NAVIGATION SYSTEM GUIDE
FOR THE
AH-64A EGI MODIFIED AIRCRAFT

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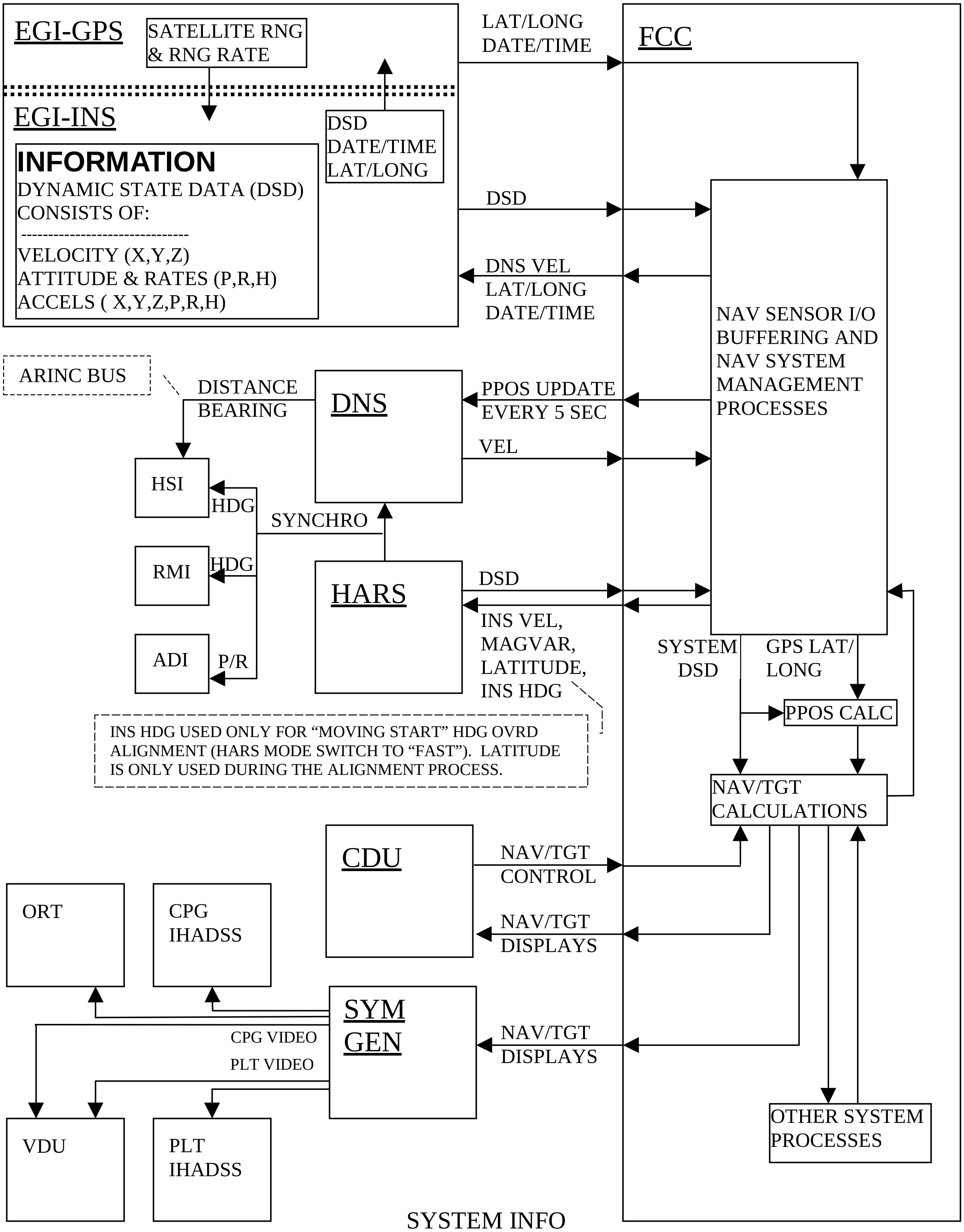
1. Introduction. This document has been prepared in response to the many and varied requests from the AH-64A user community for more information about the EGI mod. The requests come from both the maintainers and the flyers of the AH-64A. Accordingly, this document provides many diagrams and descriptions to aid in the understanding of the navigation system make-up. These should augment the readers understanding of the nav system, assist the maintainer in troubleshooting navigation system related problems, as well as clarify nav system concepts and operations to the A-Model aircrew.

If additional information or clarification is required, if questions remain, or if you feel improvements should be made to this document, please contact Nick Mazzola at Boeing. Phone: 480-891-6533 (desk) or 602-697-6525 (cell), email: nick.mazzola@ boeing.com or mazzola@compuserve.com

2. AH-64A Navigation System Description. This section provides a top-level summary of the AH-64A navigation system after the incorporation of ECP1198.

2.1 Incorporation of ECP1198. With the incorporation of ECP1198 (the EGI mod), the opportunity arose to substantially increase the navigation and targeting performance of the A-Model Apache. This could be done by totally integrating the nav/targeting functions within the FCC. In fact, that is what was done. The ECP did not include any modifications to the BBC, so it was also necessary to maintain the existing navigation system operation whenever the BBC was in control. The decision to not modify the BBC was based upon the facts that substantial change would be required (hardware and software), the development schedule was long, the risk was extremely high and the cost was very large. The net result after the ECP is incorporated, is that the aircraft now has a primary nav system and a backup nav system.

2.2 Primary Nav System Summary. The heart of the system is the FCC (see Figure 1). The FCC utilizes the EGI, HARS, DNS and ADS as nav system sensors and integrates that data into a coordinated navigation solution. The FCC performs all of the navigation (and targeting) functions, it drives all of the CDU and video displays, and it processes all keystrokes made via the CDU. The source of nav system dynamic state data (attitude, heading, velocity, rates and acceleration) is determined in the FCC by the use of a prioritizing algorithm that examines the EGI-INS (INS), HARS and DNS health status and operational suitability. The CDU NAV STATUS page provides the CPG an indication of the operational suitability of these sensors, and thus how the FCC is utilizing them in the total solution. The FCC prioritizes the determination of the nav system dynamic state data (highest to lowest) as follows: 1) INS, 2) HARS, 3) DNS, 4) manual entry, and 5) last known. If the system is not using the INS or HARS, then default dynamic state data (usually zero) is filled-in for the missing dynamic state pieces. This "processed" dynamic state data is then used to drive all of the subordinate processes. These include the targeting calculations, the weapon firing inhibits, the PPOS propagation calculation, information on the CDU and video displays that utilize these parameters in their final determination, and more.



SYSTEM INFO

NAV STATUS PAGE: INS GO, GPS GO, HARS GO, DNS GO

GPS STATUS PAGE: FOM<3, SV>2, P CODE>2, C CODE=0

NAVSTAT=1, PPOS UPDATES NOT REQUIRED, MAX HOVER BOX ACCURACY

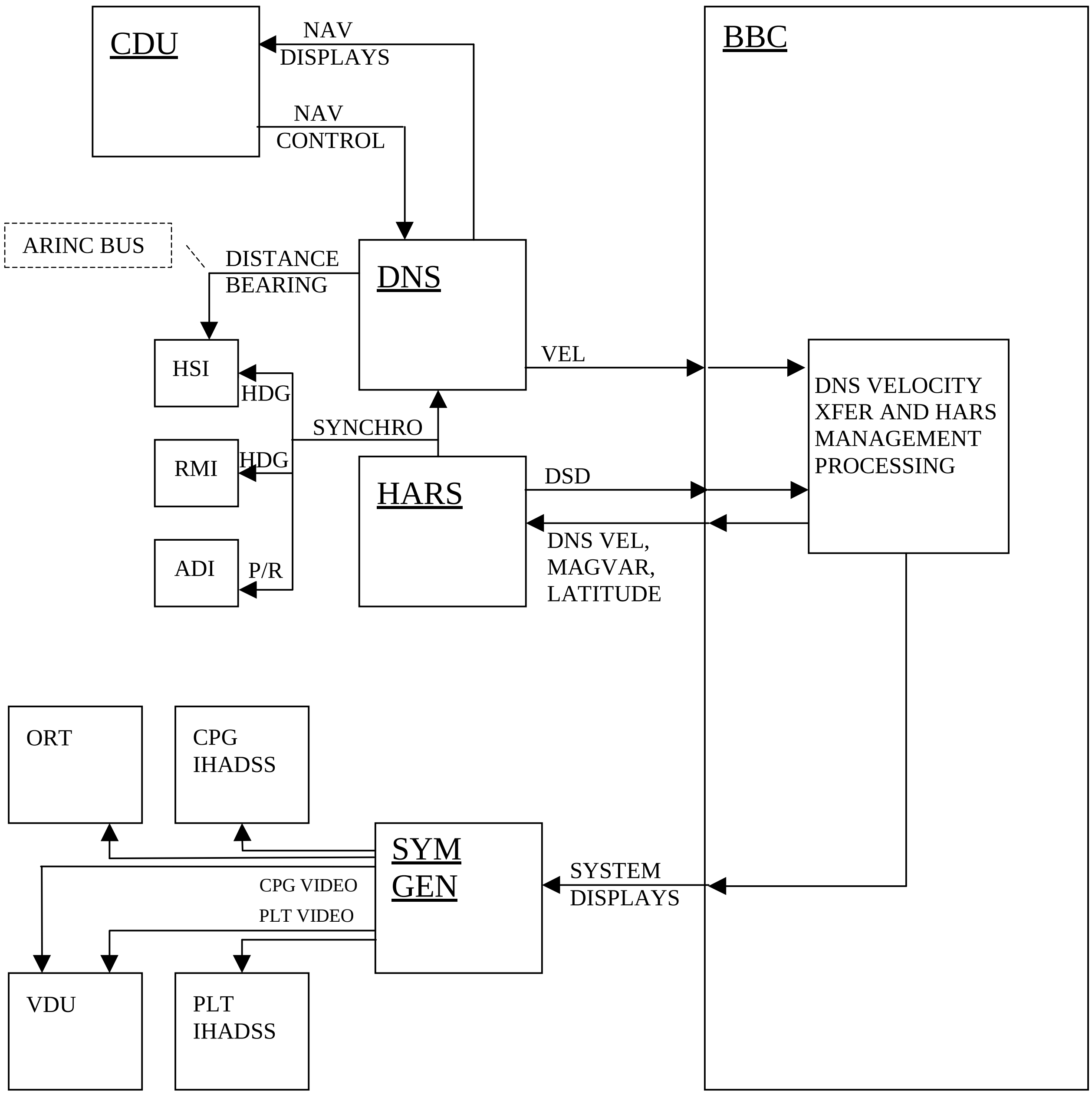
INS INFLIGHT/WATER ALIGNMENT AUTOMATIC USING GPS AIDING

USE HDG OVRD FOR HARS (MODE SW TO "FAST" WHEN HDG TAPE APPEARS)

PRIMARY NAV SYSTEM BLOCK DIAGRAM – FULL-UP (GPS KEYED)

Figure 1

2.3 Backup Nav System Summary. This system is the pre-ECP1198 nav system, which is the existing DNS (see Figure 2). This system is a non-integrated, almost stand-alone system. It only requires a attitude/heading input (hard-wired synchro lines from the HARS), and something for control and display (the CDU in the bus-controller mode). It has a remembered (last known) velocity mode and a manual speed/track entry mode. In this mode, the CDU is used exclusively for DNS control and for display of the DNS nav performance data.



BACKUP NAV SYSTEM BLOCK DIAGRAM
Figure 2

3. Essentials for achieving good, reliable nav system performance. This section hi-lights the importance of some of the major “pieces” (or ideas) of the nav system architecture. The role that each plays, how it is perceived and how the aircrew manages it is critical to achieving maximum performance.

3.1 PPOS, Altitude, EPE and the LAND/WATER mode.

A. Primary mode: Altitude is considered the 3rd dimension of the aircraft PPOS, and wherever PPOS is mentioned consider altitude as part of PPOS, unless specifically addressed otherwise. When the FCC is powered up, either from electrical power just being applied, or from a power transient during flight, the FCC will initialize PPOS, EPE and the LAND/WATER mode. PPOS is initialized to the value last saved in the FCC non-volatile memory, whether that is done automatically at HARS shutdown after a flight has completed, or manually from the DTC page. EPE is initialized at 10,000 meters. The LAND/WATER mode is initialized to LAND. This initialization occurs within the first second that power is applied to the FCC. After the power-on initialization is complete (many other things are also initialized), the FCC starts executing its operational flight program (OFP).

   Part of the FCC OFP is to continually examine the DTU to see if a DTC is or has been installed. The data on the DTC and how the DTC is used can have significant impacts upon the aircraft PPOS, EPE and the LAND/WATER mode. About 5 seconds after the FCC recognizes a DTC has been installed, the FCC will automatically update PPOS, EPE and the LAND/WATER mode if valid data is found on the DTC. The data in the DTC “save” or “init” file will update the aircraft PPOS and LAND/WATER mode depending upon the situation (see section 3.4 for details on the DTC file structure and usage). If the DTC data is used to update PPOS, then the EPE will be updated as follows:

   EPE = 50 meters for all airborne conditions
   EPE = 50 meters for ground/land/DTC “save” read condition
   EPE = 500 meters for ground/land/DTC “init” read condition
   EPE = 16,384 meters for ground/water condition (also auto INS reset & DNS RF=OFF)

   As an example, if the DTC read was caused by an aircraft power interrupt while airborne, then the FCC would read the DTC “save” file. That PPOS data and LAND/WATER mode state are no older than 5 seconds. They are both used to update the system, and EPE would be reset to 50 meters. EPE is continuously updated based upon the velocity source and the distance traveled since the last PPOS update (manual or automatic). Additionally, if automatic GPS position updates are being performed, EPE will be equal to the GPS EHE plus the radial distance between the FCC and GPS positions. Normally, when the FCC is using the GPS position data, the distance between the FCC and GPS positions will be less than 2 meters. PPOS lat/long data is propagated at 50 hz using a simple process of system velocity integration. PPOS lat/long may also be updated manually (CPG action) and/or automatically (GPS and/or DTC insertion). PPOS altitude is updated at 50 hz using ADS pressure changes, the current pressure setting (HG displayed on the ADMIN page) and the current ADS pressure sensor bias value. PPOS altitude may be updated manually by CPG altitude, pressure setting or pressure sensor bias updates (all via the ADMIN page) or automatically by DTC insertion.

B. Backup mode: If the DNS battery is OK, PPOS at power-up is the same PPOS at last power-off. The DNS propagates PPOS utilizing the DNS velocity and the HARS attitude and heading data. Manual PPOS updates are available to the CPG. There is no mission system altitude management, EPE display or LAND/WATER mode to deal with in the backup mode because the BBC is in control of the bus and the BBC does not manage these functions. It is up to the crew to determine the "EPE" based upon their observations.

3.2 Datum - What & Why.

A. Primary mode: The simplest way to perceive a datum is to view it as a set of numbers that define a model for the shape of the Earth. All maps are created with reference to a particular datum. The people that do Earth mappings, and thus create maps, must also define the Earth (how big, how circular, how much flattening, etc) as they see and measure it. This definition is the datum associated with that particular mapping.

The FCC utilizes 47 different datum. Most have different data, but some are identical. With this idea in mind, it should be clear to visualize that for any given latitude/longitude defined using datum A, the same latitude/longitude using datum B, will have a different position on the surface of the Earth. It is easy to visualize for grossly different shapes, but it is true for all of the different Earth models. This position shift on the Earth's surface is called the Molodensky shift. So now it is easy to see why just lat/long or UTM cannot define a coordinate. A complete definition must include a datum. The FCC understands the Molodensky shift and makes the appropriate compensation to allow nav/targeting operations with PPOS in datum A and the active fly-to/target in datum B.

B. Backup mode: Datum as explained above, does not exist in the DNS. Spheroid, an earlier mechanism for dealing with different mappings of the Earth, is the method used by the DNS. The DNS allows coordinate data to be associated/defined with different spheroid, but it will not perform nav calculations between a PPOS in spheroid A and a fly-to in spheroid B. The PPOS and the fly-to must be located within the same spheroid.

3.3 EGI-INS and HARS similarities and differences.

A. Similarities: Both the EGI-INS (INS) and the HARS are strapdown inertial sensor systems. Strapdown means that the sensing instruments are physically "strapped-down" (or bolted) to the vehicle they are installed in. This is in contrast to a gimbaled inertial sensor system. Here the sensing instruments are freely suspended in a 2 or 3-axis gimbal assembly. They both use rate gyros and accelerometers as their primary sensors. They both determine true heading, primarily during what is called the alignment cycle, but they continue to refine their true heading estimate for as long as they are powered-up. They both provide a "stationary" and "non-stationary" alignment cycle. They both are vulnerable to upset during the alignment cycle if not operated as prescribed. They both "attach" a magvar value to the true heading estimate in order to provide a magnetic heading output. They both provide the same dynamic state information to the host platform (linear velocity and acceleration, angular rates and acceleration, and attitude info). And they both require some form of velocity aiding to achieve acceptable mission engagement performance on the Apache platform.

B. Differences: The HARS is mid-late 1970's technology and the INS is mid 1990's technology. That's 20 years on the calendar, but different lifetimes when considering the total performance and applicability issues. The HARS uses good quality mechanical gyros (only 2), but the INS uses the highest quality, latest state-of-the-art ring laser gyros (3). Both units use high quality accelerometers (3), but the INS accelerometers have much better resolution and drift qualities, which make a big difference in the velocity accuracy, especially when the INS is un-aided. The INS stand-alone performance criteria is in a different class from the HARS, primarily because of 1) the much higher quality instrument package that it uses and 2) the overall implementation of the internal system software. The INS has a high quality GPS as its primary aiding device. The DNS aiding is an after-thought. The HARS was designed with the DNS as its primary aiding device (GPS was a test program when the HARS was developed). At alignment completion, the INS heading accuracy is at least 2 to 3 times better than the HARS (in less than half the time). The INS provides a much more "robust" implementation that makes it much more difficult to upset than the HARS. Basically, the INS is the inertial sensor that everyone always wanted the HARS to be.

3.4 Simultaneous FCC Nav and DNS Nav – What's the Big Deal. When the FCC is running it is constantly performing the navigation solution. The result is visible on the CDU and video displays. Simultaneously, the DNS is performing a navigation solution. The result is visible on the HSI distance-to-go window and #1 needle. Having two separate nav calculators utilizing different inputs, driving different displays at the same time, is not an optimal design. Part of the ECP programmatic requirements was to make the modification at minimal expense. This particular situation/mechanization is one of the beneficiaries of that decision. Normally, all nav display indicators should agree and play in concert with each other. For this situation, in order to mitigate (to the maximum extent possible) disparity in the nav display indicators, the FCC provides PPOS updates to the DNS at 5 second intervals. This effectively keeps the DNS PPOS the same as the FCC PPOS. So if the DNS has the same fly-to coordinate as the FCC (by design it does), the nav display disparity is limited to differences in the nav/display processing implementations within the FCC and the DNS.

Under normal conditions, it is difficult to see any disparity between the HSI #1 needle and the bearing to destination indications on the CDU or video display. The distance-to-go displayed on the HSI and the distance-to-go displayed on the CDU or video displays, can differ by up to 0.3km under normal conditions with good equipment. This is a result of differences in the nav calculation precision and display processing (the handling of truncation and rounding), between the FCC and the DNS. Problems with the HSI nav indications can occur if the DNS does not correctly receive the fly-to or PPOS information from the FCC. Under normal conditions, this is not an issue, but if the DNS components or the associated wiring are discrepant, then the HSI nav indicators can be totally invalid. If this abnormal situation is detectable by the FCC, the FCC will provide the following display prompts to the aircrew:

CPG – CDU advisory message "DNS/HSI NAV CUES ??"
PLT – hi-action weapon status field "HSI CUE?"

If the aircrew observes either of these prompts, the first action should be to de-select and then re-select the desired fly-to location. This will cause the FCC to re-send the fly-to coordinate data to the DNS (to try and re-sync it). If that does not help, then cycling the DNS circuit breaker will cause the DNS to re-start. After the DNS re-starts, the FCC will re-initialize the DNS. If this does not solve the problem, a review of the continuous FDLS test results, and then running a MUX FDLS test, followed by a DNS FDLS test may reveal problems. If none of these steps helps, then there is a fault with a DNS component or DNS wiring that is not detectable.

3.4 Data Transfer Receptacle (DTR) and Data Transfer Cartridge (DTC) details. The DTC is partitioned into three files. The "init", "save" and "event" files. The "save" file and the "init" file have identical structure. They both contain waypoint/target/PPOS coordinates and laser codes. From an operational perspective, the DTC "init" file should be viewed as the mission planning data that was created prior to the mission. It can always be accessed from the DTC page on the CDU. Whenever the CPG requests to load data from the DTC page, the data that will be loaded into the FCC is data from the DTC "init" file. The DTC "save" file should be viewed as the place that the FCC keeps the current active mission data, which has probably changed since the start of the mission. Normally, the "init" file is written to by the AMPS and read by the FCC. Under certain conditions, the FCC can write to the "init" file (see below). The AMPS writes to the "init" file when the operator writes the AMPS mission data to the DTC. Prior to the write, the DTC is blanked. So the only data on the DTC after an AMPS write is the "init" file data.

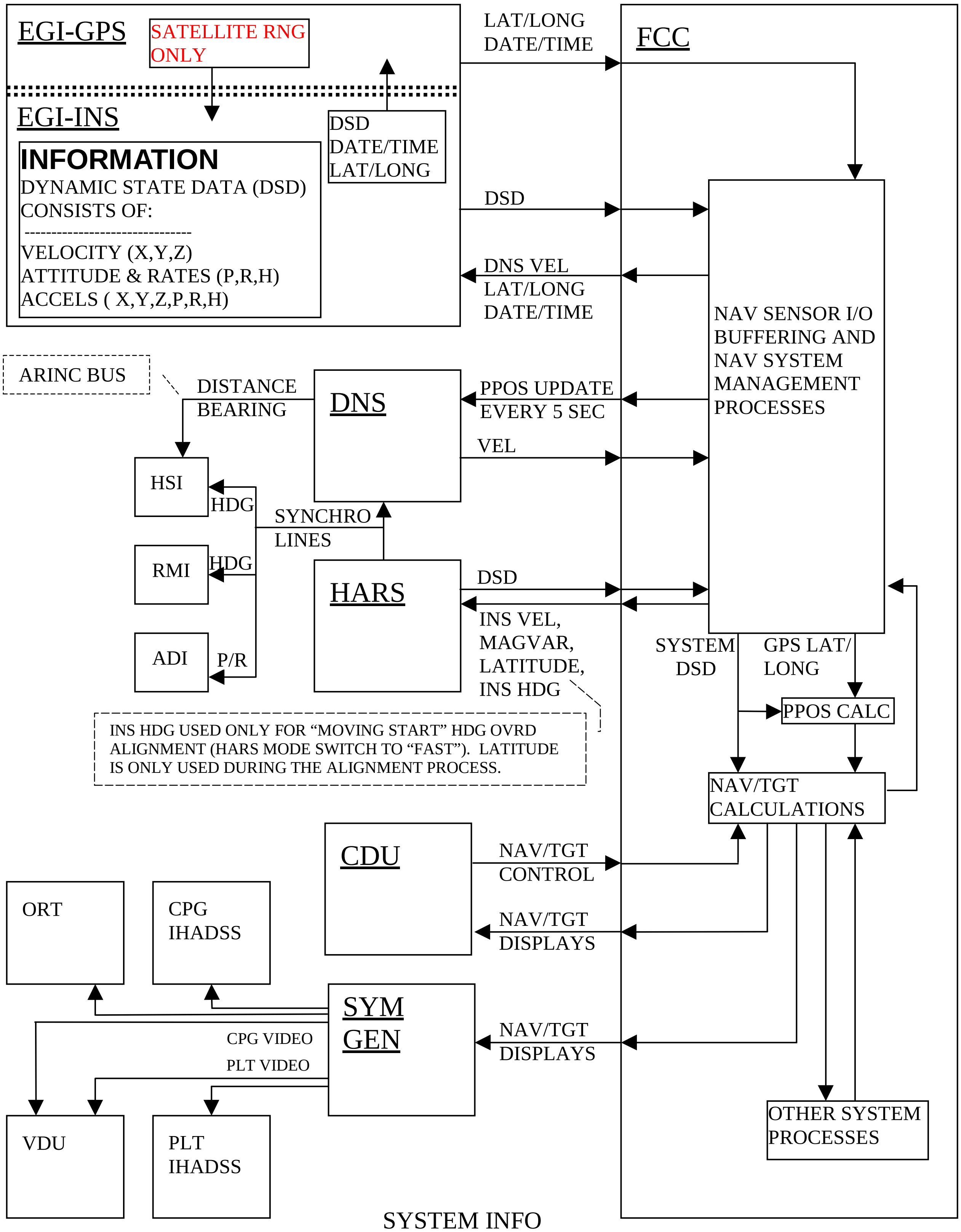
The FCC non-volatile memory is not large enough to hold 80 coordinates (40 waypoints and 40 targets). So the FCC uses the DTC "save" file as extended non-volatile memory. It writes data to the "save" file whenever any waypoint, target or laser code is modified. It also writes PPOS data to the DTC at 5-second intervals. When the FCC recognizes a DTC is installed (power-up or later) it will wait 5 seconds (DTR door open/close debounce time), then if not empty, the "save" file will automatically be read to initialize the system (PPOS WILL BE MODIFIED. A NON-FRESH DTC SHOULD NOT BE INSTALLED WHILE AIRBORNE). If the "save" file is empty (only from a fresh AMPS load) the FCC will automatically read and update the system with the DTC "init" file. This is the same as an automatic "LOAD ALL" performed from the DTC page on the CDU (EXCEPT IF AIRBORNE, PPOS WILL NOT BE LOADED).

The DTC "event" file is a file created by the FCC. A new "event" file is created whenever a DTC is installed. Any previous "event" data is over-written. It is updated with a record of FDLS GO/NOGO transitions, other FDLS operations data, and squat switch transitions. The "event" file may be downloaded using the AMPS. This data may be used for troubleshooting and maintenance record keeping.

It is possible to load the DTC "init" file with the data in the FCC. All of the waypoints, targets, laser codes, PPOS and the LAND/WATER mode should be set as desired prior to the action. Pressing VAB 6 on the DTC page with the string "RAMTOINIT" written in the scratchpad, will cause the FCC to write all of its current data to the DTC "init" file.

4. Nav system redundancy and degradation. The degradation of the nav system is all based upon data that the FCC receives from the different components that make up the system. The data that the FCC examines in making these decisions is a combination of individual component moding, operational status and bite/fault status. This data, when viewed as the net functionality of any given sub-system (within the nav system as a whole), is referred to as the operational suitability of that particular sub-system.

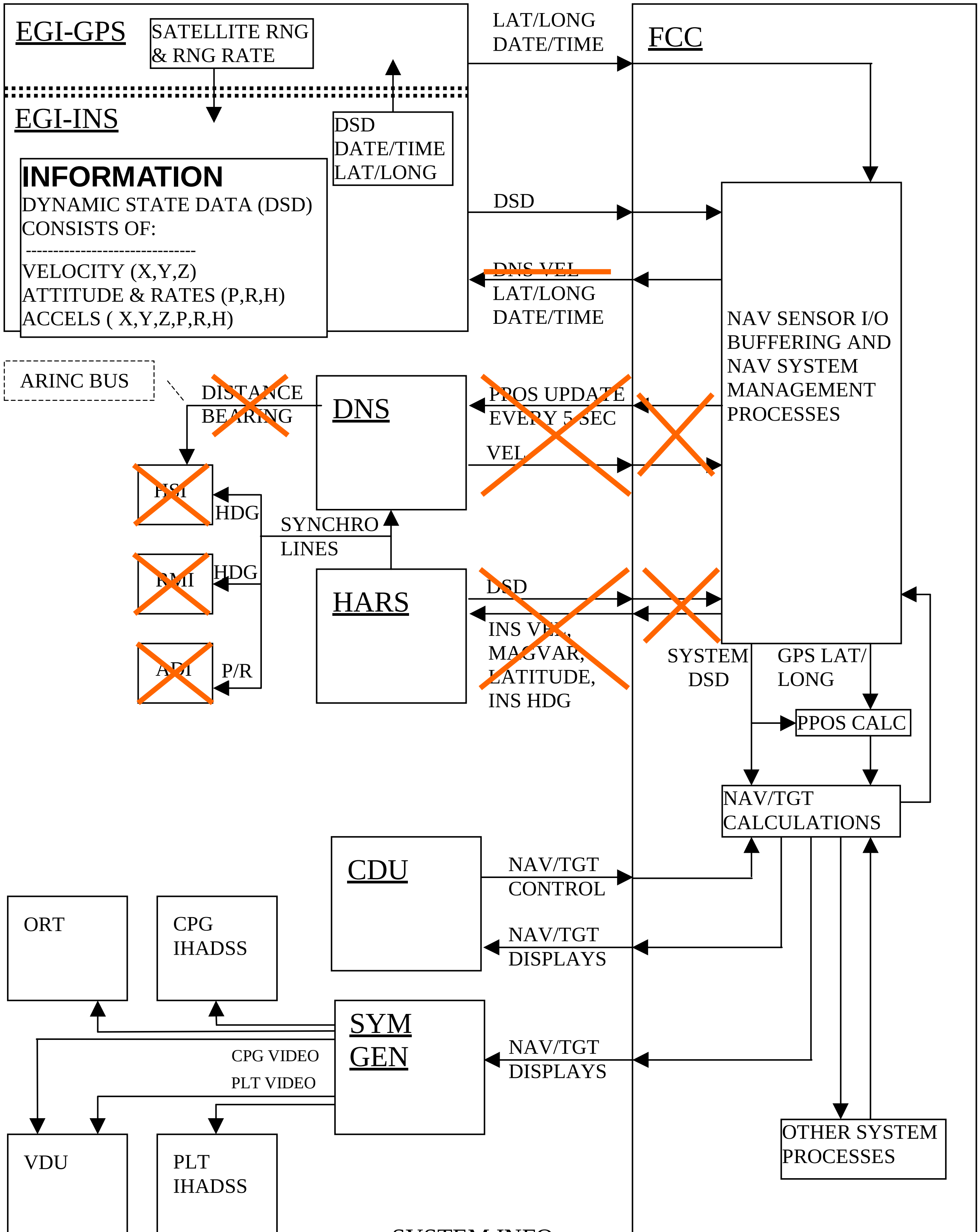
Figures 3 thru 7 provide a pictorial representation of the redundancy that is inherent in the nav system design, as well as some representative examples of nav system degradation (red text & red X's or gray if not viewed in color) at the system and component levels. If the diagrams are reviewed in detail, there is substantial knowledge to be gained on the structure, redundancy and degradation characteristics of the nav system. These diagrams use the same format and layout as the Primary Nav System Block Diagram above. At the bottom of each of the diagrams there is a wrap-up of "system info" and an indication of the level of degradation. The "system info" is a compilation of some of the more critical display indications, moding data, and errata on the INS/HARS inflight/water alignment availability and operations pertinent to the represented condition.



SYSTEM INFO

NAV STATUS PAGE: INS GO, GPS GO, HARS GO, DNS GO
GPS STATUS PAGE: FOM>2, SV>2, P CODE=0, C CODE>2
NAVSTAT<3, PPOS UPDATES NOT REQUIRED, HOVER BOX ACCURACY UNCERTAIN
INS INFLIGHT/WATER ALIGNMENT AUTOMATIC USING GPS AIDING
USE HDG OVRD FOR HARS (MODE SW TO “FAST” WHEN HDG TAPE APPEARS)

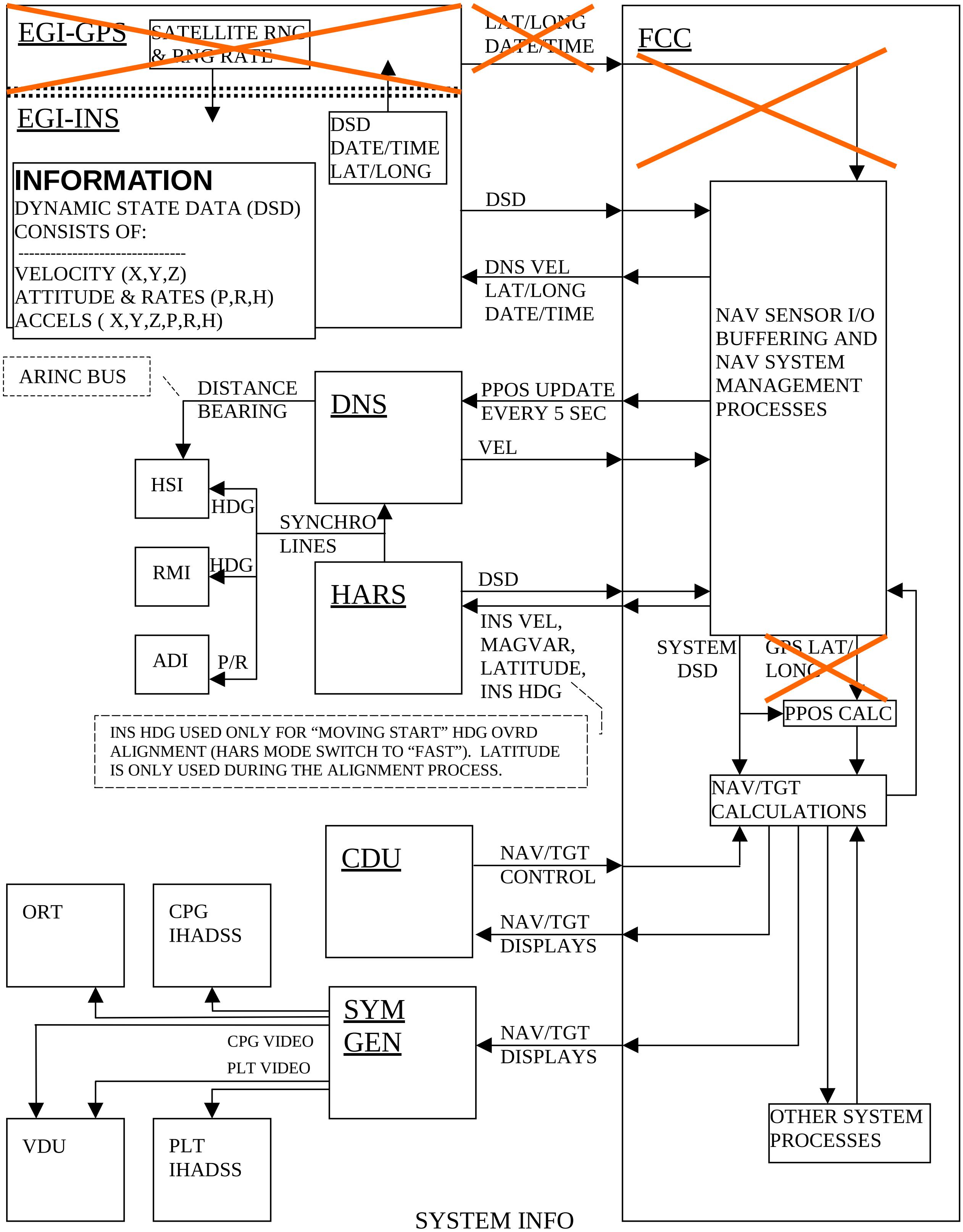
NAV SYSTEM BLOCK DIAGRAM – FULL-UP (GPS NOT KEYED)
Figure 3



SYSTEM INFO

NAV STATUS PAGE: INS GO, GPS GO, HARS NOGO, DNS NOGO
GPS STATUS PAGE: (DEPENDS UPON KEYED OR UNKEYED – SEE ABOVE)
NAVSTAT<3, PPOS UPDATES NOT REQUIRED, HOVER BOX ACCURACY UNCERTAIN
INS INFLIGHT/WATER ALIGNMENT AUTOMATIC USING GPS AIDING
TRY USING HDG OVRD FOR HARS (MODE SW TO “FAST” WHEN HDG TAPE APPEARS)

NAV SYSTEM BLOCK DIAGRAM – NO HARS, NO DNS
Figure 4



SYSTEM INFO

NAV STATUS PAGE: INS GO, GPS NOGO, HARS GO, DNS GO

GPS STATUS PAGE: (ALL DATA IS INVALID – MAY BE FROZEN)

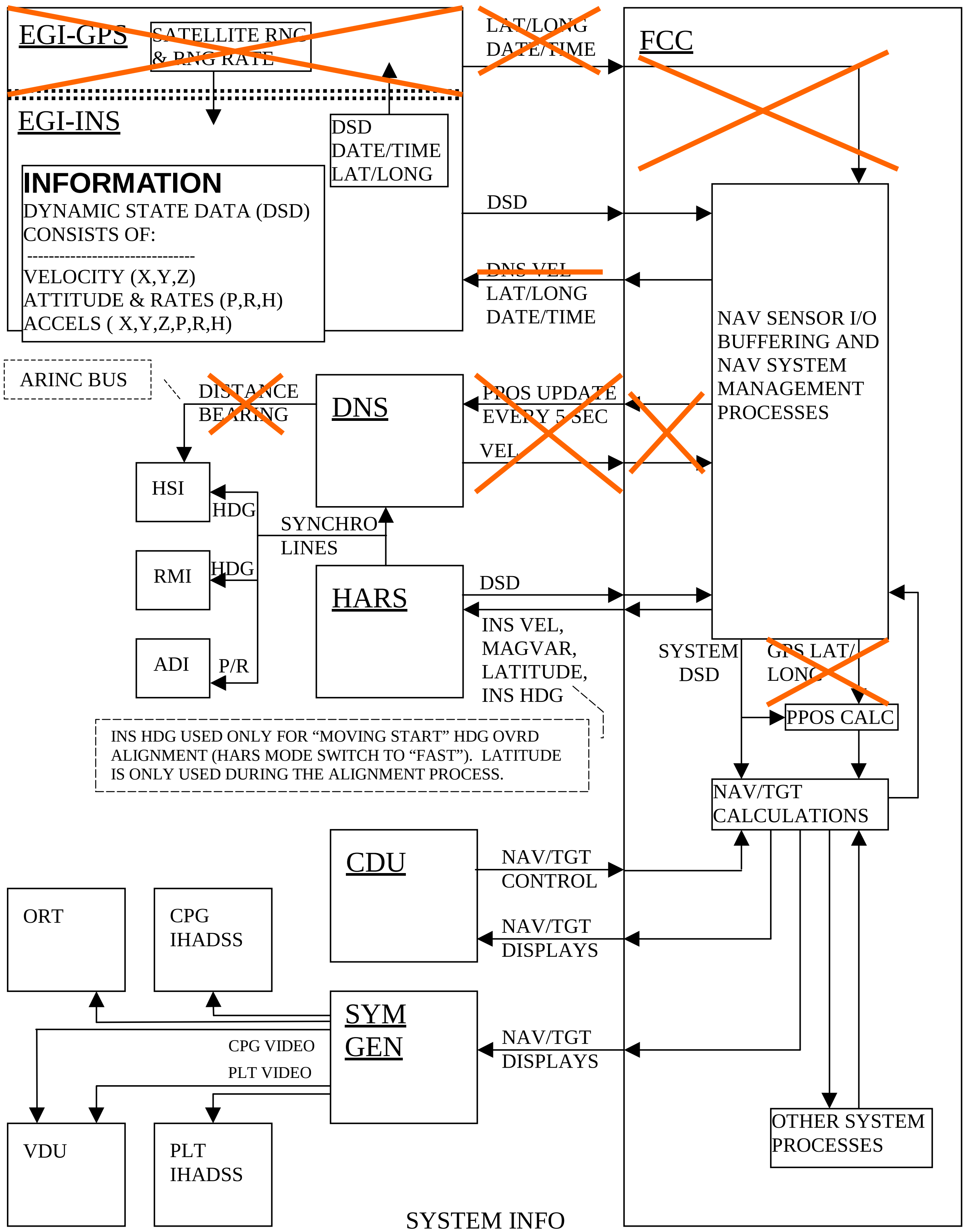
NAVSTAT>1, PPOS UPDATES REQUIRED, HOVER BOX ACCURACY UNCERTAIN

INFLIGHT ALIGNMENT REQUIRES HARS "FAST" (NEED DNS AIDING FOR INS & HARS)

WATER START REQUIRES MANUAL ENTRY OF GRND SPEED & TRACK (NAV SENSOR CONTROL PAGE)

NAV SYSTEM BLOCK DIAGRAM – NO GPS

Figure 5

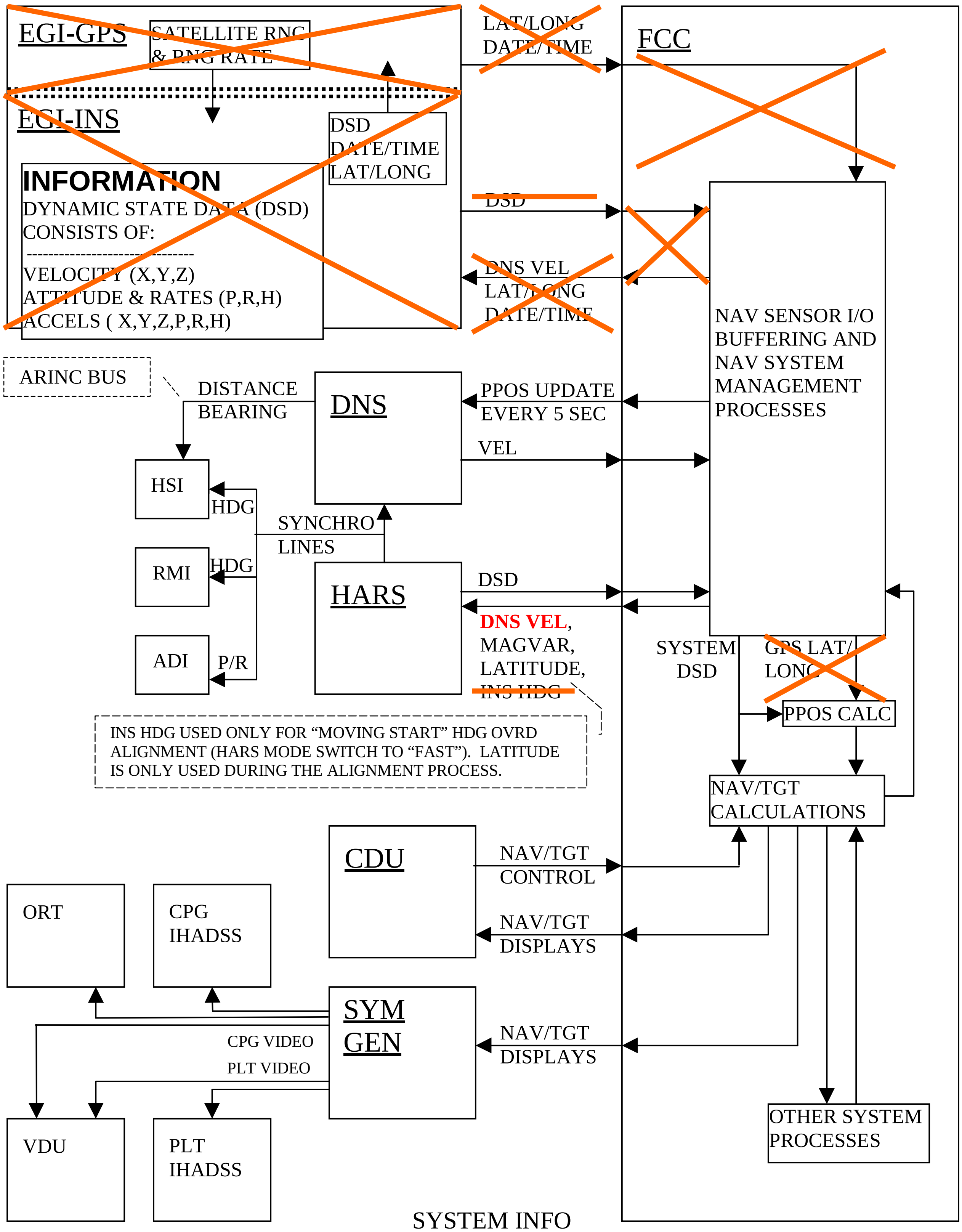


SYSTEM INFO

NAV STATUS PAGE: INS GO, GPS NOGO, HARS GO, DNS NOGO
GPS STATUS PAGE: (ALL DATA IS INVALID – MAY BE FROZEN)
NAVSTAT>1, PPOS UPDATES REQUIRED, HOVER BOX ACCURACY UNCERTAIN
INFLIGHT ALIGNMENT AND WATER STARTS REQUIRES MANUAL ENTRY OF GRND SPEED & TRACK (NAV SENSOR CONTROL PAGE)

NAV SYSTEM BLOCK DIAGRAM – NO GPS AND NO DNS

Figure 6



SYSTEM INFO

NAV STATUS PAGE: INS NOGO, GPS NOGO, HARS GO, DNS GO

GPS STATUS PAGE: (ALL DATA IS INVALID – MAY BE FROZEN)

NAVSTAT>1, PPOS UPDATES REQUIRED, HOVER BOX ACCURACY UNCERTAIN

INFLIGHT ALIGNMENT REQUIRES HARS "FAST" (NEED DNS AIDING FOR HARS)

WATER START REQUIRES MANUAL ENTRY OF GRND SPEED & TRACK (NAV SENSOR CONTROL PAGE)

NAV SYSTEM BLOCK DIAGRAM – NO EGI

Figure 7

5. Nav system operational alignment methods. With the EGI mod, there are 4 operational modes of inertial platform alignment that apply to both the EGI and the HARS. The first and the most widely recommended alignment method is the **stationary start**. The other 3 methods are all moving starts and should only be used, especially as this pertains to the HARS, when the mission needs require a rapid departure. The 3 types of moving starts are the **automatic moving start**, the **manual moving start** and the **forced moving start**.

5.1 Stationary start defined. The conditions that establish a **stationary start** are that LAND is selected, the squat switch indicates a ground condition, and the total engine torque (both engines summed) has been less than 40% for 90 seconds. The 90 second timer is initialized to 90 seconds and LAND is the default when aircraft power is applied and the FCC powers up. So if the squat switch indicates ground, and if a DTC has been installed and the DTC has not been set for a WATER start, then the FCC modes the EGI and HARS for a **stationary start**. The EGI start is automatic (assuming the CB is in) when power is applied to the aircraft. The HARS mode switch is placed to NORM to perform the full HARS alignment process. With the EGI mod, the engines may be started while the HARS is aligning (see note below). This is possible now because the HARS is no longer the primary dynamic state sensor for the FCC (HARS heading accuracy is not critical). So long as the aircraft motion during engine start is not excessive, the HARS will align properly. If the aircraft motion becomes excessive, the HARS may fail the alignment, in which case, the HARS will have to be turned OFF, and then another NORM alignment attempted.

The EGI-INS will normally complete alignment within 4 minutes. When the EGI-INS alignment is complete the heading tape will appear on both the pilot and CPG video displays. The CPG may observe the EGI-INS and HARS alignment stages by viewing the NAV STATUS page on the CDU. The HARS will normally take 7-10 minutes (depending upon the ambient temperature) to complete a full alignment. When the HARS alignment is complete the HSI and RMI heading flags are pulled from view. If for some reason the EGI was not running or did not complete alignment, then the video heading tape would also appear when the HARS finished the alignment process. When the HARS completes alignment, the HARS mode switch may be moved to OPR at any time prior to aircraft movement. The FCC will supply the HARS with zero velocity updates so long as the stationary condition remains. This is also true for extended ground taxi/park operations. Whenever the stationary conditions are satisfied, the FCC will supply the zero velocity updates to the HARS. This relieves the pilot from having to move the HARS mode switch between OPR and NORM and back to OPR during extended ground operations. Once the pilot has moved the HARS mode switch to OPR, he never needs to touch the switch again, until it’s time to turn the HARS OFF.

Note: It has been determined that the engine torque filter in the –51 FCC software can be defeated by the engine torque spikes generated by some of the 701 engines. The net result is that the FCC will mode the HARS for a moving start if this occurs. It has also been determined that if the aircraft attitude exceeds 2° nose-up during HARS alignment, the –51 FCC software will mode the HARS for a moving start. Both of these issues have been addressed and are no longer present in the planned FCC software update (see section 11).

5.2 Stationary start heading validation procedure. This section provides a procedure and the expected indications to determine if the EGI and HARS are aligning appropriately.

5.2.1 EGI – INS procedure.

1. With the EGI CB in, apply power to aircraft.

2. When the CDU illuminates, verify DATUM and PPOS are correct. If not, manually enter correct DATUM and/or PPOS.
3. Observe the INS alignment mode (line 1 right side) and the INS operational status (line 3 left side) on the CDU NAV STATUS page.
4. The normal sequence for the INS alignment mode display is INIT, LEVEL, CGA and then FGA. If CSA or FSA is displayed, then set the mode from WATER to LAND and re-align the INS. If CIFA or FIFA is displayed, then fix the squat switch airborne signal (make it indicate ground) and then re-align the INS. If ICGA or IFGA is displayed, it should clear within 20 seconds. If it does not clear, it means that the platform is too unstable to continue the alignment. Remove the reason for the instability and then re-align the INS.

   Note: normally INIT and LEVEL modes complete within 5 seconds after power is applied to the EGI. These modes can only be observed on the CDU when the EGI is re-started (by CB cycling or the BST EGI page) while the aircraft is already powered.

5. The normal sequence for the INS operational status display is INS NOGO, INS ATT?, INS VEL?, INS HDG? and finally INS GO.

   Note: normally INS NOGO and INS ATT? are only visible while the EGI is not powered or within 5 seconds after power has been applied. These indications can only be observed on the CDU when the EGI is re-started (by CB cycling or the BST EGI page) while the aircraft is already powered.

6. When the INS GO message is displayed, observe that the correct magvar is displayed on the CDU NAV page. If the magvar is not correct, re-verify the DATUM and PPOS. If they are not correct, go back to step #2. If they are correct, then the INS magvar look-up algorithm is in error. As long as the magvar is in error, then the accuracy of the magnetic heading is directly impacted, i.e. 0.5° of magvar error produces 0.5° of magnetic heading error.
7. At this point, the heading on the video indicates the fully aligned magnetic heading of the INS. If the general aircraft heading is known, or if the whiskey compass is working properly, then the INS heading should fall well within the expected heading at this aircraft orientation. If the displayed heading is off by more than 10°, then re-check what heading should be expected at this aircraft orientation. If the INS heading still seems incorrect, then re-start the EGI (pull CB and reset) and re-do this procedure. If the heading still seems incorrect, then pull the EGI CB and rotate the aircraft heading at least 90° and re-do this procedure. If the INS heading is still incorrect, then replace the EGI with a known good unit, and re-do this procedure. If the heading is still incorrect, then there is something on the aircraft that is impacting the EGI. Detailed troubleshooting will be required at this point to determine the cause of the problem.

5.2.2 HARS procedure.

1. With the EGI CB pulled, apply power to aircraft.
2. When the CDU illuminates, verify DATUM and PPOS are correct. If not, manually enter correct DATUM and/or PPOS.
3. Place the HARS mode switch to NORM.
4. Observe the HARS operational status (line 5 right side) on the CDU NAV STATUS page.
5. The normal sequence for the HARS operational status display is HARSNOGO, HARSATT?, and then HARSNORM.

6. When the HDG flag is pulled on the HSI or the video heading tape is displayed, observe that the correct magvar is displayed on the CDU NAV page. If the magvar is not correct manually input the correct magvar.
7. At this point, the heading on the HSI and the video indicates the fully aligned magnetic heading of the HARS. Place the HARS mode switch to OPR and observe HARS GO is displayed on the NAV STATUS page. If the general aircraft heading is known, or if the whiskey compass is working properly, then the HARS heading should fall well within the expected heading at this aircraft orientation. If the displayed heading is off by more than 10°, then re-check what heading should be expected at this aircraft orientation. If the HARS heading still seems incorrect, then turn the HARS OFF and re-do this procedure. If the heading still seems incorrect, then turn the HARS OFF. Zeroize the HARS MDM and then perform the HARS alignment procedure after MDM zeroize (see procedure below). If the HARS heading is still incorrect, then replace the HARS with a known good unit, and re-do this procedure. If the heading is still incorrect, then there is something on the aircraft that is impacting the HARS. Detailed troubleshooting will be required at this point to determine the cause of the problem.

5.2.3 HARS alignment procedure after MDM zeroize. Insure that the aircraft is setup for a stationary start. Place the HARS mode switch to NORM. Wait for the HARS to complete alignment (HSI hdg flag pulls). Shut the HARS OFF and rotate the aircraft heading 90°. HARS mode switch to NORM. Wait for the HARS to complete alignment. This two-position alignment allows the HARS Kalman filter to properly initialize critical instrument compensation variables.

5.3 Moving starts defined. The conditions that establish a moving start are, that any one of the stationary start conditions is not satisfied.

5.3.1 Automatic moving start. The **automatic moving start** (airborne, ground taxi or moving platform) requires that the GPS is tracking at least 4 satellites (keyed or un-keyed). The start-up is called automatic because the EGI-INS will automatically use the GPS data to aid the moving alignment process. The EGI-INS will complete the moving alignment in 1 to 3 minutes (more position change equals less time). When the EGI-INS completes alignment, the heading tape appears on the video. At this time, the HARS mode switch is moved to FAST. When the HARS wakes up it is being aided by EGI-INS heading and velocity. With these alignment aids and the mode switch moved to FAST, the HARS will perform a heading override rapid alignment. This alignment only takes about 20 seconds after the HARS wakes up. The HARS wake up time can vary from 20 to 90 seconds, and it is a function of the HARS reaching the proper operating temperature.

5.3.2 Manual moving start. The **manual moving start** is for use when the GPS is not available and the aircraft is in motion (airborne, ground taxi or moving platform). For the manual moving start, a manual ground track and speed entry is made via the CDU NAV SENSOR CONTROL page to initialize the INS and HARS. The manual track entry must be within 5 degrees of the actual aircraft ground track angle, and the manual ground speed entry must be within 5 percent of the actual aircraft ground speed. The video heading tape and the velocity vector will reflect the entry that is made. After the manual entry has been made, the HARS mode switch is moved to FAST.

For a moving platform start, it is necessary to maintain the platform speed when lifting the aircraft and moving off the platform over the Earth. Once over the Earth, the DNS RF switch (from the CDU NAV SENSOR CONTROL page) must be placed to ON.

With the **manual moving start,** the transition from using the manually entered velocity to the DNS velocity (which occurs when airborne with valid DNS velocity) may be too large for the INS and/or HARS to accept. If this happens, you must turn off the HARS and/or restart the EGI and perform a **forced moving** start.

5.3.3 Forced moving start. The last moving start option, the **forced moving start**, is for use when the automatic and manual moving starts cannot be utilized or do not work. The forced moving start can only be performed while airborne. It is performed by placing the HARS mode switch to FAST. When the HARS has completed leveling, the DNS is automatically powered on, and the HARS and INS will use the DNS velocity to complete their alignments.

5.3.4 HARS operational alignment details and warnings. For all of the HARS operational alignment modes, when the HSI and RMI flags are pulled from view, the HARS mode switch should be moved to OPR, and then the DASE may be engaged.

The HARS mode switch should never be placed to NORM during any moving start. The HARS assumes a non-moving condition when the mode switch is placed to NORM. The side effects of doing this will cause the HARS heading to be totally useless, and the possibility exists for corrupting internal calibration values.

HARS moving starts should only be performed when the mission needs require a rapid departure. If the HARS is not allowed to perform regular NORM alignments, it will eventually fail internal calibration tests. If this occurs, the HARS MDM will need to be zeroed, or possibly the unit will need to be replaced.

Anytime a HARS moving start is performed, for the first 3 minutes after the HARS wakes up, it is extremely sensitive to and intolerant of excessive aircraft dynamics. During this phase of alignment the aircraft flight profile should be kept as docile as possible. This will provide the highest probability of a successful HARS moving start.

Chart A provides a summary of the moving start mode to use under varying conditions.

Chart A --- Moving Start Selection Mode Summary Chart

Conditions Present				Operational Moving Start Mode to use	Corresponding HARS Moving Start Mode Used	Corresponding EGI Moving Start Mode Used
GPS Available	Airborne	Ground Taxi	Moving Platform			
Yes	Yes	No	No	Automatic	Heading Override	CIFA/FIFA
Yes	No	Yes	No	Automatic	Heading Override	ICGA/IFGA
Yes	No	No	Yes	Automatic	Heading Override	CSA/FSA
No	Yes	No	No	Manual or	Heading Override	CIFA/FIFA
No	Yes	No	No	Forced	FAST	CIFA/FIFA
No	No	Yes	No	Manual	Heading Override	ICGA/IFGA
No	No	No	Yes	Manual	Heading Override	CSA/FSA

Note: For Ground Taxi --- LAND is selected, for Moving Platform --- WATER is selected.

6. HARS inflight alignment – the details. In section 5, the discussion was on nav system alignment from the aircraft operational perspective. In this section, the discussion pertains to the HARS on an individual basis. This section defines the HARS "inflight alignment" modes, how they "fit" into the moving starts described in section 5.3, and the flight environment required to successfully employ these special alignment modes of the HARS. The term "inflight alignment" is a term that has been associated with the HARS as an alternative means of aligning the HARS. What it is, how it works and how to use it, has not been trained well. In this discussion, as well as how it is implemented within the FCC, the term "inflight alignment" is synonymous with the term "moving start". So future references to a HARS moving start, are actually employing variations on the existing HARS "inflight alignment" capabilities. One item common to all HARS moving start modes, is that the HARS must be provided accurate velocity aiding for several minutes after a moving start is attempted. The details are provided in the charts below.

The –51 and subsequent versions of FCC software provide the means for employing the HARS Heading Override moving start, the FAST moving start, and the Traditional moving start. The Heading Override moving start provides a capability that had not been implemented previously. To trigger any of these moving start modes, the aircraft must be in a non-stationary condition as defined in section 5. Which moving start mode is utilized depends upon whether a heading aid is available at HARS start-up, and which position the HARS mode switch is placed in at HARS start-up.

To utilize the HARS Heading Override moving start, a heading aid must be provided at HARS start-up, and the HARS mode switch must be placed in FAST. Both the automatic and manual moving start procedures (5.3.1 and 5.3.2 above) provide a heading aid to the HARS at HARS start-up. Therefore, the HARS Heading Override moving start is employed in both the automatic and manual moving start procedures.

Either the HARS FAST or Traditional moving start mode is employed when a heading aid is not available at HARS start-up. Placing the HARS mode switch to FAST or OPR employs the HARS FAST or Traditional moving start, respectively. The HARS FAST moving start is employed in the forced moving start procedure (5.3.3 above). Information is provided below on the Traditional moving start, but it is the least desirable moving start mode. It's functionality is very similar to the FAST moving start, but because of different handling within the HARS Kalman filter, the minimum alignment time is expanded with no benefit in heading accuracy or internal stability. Therefore, it is not a recommended procedure.

The Heading Override moving start is the most desirable moving start mode. It produces the fastest alignment time possible with the HARS, and a heading uncertainty equal to the uncertainty of the heading aid. The time required to complete the alignment (subsequent to reaching proper operational temperature) is approximately 20 seconds. For comparison purposes, the time to complete alignment (subsequent to reaching proper operational temperature) for the FAST or Traditional moving starts will vary from approximately 4 minutes (hover) up to 20 minutes or more (extreme dynamics), and the heading uncertainty at alignment completion is typically ±4.0°. So, now it is obvious that the Heading Override moving start, with INS aiding, is preferred to all other moving starts. But depending upon conditions, all of these modes are available and functional.

6.1 HARS vulnerability during moving starts. Whichever mode is employed, at initial HARS start-up, the HARS vulnerability to upset is inversely proportional to its run time. The HARS is extremely intolerant of large dynamic excursions or inaccurate velocity aiding during the first minute after a moving start is initiated (when the heading flag pulls), and remains intolerant of these conditions for an additional 4 minutes. What this says is that the HARS **must** be treated as a newborn baby for the first few minutes after a moving start is attempted. If it is not treated as such, the possibility exists that it will fail to properly accomplish the alignment task. If this occurs, it may manifest itself in a number of ways. It could shut down completely. If it doesn't shut down, it may cycle into and out of the free inertial mode, or just stay in the free inertial mode. It may tilt the "platform", and this will cause all of its output data to suffer. The easiest way to tell if the HARS alignment is going well or not, is by observing the HARS status info on the NAV STATUS page of the CDU. Charts B thru D provide the typical relationship of time to the aircrew actions and observations for the Heading Override, the FAST and the Traditional moving starts. The times presented in these charts are approximate times. The HARS status info displayed on the CDU is typical for a nominal alignment sequence. If these timings vary substantially and/or if the HARS status displays do not sequence as indicated, this is an indication that the HARS is not performing the desired alignment properly, and may need to have MDM zeroed, or the unit itself may be faulty.

Chart B --- Heading Override Moving Start Relationship Chart

Step	Elapsed Time	HARS Mode Switch	HARS Status on CDU	Comments
1	0:00	Off to FAST	HARSNOGO	warming up
2	0:20 to 1:30	FAST	HARSATT?	leveling
3	step2 + 0:07	FAST	HARSFAST	leveling complete, accepts heading override
4	step3 + 0:01	FAST or OPR	HARSHDG?	initializes Kalman, activates the heading override alignment
5	step4 + 0:12	FAST or OPR	HARS GO	alignment complete
6	step5 + 1:00	FAST or OPR	HARS GO	extreme vulnerability
7	step6 + 2:00	FAST or OPR	HARS GO	high vulnerability
8	step7 + 2:00	FAST or OPR	HARS GO	medium vulnerability
9	step8 until off	FAST or OPR	HARS GO	normal vulnerability

Notes: The HARS validity flags on the HSI, RMI and RAI will all be pulled at Step 3. The pilot may place the HARS mode switch to OPR (to allow DASE engagement) at any time after the HARS validity flags pull. Heading uncertainty equal to the uncertainty of the heading aid.

Chart C --- FAST Moving Start Relationship Chart

Step	Elapsed Time	HARS Mode Switch	HARS Status on CDU	Comments
1	0:00	Off to FAST	HARSNOGO	warming up
2	0:20 to 1:30	FAST	HARSATT?	leveling, extreme vulnerability
3	step2 + 0:07	FAST	HARSFAST	leveling complete, no heading override , extreme vulnerability
4	step3 + 0:01	FAST or OPR	HARSHDG?	initializes Kalman, activates <u>fast</u> inflight velocity aided alignment, extreme vulnerability
5	step4 + 1:00	FAST or OPR	HARSHDG?	extreme vulnerability
6	step5 + 2:00	FAST or OPR	HARSHDG?	high vulnerability
7	varies	FAST or OPR	HARSHDG?	medium vulnerability
8	step7 until off	FAST or OPR	HARS GO	alignment complete

Notes: The HARS validity flags on the HSI, RMI and RAI will all be pulled at Step 3. The pilot may place the HARS mode switch to OPR (to allow DASE engagement) at any time after the HARS validity flags pull. Step 7 elapsed time varies from approximately 4 minutes (hover) up to 20 minutes or more (extreme dynamics). Heading uncertainty at alignment completion is typically ±4.0°.

Chart D --- Traditional Moving Start Relationship Chart

Step	Elapsed Time	HARS Mode Switch	HARS Status on CDU	Comments
1	0:00	Off to OPR	HARSNOGO	warming up
2	0:20 to 1:30	OPR	HARSATT?	leveling, extreme vulnerability
3	step2 + 0:30	OPR	HARSHDG?	leveling complete, initializes Kalman, activates inflight velocity aided alignment, extreme vulnerability
4	step3 + 1:00	OPR	HARSHDG?	extreme vulnerability
5	step4 + 2:00	OPR	HARSHDG?	high vulnerability
6	varies	OPR	HARSHDG?	medium vulnerability
7	step6 until off	OPR	HARS GO	alignment complete

Notes: The HARS validity flags on the HSI, RMI and RAI will all be pulled at Step 3. Step 6 elapsed time varies from approximately 7 minutes (hover) up to 20 minutes or more (extreme dynamics). Heading uncertainty at alignment completion is typically ±4.0°.

6.2 Flight environment required for moving starts. No matter which moving start is employed, the HARS requires continuous valid velocity aiding in order to complete the alignment. For the FAST and Traditional moving starts, if the DNS velocity aiding is lost for more than 10 seconds during the first 30 seconds of alignment, there is a very high probability that the alignment will fail. For all moving starts, the first 3 minutes of align time is very critical. The Kalman is rapidly correcting many different variables. Some of these variables are critical for furthered success in the alignment cycle. No or inaccurate velocity aiding or exceedingly large rate or attitude changes in a short period of time, provides inputs to the HARS KALMAN filter that can/will cause it to make assessments with undesirable conditions. This will negatively effect the final outcome. It is essential that the flight environment be maintained as benign as possible during this very critical first 3 minutes of any HARS moving start. Maintaining a benign flight environment (hover is most desirable) improves the probability for the HARS to make good assessments (because of the limited aircraft motion) and thus complete the moving alignment successfully.

7. Role of the DNS and proper management of the DNS. This section will provide information on the role that the DNS plays and DNS management issues after ECP1198 has been installed.

Prior to the installation of ECP1198, the nav system is comprised of the ASN-137 (DNS), the IP-1552 (CDU), the HSI (some might include the RMI and RAI), a 1553 bus to connect the CDU to the DNS and pitch, roll and mag heading synchro connections from the HARS to the DNS. In this configuration, the DNS is considered to be the navigator (performs the nav calculations). It uses control inputs from the CDU, attitude from the HARS, and its own velocity data to propagate the aircraft position and provide the nav cues and displays to the aircrew via the CDU display and the HSI.

Once ECP1198 has been applied to an aircraft, the navigation system goes from black to white. The nav system is now comprised of dynamic state sensors (EGI, HARS, DNS, ADS) that supply inputs to the FCC (the navigator), which receives control inputs from the CDU and provides nav cues and displays to the aircrew via the CDU and the video displays. Within this system, the DNS is used solely as a velocity sensor. The DNS velocity is used as an aid to the EGI-INS, and if the INS is not operational, the DNS is used as a backup velocity aid to the

HARS. If the HSI was not directly connected to the DNS (via the ARINC interface) or if the HSI had been removed, replaced, etc, etc, etc..., that would be the end of the story about the DNS. But there were no changes made to the DNS, the HSI or any of the associated wiring, so the net result of all of that is that the DNS still drives the HSI distance-to-go and bearing-to-destination indications.

So, even after the ECP has been installed, the DNS is still a nav calculator, with its outputs driving the HSI nav cues. As described in 3.4, in order to minimize the probability that the HSI nav cues diverge from the CDU and video nav cues, the FCC insures that the DNS gets the proper coordinate data for the selected fly-to location. If the FCC detects that the DNS did not properly receive a fly-to when selected, then the CPG is prompted with a CDU advisory message "DNS/HSI NAV CUES??", and the PLT will get the message "HSI CUE?" prompt in his weapon status display. Additionally, the FCC provides PPOS updates to the DNS at 5 second intervals. With both navigators using the same fly-to coordinate and the same PPOS, any difference between the HSI and CDU/video display nav cues is absolutely minimized. Any differences are now purely a function of internal processing differences between the two nav calculators and the display hardware/resolution capabilities. So, after the ECP is installed, the DNS is still navigating, but the crew has no access to the DNS. It is completely controlled and monitored by the FCC. All of the appropriate/necessary DNS management functions are now automated within the FCC.

If problems occur with the DNS, and the DNS does not seem to be able to recover on its own, then the crew has several troubleshooting options available. Running a DNS FDLS test is a good place to start. If FDLS does not help, then if it is an HSI nav cue discrepancy, the CPG can try re-selecting known way-points to see if the DNS will sync-up. If this does not correct the problem, the PLT, who has access to the DNS CB, may try cycling the DNS CB to re-start the DNS. This may cure the discrepancy. If cycling the DNS CB does not work, then the CPG can try selecting the BBC as the bus controller. This will force the CDU to go through a power cycle. It will re-start as the bus controller for the DNS. This now re-configures the nav system to the pre-EGI configuration. If the DNS is still not functioning properly in the pre-EGI configuration, a DNS nav system test should be run from the CDU. All of these troubleshooting options are readily available to the aircrew if problems occur with the DNS. If none of these troubleshooting options seems to help, then more extensive troubleshooting to investigate all of the DNS system wiring and the synchro interfaces to the HARS is in order.

8. GPS operations and the GPS battery. This section provides information on the role of the GPS within the nav system, operation of the GPS, and GPS battery issue.

8.1 Role of the GPS within the nav system. Eventhough the GPS is just a circuit card installed within the EGI LRU, its overall design and capability's allow for it to be a complete navigation system "on-a-card", but its implementation within the EGI is limited. It is used as a "strong" aid to the EGI Inertial Navigation System (INS). As such, it makes available to the INS excellent physical observations of motion and position. The combination of the excellent instruments used within the INS and the "strong" GPS aiding is what allows the INS to provide extremely accurate velocity and heading data to the FCC. The velocity and heading data are traditionally the parameters that are most difficult to make highly accurate. And within an Apache, the accuracy of these parameters (other data also) determine the overall nav, targeting and hover box accuracy of the aircraft.

The FCC uses the INS and the GPS as separate sensors that provide inputs to the overall nav solution. As such, the FCC uses the GPS position data directly in its overall determination of aircraft PPOS. This mechanization can be viewed as “automatic” (but filtered) PPOS updates. So in review, there are two primary roles that the GPS plays in the AH-64A. It is a “strong” aid to the INS, and it provides accurate position data to the FCC.

8.2 Operation of the GPS. The data displayed on the GPS STATUS page is an excellent way to determine the performance of the GPS during both the satellite acquisition phase, and during the execution of the mission. The data displayed on the GPS STATUS page comes directly from the GPS sensor and is not “processed” by the FCC. This allows the observer to see exactly what is going on with the GPS. Because the data is not “processed”, it is possible depending upon the present conditions, that the data displayed may be totally bogus or invalid (might be stale). This could happen when the EGI CB is pulled, if GPS jamming is present, or when there are 1553 communications problems on the aircraft.

During the satellite acquisition phase, there can be wide variations in the data content/timing displayed on the GPS STATUS page. For normal everyday ops, 4 or 5 satellites should be acquired in less than 1 minute (so long as the satellites are visible to the GPS antenna). That 1 minute will expand if the GPS is not allowed to regularly (less than 48 hours) acquire satellites and update its internal time/date clock. The satellite acquisition time will expand in direct proportion to the amount of time that expires in between GPS internal time/date clock updates (time elapsed since last satellite tracking session) . The satellite acquisition time will max out at around 15-20 minutes. This is also the same amount of time that it will take for satellite acquisition after loss of the GPS time/date clock (see below) or after having transported the GPS to a different position on the Earth (while not powered). These extended acquisition times can always be (and should be) reduced (to around 1 minute) by providing accurate PPOS, TIME (UTC or ZULU) and DATE entries to the GPS via the CDU NAV and ADMIN pages.

The FOM, EHE, EVE and SV values are all directly related. At startup, the GPS receiver needs to see at least 4 SV’s before it will start updating the FOM, EHE and EVE values. Normally the SV value should be 4 or 5. The FOM, EHE and EVE values will all lessen as SV’s are acquired. Line 7 provides an indication of crypto key status. There are indications for no key (INSUFF KEYS), invalid key (KIU INCOR or KEY PARITY ERR), key not verified (KIU UNVER) and finally key verified (KIU VER). Only when a key has been verified will the P CODE value become non zero. When that happens, the GPS receiver switches to the high precision mode, and the FOM, EHE and EVE values will all reflect higher accuracy (smaller values).

8.3 GPS battery issues. The battery is used to provide continuous power to the GPS time/date clock and the GPS crypto key module. If the battery goes too low, then both of these functions are lost. The loss of the crypto key is easily determined by observing line 7 on the GPS STATUS page (INSUFF KEYS will be displayed). At startup, the GPS receiver will go into wide angle satellite search mode if it detects the loss of the GPS time/date clock. This situation manifests itself by a very slow and long satellite acquisition process (15 minutes or more). The GPS BAT LO display on the NAV STATUS page is the indication to change the battery. There is a 1553 signal interface problem with the current GPS BAT LO indicator on the AH-64A only. The indication from the EGI to the FCC always indicates the battery is good. This problem has been acknowledged and will be corrected (see section 11).

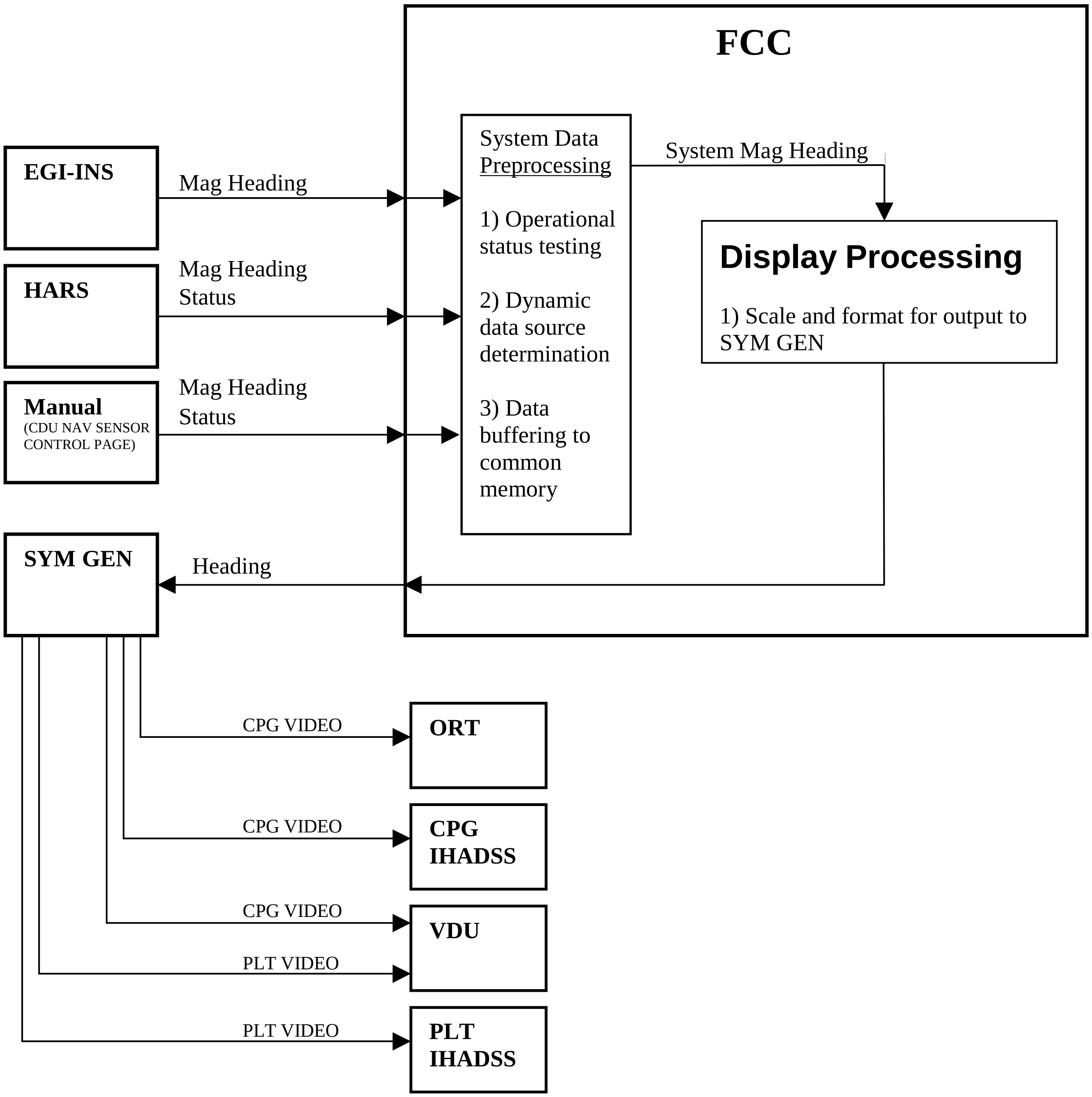
9. Video heading tape and the HSI – the details. This section provides information on how the video heading tape and the HSI are mechanized in the EGI modified AH-64A.

9.1 HARS interfaces and the HSI before and after ECP1198. It is important to remember that with the EGI modification to the AH-64A there were absolutely no changes made to the HARS, nor to any of the HARS interfaces, except for one. The only wiring change associated with the HARS was to utilize the HARS ready/valid (alignment complete used to drive the hdg/att valid flags on the HSI, RMI and ADI) 28 vdc discrete output as an alternate signal to supply power to the DNS. The primary signal source for supplying power to the DNS is the CDU. This alternate DNS power signal source (from the HARS) allows the CDU to be power cycled (when switching bus controllers) without removing power from the DNS. This was necessary in order for the DNS to perform gracefully when switching between the FCC and the BBC and vice-versa. So essentially, there have been no changes made related to the HARS or any of its interfaces, after ECP1198 has been installed.
What this means is that the HARS and its interface to the HSI are unchanged. So all previous troubleshooting techniques still apply after ECP1198 has been incorporated. After ECP1198 has been installed, the heading indication on the video displays will normally be driven by the EGI. But the HSI is still driven by the HARS. The magnetic heading synchro output from the HARS is what drives the HSI heading tape. The HARS magnetic heading is a combination of the HARS true heading estimate and the magvar that is supplied to the HARS from the bus controller. The HARS true heading estimate is internally calculated, and because the HARS has not been modified, the accuracy of this true heading estimate is still prone to the limitations of the current HARS mechanization. Figure 8 provides a simplified block diagram of the video magnetic heading tape signal flow.

9.2 Magvar handling before and after ECP1198. Prior to ECP1198, the FCC calculated the system magvar and supplied it to the HARS based upon changes in magvar received from the DNS. After ECP1198, the FCC determines if the system magvar is to be updated automatically by the INS or manually by the CPG. This system magvar is then summed with a heading difference correction and supplied to the HARS (pseudo magvar). The heading difference correction is a value the FCC calculates by subtracting the EGI magnetic heading from the HARS magnetic heading. The FCC sends this pseudo magvar to the HARS continuously so that the HARS heading matches the EGI heading. This is done to keep the HARS magnetic heading output as accurate as possible, and to keep it equivalent to the EGI magnetic heading. It would not be good for the pilot to observe one heading indication on the HSI, and a different heading indication on his video display.

9.3 Troubleshooting erroneous HSI heading indications. In order to determine if there is an "HSI only" heading display problem or a "system" heading problem, the aircraft needs to be configured so that the HARS is also driving the heading tape on the video display. For non-EGI aircraft this is not an issue, the HARS always drives the video heading. For EGI modified aircraft, the EGI CB should be pulled to allow the HARS to drive the video heading tape. If the HSI and video heading indications differ when the HARS is driving the video heading, then the observer must determine if the problem is associated with the instrument (HSI), the wiring, or the HARS. The instrument and the HARS can be easily swapped out to eliminate them. If replacing both of them does not fix the problem, then the problem resides in the wiring between the HARS and the HSI.

For EGI modified aircraft, if the invalid HSI heading indication is only exhibited when both the EGI and the HARS are running, then this means that the "keep the HARS heading equal to the EGI heading" concept (described in 9.2 above) is not working in total. What could cause something like this to occur is certainly not predictable (it would never be expected). If this does occur, the first thing that should be done is to zeroize the HARS MDM. If this does not fix the problem, then there must be something else on the aircraft that is causing the communication between the FCC and the HARS (via the DASE) to become corrupt. At this point, a more rigorous troubleshooting effort is required. Inspecting the magvar input to the HARS (002232), the HARS status word (002154) and the HARS magnetic heading output (002162) utilizing the FCC memory read function may provide some insight on which action to take next.



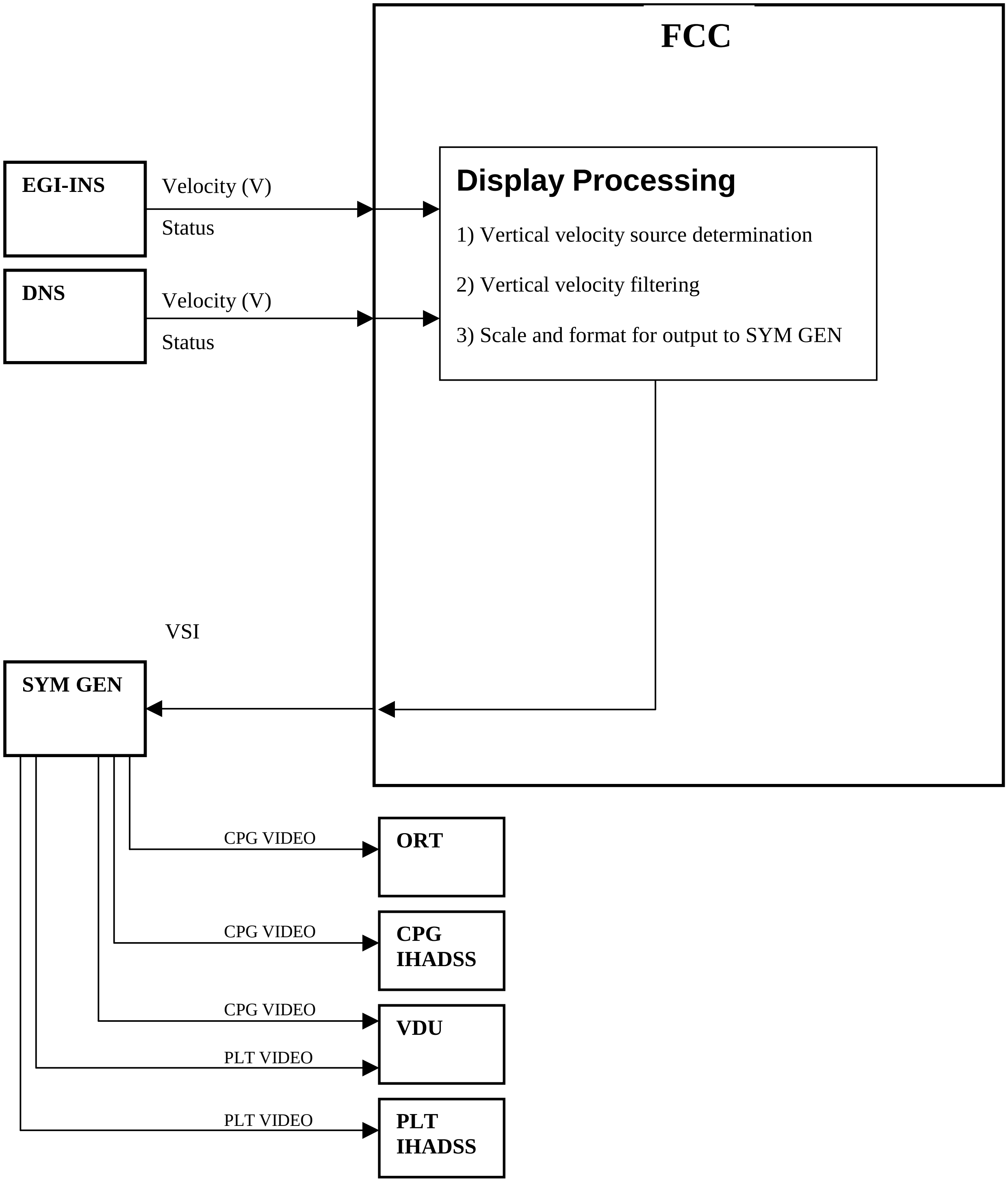
Details: EGI-INS and HARS mag heading/status data is updated to the FCC at 50 hz. Manual mag heading is updated to the FCC when manually input by the CPG. The System Data Preprocessing block is performed at 50 hz. The Display Processing block is performed at 12.5 hz. The Heading data from the FCC to the SYM GEN is refreshed at 25 hz.

Simplified Heading Tape Implementation Diagram
Figure 8

10. Video VSI mechanization. Prior to the EGI mod, the source data for the video VSI was the DNS. After the EGI mod, the EGI-INS is the primary source of vertical speed for driving the VSI and the DNS is now utilized as a backup. The FCC provides the control information to the SYM GEN for the VSI (as well as almost all the other symbology). The modification to the FCC to utilize the INS as the primary source and the DNS as the backup source was simple and straightforward. The existing (pre-EGI) mechanization in the FCC was left in place, with only the examining of the INS status and use of the INS vertical speed added to the new mechanization. The display smoothing was not changed, nor was the “zero-freeze” indication when there is no data to drive the VSI.

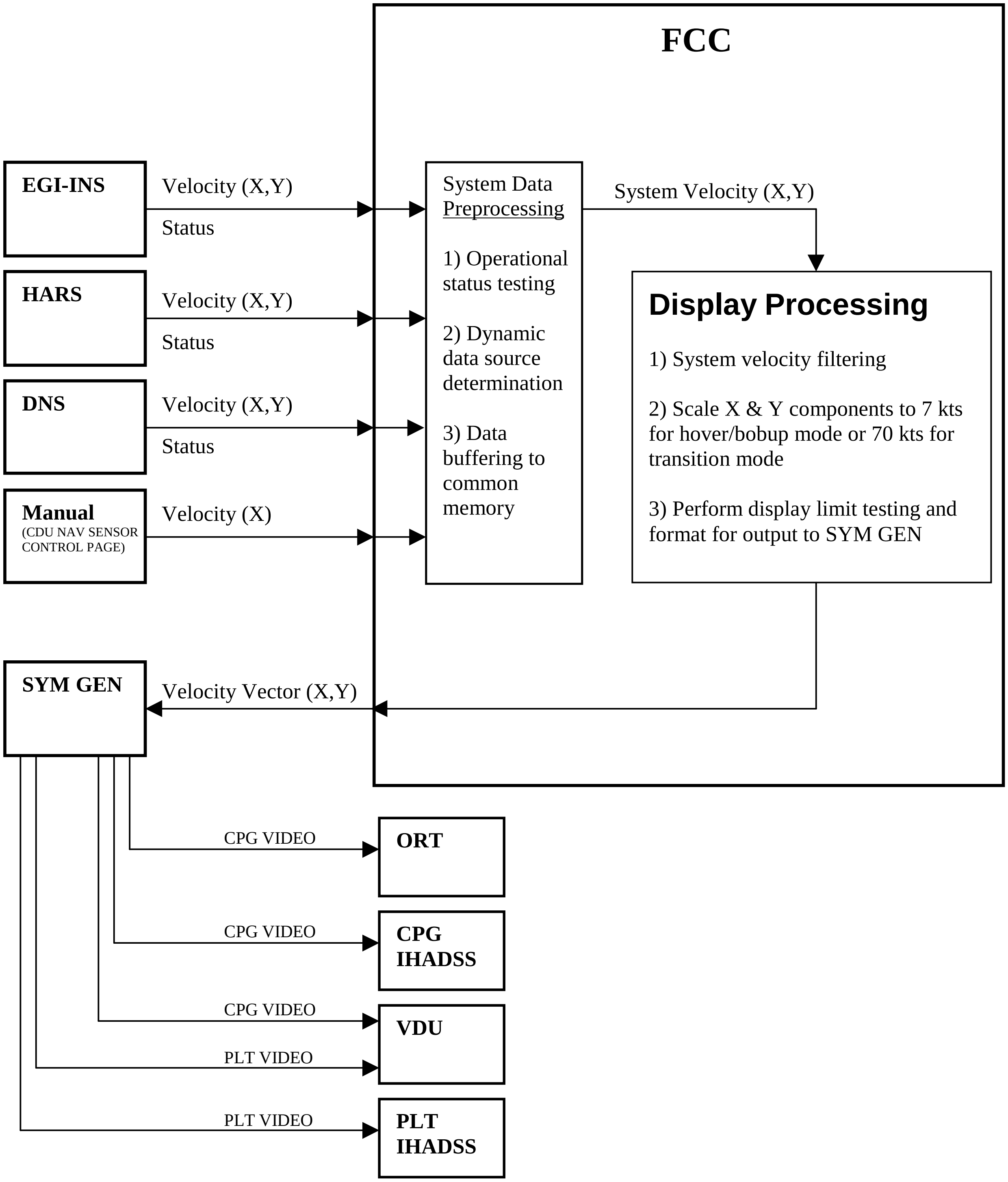
10.1 Troubleshooting VSI problems. If the VSI is behaving poorly (not doing what the aircraft is doing), the troubleshooting procedure to determine what is causing this indication is fairly simple. The LRU’s that are involved in driving the video VSI are the SYM GEN, the FCC, the INS and the DNS. Here is a logical sequence for troubleshooting anomalous video VSI indications while in flight:

1. If other symbols are also indicating erratic or “sticky” behavior or they look like they are “stale”, then the possible problem could be the SYM GEN. It is always a good idea to turn the SYM GEN “off” then “on” when troubleshooting anomalous display problems. This allows the SYM GEN to re-start, and if there were any processing hang-ups, a power-on initialization cycle will normally clear the problem. If the SYM GEN seems OK then proceed on. If not, then try changing the SYM GEN.
2. If the VSI indication is anomalous with an INS GO indication on the NAV STATUS page, it is possible that the INS is malfunctioning. At this point it would be good to switch to the DNS as the vertical speed source. Normal DNS performance requires a DNS GO on the NAV STATUS page, and no “MEM” indication displayed on the system annunciator line (left of the NAVSTAT indicator). If the DNS is OK, then pull the EGI CB to switch to the DNS. If the VSI indication now seems like normal DNS performance, then the INS could be the problem. The INS may or may not be malfunctioning at this point. A process of cycling the EGI CB, waiting for the INS GO on the NAV STATUS page, continuing to observe the VSI, as well as the velocity vector accuracy while at a “zero” hover, are all things that could and should be done to evaluate the INS performance. The INS is not expected to create velocity errors, but it is an aided system. It is possible (not expected) that some set of conditions could cause a temporary velocity error.
3. If the VSI indication does not seem normal when the DNS is the source, then the cause may just be “normal” DNS performance if the aircraft is on the ground or close to the ground. So to test the DNS properly, the aircraft should be at least 100 feet AGL.
4. If the VSI is still indicating abnormal when using the DNS above 100 feet AGL, then the cause may be a faulty SDCC or RTA. If swapping these units or the EGI does not solve the problem, then the possibility exists that there may be a more serious problem associated with proper multiplex system communications. If this were the case, then there are normally other systems or display indications that will be performing erratically. At this point a more rigorous troubleshooting procedure (requiring special test equipment) is necessary. As a last resort, the FCC could be swapped for a known good unit. It is unlikely that swapping FCC’s will fix the problem, but without any special test equipment, this can be tried.
5. Figures 9 thru 11 provide simplified block diagrams of the VSI signal flow, velocity vector signal flow and the acceleration cue signal flow, respectively, as an aid in troubleshooting invalid VSI or velocity vector/accel cue indications.



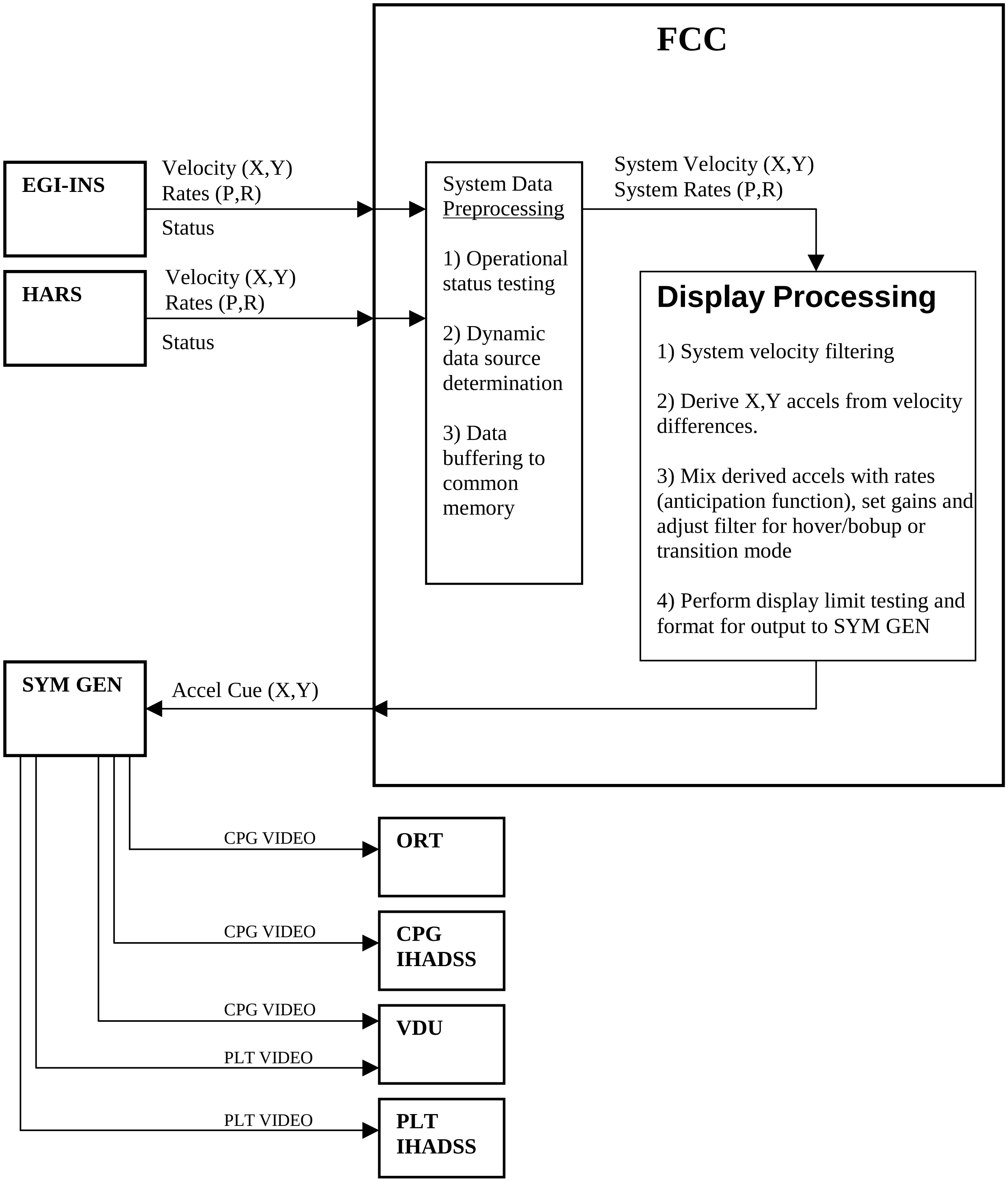
Details: EGI-INS velocity/status data is updated to the FCC at 50 hz. DNS velocity/status is updated to the FCC at 25 hz. The Display Processing block is performed at 25 hz. The VSI data from the FCC to the SYM GEN is refreshed at 25 hz.

Simplified Video VSI Implementation Diagram
Figure 9



Details: EGI-INS and HARS velocity/status data is updated to the FCC at 50 hz. DNS velocity/status is updated to the FCC at 25 hz. Manual velocity is updated to the FCC when manually input by the CPG. The System Data Preprocessing block and the System velocity filtering (item 1 in the Display Processing block) are performed at 50 hz. Items 2 and 3 in the Display Processing block are performed at 25 hz. The Velocity vector data from the FCC to the SYM GEN is refreshed at 25 hz.

Simplified Velocity Vector Implementation Diagram
Figure 10



Details: EGI-INS and HARS velocity/rates/status data is updated to the FCC at 50 hz. The System Data Preprocessing block and the System velocity filtering (item 1 in the Display Processing block) are performed at 50 hz. Items 2, 3 and 4 in the Display Processing block are performed at 25 hz. The Accel Cue data from the FCC to the SYM GEN is refreshed at 25 hz.

Simplified Acceleration Cue Implementation Diagram
Figure 11

11. Future FCC Updates. As this manual is being prepared, negotiations are in progress to provide an FCC update to the fleet. There are a number of issues that are being addressed in this update. The primary issues being addressed in this FCC update are:

1. Adding a selectable Flechette rocket type.
2. Making the GPS BAT LOW indication work.
3. Adding AWS firing inhibits for an invalid, failed or over-ridden LOS or whenever the AWS command reaches a rate limit.
4. Eliminating un-intended HARS inflight alignments due to engine start noise spikes and aircraft attitude limitations.
5. DNS power-up bit false synchronization failures.
6. "LRFD ENRGY LO" AND display logic correction.
7. Adding a system wide GPS inhibit function.
8. Adding aircraft flight data parameter recording to the DTC event file.
9. Adding a single FAB press for displaying the AND on the CDU.

Besides these primary issues, all issues that have been reported from the field that could be duplicated, as well as issues discovered in-house, have all been addressed in this FCC update. This update when fielded, should provide an even more capable nav/targeting platform, with added performance and stability.

Glossary

ADI	**Attitude Direction Indicator**
ADS	**Air Data System**
AGL	**Above Ground Level**
AND	**Alpha Numeric Display**
AWS	**Area Weapon System (the 30mm canon)**
BBC	**Backup Bus Controller**
CB	**Circuit Breaker**
CDU	**Control Display Unit**
CGA	**Coarse Ground Alignment**
CIFA	**Coarse In Flight Alignment**
CPG	**Co-Pilot/Gunner**
CSA	**Coarse Sea Alignment**
DASE	**Digital Aircraft Stabilization Equipment**
DNS	**Doppler Navigation System**
DSD	**Dynamic State Data**
DTC	**Data Transfer Cartridge**
ECP	**Engineering Change Proposal**
ECP1198	**The installation of the EGI, and more, on the AH-64A**
EGI	**Embedded GPS Inertial**
EHE	**Estimated Horizontal Error**
EVE	**Estimated Vertical Error**
FAB	**Fixed Action Button**
FCC	**Fire Control Computer – Primary Bus Controller**
FGA	**Fine Ground Alignment**
FIFA	**Fine In Flight Alignment**
FOM	**Figure Of Merit**
FSC	**Fine Sea Alignment**
GPS	**Global Positioning System**
HARS	**heading Attitude Reference System**
HSI	**Horizontal Situation Indicator**
ICGA	**Interrupted Coarse Ground Alignment**
IFGA	**Interrupted Fine Ground Alignment**
IHADSS	**Integrated Helmet And Display Sighting System**
INS	**Inertial navigation System (or Set)**
KIU	**Keys In Unit**
LOS	**Line Of Sight**
LRFD	**Laser Range Finder/Designator**
MDM	**Mission Data Memory (HARS)**
MEM	**Memory (DNS)**
NAV or nav	**Navigation**
NAVSTAT	**Navigation Status**
OFP	**Operational Flight Program**
ORT	**Optical Relay Tube**
P/R	**Pitch and Roll**
PLT	**Pilot**
PPOS	**Present Position**
RMI	**Remote Magnetic heading Indicator**
RTA	**Receiver/Transmitter Assembly**
SDCC	**Signal Data Converter Computer**
SV	**Space Vehicles or Satellites**
SYM GEN	**Symbol Generator**
VDU	**Video Display Unit**
VSI	**Vertical Speed Indicator**

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