provides inputs, invokes speed control and receives speed commands through this interface.
- **Speed Control Handler**: Responsible for the setup, processing and cleanup. Calculates the spacing clearance based on IM state transitions, and trajectory generator valid. Invalidates outputs if no clearance is selected.
- **Spacing Clearance**: Selects the control law and transitions between control laws based on the input conditions.

- **Speed Conformance Monitor**: Determines aircraft CAS / Mach conformance to commanded IM speed

- **Speed Control Inputs**: Processes inputs from the HMI, IO and trajectory generator and makes them available within the Speed Control module.

- **Speed Control Outputs**: Holds the speed control outputs, making them available to the HMI. Outputs are invalid when spacing clearance is not setup.

- **Constant Time Delay & Trajectory Based Operation**: Implement the respective control law

- **Spacing Clearance**: Controls selection and transition between control laws based on input conditions

The general data flow within the SC module is illustrated below. Note that while TBO and CTD are both illustrated simultaneously, only one methodology is in operation at a time. Data logging and error handling are provided by the FIM Host, and are common services available to all modules.

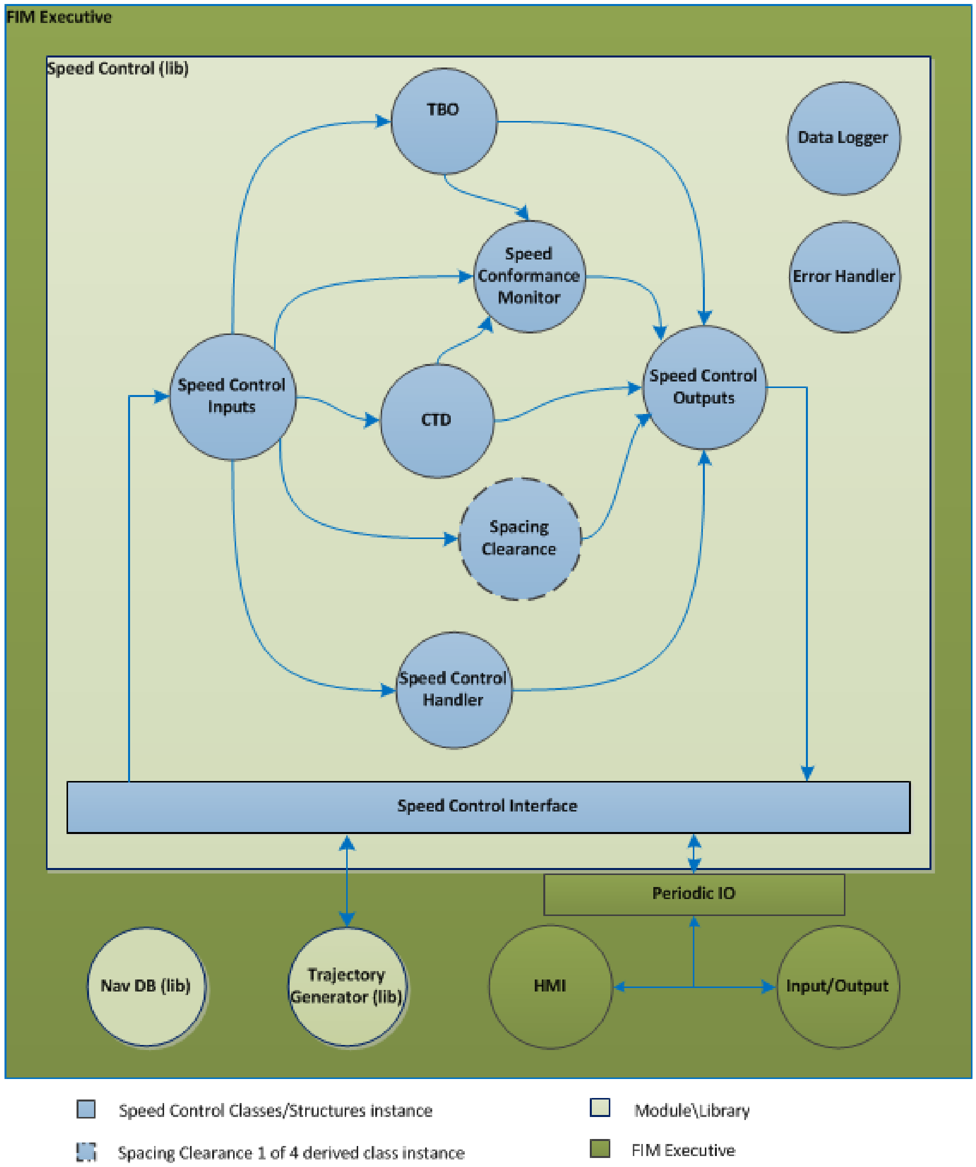


Figure 17 Speed Control Data Flow

Speed Control receives HMI state and IO via the Speed Control Interface. The state provided by the HMI determines the SC operation. The Speed Control Inputs element abstracts the data from the interface for use within the SC module.

Depending on the clearance and HMI inputs, the Speed Control Handler filters the input and prepares the SC module to begin a clearance. Once the needed data is available, the specific control law module (TBO/CTD) is instantiated and begins executing. The Spacing Clearance element manages transitions between the control laws as needed.

The selected CTD or TBO control law module execution is controlled by data arrival, and results in the generation of a commanded IM speed which is provided to the HMI. The Speed Control Outputs element holds the current commanded IM speed between SC invocations.

3.1.7 Navigation Database

The ability to perform lookups in a navigation database is independent functionality used by a variety of applications including FMS systems. The database lookup functionality is heavily based on the reuse of FMS capabilities, utilizing the same database structure. The ATD-1 FIM Navigation database module provides independent access to the database, based on the FMS access methods, but without requiring the FMS interfaces.

The navigation database module (NDB) is based on the Honeywell NextGen FMS software. The database is the Honeywell FLEX2 format, transformed from Jeppeson A242 data. Additionally, a custom database is used to store non standard waypoints. The custom database is used by the Trajectory Generator for temporary storage of generated along track waypoints.

The database file is loaded by the FIM Host into memory on startup. Updated databases are simply copied onto the MS Windows file system into the FIM Host application directory, replacing the old files, such as from a USB memory device containing the updated database file.

The navigation database module provides access and lookup to the CDTI, Speed Control and Trajectory Generator modules. Each modules uses the NDB interface to request data as needed, which the NDB retrieves from the actual database file.

3.1.8 Field Upgrades – FIM Host Application

Being a MS Windows based platform, the FIM Host software upgrades are performed by simply replacing the appropriate files in the "C:/FIM" directory using the standard MS Window File Manager. The file structure is described in section 3.1.2.

In the field, upgrades will be loaded onto a USB memory stick and copied to the FIM Host directory structure.

1. Plug the memory stick into the EFB
2. Open the Windows File manager and find the USB memory
3. Navigate to the FIM Host
4. Copy the files from the USB stick
5. Navigate to the local directory containing the FIM Host and paste the copied files. This will replace the local copy of files.

Alternatively, the files can be copied using drag-and-drop from the USB memory to the local directory.

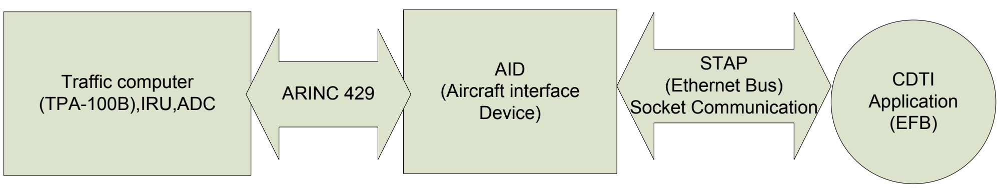
3.1.9 Field Upgrades – Traffic Computer

The traffic computer will be upgraded as any other Honeywell COTS TPA 100 B, as described in the TPA 100 B Maintenance Manual.

3.1.10 TCAS / FIM coexistence

As shown previously in Figure 1, this implementation of FIM Avionics maintains separation between the TCAS and the FIM software. The TCAS software operates as usual on the traffic computer hardware, with minor changes to support additional FIM application data needs. The FIM Software executes on the separate EFB COTS hardware.

The interaction between the FIM software and the TCAS through the aircraft interface device (AID). The AID collects bus data, including from the TCAS, and makes it available to the EFB via an Ethernet connection. The FIM Software on the EFB uses STAP (Simple Text Avionics Protocol) to subscribe to data available from the AID.



3.2 FIM Application Software Architecture Description

3.2.1 Resource Requirements

The UTC EFB was pre-selected for use as the FIM hardware platform. The resource requirements are provided as average and max usage of resources during typical IM operations. The resource testing was performed with traffic ranging from 5 to a full 127 over several MOPS test cases.

CPU Max usage: 47%

CPU Avg. usage: 29 %

RAM Max usage: 255MB

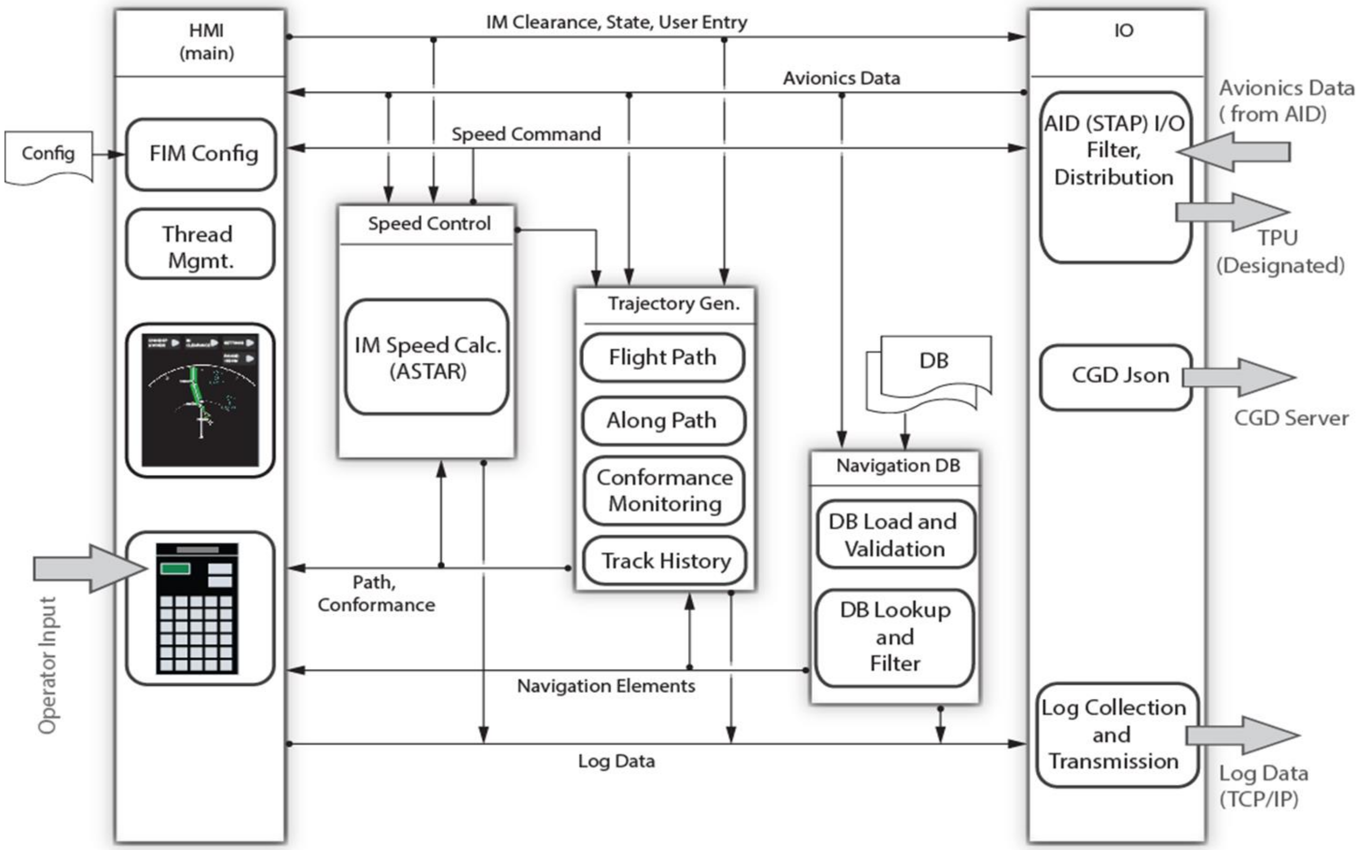
RAM Avg. usage: 225 MB

The consumed resources place the FIM application well within the capabilities of the core i7 based UTC G700 EFB and allow headroom for future growth.

3.2.2 FIM Application Architecture

The full FIM Application architecture design is contained in EG-003690-6.3.D *Software Design Description for the FIM Software*.

The FIM application is comprised of several modules. The FIMHost.exe, main application, contains the CDTI, IO and thread management. Speed control, trajectory generation and navigation database functionality is contained in separate libraries loaded by the FIMHost.



3.2.2.1 FIM Host

See section 3.1.4 for the general theory of operation and FIM state flow. The *Software Design Description for the FIM Software* contains the detailed design for the FIM avionics software and the *FIM Software Requirements Specification* contains the detailed software requirements which provide additional detail on the FIM Host operation.

The FIM Host provides the main application, along with the HMI/CDTI, IO and thread management. The architecture and code are based on previous CDTI projects. The architecture allows for minimal coupling, increased reuse and a designed path to implementation on a real time operating system.

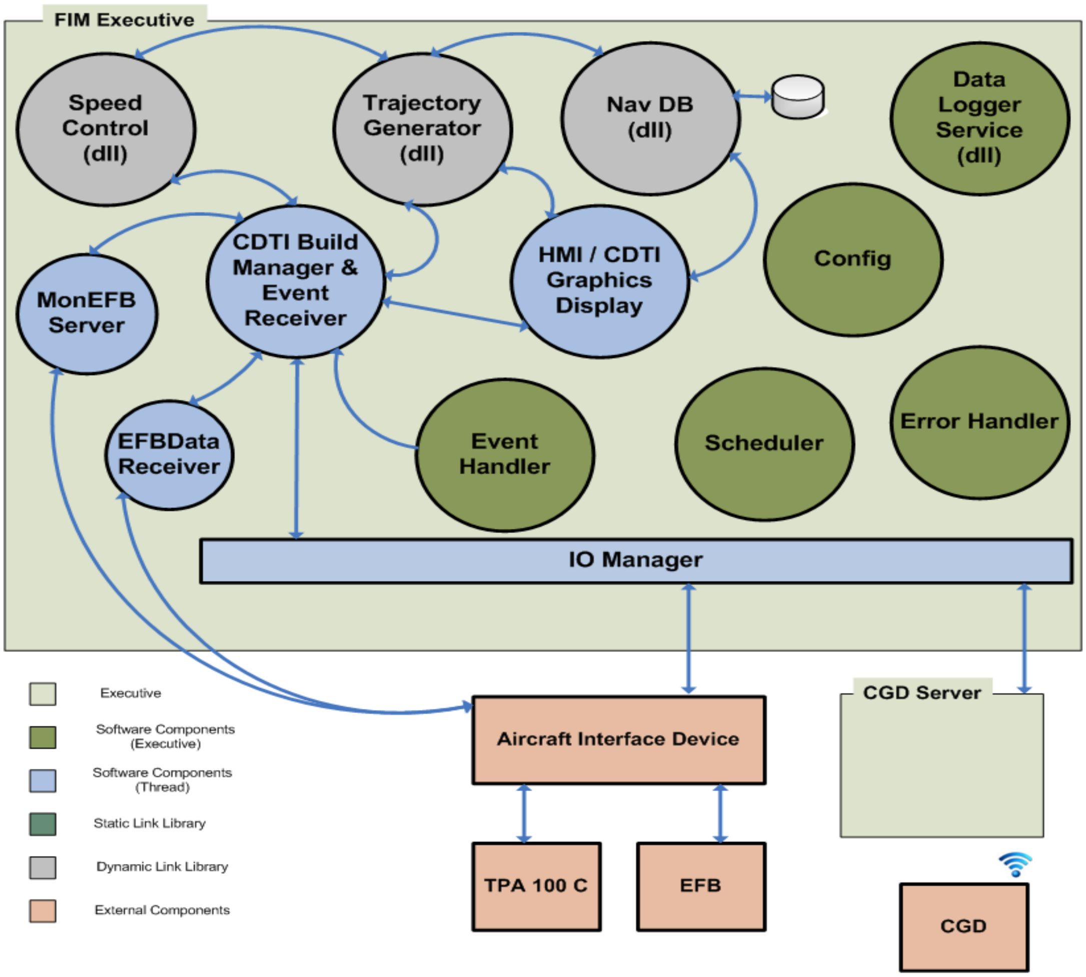


Figure 18 FIM Host Executive Architecture

The FIM Host IO configures the AID via STAP configuration, as described in 3.1.3. The AID retrieves the requested bus data and passes it to the FIM Host over an Ethernet connection. Connection and interfacing with the AID are described in D06412904-B *G700AB Software Design Guide* and the ARINC 834 *Aircraft Data Interface Function* standard for the STAP protocol.

The FIM Host IO stores received data in a ping-pong buffer which is available to Speed Control and Trajectory Generator. Speed Control and Trajectory Generator in turn store results in the ping pong data buffer for use by the HMI and IO functions.

The HMI/CDTI provides the user interface and information display. The HMI follows the NASA implementation, adapted to a landscape orientation and soft buttons to better suit the EFB, CGD and provide the most usable display area. The HMI wireframe design is fully documented in the EG-003690-6.3.D *Software Design Description for the FIM Software*.

The Build Manager is responsible for implementing the FIM state machine, previously described in 3.1.4.1, and invoking the Speed Control and Trajectory Generator according to the state flow, which is driven by user actions and data inputs.

The FIM Host also provides several general services necessary for the system operation. The EFB Data Receiver manages input synchronization between the master and slave EFB. The MonEFB server provides data logging capabilities used by all of the FIM modules. Additionally config file handling, local data logging and error handling services are provided.

3.2.2.2 Speed Control

See section 3.1.6 for Speed Control theory of operation which describes the general operation and data flow for the Speed Control module. The *Software Design Description for the FIM Software* contains the detailed design for the FIM avionics software and the *FIM Software Requirements Specification* contains the detailed software requirements which provide additional detail on the Speed Control operation.

The following show the internal sequence diagrams, describing the internal architecture of the Speed Control module. Refer to the Speed Control source code package, section 6.0 provided for implementation details.

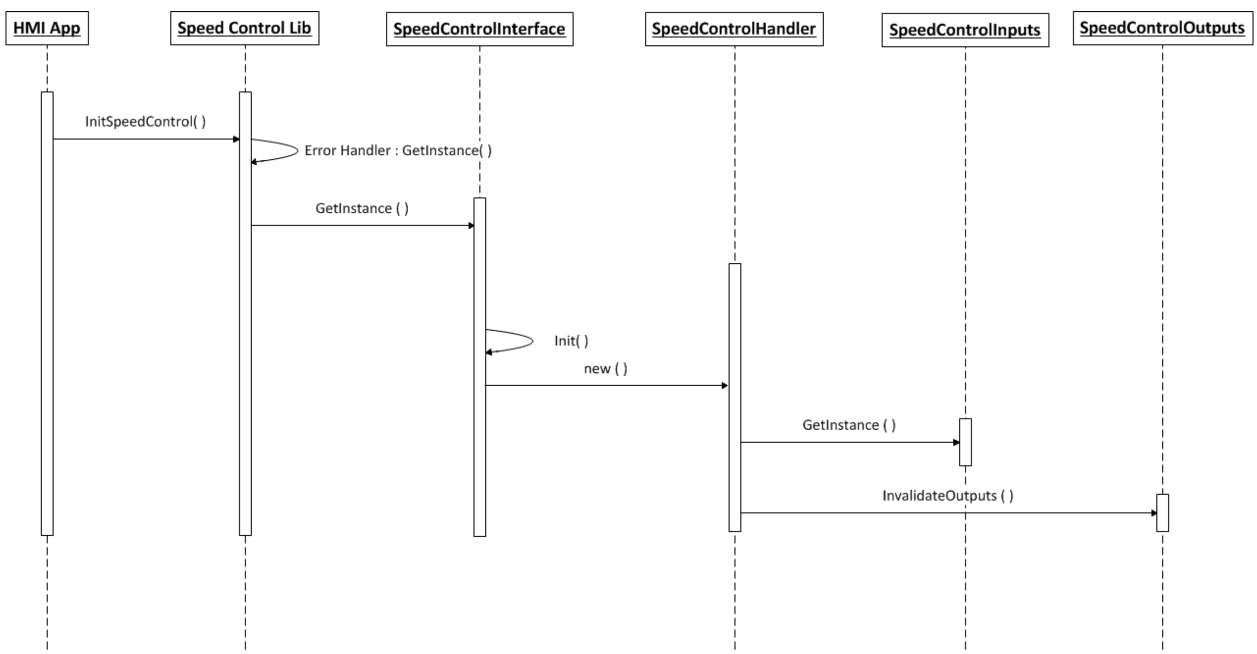


Figure 19 Speed Control Power Up Sequence Diagram

Figure 19 shows the control flow when the InitSpeedControl() interface is invoked first time by HMI after loading the speed control module. InitSpeedControl() creates a singleton instance of the Speed Control Interface and Error Handler. Speed Control Interface instantiates the Speed Control Handler and Speed Control Handler creates a Singleton instance of Speed Control Inputs.

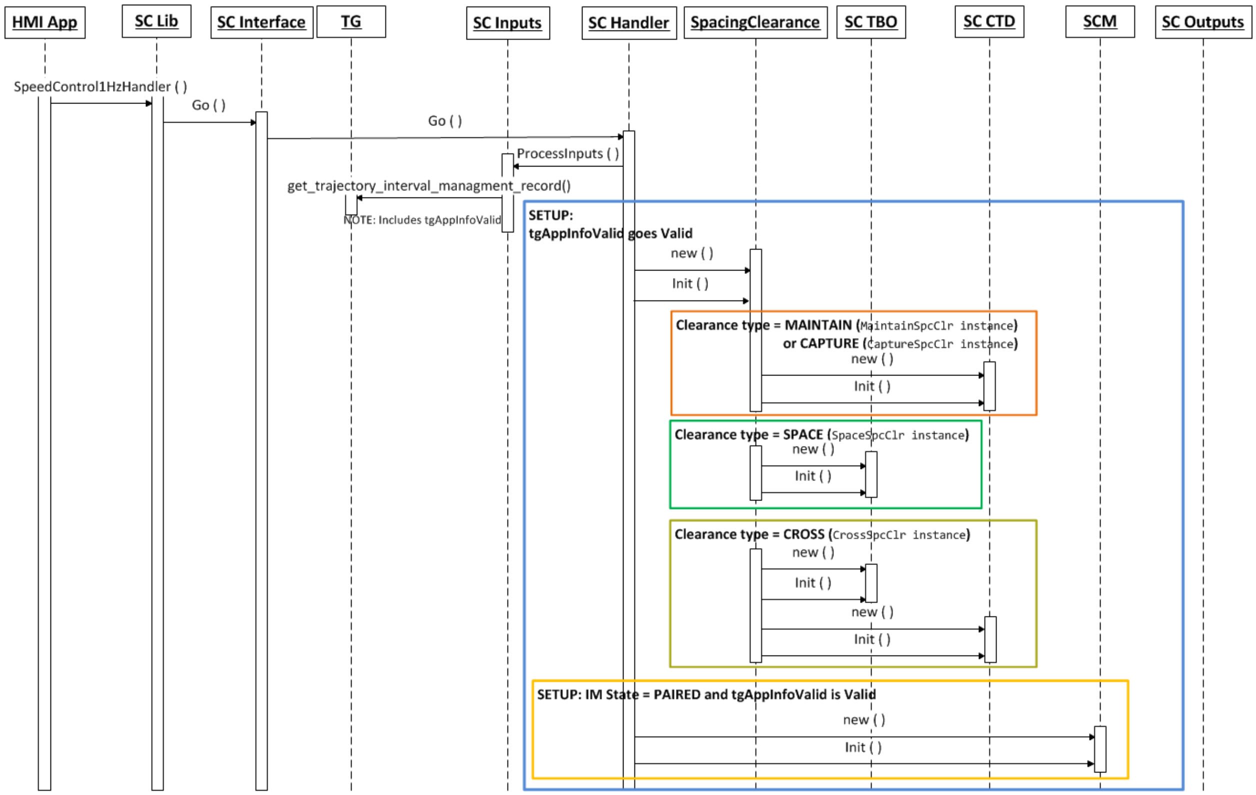


Figure 20 Speed Control Setup Sequence

Figure 20 illustrates the control flow for setting up a new Spacing Clearance, and sets TG valid.

SpeedControl1HzHandler() is an export interface to the HMI and is invoked once every second. Control flows via the Go() function to Speed Control Interface's periodic function which in turn invokes Speed Control Handler's periodic function.

SC Handler invokes the SpeedControlInputs::ProcessInputs() function which updates the inputs from HMI/IO for use by other Speed Control modules. It also updates the inputs from TG by getting the latest inputs for the current iteration using TG interface get_trajectory_interval_managment_record().

When the TG is ready with valid inputs, SC instantiates the appropriate Spacing Clearance object as defined by the clearance type.

- For MAINTAIN & CAPTURE, a CTD object is instantiated.
- For SPACE, TBO object is instantiated.

- For CROSS, both TBO and CTD are instantiated

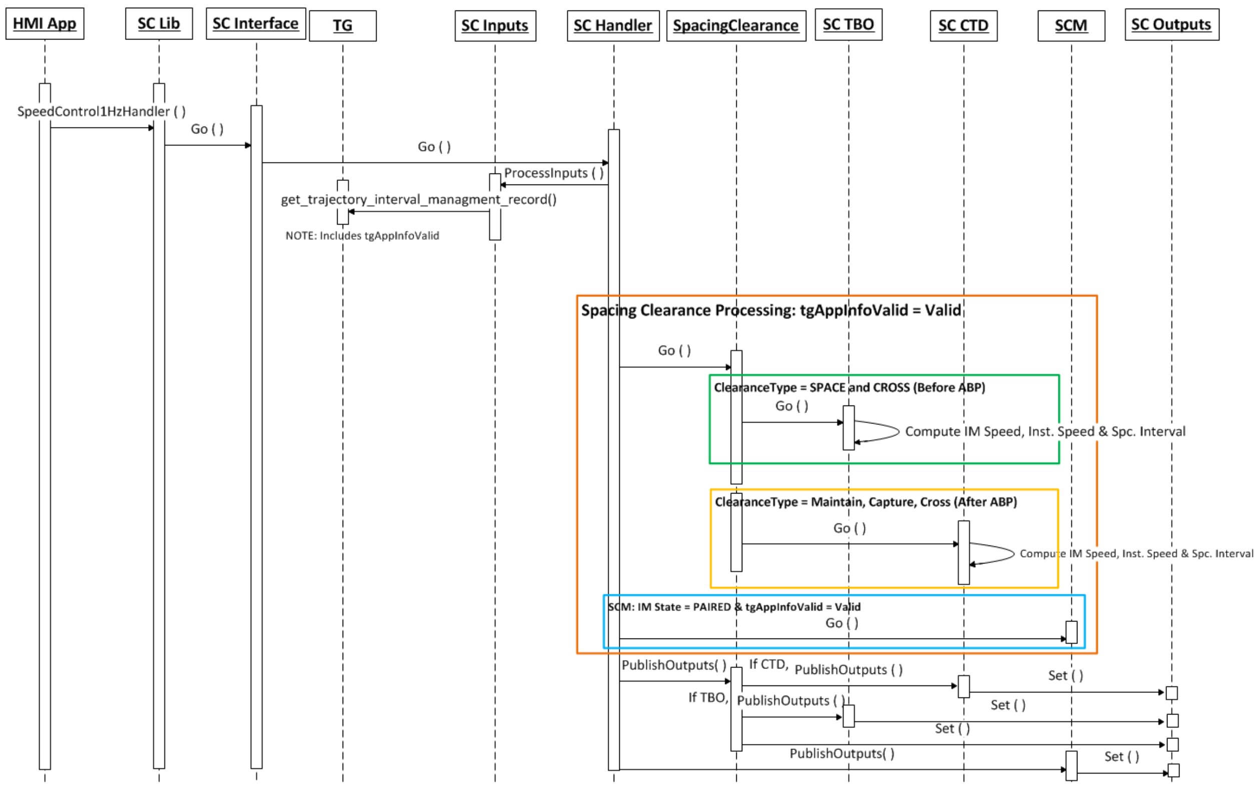


Figure 21 Spacing Clearance Sequence Diagram

Figure 21 shows the control flow sequence when a valid Spacing Clearance is setup and TG inputs to Speed Control are valid. SC Handler invokes the periodic functions of the Spacing Clearance object instance.

Based on the setup clearance type and input condition ABP Passed/Not passed, the Spacing Clearance i periodic handler invokes the applicable control law periodic handler as follows.

- If clearance type is SPACE or CROSS (Before ABP), TBO's periodic handler is invoked.
- If clearance type is MAINTAIN or CAPTURE or CROSS (After ABP), CTD's periodic handler is invoked.

The TBO/CTD periodic handler computes Command IM Speed, Instantaneous Speed and outputs to HMI. If IM State is PAIRED, the handler periodic function also invokes the Speed Conformance

Monitor periodic function which monitors Aircraft CAS/Mach conformance to expected CAS/Mach values. The result is used to drive the HMI Speed conformance output (IM Command flashing). SpeedControl1HzHandler() sets the outputs into Speed Control Outputs before returning the control back to HMI where the results are consumed.

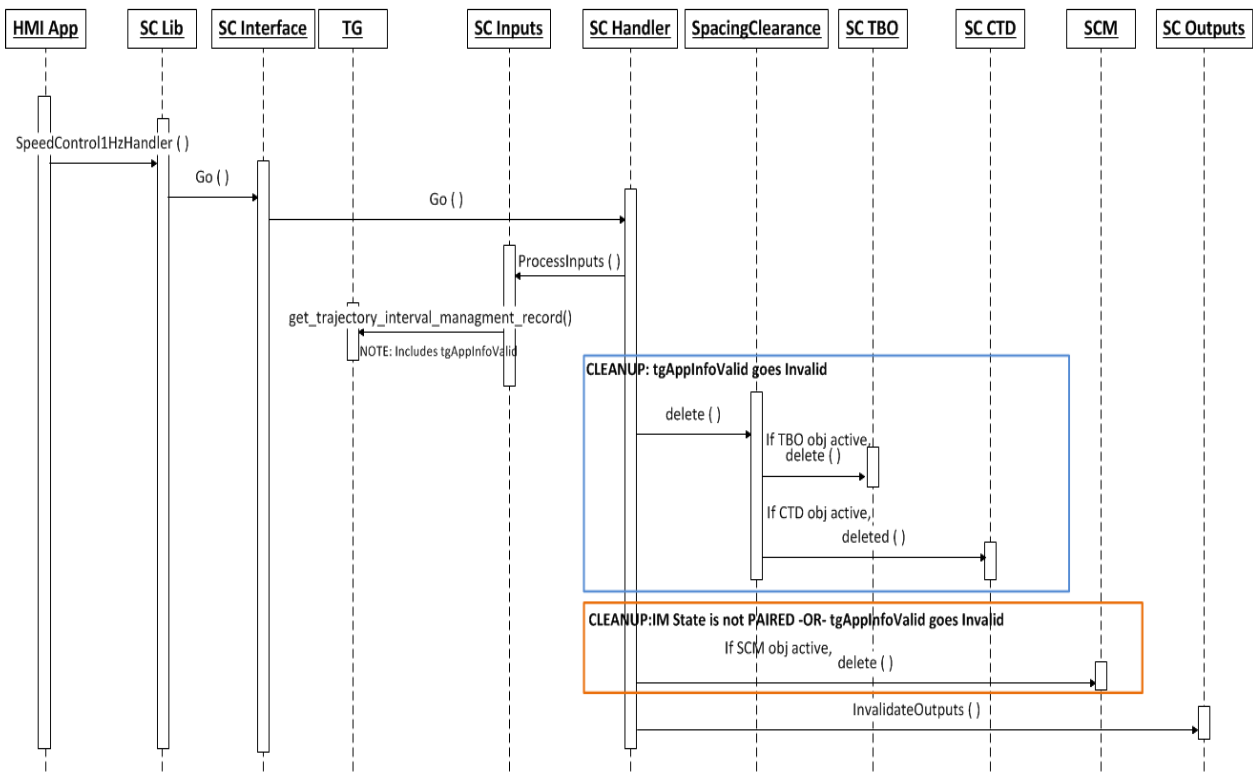


Figure 22 Spacing Clearance Cleanup Sequence Diagram

The Spacing Clearance Cleanup sequence is followed when the TG inputs to Speed Control become invalid. During this sequence the Spacing Clearance object is deleted, which in turn deletes the control law objects.

The following call graphs illustrate the arrangement and connectivity between the functions within the Speed Control module.

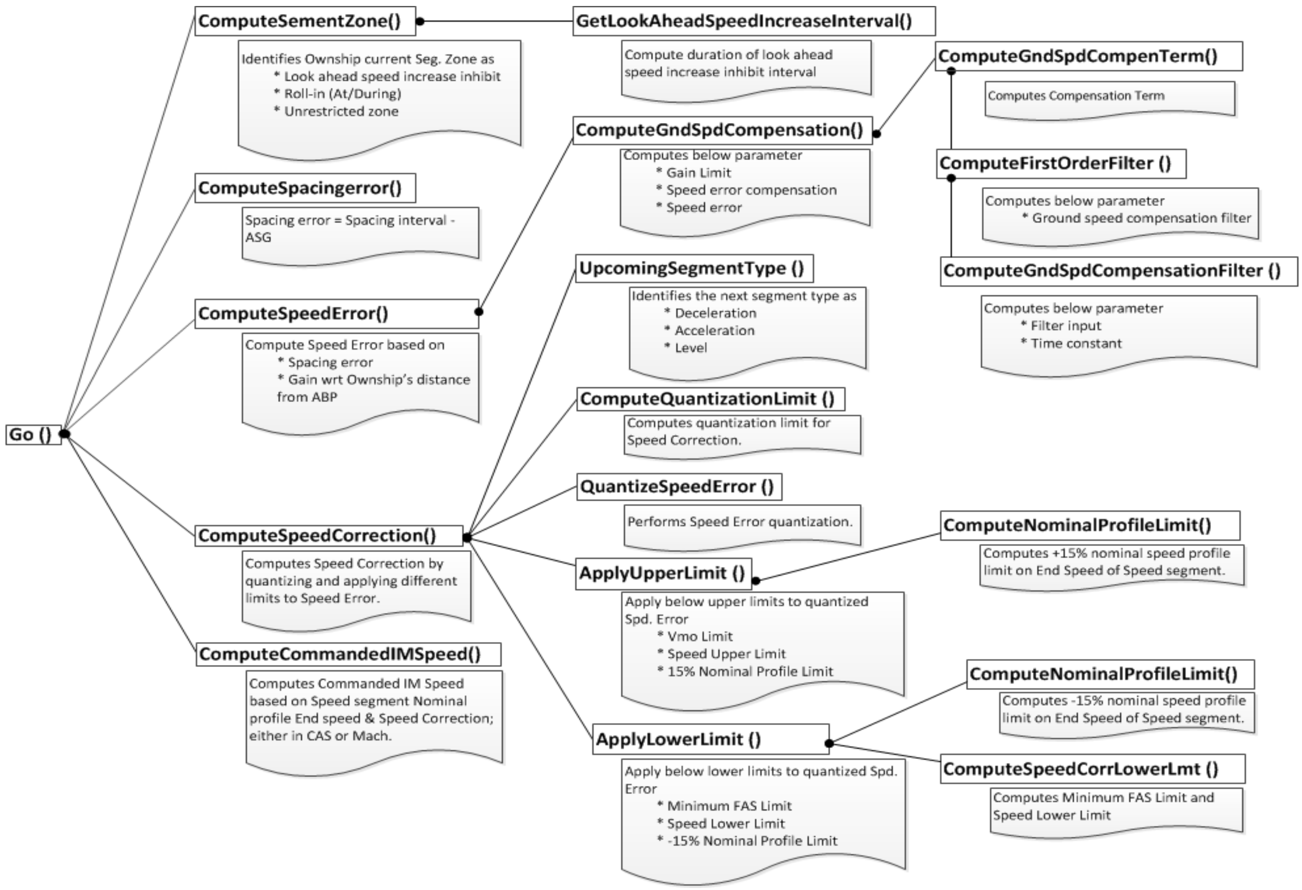


Figure 23 TBO Speed Correction & Commanded IM Speed Call Graph

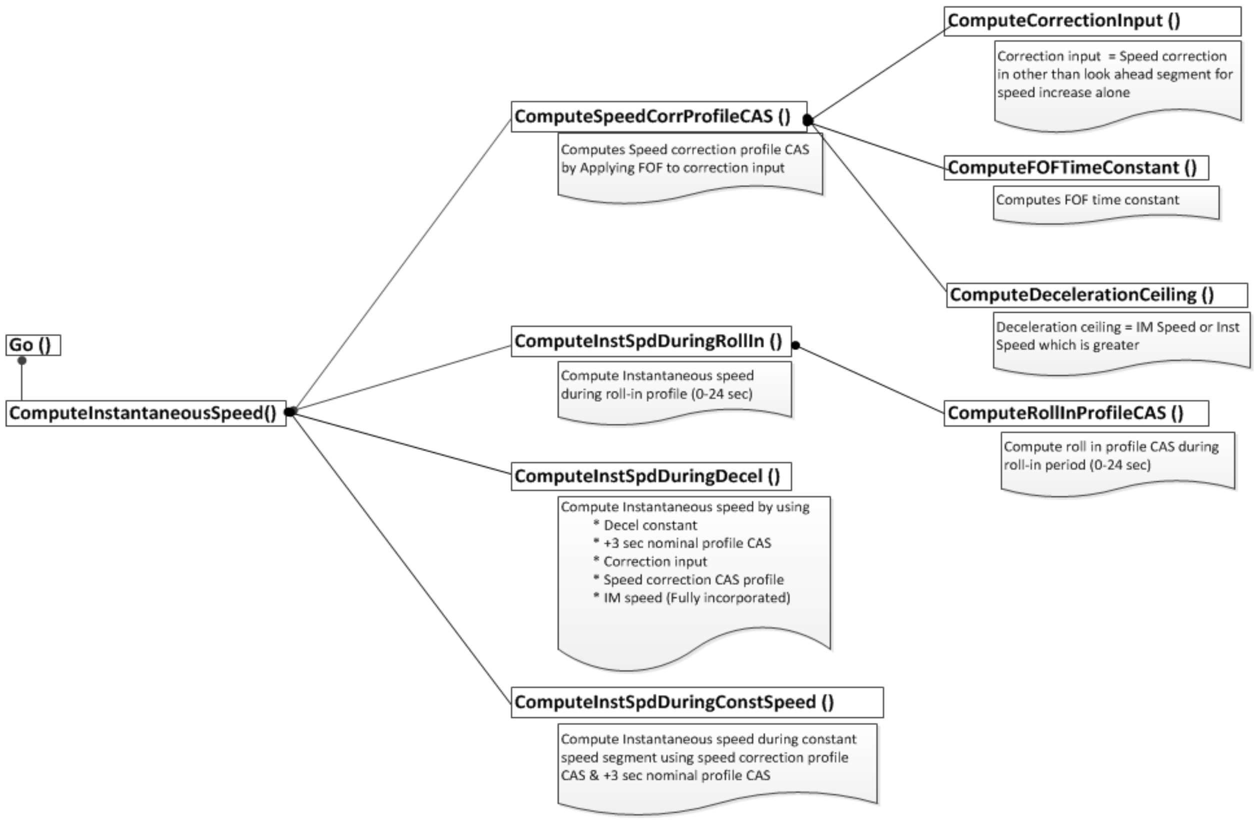


Figure 24 TBO Instantaneous Speed Call Graph

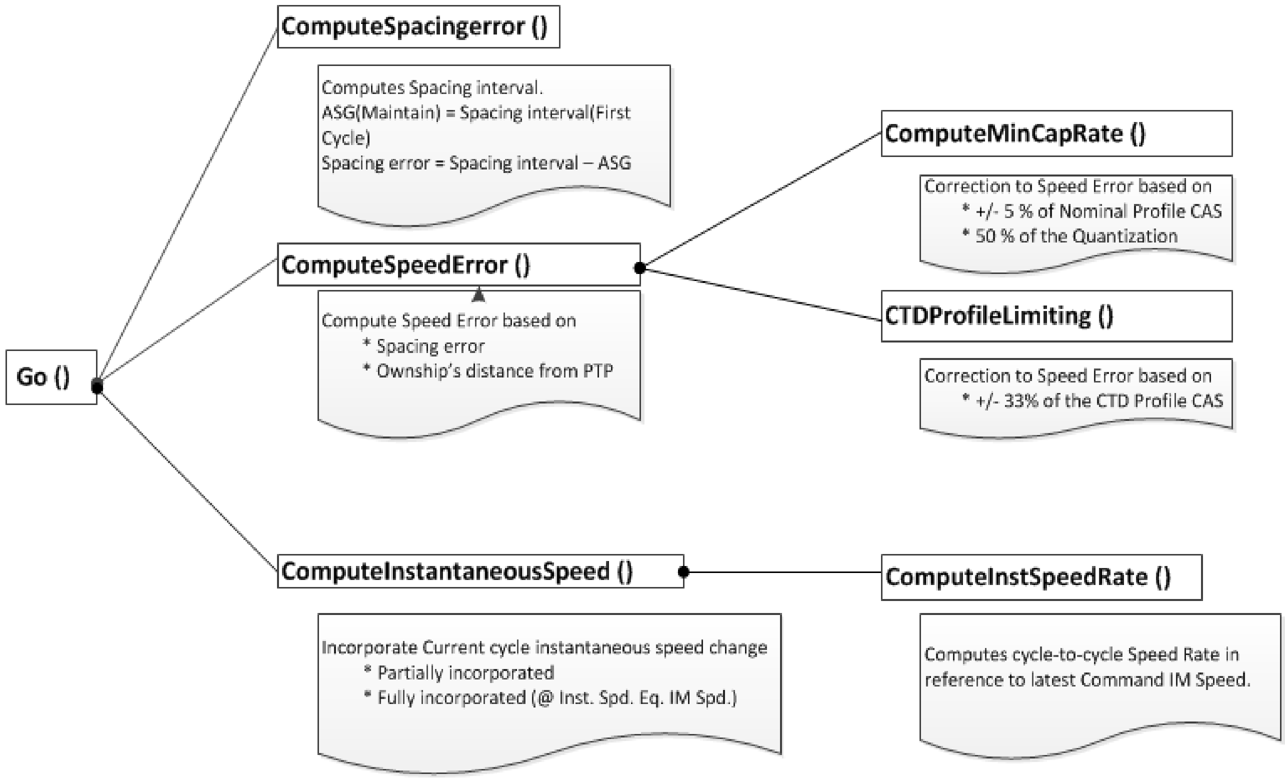


Figure 25 CTD Call Graph

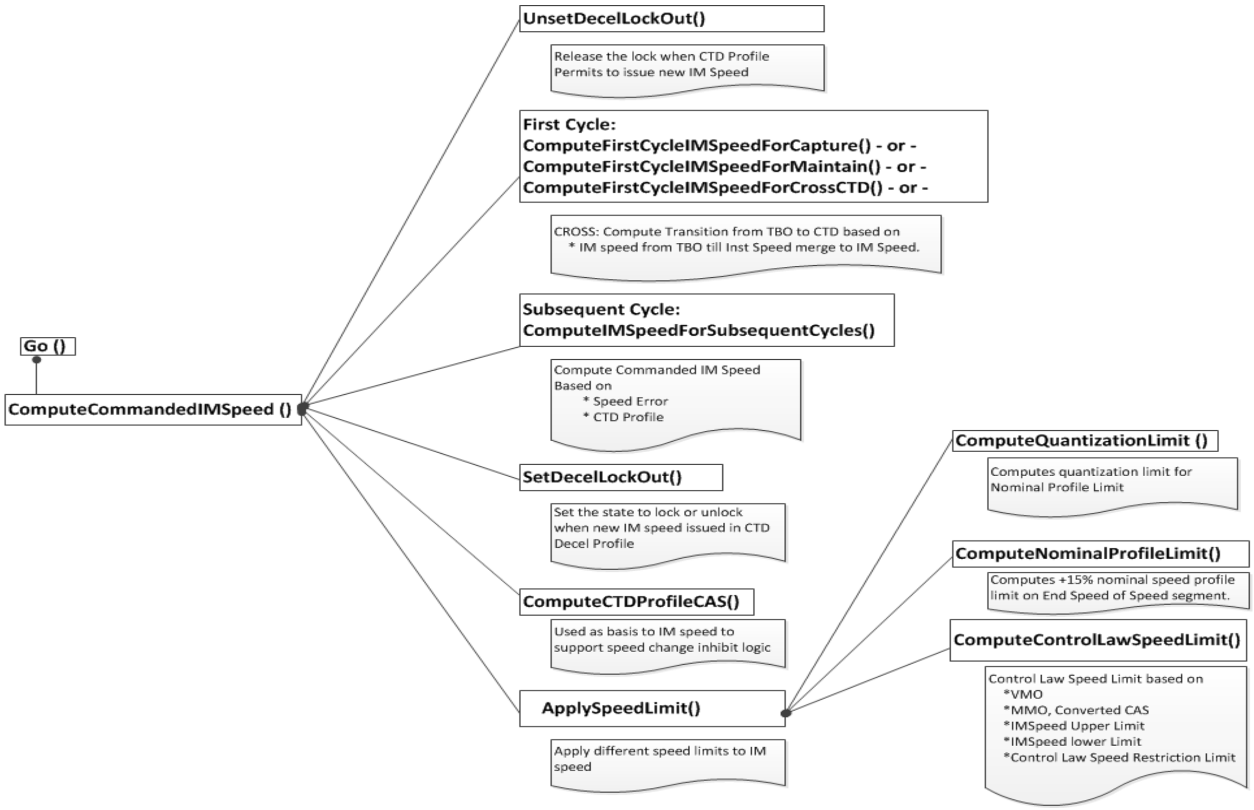


Figure 26 CTD Commanded IM Speed Call Graph

3.2.2.3 Trajectory Generator

See section 3.1.5 for Trajectory Generator theory of operation which describes the general operation of the TG module. The *Software Design Description for the FIM Software* contains the detailed design for the FIM avionics software and the *FIM Software Requirements Specification* contains the detailed software requirements which provide additional detail on the Trajectory Generator operation.

The following shows the internal architecture of the module.

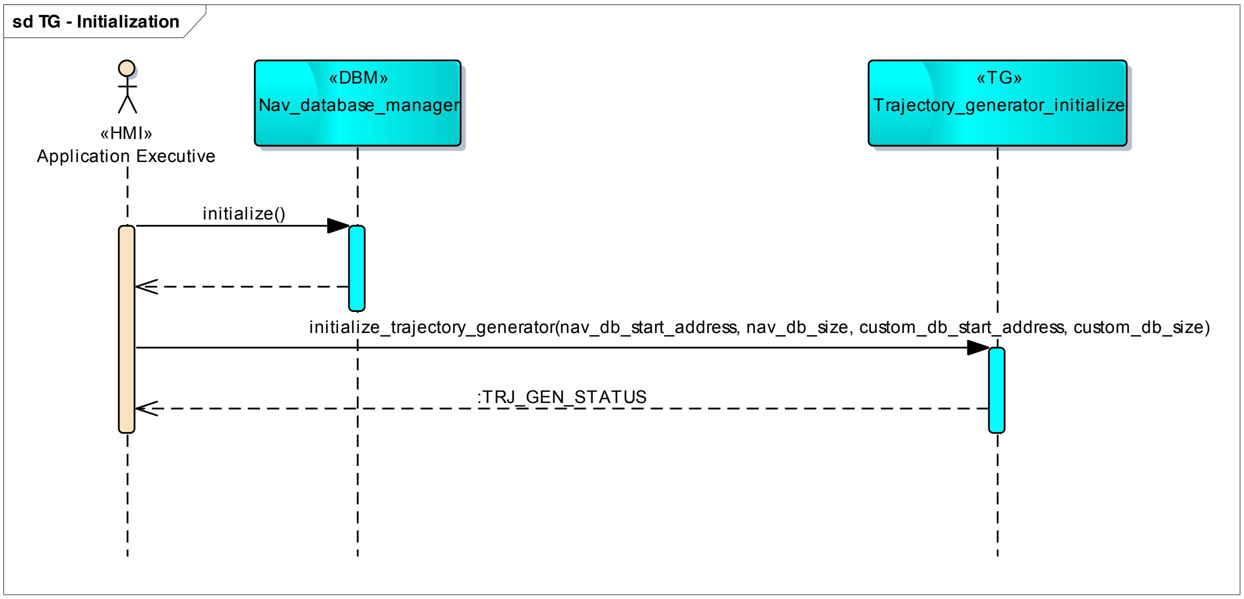


Figure 27 Trajectory Generator Initialization Sequence

A. Lateral Revision Interface

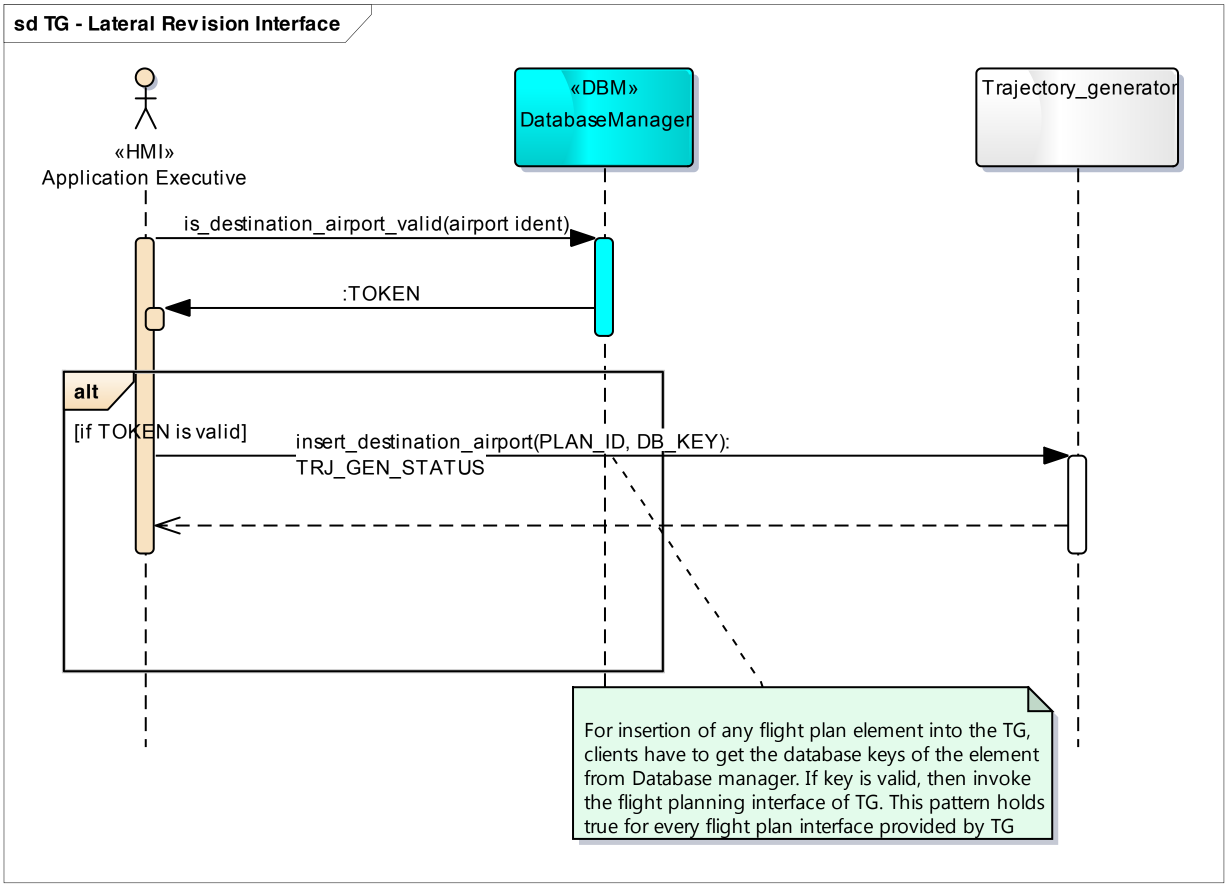


Figure 28 Trajectory Generator Lateral Revision Sequence

B. Periodic update Interface

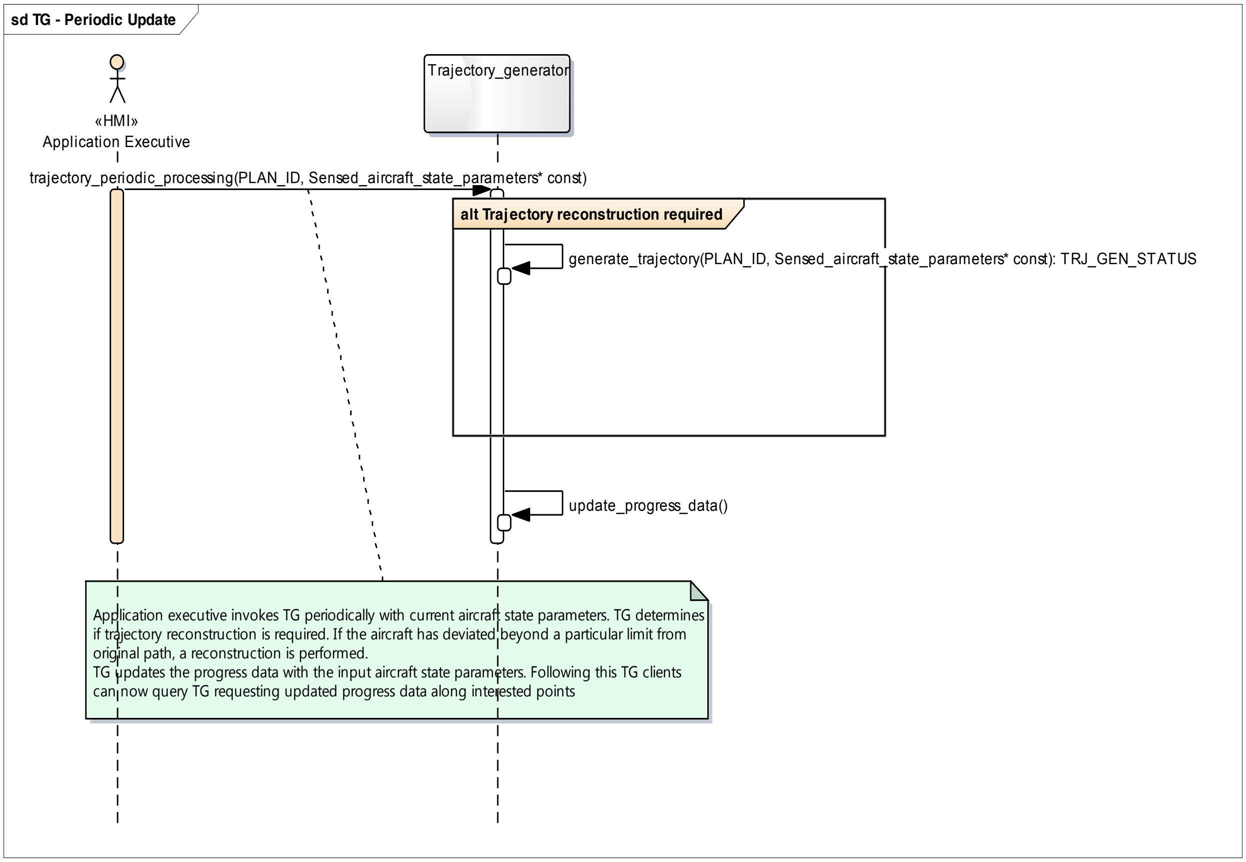


Figure 29 Trajectory Generator Periodic Sequence

C. Progress Data Interface

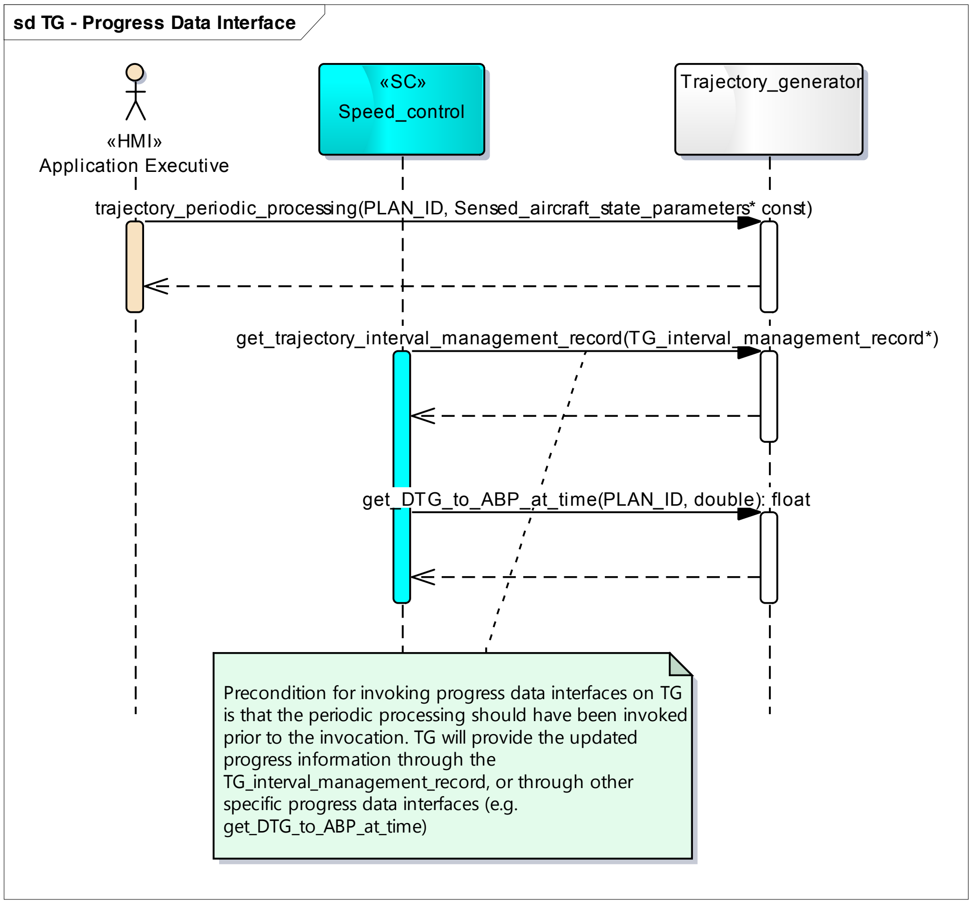


Figure 30 Trajectory Generator Progress Data Sequence

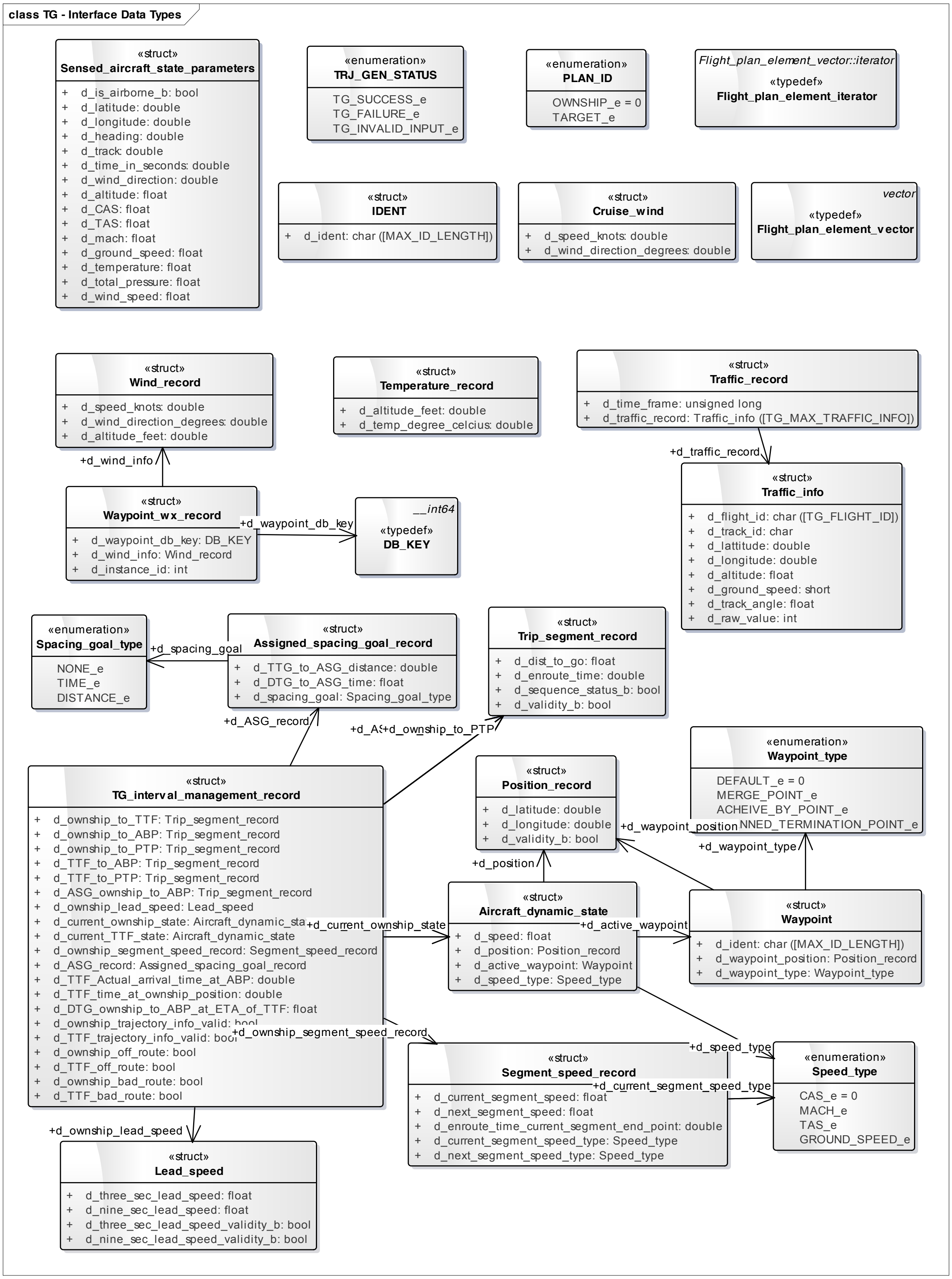


Figure 31 Trajectory Generator Interface Data

3.3.1.1 Navigation Database

See section 3.1.7 for Navigation Database theory of operation which describes the general operation of the Nav DB module. The *Software Design Description for the FIM Software* contains the detailed design for the FIM avionics software and the *FIM Software Requirements Specification* contains the detailed software requirements which provide additional detail on the Navigation Database operation.

The following shows the internal architecture of the module.

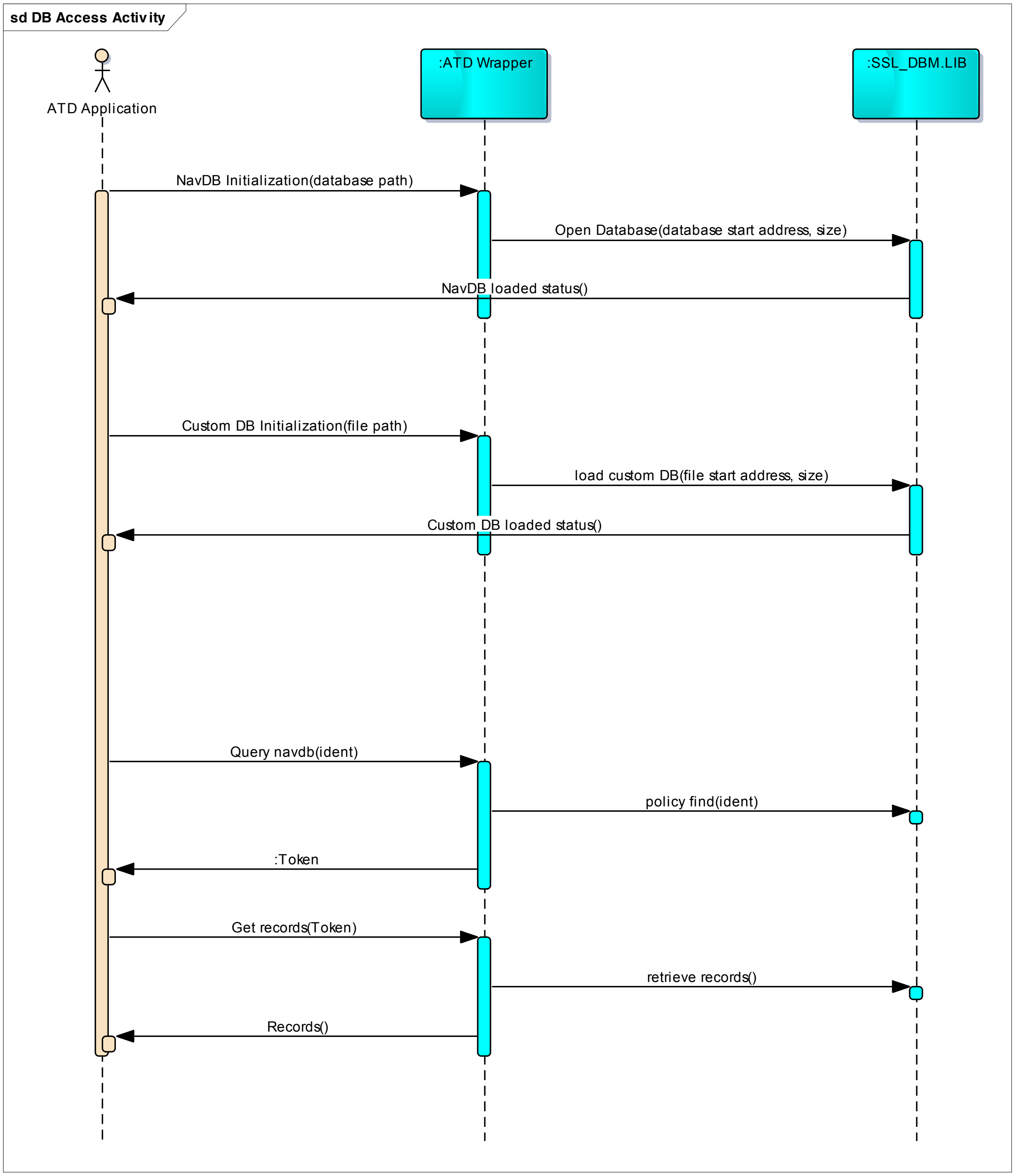


Figure 32 Use Case Diagram For DBM Module Interaction

The ATD application executive initiates the NAVDB loading and custom DB loading. The initialization status will be provided back to the user to indicate the initialization was successful or unsuccessful. The executive also needs to set the appropriate Database cycle. Usually this should match with the onboard avionics Navigation database cycle.

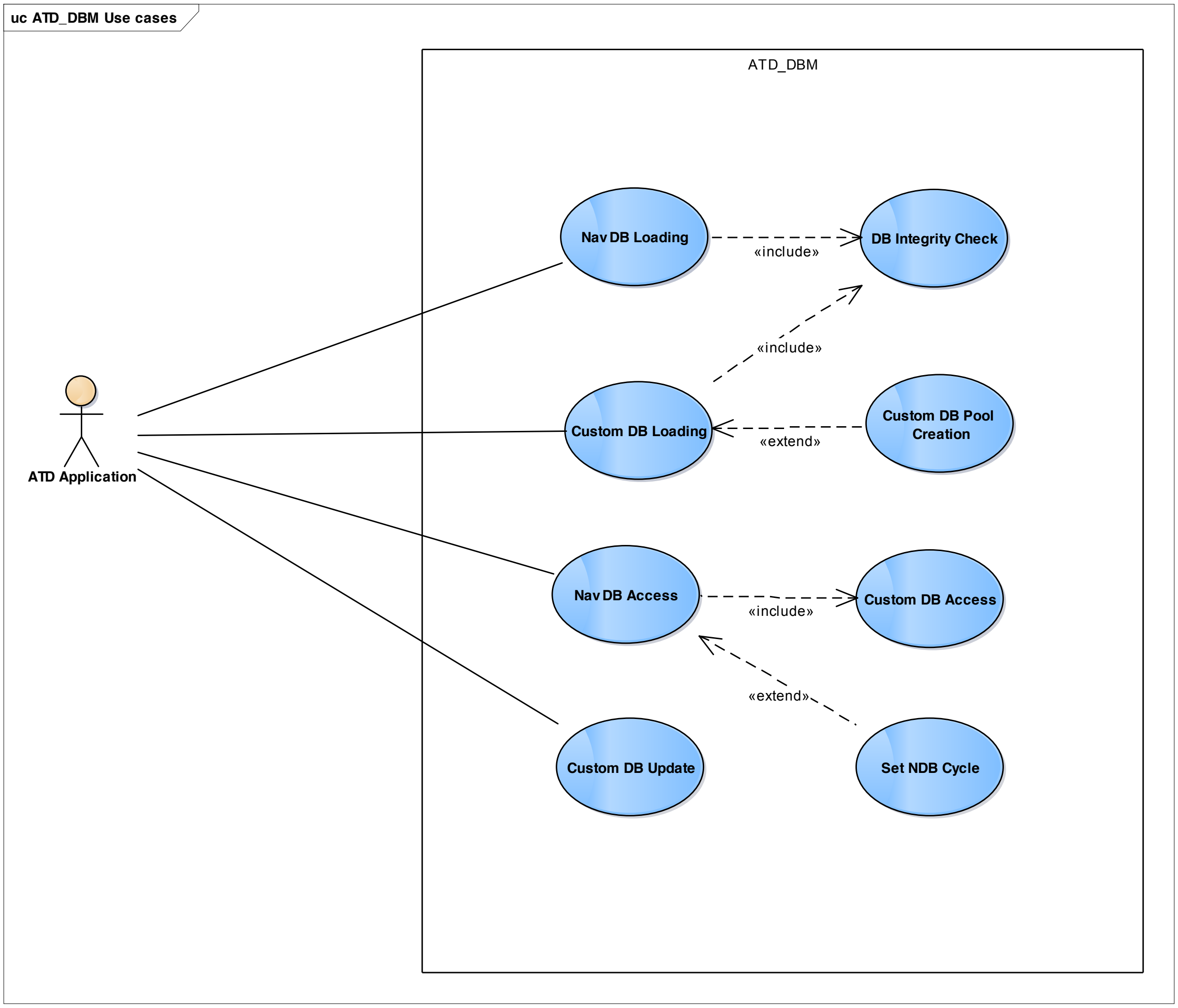


Figure 33 Use Case Diagram for DBM Loading

3.3.1.2 FIM Host Interface

The following table documents the inter-module data interface. With the exception of the Speed Control module, the detailed interface API is not provided. The Speed Control source code containing the API is provided as a separate source code package.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
1	EFB-HMI	Spd-Ctrl	IM_State	n/a	enum	ARMED, AVAILABLE,SUSPEND,RESUME,PAIRED,CANCEL
2	EFB-HMI	Spd-Ctrl	ASG	n/a	Float	eg: 120.0
3	EFB-HMI	Spd-Ctrl	ASG_Units	Sec or NM	enum	eSEC, eNM
4	EFB-HMI	Spd-Ctrl	DesignatedTrafficID	n/a	char*	eg: ASQ7Q44
5	EFB-HMI	Spd-Ctrl	IM_ClearanceType	n/a	enum	MAINTAIN, CAPTURE,CROSS,SPACING,NONE
6	EFB-HMI	Spd-Ctrl	Altitude entry for Wind	Feet	int	eg:10000, 0 for Surface
7	EFB-HMI	TG	Ownship_IFPI_Record	n/a	struct	Contains upto 10 IFPI elements entered by crew manually or by selection of arrival ,approach and transition
8	EFB-HMI	TG	DescentWinds	n/a	struct	Contains upto 5 altitudes including surface and corresponding wind direction and speed.
9	EFB-HMI	TG	ABP	n/a	struct	Contains an Ident of a waypoint common to Tgt and Ownship and an along path distance from this waypoint where Achieve By Point is desired.
10	EFB-HMI	TG	PTP	n/a	struct	Contains an Ident of a waypoint common to Tgt and Ownship and an along path distance from this waypoint where Planned Termination Point is desired.
11	EFB-HMI	TG	IM_ClearanceType	n/a	enum	MAINTAIN, CAPTURE,CROSS,SPACING,NONE

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
12	EFB-HMI	TG	Dest	ICAO	char*	eg: KDEN
13	EFB-HMI	TG	Ownship_IFPI_Record	n/a	struct	Contains upto 10 IFPI elements entered by crew manually or by selection of arrival ,approach and transition . Also wind speed and direction are included for each waypoint if entries were made.
14	EFB-HMI	TG	HMI.Tgt_IFPI_Record	n/a	struct	Contains upto 5 waypoints entered by crew manually or by selection of arrival ,approach and transition . Also wind speed and direction are included for each waypoint if entries were made.
15	EFB-HMI	TG	IM TARGET APPROACH	n/a	char*	eg: ILS17R
16	EFB-HMI	TG	Selected RANGE	NM	float	eg: 25.0
17	IO	TG	Traffic Data record	n/a	struct	The Entire Traffic List as received from TCAS
18	EFB-HMI	TG	DescentWinds	n/a	struct	Contains upto 5 altitudes including surface and corresponding wind direction and speed.
19	EFB-HMI	TG	Ownship_IFPI_Record	n/a	struct	Contains upto 10 waypoints entered by crew manually or by selection of arrival ,approach and transition . Also wind speed and direction are included for each waypoint if entries were made.
20	EFB-HMI	TG	ABP	n/a	struct	Contains an Ident of a waypoint common to Tgt and Ownship and an along path distance from this waypoint where Achieve By Point is desired.
21	EFB-HMI	TG	PTP	n/a	struct	Contains an Ident of a waypoint common to Tgt and Ownship and an along path distance from this waypoint where Planned Termination Point is desired.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
22	Spd-Ctrl	EFB-HMI	SpeedConformanceMonitor	In Conformance/ Out Of Conformance	enum	
23	Spd-Ctrl	EFB-HMI	SpacingInterval	N/a	int	Spacing Interval
24	Spd-Ctrl	EFB-HMI	SpacingIntervalUnits	NM/Secs	enum	Spacing interval units
25	Spd-Ctrl	EFB-HMI	ASG_Time	n/a	int	Assigned Spacing Goal in secs
26	Spd-Ctrl	EFB-HMI	ASG_Dist	Sec or NM	enum	Assigned Spacing Goal in NM
27	NavDB	EFB-HMI	IM CAUTION, ADVISORY and INFO MESSAGES	n/a	enum	NM/Secs
28	NavDB	EFB-HMI	Airports	ICAO	Array of char*	List of Airport Names
29	NavDB	EFB-HMI	Arrival	n/a	Array of char*	List of Arrivals for the Airport
30	NavDB	EFB-HMI	Transision	n/a	Array of char*	List of Transision for the Arrial
31	NavDB	EFB-HMI	Approach	n/a	Array of char*	List of Approach for the Arrival List of Approach for the Transition List of Approach for the Arrival and Transition
32	EFB-HMI	Spd-Ctrl	CASMachSelection	n/a	enum	DEFAULT, MACH, CAS
33	IO	Spd-Ctrl	Ownship Maximum Operating Limit Speed - CAS (Vmo)			
34	IO	Spd-Ctrl	Ownship Maximum Operating Limit Speed - Mach (Mmo)	MACH	float	

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
35	EFB-HMI	Spd-Ctrl	IMSpeedUpper Limit			
36		Spd-Ctrl	Maximum Speed for current flaps configuration			
37	EFB-HMI	Spd-Ctrl	IMSpeedLowerLimit			
38	IO	Spd-Ctrl	Minimum Final Approach Speed	CAS		
39	Spd-Ctrl	EFB-HMI	ASG_Units	n/a		Spacing Goal Units
40	Spd-Ctrl	EFB-HMI	IMCommandedSpeed	CAS/MACH	Float	Speed in CAS /MACH to be commanded by pilot
41	Spd-Ctrl	EFB-HMI	IMSpeedUnits	n/a	Enum	The units of supplied IM speed
42	Spd-Ctrl	EFB-HMI	IMSpeedValid	n/a	Enum	Valid /Invalid (Indicates completion of IM speed computation)
43	Spd-Ctrl	EFB-HMI	TgtDataLost	n/a	Enum	True,False
44	Spd-Ctrl	EFB-HMI	SpdLimited	n/a		True,False
45	TG	EFB-HMI	OwnshipTrajectoryRecord		Float	Structure containing list of waypoints including specialwpts (like ABP,PTP,mergepoint) and their associated lat,lon,alt and speed constraints.
46	TG	EFB-HMI	TgtTrajectoryRecord		Float	Structure containing list of waypoints including specialwpts (like ABP,PTP,mergepoint) and their associated lat,lon,alt and speed constraints.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
47	TG	EFB-HMI	IM_ApplicationInfoValid	Valid /Invalid	Enum	If any IM Application Information (for all of “a” through “e” above) is Invalid, the FIM Avionics System shall (FRAC.014) set the IM Application Information Status to Invalid and provide the Invalid IM Application Information Criteria to the HMI/CDTI Interface.
48	TG	EFB-HMI	OwnshipOffRoute	True,False	Enum	4.1.3.3 Horizontal Path Conformance Monitoring Status MOPS Status: Modified The Ownship and Designated Traffic are expected to comply with the navigation requirements associated with the procedure(s) identified by the Intended Flight Path Information (IFPI). Horizontal Path Conformance Monitoring Status identifies when the Ownship or the Designated Traffic are not conforming to the Horizontal Path calculated by the FIM Avionics System, which may result in significant errors in the PSI or MSI and thus Commanded IM Speeds.
49	TG	EFB-HMI	TgtOffRoute	True,False	Enum	4.1.3.3 Horizontal Path Conformance Monitoring Status MOPS Status: Modified The Ownship and Designated Traffic are expected to comply with the navigation requirements associated with the procedure(s) identified by the Intended Flight Path Information (IFPI). Horizontal Path Conformance Monitoring Status identifies when the Ownship or the Designated Traffic are not conforming to the Horizontal Path calculated by the FIM Avionics System, which may result in significant errors in the PSI or MSI and thus Commanded IM Speeds.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
50	TG	EFB-HMI	OwnshipTTGABP	Seconds	Integer	4.1.3.2.14 Time-to-Go Calculation MOPS Status: Modified (Not everything included from sections C.3.3-4 in Appendix C of MOPS for FIM V7.0) For the Achieve Stage, the FIM Avionics System shall be capable of calculating the Ownship's Time-to-Go to the Achieve-by Point from the current Along-path Position that is consistent with the Ground Speed Profile
51	TG	EFB-HMI	OwnshipDTGABP	NM	Integer	4.1.3.2.14 Time-to-Go Calculation MOPS Status: Modified (Not everything included from sections C.3.3-4 in Appendix C of MOPS for FIM V7.0) For the Achieve Stage, the FIM Avionics System shall be capable of calculating the Ownship's Time-to-Go to the Achieve-by Point from the current Along-path Position that is consistent with the Ground Speed Profile
52	TG	EFB-HMI	PTPMonitoringStatus	Reached/Not Reached	Enum	4.1.10 Planned Termination Point Monitoring Status MOPS Status: As Is FIM Avionics System will monitor the Along-path Position of the Ownship and indicate to CDTI when Ownship has reached Planned Termination Point. The Planned Termination Point Monitoring Status is in one of the following two states: 1. "Not Reached:" Ownship's Along-path Position has not reached the Planned Termination Point. 2. "Reached:" Ownship's Along-path Position has reached the Planned Termination Point
53	TG	EFB-HMI	PTPWpt	Planned termination point	Waypoint Record	

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
54	TG	EFB-HMI	TgtBadRoute	True,False	Enum	A valid Ownship traffic record and an Ownship route definition exists, but the calculated trajectory cannot be calculated, or it does not meet speed or altitude constraints
55	TG	EFB-HMI	OwnshipBadRoute	True,False	Enum	A valid Target traffic record and a Target route definition exists, but the calculated trajectory cannot be calculated, or it does not meet speed or altitude constraints.
56	EFB-HMI	TG	IMInfoClear	True,False	enum	Transient 2 secs signal to clear all IM information
57	IO	EFB-HMI	TCVertRAStatus	Enum	Enum	For TCAS annunciation Display
58	IO	EFB-HMI	TCMode	Enum	Enum	For TCAS annunciation Display
59	IO	EFB-HMI	TCModeStatus	Enum	Enum	For TCAS annunciation Display
60	IO	EFB-HMI	TrfcAppAvailableStatus	Enum	enum	Traffic Application availability word status
61	IO	EFB-HMI	TrfcEVAcqGrpAvail	Enum	enum	EV Acq application availability
62	IO	EFB-HMI	TrfcIntervalMgmtGrpAvail	Enum	enum	IM application availbility
63	IO	EFB-HMI	TrfcGrndBasedGrpAvail	Enum	enum	SURF appln availaibility
64	IO	EFB-HMI	TrfcEVApprGrpAvail	Enum	enum	EV appr Appln availbility
65	IO	EFB-HMI	TrfcItpGrpAvailable	Enum	enum	ITP application availability
66	IO	EFB-HMI	TrfcFaultLabelStatus	Enum	enum	For TCAS annunciation Display
67	IO	EFB-HMI	TrfcSystemStatus	Enum	enum	For IM system status display
68	IO	EFB-HMI	AsasSystemStatus	Enum	enum	For IM system status display
69	IO	EFB-HMI	TrfcDtifTransmit	Enum	Enum	TCAS Dtif status
70	IO	EFB-HMI	TrfcDtifTransmitStatus	Enum	Enum	TCAS Dtif status
71	IO	EFB-HMI	UTCTime	Struct	Float	UTC time as reported by TCAS computer
72	IO	EFB-HMI	OwnshipTrackAngle	float	float	Ownship track angle
73	IO	EFB-HMI	OwnshipTrackAngleStatus	Enum	enum	Ownship track angle status
74	IO	EFB-HMI	OwnshipPressureAlt	float	float	Ownship pressure altitude

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
75	IO	EFB-HMI	OwnshipPressureAltStatus	Enum	enum	Ownship pressure altitude status
76	IO	EFB-HMI	OwnshipLatitudeCoarse	float	float	
77	IO	EFB-HMI	OwnshipLatitudeCoarseStatus	Enum	enum	
78	IO	EFB-HMI	OwnshipLongitudeCoarse	float	float	
79	IO	EFB-HMI	OwnshipLongitudeCoarseStatus	Enum	enum	
80	IO	EFB-HMI	OwnshipLongitudeFine	float	float	
81	IO	EFB-HMI	OwnshipLongitudeFineStatus	Enum	enum	
82	IO	EFB-HMI	OwnshipLatitudeFine	float	float	
83	IO	EFB-HMI	OwnshipLatitudeFineStatus	Enum	enum	
84	IO	EFB-HMI	OwnshipGroundSpeed	float	float	
85	IO	EFB-HMI	OwnshipGroundSpeedStatus	Enum	enum	
86	IO	EFB-HMI	OwnshipWindSpeed	float	float	
87	IO	EFB-HMI	OwnshipWindSpeedStatus	Enum	enum	
88	IO	EFB-HMI	OwnshipWindDirection	float	float	
89	IO	EFB-HMI	OwnshipWindDirectionStatus	Enum	enum	
90	IO	EFB-HMI	OwnshipMach	float	float	
91	IO	EFB-HMI	OwnshipMachStatus	Enum	enum	
92	IO	EFB-HMI	OwnshipCAS	float	float	
93	IO	EFB-HMI	OwnshipCASStatus	Enum	enum	
94	IO	EFB-HMI	OwnshipStaticAirTemp	float	float	
95	IO	EFB-HMI	OwnshipStaticAirTempStatus	Enum	enum	
96	IO	Spd-Ctrl	MaxIMSpeedCorrectionPercent	percent	int	The limits on the IM Speeds in the FIM Avionics System shall (new_2.2.4.5.3B) be configurable at installation with a default value of 15%.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
97	IO	Spd-Ctrl	GroundSpeedToleranceWithTgtAC	knots	int	For Distance-based ASG, after the Designated Traffic reaches the Planned Termination Point, and until Ownship reaches the Planned Termination Point, the FIM Avionics System shall (new_2.2.4.5A) compute IM Speeds such that the Ownship has a ground speed at the Planned Termination Point that is within 10 knots of the ground speed of the Designated Traffic at the Planned Termination Point.
98	IO	Spd-Ctrl	OwnshipCAS	float	float	When the IM Speed Mach/CAS selection is computed in CAS, the FIM Avionics System shall (FRAC.251) evaluate the Speed Conformance Monitoring Status on one (1) second intervals starting 11 seconds after the new IM Speed, and ending when Ownship's CAS is within 5 knots of the new IM Speed.
99	IO	Spd-Ctrl	OwnshipCASStatus	Enum	enum	
100	IO	Spd-Ctrl	OwnshipMach	float	float	
101	IO	Spd-Ctrl	OwnshipMachStatus	Enum	enum	
102	IO	THDB	Traffic Data record	record	struct	All traffic data received from TPU
103	IO	Spd-Ctrl	OwnshipPressureAlt	Feet	float	
104	IO	Spd-Ctrl	OwnshipPressureAltStatus	enum	Enum	
105	IO	Spd-Ctrl	OwnshipWindSpeed	knots	float	
106	IO	Spd-Ctrl	OwnshipWindSpeedStatus	Enum	Enum	
107	IO	Spd-Ctrl	OwnshipWindDirection	deg	float	
108	IO	Spd-Ctrl	OwnshipWindDirectionStatus	Enum	Enum	
109	IO	Spd-Ctrl	OwnshipStaticAirTemp		float	
110	IO	Spd-Ctrl	OwnshipStaticAirTempStatus	Enum	Enum	
111	TG	Spd-Ctrl	OwnshipABPMonitor	Passed/Not Passed	enum	Ownship Passed ABP

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
112	TG	Spd-Ctrl	TgtABPMonitor	Passed/Not Passed	enum	Target Passed ABP
113	TG	Spd-Ctrl	OwnshipToTTFAlongPathDist	Dist in NM	int	
114	TG	Spd-Ctrl	OwnshipTTFAlongPathDistStatus	Valid/Invalid	enum	
115	TG	Spd-Ctrl	OwnshipCurrentTrajProfileCAS	CAS in knots	float	
116	TG	Spd-Ctrl	TgtNominalProfileGroundSpeed	knots	float	Nominal profile ground speed at current traffic position.
117	TG	Spd-Ctrl	OwnshipTimeToGoABP	Seconds	int	
118	TG	Spd-Ctrl	OwnshipTimeToGoPTP	Seconds	int	
119	TG	Spd-Ctrl	TgtTimeToGoABP	Seconds	int	
120	TG	Spd-Ctrl	OwnshipDistToGoABP	NM	float	
121	TG	Spd-Ctrl	OwnshipDistToGoPTP	NM	float	
122	TG	Spd-Ctrl	TgtDistToGoPTP	NM	float	
123	TG	EFB-HMI	OwnshipAlongPathPosition	lat lon pair	struct	projected along path position of ownship
124	TG	EFB-HMI	TgtAlongPathPosition	lat lon pair	struct	projected along path position of target
125	TG	EFB-HMI	OwnshipABPMonitor	Passed/Not Passed	Enum	
126	TG	EFB-HMI	TgtABPMonitor	Passed/Not Passed	Enum	
127	TG	EFB-HMI	TgtNextWpt	wpt ident	Waypoint Record	
128	TG	EFB-HMI	OwnshipNextWpt	wpt ident	Waypoint Record	
129	EFB-HMI	TG	CruiseWinds	n/a	struct	Contains wind direction and speed information for upto 10 enroute waypoints
130	Spd-Ctrl	EFB-HMI	IMInstantaneousSpeed	CAS/MACH	Float	Speed for use in the FAST slow indicator

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
131	TG	Spd-Ctrl	OwnshipPTPMonitoringStatus	Reached/Not Reached	Enum	4.1.10 Planned Termination Point Monitoring Status MOPS Status: As Is FIM Avionics System will monitor the Along-path Position of the Ownship and indicate to CDTI when Ownship has reached Planned Termination Point. The Planned Termination Point Monitoring Status is in one of the following two states: 1. “Not Reached:” Ownship’s Along-path Position has not reached the Planned Termination Point. 2. “Reached:” Ownship’s Along-path Position has reached the Planned Termination Point
132	TG	Spd-Ctrl	OwnshipTTGtoTTFPosition	Seconds	int	Ownship Time to go to TTF current position.
133	TG	Spd-Ctrl	OwnshipCurrentSegmentEndSpeed	knots	Float	
134	TG	Spd-Ctrl	OwnshipNextSegmentEndSpeed	knots	Float	
135	TG	Spd-Ctrl	OwnshipTTGtoEndOfCurrent SpeedSegment			
136	TG	Spd-Ctrl	OwnshipTTGtoPointASGDistance FromABP	Seconds	int	Time Equivalent of Distance based spacing.
137	IO	Spd-Ctrl	CasMachCrossOverAltitude	Feet	Float	
138	IO	Spd-Ctrl	OwnshipLatitudeCoarse	float	float	
139	IO	Spd-Ctrl	OwnshipLatitudeCoarseStatus	Enum	enum	
140	IO	Spd-Ctrl	OwnshipLongitudeCoarse	float	float	
141	IO	Spd-Ctrl	OwnshipLongitudeCoarseStatus	Enum	enum	
142	IO	Spd-Ctrl	OwnshipLongitudeFine	float	float	
143	IO	Spd-Ctrl	OwnshipLongitudeFineStatus	Enum	enum	
144	IO	Spd-Ctrl	OwnshipLatitudeFine	float	float	
145	IO	Spd-Ctrl	OwnshipLatitudeFineStatus	Enum	enum	
146	IO	TG	OwnshipLatitudeCoarse	float	float	
147	IO	TG	OwnshipLatitudeCoarseStatus	Enum	enum	

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
148	IO	TG	OwnshipLongitudeCoarse	float	float	
149	IO	TG	OwnshipLongitudeCoarseStatus	Enum	enum	
150	IO	TG	OwnshipLongitudeFine	float	float	
151	IO	TG	OwnshipLongitudeFineStatus	Enum	enum	
152	IO	TG	OwnshipLatitudeFine	float	float	
153	IO	TG	OwnshipLatitudeFineStatus	Enum	enum	
154	TG	Spd-Ctrl	TgtActualTimeOfArrivalatABP		UTC time	
155	THDB	TG	Designated Traffic History Buffer	Struct		
157	EFB-HMI	THDB	Designated Traffic ID		Char array	
158	IO	Spd-Ctrl	EpochTime	Seconds	int	
159	TG	Spd-Ctrl	DesignatedTrafficsTimeAtCurrentOwnshipPosition	Struct		
160	TG	Spd-Ctrl	OwnshipDTGtoABPat<current time + TgtTimeToGoABP>	NM		For distance based clearance in Achieve phase, the Predicted spacing interval is computed as the ownships distance to go at the time the deignated traffic is predicted to cross the ABP.
161	TG	Spd-Ctrl	OwnshipTrajProfileCASWith3secLead	knots	Float	Ownship Profile Speed 3 seconds from now
162	TG	Spd-Ctrl	OwnshipTrajProfileCASat9secAfterSpeedSegmentStart	knots	Float	Ownship profile Speed 9 seconds from start of a segment
163	Spd-Ctrl	EFB-HMI	SpacingErrorInTime	Seconds	int	Spacing Error for the early late indicator
164	TG	Spd-Ctrl	TgtPTPMonitor	Passed/Not Passed	enum	Target Passed PTP
165	TG	Spd-Ctrl	TgtTimeToGoPTP	Seconds	int	Target Time to go PTP.
166	TG	Spd-Ctrl	TgtActualTOAatPTP	Seconds	int	Target Actual Time of Arrival at PTP
167	TG	Spd-Ctrl	TgtTimeAtOwnshipProximatePosWith15secLead	seconds	int	Target history time at ownship proximate position +15 sec lead
168	TG	Spd-Ctrl	TgtReportedGroundSpeed	knots	float	Reported ground speed at current traffic position.

Sl No.	Source	Destination	Parameter	Units	Data Type	Comments
169	TG	Spd-Ctrl	TgtNominalHistoryCAS	knots	Float	Traffic's time history data from 15 seconds in front of the ownship's current position converted to CAS using avergae ground speed.
170	IO	Spd-Ctrl	OwnshipPressureAlt	float	float	Ownship pressure altitude
171	IO	Spd-Ctrl	OwnshipPressureAltStatus	Enum	enum	Ownship pressure altitude status

3.3.2 Data Logging

Data logging is performed by a combination of the EFB FIM software, the TPU software and external data logging applications. The data logging elements are highlighted in the diagram below.

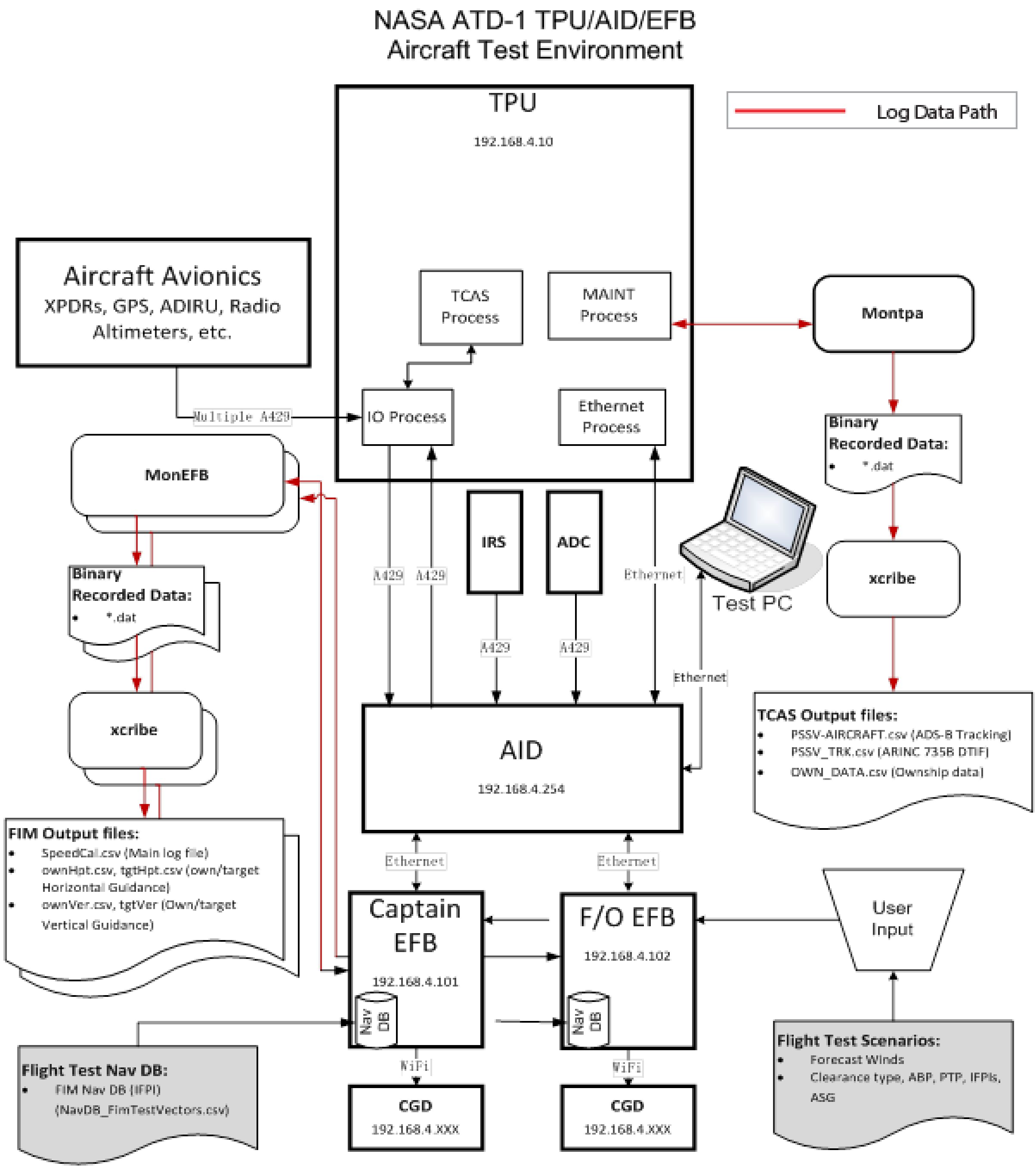


Figure 34 Aircraft Data Logging Environment

The red lines in the diagram above indicate the logging data flow from the EFB and TPU. The TPU and FIM software use the same data logging methodology. Both transmit log data via Ethernet to a data logging PC. TPU data is logged by the legacy MonTPA application while EFB data is logged by the MonEFB software. MonEFB is derived from MonTPA, with modifications to display EFB data rather than TPU data. Two instances of MonEFB may run on the data logging PC to capture data from both EFBs.

Both MonEFB and MonTPA are capable of displaying live data as it is received, and capture data to a binary log file. Post exercise, the binary log files can be parsed out into CSV files using the existing xcribe parsing software for further analysis.

The data logging applications MonTPA and MonEFB run on a single data logging PC, external to the FIM avionics.

The same data logging system is available in integration lab and the aircraft.

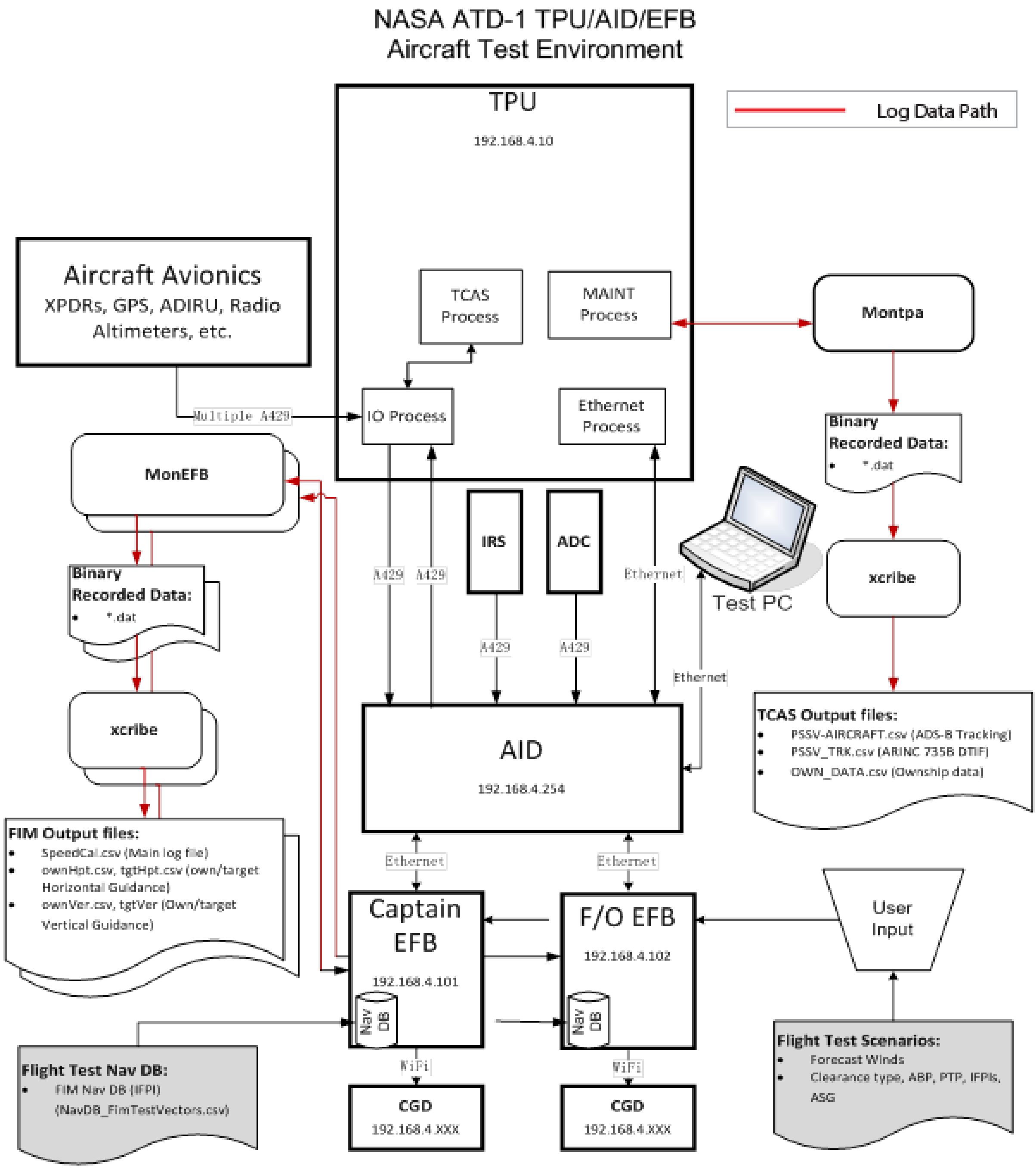


Figure 35 Aircraft Data Logging Environment

The red lines in the diagram above indicate the logging data flow from the EFB and TPU. The TPU and FIM software use the same data logging methodology. Both transmit log data via Ethernet to a data logging PC. TPU data is logged by the legacy MonTPA application while EFB data is logged by the MonEFB software. MonEFB is derived from MonTPA, with modifications to display EFB data rather than TPU data.

Both MonEFB and MonTPA are capable of displaying live data as it is received, and capture data to a binary log file. Post capture, the binary log files can be parsed out into CSV files using the Honeywell xcribe parsing software for further analysis. Xcribe uses parsing definition files (.def) which define not only how to read the binary data, but how to format the resulting CSV files – which fields to include, order, etc. The operation of the XCRIBE and definition files is described in the Honeywell XCRIBE Programming Manual.

The data logging applications MonTPA and MonEFB run on a data logging PC, external to the FIM avionics.

3.4 Interface Control Specifications

3.4.1 TPU to FIM Avionics ICD

The TPU bus interface is described in the TPA 100B Maintenance Manual. The FIM avionics application selects which data to receive, via the AID, using the STAP protocol. The AID latches the selected TPU data from the aircraft bus and transfers it to the FIM avionics application. The TPU data transferred to the FIM application is documented in Table 3 STAP Label Configuration.

3.4.2 TPU Dependency

The TPU used in the ATD-1 demonstration was a Honeywell TPA-100B with limited modifications to provide enhanced data for the FIM Host application. The FIM avionics as demonstrated is dependent on such a TPU.

The following modifications have been made to the Honeywell traffic computer to support the FIM software.

TCAS process:

- The IM Application now has its own set of crosschecks because of the different crosscheck requirements imposed by the NASA Spec.
- Logical changes made to always keep the Traffic to Follow (TTF) in the ESTB list, even if it is out prioritized by other traffic. If a given target matches the TTF, the target will always be promoted, demoting the traffic with the least priority on the list. If the TTF has the least priority on the list, and a new higher priority target is about to be promoted, a target with the second least priority will be demoted instead.
- Similar to the Mode S ID hash table, a Flight ID Hash Table has been created to keep track of duplicate flight ID's.

I/O process:

- Logical changes made to reorder the DTIF to include the TTF when merging the active and passive lists together. If the TTF is specified, the DTIF's ordering will be as follows:
    - RA
    - TA
    - PA
    - TTF
    - all others with priority sorting
- Functional changes have been made to receive a DTIF (L366, L367) from the previously unused Traffic Display Control Bus #1/#2. The bus now processes a DTIF and pulls out the necessary information it needs from the intruder. In our case it is flight ID, but could later be modified to pull out other elements.
- The I/O Process now packs L165, L166, L174, L313, L110, L111, L120, and L121 according to ARINC 735B.

I/O output (hw output interface):

- The I/O Process now outputs Label 163, the application availability word, with the availability of the Interval Management availability in bits 14, 15 and 16.
- The I/O Process now outputs Label 366 Type 4, intruder information quality, with the Interval Management Quality Level in bits 17, and 18.
- The I/O Process now outputs an intruder's velocity coast status in bit 14 of Label 366 Type 3.
- The I/O Process now outputs the following labels on the TA/RA Bus #1/#2 according to ARINC 735B

3.4.2.1 FIM Avionics Operator Troubleshooting Guide

3.4.2.1.1 FIM Host Software and Platform Troubleshooting

Many of the potential FIM Host troubleshooting issues can be resolved by verifying the configuration file settings. The following are a list of checks to review when the FIM Host is not operating as expected.

- Ensure that the IP addresses for the master and slave do not conflict, and correct in the FIM Host configuration file. See the config file section.
- Verify the the EFB operates as expected without the FIM Host running – normal MS Windows functionality.
- Verify that the files in the FIM\ directory are from the intended version of the application and libraries from different versions are not loaded.

The FIM EFB platform is a COTS MS Windows based device. In the case of general platform errors the device should be powered down and restarted. Non-FIM Host crashes, operating error or hardware failures should be referred to the COTS vendor, United Technologies.

3.4.2.1.2 Aircraft Specific Troubleshooting

The FIM EFB and aircraft interface device (AID) are COTS products from United Technologies. The interface installation varies by aircraft. Document EG---3690-6.22 provides the installation plan as applied on the ATD-1 program.

Installation and troubleshooting of these devices should follow the UT installation guide appropriate for the specific aircraft. Section 2.3 includes references to vendor documents relevant to the ATD-1 equipment.

3.4.2.1.2.1 Installation Checkout

The following steps can be used to verify the installation and identify possible installation errors.

The following equipment is required:

- Two EFB
- One Aid
- Two CGD

- USB Power Hub (one is already on the aircraft)
- One Wireless Router (one is already on the aircraft)
- One TPA-100 Traffic Computer
- One TRA-100B
- Engineering Laptop with MonEFB, MonTPA and FIM Host software (for test director display)

3.4.2.1.2.2 Non-FIM Avionics

- The TRA-100B may or may not be certified by the time of the flight test, if it is not certified it will be considered part of the experimental equipment. Check out of the TPA-100B and TRA-100B should be done per the maintenance or installation manual appropriate for the equipment.
- All other required avionics should installed and maintained per normal aircraft procedures.

3.4.2.1.2.3 FIM Equipment Installation

This test can be performed with partial equipment if necessary, but must be repeated for each EFB SDU and CGD location. For final checkout before flight test, all equipment must be installed.

This description applies to the 757 configuration, other aircraft may be slightly different.

Install and check out the items listed in the table below.

- Detailed instructions are provided after the table.
- Install and check: OK?
- TRA-100 Traffic Computer
- TRA-100B Transponder
- Wi-Fi Router
- USB Power Hub
- Aircraft Interface Device
- EFB Location 1 (Captain's Side)
- EFB Location 2 (First Officer's Side)

- CGD Location 1 (Captain’s Side)
- CGD Location 2 (First Officer’s Side)
- Engineering Laptop
- MonTPA
- MonEFB
- Test Director Display

If you need to verify or perform original installation, perform the following steps. If the installation has already been performed and the equipment configured, these steps are not necessary.

(Initial install only) To make it easier to operate the EFB during the installation process, bring a USB hub, keyboard, mouse and memory stick. Configure files and manually start the system as follows:

1. Start the EFB (username: SDU password: SDU) and configure the Windows orientation appropriate for the side of the aircraft it is installed on.

2. Load the flight STAP config file if necessary. (alternate methods are available, one method is to connect a laptop computer to the Ethernet network, attached to the EFB using Windows file explorer (address \\192.168.4.101 for captain, \\192.168.4.101 for first officer. Copy the file StapLabelChannel_aircraft.conf to “StapLabelChannel.conf.” (These files are found in the Honeywell folder, build subfolder, config files folder). Repeat for Capt & FO EFBs. (This step may not be necessary if EFB’s have already been configured for flight)

3. If necessary, update cgd.htm in the directory below, edit with notepad:

ws = new WebSocket("ws://192.168.4.102:9099 (May not be necessary if EFB’s have already been configured for flight)

use 101 for captain’s side, 102 for first officer side.

4. Start the CGD Server (go to C:\honeywell\nodejs-v0.12.7\newcgd\...(pick latest folder)..\CGD.bat)

5. Start the FIM Host (go to C:\Honeywel\...(latest directory)…\FIMHost.exe start FimHost.exe) or use the desktop shortcut.

6. Connect the CGDs to the wireless network. This may need to be done manually using phone settings. (CGD may report no SIM card, this is normal) If manual connection is required, use SSID: TP-LINK_D89F26 Password: 27D889F26 Case Sensitive.) iPhone password, if there is one, is 123456)

3.4.2.1.2.4 Normal Start up

This procedure applies after files have been configured per the previous section.

If the EFB's come up with a logon screen, enter:

User: SDU

Password: SDU

Start the FIM application and CGDs:

1. On Capt, EFB double click "Primary" shortcut (this starts the FIM host application and the CGD server. By default, the Capt EFB will always be the master.)

2. On FO EFB double click "Secondary" shortcut (this starts the FIM host application but not the CGD server. By default the FO EFB will always be the slave.)

3. On Capt CGD, select the "Primary" shortcut (this will connect the CGD to the Primary/Master EFB).

4. On FO CGD, select the "Primary" shortcut (this will connect the CGD to the Primary/Master EFB, both Capt and FO CGD's should always be connected to the Master).

(Note that the CGD's have a "Secondary" shortcut that should only be used if the Capt EFB is not operational and the FO EFB is acting as the master.)

Since several required FIM inputs are not valid when the aircraft is not airborne (e.g. True Track, CAS, etc.) the system will always show IM SYS FAIL when stationary on the ground. To verify the correct inputs are being supplied, perform the Alternate Check below using the MonEFB tool.

Alternative check:

1. Configure the MonEFB laptop to be on the 192.168.4.x subnetwork (use some address between 105..119, the WiFi route will be assigning address above this rage).

2. Verify the WiFi router is configured on this subnet (we use 192.168.4.117 for the router address)

3. Configure the WiFi router for DHCP (so iphones will get the address)

4. Connect Laptop with MonEFB
5. In the MonEFB Connection dialog, use the address 192.168.4.101 to connect to the captain EFB or 192.168.4.102 to connect to the FO EFB.

6. Verify the labels under IM Sys Fail Status in IM STATE page of MonEFB:

- GPS will be stale
- IM Availability will be UNAVAILBLE

Everything else should be FRESH or NORMAL or YES

If the above produres to not produce the intended results, verify the IP addresses in the FIM Host configuration files, verify the AID installation and wiring per the manufacturers installation documentation appropriate for the specific aircraft.

3.4.2.1.2.5 Ground Functional Checks

Since Flight Deck Interval Management is a strictly airborne procedure, only limited functional checks are possible in a ground test. The procedures above test basic connectivity. These additional tests check the few additional functions that can be tested on the ground.

- Run the TCAS self test, verify same pattern is shown on the TCAS and FIM CDTI
- Check the functions on the FIM application, captain side:
    - Display Range setting
    - Filter Selection
    - Arc/Plan mode
- Reat above on the FO side

If the FIM software does not display correctly restart the EFB. If the functions continues to fail, resinstall the FIM software.

4.0 SAMPLE FILES

The following are sample configuration and data files for reference. These examples provide reasonable starting values as a reference or regression comparison.

4.1 Sample FIM Host Configuration Files

Below are sample FIM Host configuration files, as described in section 3.1.3.

4.1.1 ConfigIM.conf Sample

```
######################################################################
###########################################################
## Module name: IM Config Data
##
## Purpose:     This Configuration file defines the IM configuration
parameters and values
##
## Modification History:
## CR           Date             Name  Comment
## ---               ----             ----  -------
##
## XX_XX        21-Mar-2016           PS          Initial Revision.
##
##
## The format is <IMPARAM><EQUAL><IMPARAMVALUE>
## Comments start with '#' Symbol
######################################################################
###########################################################

####################################
# IM Config Data  #
# <IMPARAM><EQUAL><IMPARAMVALUE>   #
####################################
AIR_SPEED_PROFILE_TOLERANCE_PERCENT = 1
TIME_BASED_TOLERANCE = 2
GROUND_SPEED_DIFFERENCE_AT_PTP = 3
MAX_IMSPEED_CHANGE_PERCENT = 15
ASG_MSI_DIFF = 5
VMO = 350
MMO = 0.8
IMSPEED_UPPER_LIMIT_IN_MACH = 0.77
IMSPEED_UPPER_LIMIT_IN_CAS = 540
IMSPEED_LOWER_LIMIT_IN_CAS = 120
MIN_FINAL_APPROACH_SPEED = 120
HORIZONTAL_PATH_CONFROMANCE_LIMIT = 9
CRUISE_PROFILE_ALTITUDE_IN_FL = 230
CRUISE_PROFILE_SPEED_IN_MACH = 0.75
DESCENT_PROFILE_SPEED_IN_CAS = 240
AIRSPACE_RESTRICTION_SPEED_IN_CAS = 250
```

```
AIRSPACE_RESTRICTION_ALTITUDE = 10000
```

4.1.2 EFBCom.conf

```
##
## Purpose:      This EFB communication interfaces
##
## Modification History:
## CR            Date            Name  Comment
## ---               ----            ---- -------
##
## XX_XX         09-DEC-2015           AR   Initial Revision.
## XX_XX         25-AUG-2016           PS   Test Director IP Added.
##
##
## The format is <LABEL><SPACE><IP ADDRESS>
## Comments start with '#' Symbol
######################################################################
###########################################################

####################################
# EFB MASTER AND SLAVE  #
# <LABEL><SPACE><IP ADDRESS>   #
####################################
CAPTAINEFBIP 159.99.196.91                 # Master side EFB IP
FIRSTOFFICEREFBIP 159.99.196.129           # Slave side EFB IP
TESTDIRECTOREFBIP  159.99.196.190               # Test Director EFB
IP
AIDUIP  192.168.4.254                       # AIDU IP Address
```

4.1.3 StapLabelChannel.conf

```
######################################################################
###########################################################
##
## Module name: Label and Channel Configuration
##
## Purpose:      This Configuration file defines the ARINC LABELS and
their CHANNELS
##
## Modification History:
## CR            Date            Name  Comment
## ---               ----            ---- -------
##
```

```
## XX_XX        12-DEC-2014          AR   Initial Revision.
## XX_XX        25-FEB-2015          AR   Modified Ownship Labels to
be received on channel 1.
##                                   Consume only Labels 110, 111,
203 and 247
## XX_XX        01-Sep-2016          AR   Added Label 140 and 150 in
Misc IO.
##
##
## The format is <LABEL><SPACE><CHANNEL NUMBER>
## Comments start with '#' Symbol
#####################################################################
##########################################################

####################################
# TRAFFIC DTIF LABELS and CHANNELS #
# <LABEL><SPACE><CHANNEL NUMBER>   #
####################################
367 0
366 0


##################################
# OWNSHIP, MISCIO LABELS and CHANNELS #
# <LABEL><SPACE><CHANNEL NUMBER> #
##################################
13  0 # TCAS Display Control
15  0 #  TCAS Altitude Selection Limit
110 0 # GPS Latitude Coarse
111 0 # GPS Longitude Coarse
120 0 # GPS Latitude Fine
121 0 # GPS Longitude Fine
125 0 # UTC Time HH:MM.M
140 0 # UTC Time Seconds Fine
150 0 # UTC Time HH:MM:SS
163 0 # Availability of different application
203 0 # Baro Altitude
205 0 # MACH
206 0 # CAS
213 0 # Static Air temperature
#247 1     # GPS Quality (HFOM - Horizontal Figure Of Merit)
270 0 # Advisory
274 0 # TCAS Mode
#312 0     # IRS Ground Speed
313 0 # IRS True Track
314 0 # IRS True Heading
315 0 # Wind Speed
316 0 #  Wind Direction
#320 0     # Magnetic Heading
350 0 # TCAS System Health
```

5.0 DATA LOGGING VALUES

The following tables identify the data output from the FIM software, to the MonEFB data logging application. These data messages are captured and avalable for parsing by the Honeywell XCRIBE tool.

HMI/IO

Structure Name	Msg Version	Field	Data Type	Units
IM State (Msg 320)				
		speedType	uchar	1:CAS,2:Mach
		imSpdValid	uchar	1:invalid, valid
		fastSlow	int	n/a
		asg	float	Time or distance
		CDTIDisplayRange	int	nm
		EGBMessage	char[4][32]	string
		allignment	uchar[2]	n/a
Ownship State (324)				
		latitude	float	deg
		longitude	float	deg
		baroAlt	int	Ft
		CalibratedAirSpeed	float	Kts
		MachSpeed	float	Mach
		StaticAirTemperature	float	degrees
		TrueTrkAngle	float	degrees
		WindSpeed	int	kts
		WindDirection	float	Degrees

		TrueHeading	float	Degrees
		GroundSpeed	float	Kts
		verticalRate	float	Fpm
		UTCHour	uchar	Hours
		UTCMinute	uchar	Minutes
		UTCSecond	uchar	Seconds (resolution 1 sec)
		UTCSecFine	float	Seconds - fractional
		EpochInSec	uint	Seconds
		EpochInMs	uint	Miliseconds
		alignment	uchar[1]	n/a
Designated Traffic (325)	0			
		latitude	float	deg
		longitude	float	deg
		trackAngle	float	deg
		groundSpeed	float	Kts
		pressureAlt	int	Ft
		verticalRate	float	Fpm
		Range	float	Nm
		Bearing	float	degrees
		VelocityCoastStatus	enum(uint)	eRawStatus, /* 0 - Raw */ eCoastedStatus /* 1 - Coasted */
		airGroundState	enum(uint)	eAirborne, /* 0 - Airborne */ eOnGround /* 1 - Ground */

		qualIM	enum(uint)	eInValidQual, /* 0 - Invalid (Do Not Display) */ eResvQual, /* 1 - Reserved */ eDegradedQual, /* 2 - Degraded Performance Accuracy */ eGoodQual /* 3 - Good Performance Accuracy */
		trafficID	uchar[9]	String
		trackID	uint	
		versionNumber	enum(uint)	eVersion0, /* 0 - Version0 */ eVersion1 /* 1 - Version1 */
		alignment	uchar[3]	n/a
IM SYS Fail status (326)	0			
		bIsIMSysFail	bool (uchar)	True: IM Sys Fail Set
		tcasSystemHealthAvlStatus	enum (uint)	Stale = 0, Fresh = 1
		appAvailabilityAvlStatus	enum (uint)	
		tcasDispCtrlAvlStatus	enum (uint)	
		trueTrkAglAvalStatus	enum (uint)	
		altitudeAvalStatus	enum (uint)	
		gpsLatitudeCoarseAvalStatus	enum (uint)	

		gpsLatitudeFineAvalStatus	enum (uint)	
		gpsLongitudeCoarseAvalStatus	enum (uint)	
		gpsLongitudeFineAvalStatus	enum (uint)	
		windDirectionAvalStatus	enum (uint)	
		windSpeedAvalStatus	enum (uint)	
		machSpeedAvalStatus	enum (uint)	
		calibratedAirSpeedAvalStatus	enum (uint)	
		staticAirTemperatureAvalStatus	enum (uint)	
		asasSystemStatus	enum (uint)	0: TCAS Normal, l 1 :TCAS has Failed
		tcasSystemStatus	enum (uint)	
		imAvailability	enum (uint)	
		tcasFaultLblStatus	enum (uint)	{NorOpr = 0, NCD, FT, Failed }
		applLblStatus	enum (uint)	
		trueTrkAglStatus	enum (uint)	{Failed = 0, NCD, FT, NorOpr}
		altitudeStatus	enum (uint)	
		gpsLatitudeStatusCoarse	enum (uint)	
		gpsLatitudeStatusFine	enum (uint)	
		gpsLongitudeStatusCoarse	enum (uint)	
		gpsLongitudeStatusFine	enum (uint)	
		windDirectionStatus	enum (uint)	
		windSpeedStatus	enum (uint)	
		machSpeedStatus	enum (uint)	
		calibratedAirSpeedStatus	enum (uint)	
		staticAirTemperatureStatus	enum (uint)	
		dtifTransmission	bool (uchar)	
		allignment	uchar[2]	n/a
IM Config Information (327)				

		MaxIMSpeedChangePercent	int	
		VMO	float	
		MMO	float	
		IMSpeedUpperLimitInMach	float	
		IMSpeedUpperLimitInCAS	int	
		IMSpeedLowerLimitInCAS	int	
		MinFinalApproachSpd	float	
		HorizantalPathConformanceLimit	float	
		CruiseProfileAltitudeInFL	int	
		CruiseProfileSpeedInMACH	float	
		DescentProfileSpeedInCAS	int	
		AirSpaceRestrictionSpeedInCAS	int	
		AirSpaceRestrictionAltitude	int	
		FinalApproachDeltaAngle	float	
Version Info (328)				

		SpeedDLLVersion	version_data_typ	Struct version_data_type{
				Module_enum enumId;
				Uint major version;
				Uint minor version;
				Uint subMinorVersion;
				}
				
				Module_enum:
				0: unknown/unsupported
				1: SpeedControl Library
				2: Trajectory Library
				3: NavDB Library
				4: Nav DB
				5: Fim Application

		TrajDLLVersion	version_data_typ	See above
		NavDBDLLVersion	version_data_typ	See above
		NAVDBVersion	version_data_typ	See above
		FIMAppVersion	version_data_typ	See above
Application Start Time (334)				
		day	uchar	
		month	uchar	
		year	uint	
		hour	uchar	
		minute	uchar	
		epochInSec	uint	
		epochInMilisec	uint	
OwnshipEnrty (336)				
		DestinationAirport	uchar[24]	String name
		Runway	uchar[24]	String name

		CruiseProfileAltitude	int	feet
		CruiseProfileSpeed	float	Mach
		DescentProfileSpeed	int	Cas
		DirectToPoint	char[24]	
CruiseWindsEntry (337)				
		WaypointIdent	uchar[32]	String name
		Direction	int	degrees
		Speed	int	kts
DescentWindsEntry (338)				
		Altitude	int	ft
		Direction	int	degrees
		Speed	int	kts
IMClearanceEntry (339)				

		IMClearanceType	uint	enum {
				eIMNone,
				eIMCapture,
				eIMCross,
				eIMMaintain,
				eIMSpacing
				};

		SpacingGoalUnit	uint	enum
				{
				eSECONDS,
				eMILES
				};

		SpacingGoalVal	float	Seconds or miles (per above)

		TargetIdent	uchar[9]	String id

		AcheiveByType	uint	enum {
				eSelect,
				eDefault,
				eWPT,
				eAfter,
				eBefore
				}

		AcheiveByRange	float	Nm
		AcheiveByWaypoint	uchar[32]	String ident

		TerminateAtType	uint	enum {
				eSelect,
				eDefault,
				eWPT,
				eAfter,
				eBefore
				}

		TerminateAtRange	float	

		TerminateAtWaypoint	uchar[32]	String ident
		allign	uchar[3]	n/a
OwnshipWaypointList (340)				
		waypoint	uchar[24]	String ident
IMSpeedSettingsEntry (341)				
		IMSpeedUpperLimitMach	float	Mach
		IMSpeedUpperLimitCAS	int	kts
		IMSpeedLowerLimitCAS	int	kts
		IMSpeedUnit	enum	{ enMACH, enCAS, enDEFAULT, }
		AirSpeedRestriction	int	kts
		AltitudeRestriction	int	ft
NavDBSettingsEntry (342)				

		NavDBCurrentCycle	enum	{
				eFIRSTCYCLE = 0,
				eSECONDCYCLE = 1
				}

		EffectiveStartDate	struct	St_DateType - typedef struct { int nDay; int nMonth; int nYear; }St_DateType
		EffectiveEndDate	struct	St_DateType - typedef struct { int nDay; int nMonth; int nYear; }St_DateType
OwnshipFlightPath (345)				
		FlightPath	uchar[488]	String list of nav points
TargetFlightPath (346)				
		FlightPath	uchar[488]	String list of nav points
ThreadTime(347)				
		IOThreadEntryTime	uint	millisecond
		NumberOfEntriesPerSecIO	uint	n/a

		BuildThreadEntryTime	uint	millisecond
		NumberOfEntriesPerSecBuild	uint	n/a
		TGSCThreadEntryTime	uint	millisecond
		NumberOfEntriesPerSecTGSC	uint	n/a
		DisplayThreadEntryTime	uint	millisecond
		NumberOfEntriesPerSecDisplay	uint	n/a
TrafficData(348)				
		timeFrame	double	sec
		trfcNumber	uint(short)	n/a
		relAltStatusT2	Enum(uint)	eInValid, /* 0 - Invalid */ eValid /* 1 - Valid
		bearingStatus	uint	0 - Invalid 1 - Valid
		vertSpdStatus	uint	
		trackAngleStatus	uint	
		gndSpdStatus	uint	

		closureRateStatus	uint	

		advisory	uint	0 - Non Threat 1 - Traffic Advisory 2 - Resloution Advisory 3 - Proximate Traffic 4 - Reserved 5 - Reserved 6 - Reserved 7 - Reserved 8 - Airborne Military Target 9 - Reserved Military Target 10 - Reserved Military Target 11 - Reserved Military Target 12 - Reserved Military Target 13 - Reserved Military Target 14 - Reserved Military Target 15 - Reserved Military Target
		trfcSource	uint	0 - Invalid 1 - TCAS 2 - ADS-B 3 - ADS-R 4 - TIS-B 5 - Reserved 6 - Reserved 7 - Multi-Source Traffic Data
		onGround	uint	0 - Airborne 1 - Ground
		flightID[9]	uchar	
		trfcRange	Float	

		trfcBearing	Float	degrees
		lat	float	

		lon	float	degrees
		relAltitudeT2	int	
		trfcVertSenseT2	uint	0 - No Vertical Rate (Level Flight) 1 - Climbing 2 - Descending 3 - No Data
		vertVelocity	uint(short)	
		velocityCoastStatus	uint	0 - Raw 1 - Coasted
		magTruHdgIndication	uint	0 - True Heading 1 - Magnetic Heading
		hdgTrackAngle	float	degrees
		gndSpeed	uint(short)	kts
		closureRate	float	
		qualITP	uint	0 - Invalid (Do Not Display) 1 - Reserved 2 - Degraded Performance 3 - Good Performance Accuracy
		itpDistancePassFail	uint	0 - Failed 1 - Passed
		gndSpdDiffPassFail	uint	
		similarTrackStatus	uint	

		relAltCriteria	uint	
		itpDistance	float	
		gndSpdDiff	uint(short)	0 - SET A 1 - SET B 2 - SET C 3 - SET D 4 - RESERVED 5 - RESERVED 6 - RESERVED 7 - RESERVED
		relTrackAngle	uint(short)	
		acType	uint	
		acCategory	uint	
		coarseFineRange	uint	0 - Coarse Range (1/4 NM to 256 NM) 1 - Fine Range (1/512 NM to 2 NM)
		trafficRangeValidity	uint	0 - Valid 1 - Invalid
		relAltStatusT1	uint	0 - Invalid 1 - Valid
		relAltitudeT1	int	
		trfcVertSenseT1	uint	0 - No Vertical Rate (Level Flight) 1 - Climbing 2 - Descending 3 - No Data
		qualAIRB	uint	0 - Invalid (Do Not Display) 1 - Reserved 2 - Degraded Performance Accuracy 3 - Good Performance Accuracy

		qualSURF	uint	typedef enum
				{
				eValidRev, /* 0 - Valid */
				eInValidRev /* 1 - Invalid */
				}

		qualIM	uint	0 - Invalid 1 - Valid
		qualTSAA	uint	
		qualACM	uint	0 - No Vertical Rate (Level Flight) 1 - Climbing 2 - Descending 3 - No Data
		qualVSA	uint	0 - Invalid (Do Not Display) 1 - Reserved 2 - Degraded Performance Accuracy 3 - Good Performance Accuracy
		posOffsetApplied	uint	
		width	uint	
		length	uint	
		lengthWidthStatus	uint	
		nUTCSeconds	int	0 - extended beyond length/width 1 - matches length/width
		nUTCMinutes	int	

		nUTCHours	int	

		dUTCFineSeconds	double	
		timeOfApplicability	uint	0 - Valid 1 - InValid

Speed Control

Structure Name	Msg Version	Field	Data Type	Units
Speed Control State (Msg 321)	0			
		RecID	short (uint16)	

		IM_State	enum (uint)	OFF_TERMINATE=1, ARMED=2, AVAILABLE=3, SUSPEND_ARMED=4, SUSPEND_AVAILABLE=5, PAIRED=6, UNABLE=7
		IMClearanceType	enum (uint)	MAINTAIN=1, CAPTURE, CROSS, SPACE, NONE
		SpeedControlState	bool (uchar)	
		ABPMonitor	enum (uint)	abpPassed=1, abpNotPassed=2
		PTPMonitor	enum (uint)	ptpReached=1, ptpNotReached=2
		ASGValidForMaintClr	bool (uchar)	
		ASGComputedForMaintClr	bool (uchar)	
		alignment	uchar[3]	
TBO Control Law (Msg 322)	0			
		RecID	short (uint16)	
		SCSystemTimeInSec	double	Sec
		FirstCycle	bool (uchar)	

		ASG	float	
		ASGUnits	enum(uint)	asguSEC=1, asguNM, asguINVALID
		QuantizationSpeedLimit	float	Kts
		SegZone	enum (uint)	segzoneINVALID=0, segzoneAtRollIn=1, segzoneDuringRollIn, segzoneLookAhead, segzoneUnrestricted
		SegType	enum (uint)	stypeLevel, stypeAccel, stypeDecel, stypeINVALID
		RollInCount	int	
		LookAheadDuration	int	Secs
		SpacingInterval	float	Nm/sec
		SpacingIntervalStatus	enum(uint)	scINVALID=1, scVALID
		SpacingErrorInSecs	int	Nm/sec
		SpacingErrorFP	float	Nm/sec
		ProgressIndicatorStatus	enum(uint)	piOFF=1, piON
		EarlyLateIndicatorScale	enum(uint)	els45SEC=1, els120SEC, elsINVALID
		GSCTau	float	sec
		GSCoastedState	enum	csNonCoasted=1, csCoasted
		GSCDeltaTime	int	
		GSC2Tau	float	sec

		GSCFilterInput	float	Kts
		GSCGndSpdCompTerm	float	Kts
		GSCGndSpdCompFilter	float	kts
		GSCGainLimit	float	
		GSCSpeedErrorCompensation	float	Kts
		GainforSpeedError	float	
		SpeedError	float	Kts
		VmoLimit	float	Kts
		MMOLimitInMach	float	
		MMOLimitInKts	float	Kts
		IMSpeedUpperLimitInKts	float	Kts
		IMSpeedUpperLimitInMach	float	Mach
		IMSpeedUpperLimitAsMachInKts	float	Kts
		SelIMSpeedUpperLimitInKts	float	Kts
		ArspcAirspaceRestrictionAltInFt	double	Feet
		ArspcRateInKtsPerSec	float	kts/sec
		ArspcTimeNeededToReduceSpeed	float	Sec
		ArspcSmallerTimeNeeded	float	Sec
		ArspcOwnshipEstimatedVerticalRateInFps	float	Fps
		ArspcDerivedAltInFt	float	Feet
		ArspcsrState	enum (uint)	INACTIVE:1, ACTIVE:0
		ArspcRestrictionLimitInKts	float	kts
		RFUpcomingRFRestrictedLeg	bool (uchar)	
		RFActiveRFRestrictedLeg	bool (uchar)	
		RFOwnshipDTGToStartOfRFLeg	float	NM
		RFRestrictedSpeedForUpcomingRFLeg	float	kts
		RFRateInKtsPerSec	float	Kts/sec

		RFTimeNeededToReduceSpeed	float	Sec
		RFEstDTGToStartOfRFLeg	float	NM
		RFOwnshipEstimatedGroundSpeedInKts	float	kts
		RFRestrictionLimitInKts	float	kts
		RFSpeedRestrictionState	enum (uint)	INACTIVE:1, ACTIVE:0
		CtrlLawRestrictionState	enum (uint)	
		CtrlLawRestrictionLimitInKts	float	Kts
		CtrlLawSelectedSpeedRestriction	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		CtrlLawTimeUntilCrossing	float	Sec
		CtrlLawTimeUntilStartOfLeg	float	Sec
		CtrlLawRemainingSpeedReductionForAirspace	float	Kts
		CtrlLawRemainingSpeedReductionForRF	float	Kts
		CtrlLawSpdRestrictionDecelRate	float	
		NomProfUpperSpdLimitInKts	float	Kts
		NomProfLowerSpdLimitInKts	float	Kts
		IMSpeedLowerLimitinKts	float	Kts

		SelectedUpperSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		SelectedLowerSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		AppliedSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		SpeedLimited	bool (uchar)	
		IsUprSpdLmtApplied	bool (uchar)	

		SpeedCorrection	float	Kts
		OwnshipCurrSegEndSpdInKts	float	Kts
		OwnshipNextSegEndSpdInKts	float	Kts
		DTGInNm	float	NM
		IMCommandedSpeedInKts	float	Kts
		SpdInMachBeforeRoundup	float	
		IMCommandedSpeedInMach	float	
		IMSpeedUnits	enum(uint)	imsouKNOTS=1, imsouMACH
		IMSpeedStatus	enum(uint)	scINVALID=1, scVALID
		InstSpdInputSource	enum(uint)	tboISISNotUpdated, tboISISSpeedRate, tboISISSpeedRestrictionDecelRate, tboISISSpeedCorrProfileCAS, tboISISRollInProfileCAS, tboISISFASInterceptProfile
		IMInstantaneousSpeed	float	
		InstSpdCorrectionInput	float	kts
		InstSpdDecelCeiling	float	kts
		LastInstSpdSpeedCorrProfileCAS	float	kts
		InstSpdSpeedCorrProfileCAS	float	kts
		InstSpdTermA	float	
		InstSpdFOFTimeConstant	float	
		InstSpdRollInProfileCAS	float	kts
		InstSpdOwnshipAtRollInCAS	float	kts
		InstSpdRollInSpeedDiff	float	kts
		CurrSegType	enum (uint)	stypeLevel:0, stypeAccel, stypeDecel

		SegZoneInstSpd	enum (uint)	segzRollIn, segzConsSpd, segzDecel
		FASSpeedApplied	bool (uchar)	True,False
		FASInterceptProfile	float	
		DTGToFASInterceptProfile	float	
		TBOInstSpeedRateForTTFAfterPTP	float	
		FastSlowIndicatorOutput	float	Kts
		alignment	uchar[1]	
CTD Control Law (Msg 332)	0			
		RecID	short (uint16)	
		SCSystemTimeInSec	double	Sec
		FirstCycle	bool (uchar)	
		CrossClrFirstCycle	bool (uchar)	
		ASG_Units	enum (uint)	asguSEC=1 asguNM=2 asguINVALID=3
		ASG	float	
		ASGComputedForMaintClr	bool (uchar)	
		QuantizationSpeedLimit	float	
		SpacingIntervalStatus	enum (uint)	scINVALID=1, scVALID=2
		SpacingInterval	float	NM/Sec
		SpacingErrorInSecs	int	NM/Sec

		SpacingErrorFP	float	NM/Sec
		TimeAtASGBehindTTFPos	double	Sec
		TimeAtOwnToTTFDistBehindTTFPos	double	Sec
		GainforSpeedError	float	
		SpeedError	float	Kts
		MinCaptureRate	bool (uchar)	
		ProgressIndicatorStatus	enum (uint)	piOFF=1, piON
		EarlyLateIndicatorScale	enum (uint)	els45SEC=1, els120SEC, elsINVALID
		VmoLimit	float	Kts
		MMOLimitInMach	float	Kts
		MMOLimitInKts	float	Kts
		IMSpeedUpperLimitInKts	float	Kts
		IMSpeedUpperLimitInMach	float	Mach
		IMSpeedUpperLimitAsMachInKts	float	kts
		SelIMSpeedUpperLimitInKts	float	kts
		ArspcAirspaceRestrictionAltInFt	double	Feet
		ArspcRateInKtsPerSec	float	kts/sec
		ArspcTimeNeededToReduceSpeed	float	Sec
		ArspcSmallerTimeNeeded	float	Sec
		ArspcOwnshipEstimatedVerticalRateInFps	float	Fps
		ArspcDerivedAltInFt	float	Feet
		ArspcsrState	enum (uint)	INACTIVE:1, ACTIVE:0
		ArspcRestrictionLimitInKts	float	kts

		RFUpcomingRFRestrictedLeg	bool (uchar)	
		RFActiveRFRestrictedLeg	bool (uchar)	
		RFOwnshipDTGToStartOfRFLeg	float	NM
		RFRestrictedSpeedForUpcomingRFLeg	float	kts
		RFRateInKtsPerSec	float	kts/sec
		RFTimeNeededToReduceSpeed	float	Sec
		RFEstDTGToStartOfRFLeg	float	NM
		RFOwnshipEstimatedGroundSpeedInKts	float	kts
		RFRestrictionLimitInKts	float	kts
		RFSpeedRestrictionState	enum (uint)	INACTIVE:1, ACTIVE:0
		CtrlLawRestrictionState	enum (uint)	INACTIVE:1, ACTIVE:0
		CtrlLawRestrictionLimitInKts	float	Kts
		CtrlLawSelectedSpeedRestriction	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		CtrlLawTimeUntilCrossing	float	Sec
		CtrlLawTimeUntilStartOfLeg	float	Sec
		CtrlLawRemainingSpeedReductionForAirspace	float	Kts
		CtrlLawRemainingSpeedReductionForRF	float	Kts
		CtrlLawSpdRestrictionDecelRate	float	

		NomProfUpperSpdLimitInKts	float	Kts
		NomProfLowerSpdLimitInKts	float	Kts
		IMSpeedLowerLimitinKts	float	Kts
		SelectedUpperSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		SelectedLowerSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt
		AppliedSpeedLimit	enum (uint)	spNomProfileUprLmt, spVmoUprLmt, spMmoUprLmt, spIMSpdUprLmt, spAirSpcRestrUprLmt, spRFSpdRestrUprLmt, spNomProfileLwrLmt, spIMSpdLwrLmt, pMinFASLwrLmt

		SpeedLimited	bool (uchar)	
		IsUprSpdLmtApplied	bool (uchar)	
		IMCommandedSpeedInKts	float	Kts
		SpdInMachBeforeRoundup	float	
		IMCommandedSpeedInMach	float	Mach
		IMSpeedUnits	enum (uint)	imsouKNOTS=1, imsouMACH
		IMSpeedStatus	enum (uint)	scINVALID=1, scVALID
		TgtHistCASAt15SecLeadFromOwnship	float	
		CTDProfileCAS	float	
		CTDDecelIndication	bool (uchar)	
		TTFTOADecelSegEnd	float	
		OwnshipDecelEndSpeed	float	
		LastIMSpeedElapsedCycleCount	int	
		LockoutCounter	int	
		DecelLockout	enum (uint)	decelLOCK, decelUNLOCK, decelINVALID
		RoundEndCAS2ktsPosBiasCorrection	float	Kts
		RoundCAS2ktsPosBiasCorrection	float	Kts
		Round15sLeadCAS5ktsPosBiasCorrection	float	Kts
		Round15sLeadCAS2ktsPosBiasCorrection	float	Kts
		RoundCAS2ktsPosBias	float	kts
		Round15sLeadCAS2ktsPosBias	float	kts
		CAS2ktsNegBiasWithCorrection	float	kts
		FiveDecel	bool (uchar)	
		TwoDecel	bool (uchar)	

		FiveAccel	bool (uchar)	
		TwoAccel	bool (uchar)	
		InstSpdInputSource	enum(uint)	ctdISISNotUpdated, ctdISISSpeedRate, ctdISISSpeedRestrictionDecelRate
		IMInstantaneousSpeed	float	
		CTDInstSpeedRate	float	
		SpeedChange	float	kts
		SegmentLength	float	Sec
		FastSlowIndicatorOutput	float	
		alignment	uchar[1]	
Speed Conformance Monitor (Msg 323)	0			
		RecID	short (uint16)	
		SCM_State	enum (uint)	scmInactive:1, scmActive:2
		SegType	enum (uint)	stypeLevel:0, stypeAccel, stypeDecel
		CommandedIMSpd	float	Kts
		NewIMSpeedFirstCAS	float	Kts
		NewIMSpeedFirstMach	float	Mach
		NoOfCycle	int	
		ExpectedCAS	float	Kts

		ExpectedMACH	float	Mach
		SpdConformance	enum (uint)	InConformance=1, OutOfConformance=2
		OwnshipCASInKts	float	Kts
		OwnshipMach	float	Mach
		alignment	uchar[2]	
TG IM Record (Msg 333)				
		RecID	short (uint16)	
		OwnToTTF_DTG	float	NM
		OwnToTTF_TTG	float	Secs
		OwnToABP_DTG	float	NM
		OwnToABP_TTG	double	Secs
		OwnToPTP_DTG	float	NM
		OwnToPTP_TTG	double	Secs
		TTFToABP_DTG	float	NM
		TTFToABP_TTG	double	Secs
		TTFToPTP_DTG	float	NM
		TTFToPTP_TTG	double	Secs
		Owniship_Vertical_Deviation	float	
		TTF_Vertical_Deviation	float	
		Owniship_Lateral_Deviation	float	
		TTF_Lateral_Deviation	float	
		OwnshipLeadSpeed_3SECS	float	
		OwnshipLeadSpeed_27SECS	float	
		CurrentOwnshipState_CAS	float	Kts
		CurrentOwnshipState_GroundSpeed	float	Kts

		CurrentOwnshipState_CrossoverAlt	float	kts
		CurrentOwnshipState_Latitude	float	deg
		CurrentOwnshipState_Longitude	float	deg
		CurrentOwnshipState_SpeedType	enum (uint)	CAS_e = 0, MACH_e, TAS_e, GROUND_SPEED_e
		CurrentTTFState_CAS	float	Kts
		CurrentTTFState_GroundSpeed	float	Kts
		CurrentTTFState_CrossoverAlt	float	Kts
		CurrentTTFState_Latitude	float	deg
		CurrentTTFState_Longitude	float	deg
		CurrentTTFState_SpeedType	enum (uint)	CAS_e = 0, MACH_e, TAS_e, GROUND_SPEED_e
		OwnshipCurrentSegmentSpeedRecord_SegmentSpeed	float	Kts
		OwnshipCurrentSegmentSpeedRecord_EnrouteTimeSegmentEndPoint	float	Kts
		OwnshipCurrentSegmentSpeedRecord_SegmentSpeedType	enum (uint)	CAS_e = 0, MACH_e, TAS_e, GROUND_SPEED_e
		OwnshipNextSegmentSpeedRecord_SegmentSpeed	float	Secs
		OwnshipNextSegmentSpeedRecord_SegmentSpeedType	enum (uint)	CAS_e = 0, MACH_e, TAS_e, GROUND_SPEED_e

		TTFRecordOwnshipPosition_TimeBasedAvgGroundSpeed	float	Kts
		TTFRecordOwnshipPosition_CurrentGroundSpeed	float	Kts
		TTFRecordOwnshipPosition_TimeCTDProfileCAS	float	Kts
		TTFRecordOwnshipPosition_DistCTDProfileCAS	float	Kts
		TTFRecordOwnshipPosition_OwnshipRefAvgCASPTPSeqPoint	float	Kts
		TTFActualArrivalTimeAtABP	double	Secs
		TTFActualArrivalTimeAtPTP	double	Secs
		TTFTimeAtOwnshipPosition	double	Secs
		TTGOwnshipASGDistanceFromABP	double	Secs
		DTGOwnshipToABPatETAofTTF	float	NM
		OwnshipTrajectoryInfoValid	Uchar(bool)	
		TTFTrajectoryInfoValid	Uchar(bool)	
		OwnshipOffRoute	Uchar(bool)	
		TTFOffRoute	Uchar(bool)	
		OwnshipBadRoute	Uchar(bool)	
		TTFBadRoute	Uchar(bool)	
		IMApplicationInfoValid	Uchar(bool)	
		TTFRecordOwnshipPosition_EndDecelCAS	float	
		TTFRecordOwnshipPosition_TTFTimeEndOfDecel	float	
		TTFRecordOwnshipPosition_DecelValidity	uchar	
		OwnshipDTGtoEndOfCurrSpdSegInNM	float	
		OwnshipCurrFASSegment	uchar	

		OwnshipNextFASSegment	uchar	
		SpeedRestrictionRecord_NominalDecelRateSpeedLimit	float	
		SpeedRestrictionRecord_DownpathRFMostRestrSpeedValidity	uchar	
		SpeedRestrictionRecord_DownpathRFMostRestrSpeed	float	
		SpeedRestrictionRecord_DTGStartOfRFLeg	float	
		SpeedRestrictionRecord_ActiveRFMostRestrSpeedValidity	uchar	
		SpeedRestrictionRecord_ActiveRFMostRestrSpeed	float	
		NomCASAtEndOfDecel	float	
		OwnshipDeltaCASPerNM	float	
		alignment	uchar[2]	

Trajectory Generator

Structure Name	Msg Version	Field	Data Type	Units
Vertical And Lateral TCP(msg 329)	0			
		planId	enum(uInt)	OWNSHIP_e = 0 TARGET_e =1

		TCPType	bool (uchar)	TRUE = Lateral TCP FALSE = Vertical TCP
		TGGenerationReason	enum(uInt)	INITIAL_TRAJECTORY_e = 0 WIND_DEV_e = 1 VERTICAL_DEV_e = 2
Vertical TCP		nomPathAlt	float	feet
		waypointIdentity	uChar[24]	
		nomGndSpeed	float	Kts
		nomCASorMach	float	Kts
		nomTrueAirspeed	float	Kts
		forecastWindVec	float	Kts
		forecastWindDirection	float	Degrees
		predictedWind	float	Kts
		predictedWindDirection	float	Degrees
		forecastTemp	float	Centigrade
		speedErrorValue	float	Kts
		speedSegmentErrorReason	enum(uInt)	NO_ERROR_e = 0, SPEED_ERROR_e = 1, ALTITUDE_ERROR_e = 2
		altitudeErrorValue	float	feet
		altitudeSegmentErrorReason	enum(uInt)	NO_ERROR_e = 0, SPEED_ERROR_e = 1, ALTITUDE_ERROR_e = 2
Lateral/Horizontal TCP		ABPValidity	bool(uchar)	TRUE = Valid ABP FALSE = INVALID ABP

		segmentType	enum(uInt)	Straight = 0 Trun = 1
		distanceToGoPTP	float	NM
		distanceToGoABP	float	NM
		turnRadius	float	NM
		course	float	Degrees
		latitude	float	Degrees
		longitude	float	Degrees
		timeToGoABP	double	Time in seconds (Epoch)
		timeToGoPTP	double	Time in seconds (Epoch)
		unitX	double	Meters
		unitY	double	Meters
		unitZ	double	Meters
		alignment	uchar[2]	
Flight Plan Waypoints (Msg 330)	-			
		planId	enum(uInt)	OWNSHIP_e = 0, TARGET_e
		waypointIdentity	uChar[24]	
		waypointLatitude	float	Degrees
		waypointLongitude	float	Degrees
		waypointAltitudeConstraintLower	float	feet
		waypointAltitudeConstraintLowerValidity	enum(uInt)	VALID_e = 0 INVALID_e = 1
		waypointAltitudeConstraintLowerType	enum(uInt)	AA_e = 0, AB_e=1, AT=2

		waypointAltitudeConstraintLowerSourceType	enum(uInt)	ST_NO_SOURCE_e =0, ST_COMPUTED_e = 1 ST_DEFAULT_e = 2 ST_DATABASE_e = 3
		waypointAltitudeConstraintUpper	float	feet
		waypointAltitudeConstraintUpperValidity	enum(uInt)	VALID_e = 0 INVALID_e = 1
		waypointAltitudeConstraintUpperType	enum(uInt)	AA_e = 0, AB_e=1, AT=2
		waypointAltitudeConstraintUpperSourceType	enum(uInt)	ST_NO_SOURCE_e =0, ST_COMPUTED_e = 1 ST_DEFAULT_e = 2 ST_DATABASE_e = 3
		waypointSpeedConstraint	float	Kts
		waypointSpeedConstraintValidity	enum(uInt)	VALID_e = 0 INVALID_e = 1
		waypointSpeedConstraintSourceType	enum(uInt)	ST_NO_SOURCE_e =0, ST_COMPUTED_e = 1 ST_DEFAULT_e = 2 ST_DATABASE_e = 3
		waypointFPA	float	Degrees
		waypointFPAValidity	enum(uInt)	VALID_e = 0 INVALID_e = 1
		waypointWindSpeed	float	Kts
		waypointWindDirection	float	Degrees
		waypointWindAltitude	float	feet
		temperature	float	Centigrade
		waypointTurnRadius	float	NM
		waypointTurnCenterLat	float	Degrees
		waypointTurnCenterLon	float	Degrees

TG Perf data (Msg 331)	0			
		planId	enum(uInt)	OWNSHIP_e = 0, TARGET_e
		cruiseAltitude	float	feet
		cruiseAltitudeValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		cruiseCAS	float	Kts
		cruiseCASValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		cruiseMach	float	Mach number
		cruiseMachValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		descentCAS	float	Kts
		descentCASValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		descentMach	float	Mach number
		descentMachValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
TG Forecast Wind data (Msg 335)	0			
		planId	enum(uInt)	OWNSHIP_e = 0, TARGET_e
		waypointIdentity	uChar[24]	
		forecastWindMag	float	Kts
		forecastWindDirection	float	Degrees
		forecastWindAlt	float	feet

TG Discoery data (Msg 343)	0			
		discoveryAlgoStatus	bool(uchar)	TRUE = Success FALSE = Failure
		metaPhase	enum(uInt)	NO_PHASE_e = 0, CRUISE_e = 1, DESCENT_e = 2
		cruiseAltitude	float	feet
		cruiseAltitudeValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		cruiseCAS	float	Kts
		cruiseCASValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		cruiseMach	float	Mach number
		cruiseMachValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		descentCAS	float	Kts
		descentCASValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		descentMach	float	Mach number
		descentMachValidity	enum(uInt)	DATA_VALID_e = 0 , DATA_INVALID_e = 1
		alignment	uchar[3]	
TG Traffic records (Msg 344)	0			
		timeFrame	double	Time in seconds (Epoch)
		flightId	uchar[9]	

		trackId	uint	
		latitude	float	Degrees
		longitude	float	Degrees
		altitude	float	feet
		groundSpeed	float	Kts
		trackAngle	float	Degrees
		rawValue	uint	
		VelocityCoastStatus	enum(uint)	RAW_e = 0, COASTED_e = 1
		alignment	uchar[3]	
End of decel Computation Data (Msg 349)	0			
		trafficTimeFrame	double	Time in seconds (Epoch)
		ownshipTrack;	double	degrees
		ownshipWindSpeedKnots	double	kts
		ownshipWindDirectionDegrees	double	degrees
		ownshipAlt	double	feet
		ownshipISADev;	double	Degree celcius
		trafficAltitudeAtOwnhipPositon	float	feet
		speed1	float	kts
		speed1Validity	enum(uint)	EOD_DATA_INVALID_e = 0, EOD_DATA_VALID_e = 1
		speed2	float	kts

		speed2Validity	enum(uint)	EOD_DATA_INVALID_e = 0, EOD_DATA_VALID_e = 1
		speed3	float	kts
		speed3Validity	enum(uint)	EOD_DATA_INVALID_e = 0, EOD_DATA_VALID_e = 1
		speed4	float	kts
		speed4Validity	enum(uint)	EOD_DATA_INVALID_e = 0, EOD_DATA_VALID_e = 1
		avgGroundSpeed	float	kts
		trafficTrack	double	degrees
		trafficAlt	double	feet
		testCAS	float	kts
		testTimeStamp	double	Time in seconds (Epoch)
		endOfDecel	float	kts
		endOfDecelTime	double	Time in seconds (Epoch)
		result	enum(uint)	INIT_e = 0, EOD_DEFAULT_e = 1, FOURTY_SEC_LAPSED_e = 2, END_OF_TRAFFIC_RECORD_e = 3, ACCEL_SEG_e = 4, DECEL_SEG_e = 5

6.0 SPEED CONTROL SOURCE

This section has been redacted to comply with the Intellectual Property clause of the contract.

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7.0 ACRONYMS

AID	Aircraft Interface Device
FIM	Flight Deck Interval Management
NDB	Navigation Database module
SC	Speed Control module
STAP	Simple Text Avionics Protocol
TG	Tragectory Generator module
THDB	Traffic History Database
TTF	Traffic To Follow

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