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IPC DATA LOGGER (A Flight Data Recorder): Operation Manual

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1. Introduction

The IPC Data Logger (a flight data recorder) is designed to support research involving pilot performance in executing instrument flight procedures. The system is designed for use in small single engine aircraft and can easily be removed to return the aircraft to normal service. The system is based on a commercial single board computer, recording data at the rate of one frame per second. In addition to aircraft position and altitude, pitch, roll, yaw, magnetic heading, vertical speed, and airspeed are recorded. The radio-navigation displays (Very-high-frequency Omni Range/LOCalizer (VOR/LOC) and Glideslope) are also recorded. Provision is made for the check pilot/operator to mark sections of the flight records to aid in the subsequent analysis of the data. Apart from connection to the pitot/static system and the navigation displays, instruments internal to the Data Logger generate all data.

The data logger is housed in an aluminum enclosure 22 inches in width, 24 inches in length, and approximately 12 inches in height. The weight is approximately 42 pounds. To install the IPC Data Logger in the aircraft (Beech Sundowner C-23, in this application), the rear seats were removed and the logger mounted in their place; a custom floor plate to which the Data Logger is mounted replaced the original floor of the rear seating and baggage area. A flux-gate magnetic compass system is mounted in a separate non-magnetic enclosure so as to allow its positioning within the airframe in order to provide the most accurate heading information possible.

Wiring of the aircraft has been modified to supply 12-volt DC power and to provide the data from the aircraft's VOR/LOC's and Glideslope systems to the Data Logger. An FAA/PMA approved GPS antenna was installed on the fuselage above the front seating area. This is the only available horizontal area with an unobstructed view of the sky. The VOR/LOC antenna distribution system was modified to allow connection of the RDS (differential correction system) receiver. The pitot and static air systems were modified to provide for connection to the data logger for measurement of airspeed.

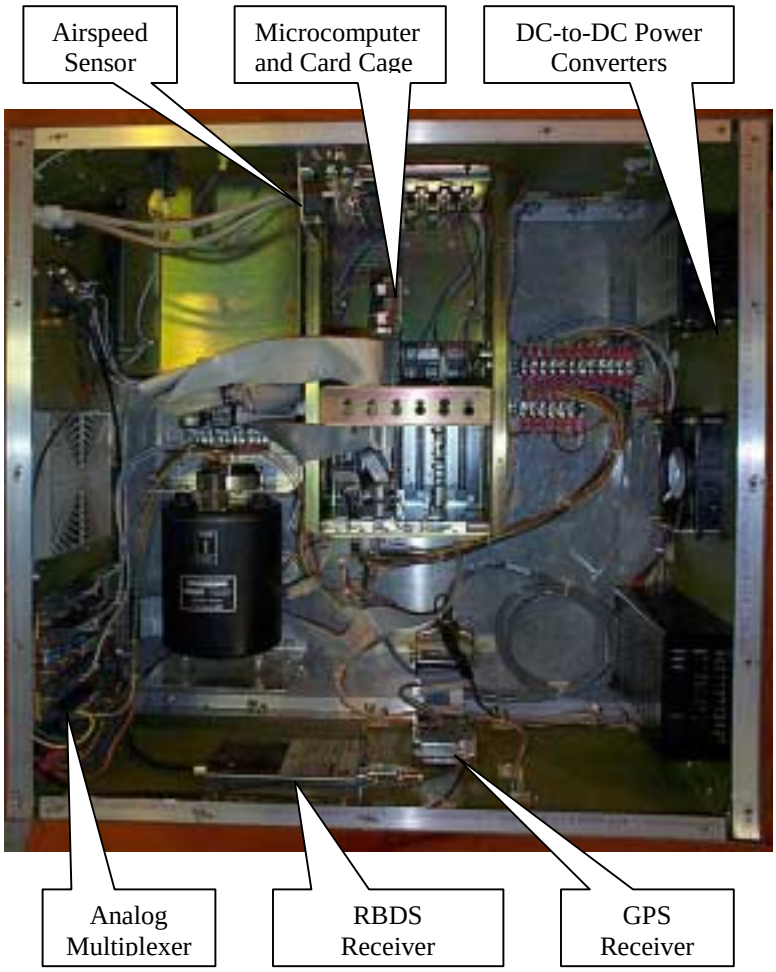
These modifications were field approved by the local Flight Service District Office (FSDO). A test flight was required by the FAA to demonstrate the data logger did not adversely effect the operation of critical aircraft systems. FAA Form 337 (Major Repair or Alteration) was submitted to document these modifications.

The Data Logger may be adapted to aircraft other than the Beech Sundowner. Some component changes and wiring modifications would be required to operate the system in an aircraft that is equipped with a 24 volt DC power system. Re-calibration of the airspeed may be required to accommodate a different pitot-static system.

The interface to the radio-navigation systems (VOR/LOC and GS) was designed for the Bendix/King KI-2xx system of outputs; wiring modifications within the Data Logger may be required if other navigation radios are employed.

2. Components

All the components of the Data Logger System are houses in a single enclosure with the exception of the Compass System and User Display/Control Console. The locations of the major components are inlustrated in the Figure below.



Single Board Computer

The central component of the Data Logger is the single board computer. This unit is essentially an IBM PC compatible computer that is fabricated on a single Industry-Standard- Architecture (ISA) board yet is capable of operation in a greater range of environmental conditions than a standard desktop personal computer. The Industrial Computer Source Model SB486PV single board computer is designed around an Intel 486DX100 microprocessor and provides support for keyboard control, video adapter, both fixed and floppy disks, two serial ports, and one parallel port. The Intel 486DX100 has a built-in numeric co-processor, which would not normally be needed since no extensive floating-point mathematical calculations are required in the operation of the Data Logger. However, the present compilation of the software assumes such a co-processor is present. The keyboard and video adapter/display are used only during development and repair/maintenance functions. A rugged card cage/passive motherboard is used to house the SB486PV, an additional serial port interface, and an analog-to-digital converter. There are at least two additional ISA slots available for additional hardware if required for additions to the present configuration.

The disk operating system is MSDOS 6.22 and is completely standard. The system is capable of operating as a normal personal computer with no modification except for changes to the autoexec.bat file, which is designed to start the data logger software automatically following the load of the MSDOS operating system when the system is powered.

There are a number of settings in the BIOS of the SB486PV single board computer that have been modified from the standard configuration to facilitate the operation of the Data Logger. These are documented in Appendix 1.

Digital Storage Devices

The system is equipped with a 3 Gigabyte IDE fixed disk that contains the MSDOS operating system, the data logger software, and provides primary storage for the recorded flight data files.

A 3½" floppy disk drive is also provided to permit a convenient method of updating the software and to off-load the Data Logger data files at the end of each logging session. The Data Logger will not attempt to load an operating system from the floppy drive and depends completely on the fixed disk for operation.

Serial Data Ports

Two serial data ports (RS-232) are the standard hardware provided on the SB486PV single board computer. These are configured in the industry-standard manner as COM1 (I/O Ports 3F8-3FF, IRQ 4) and COM2 (I/O Ports 2F8-2FF, IRQ 3).

A third serial port is required for data logger operations. A SIIG I/O Professional multifunction input/output board, Model IO1809, provides this capability. This board has two additional serial ports and one additional parallel port. In this application, only one serial port is used and the remaining serial port and the parallel port are disabled. The serial port on the SIIG board is configured in a non-standard manner since all serial input/output in the data logger uses interrupt driven routines and each serial port must have a unique IRQ (hardware interrupt request) channel. This port is designated COM3 (I/O Ports 2E8-2EF, IRQ 5). The hardware configuration of this board is documented in Appendix 2.

COM1 communicates with the Global Positioning receiver; COM2 with the User Display/Control Console, and COM3 with the KVH Compass System.

All serial ports operate at 9600-baud, no parity, 8-bit of data with 1 stop bit (9600N81).

Analog to Digital Converter

An analog-to-digital converter allows the recording of the following analog variables in digital format.

- Aircraft pitch and roll data from the Vertical Gyroscope
- Aircraft yaw data from the Pendulum
- Airspeed data, derived from a differential pressure sensor
- Electronic Navigation data from VOR, LOC, Glideslope

In total, there are twelve channels of analog information that are sampled and converted into digital data in this application. It is possible to add significant number of additional analog sensors to the system, up to 128-channels. The magnitude of the variables to be measured range from a few tenths of a volt full scale to 10 volts full scale. Additionally, some variables are referenced to ground potential while others are the difference between two voltages (differential).

In order to accommodate the range and types of signal voltages, an analog-to-digital converter plus a 16-channel analog multiplexer are employed. The analog-to-digital converter is a Model AD12-8 manufactured Industrial Computer Source, the multiplexer is Model AT16-P by the same manufacturer. The hardware configuration of these boards is documented in Appendix 4.

The basic analog-to-digital converter used is capable of 12-bit resolution: one part in 4096. The combination of the AD12-8 and AT16-P allow up to sixteen channels of both single-ended and differential inputs with the gain (amplification) of each channel individually selected under control of the software.

The A/D system incorporates a counter/timer system that is used to automatically sequence through all of the active channels once given the command to begin the analog-to-digital conversion. Hardware interrupts are used to determine when each conversion is complete. A number of sequential conversions are averaged to determine the final value to be recorded for each of the variables measured.

A precision + 10 volt DC reference voltage output is provided by the AD12-8 to excite those sensors which require such an external source (the vertical gyroscope, pendulum, and airspeed sensor).

Vertical Gyroscope

A vertical gyroscope is employed to provide aircraft pitch and roll information for the Data Logger. The component used is the Model VG24-0825-1 manufactured by Humphrey, Inc. The time to erect is less than nine minutes, ± 0.5 degrees. The unit weighs 3.0 pounds and requires 1 amp of starting current, 0.4 amps running current at 28 volts DC. The operational limits are ± 60 degrees of pitch; the roll axis is continuous (360 degrees).

The unit is shock mount in a specially fabricated carrier (which also is used to mount the Pendulum system described below) and this carrier is further isolated from the Data Logger enclosure by Lord mounts.

The outputs are provided by two potentiometers requiring an external DC excitation voltage (the +10 volts DC supplied from the analog-to-digital converter system described above). The signal is nominally 66 millivolts per degree in the roll axis and 80 millivolts per degree in the pitch axis. Both axes are calibrated initially on the bench at 0 degrees and ± 45 degrees. Flight tests are performed to verify that the recorded data accurately represents the data provided to the pilot by the standard aircraft instruments.

Pendulum

A standard pendulum is employed to sense aircraft yaw in the same manner as the ball of a rate-of-turn indicator. The instrument used is the Model CP17-0601-1 produced by Humphrey, Inc. This is a passive instrument with a range of ± 45 degrees and a weight of 6 ounces.

Output is by means of a center-tapped potentiometer excited by the same 10 volt DC source used for the gyroscope excitation. The voltage is sensed differentially between the center tap and the wiper yielding an output of zero volts in the vertical position. Positive voltage indicates deflection to the right; negative voltage, deflection to the left. The signal is nominally 110 millivolts per degree.

The pendulum is mounted on the gyroscope carrier described above and is mechanically adjusted to provide a zero volt output when the Data Logger is precisely oriented in the horizontal plane and at rest. Flight tests verified the correspondence between the ball of the pilot's turn coordinator instrument and the pendulum sensor.

Compass System

Although the Global Positioning System is capable of providing the course-over-ground (COG), the Data Logger is equipped with a magnetic compass system to provide the true aircraft heading. The unit chosen is an electronic flux-gate compass system that provides data via a serial RS-232 output.

KVH Industries, Inc manufactures the C100 Compass Engine. It is available in two configurations, the SE-10 gimbaled coil was chosen for this application. The compass engine is mounted in a separate non-magnetic enclosure and positioned in the aircraft cabin in order to minimize magnetic, electrical, and electronic interference from the aircraft frame and electrical systems. The output is in units of degrees with a resolution of 0.1 degrees. The compass engine is provided with user selectable output filters and a selectable time-constant for this filter. The filter selected for this application is a double low-pass filter with a time constant of three (3) seconds.

The C100 Compass Engine has a built-in autocompensation system that enables the system to calibrate itself to maintain accuracy to a fraction of a degree even when surrounded by the airframe that distorts the earth's magnetic field. The autocompensation procedure is performed upon initial installation of the Data Logger.

The Data Logger displays the heading determined by the compass system during the start-up procedures. The operator is given the opportunity to compare this reading with the aircraft magnetic compass to verify proper operation. In the event of a discrepancy, the operator or a technician can initiate a new autocompensation procedure directly from the Display/Control Console. See the Maintenance and Troubleshooting section for details.

The flux-gate compass system is not gyroscopically aided. This implies that large errors in the magnetic heading will occur during periods the maneuvers of the aircraft cause the flux-gate to deviate from the horizontal plane. A coordinated turn is one such maneuver: where the perceived gravitational force is perpendicular the plane of the aircraft's' wings and not perpendicular to the surface of the earth.

Positioning System

GPS Receiver System

The Ashtech Model G12 Global Positioning System (GPS) receiver is installed in the Data Logger. This receiver is capable of tracking up to twelve satellites simultaneously using both code and carrier phase data. It can accept standard RTCM SC-104 V2.1 differential corrections. The G12 used is the OEM version: Part Number 990190. The receiver is connected to a "keep-alive" battery to maintain the GPS constellation almanac data between operating sessions.

An active GPS L1 band aircraft type antenna is mounted on the fuselage of the aircraft above the front seating area to provide the most unobstructed view of the sky possible.

Communication with the GPS receiver is by way of two RS-232 serial ports (Ports A and B). Port A is used for GPS receiver control and data output; Port B is dedicated to receiving differential correction data from the DCI differential correction system described below. Both ports are operated at 9600 baud, 8 data bits, 1 stop bit, and no parity.

The Ashtech G-12 receiver remains configured in the factory default mode. The Data Logger software accomplishes all initialization of the receiver. The Data Logger software is configured so that flight logging can not begin until and unless the GPS receiver is providing differentially corrected three-dimensional position data. If three-dimensional position and/or differential corrections are lost after data logging has begun, the session continues with the appropriate notations recorded in the data file.

The time-stamped navigation messages from by the GPS receiver are used to provide the timing of data acquisition. The receiver provides a position fix once per second and the receipt of this position fix causes the Data Logger to record the position information and all other measured parameters to the logging data file.

If, while recording flight data, the Global Position System loses lock and fails to provide data output, the Data Logger will continue to record data using the internal operating system clock to trigger the storage of data points. No position data will be available, but all other variables continue to be recorded. When and if the GPS reacquires the satellites, logging will revert to timing using the GPS position message as described above.

GPS system time is used to set the internal real-time clock of the underlying operating system (MSDOS 6.22) upon initial GPS receiver lock-on.

Differential Correction System

There were several options available as to the method used to obtain the RTCM differential correction data needed to provide the level of accuracy required. The simplest and most cost effective was determined to be the Radio Data System (RDS), which distributes digital data via a sub-carrier on standard FM commercial broadcasts. Differential Corrections Inc. (DCI) provides the service used in this application.

This is a subscription service requiring a separate license for each RDS receiver serviced. An RDS-3000 receiver (also supplied by DCI) is required to access and decode the FM RDS sub-carrier. The RDS-3000 is an automatic frequency scanning FM receiver that searches for a useable RDS sub-carrier, locks-on, decodes the differential correction information, and outputs this information via a serial RS-232 connection to a differential-ready GPS receiver. This output is connected directly to the Ashtech G-12 GPS receiver as described above. The combination of the G-12 and RDS-3000 provides a differentially corrected horizontal accuracy of 1 meter (2d RMS). Vertical accuracy is on the order of 1.6 meters RMS.

The VHF navigation antenna of the aircraft is used to receive the FM broadcast stations. It was determined by flight tests that this was a satisfactory solution for ranges of at least 55 nautical miles from the FM station location. Since the flight tracks used in the present application are never further than 30 nautical miles from a ground station broadcasting DCI correction data, no difficulties have been experienced in obtaining correction data during any flight logging sessions.

Radio-Navigation Instruments

The Data Logger records the radio-navigation indications from two VOR/LOC displays and one Glideslope display. The left-right (up-down) deflection of the course-deviation-indicators (CDI's) is recorded in addition to the state of the system flags and TO-FROM indicators (in the case of VOR operations). This requires a total of eight analog-to-digital channels.

This data are derived from the outputs of the panel mounted display units normally used to connect to an autopilot. The Bendix/King units installed in the Beech Sundowners used in this application provide industry-standard CDI signal voltages (±150 millivolts for a full scale deflection); however, the flags and TO-FROM signals are not exactly standardized and the Data Logger software is designed to accommodate the voltages specific to these instruments.

As a safety precaution, all connections to the aircraft navigation displays are routed through relays which totally isolate the aircraft navigation circuitry from that of the Data Logger when the Data Logger is turned off (or loses primary power).

Airspeed Sensor

The Data Logger measures airspeed in the same manner as an aircraft airspeed indicator, which senses the differential pressure between the pitot port and the static port. However, the processing and conversion of differential pressure to altitude is accomplished electronically in the Data Logger.

The differential pressure sensor is a Model 140PC01D produced by the Micro Switch Division of Honeywell. It requires an excitation voltage (the same +10 volt DC source used for the gyroscope and pendulum) and produces an output voltage proportional to the pressure difference between units' two ports.

From standard FAA calibration specifications it was determined that following formula defines the relationship between the differential pressure (expressed in inches of mercury) and the airspeed (expressed in Knots).

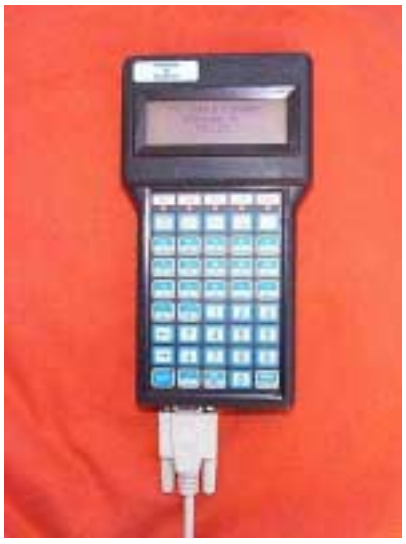
$$Airspeed = 142.91\sqrt{differential\ \ pressure}$$

This relation is employed in the Data Logger and flight-testing indicates the recorded airspeed is within 1 or 2 Knots of that of the aircraft's airspeed indicator within the speed range of interest (approximately 65 to 110 Knots).

User Display/Control Console

The User Display/Control Console is a handheld ASCII terminal that has two primary functions.

- Allow the operator to start/stop the logging of flight data and optionally mark data records
- Display the state of the Data Logger and indicate the progress of the logging operations



The unit used in this application is the QTERM-II ™ manufactured by QSI Corporation. The particular model chosen has a backlighted display, RS-232 9-pin "D" type connector, and the wide-temperature option. The alphanumeric display is four lines of twenty characters each. The unit has a forty (40) key tactile keypad; of which, five are user-definable. Five light-emitting-diode (LED) indicators are available for displaying status information in addition to the alphanumeric display.

The five LED indicators are labeled REC, GPS, DIFF, GYRO, and MARK.

- REC indicates that the Data Logger is recording data.
- GPS indicates that the GPS receiver is providing 3-dimensional position data.
- DIFF indicates differential corrections are being applied to the GPS data.
- GYRO indicates that the vertical gyroscope has erected.
- MARK indicates that the data being recorded is being “marked” (to aid later analysis).

Below the five LED indicators are five custom keys labeled START-STOP, EXIT, RESTART, CAL COMP, and TGGLE. These are the only keys that the operator normally uses during operation of the system.

- START-STOP allows the operator to start and stop logging data. The GPS, DIFF, and GYRO LED’s must be lit before logging can be started. Logging can be started and stopped as often as required; all the recorded data is stored in a single file.
- EXIT allows the operator to start the shutdown procedures after the final termination of data logging. "EXIT"ing copies the present data file to floppy disk (if present) and terminates the Data Logger functions allowing the power to the system to be safely turned off.
- RESTART allows the operator to restart data logging after some abnormal behavior terminated the previous logging session. If restarting is possible, the operator will be informed by text on the display.
- CAL COMP (calibrate compass) allows the operator to command the system to perform an autocompensation procedure on the magnetic compass system. This key is inoperative if the Data Logger is presently logging flight data!
- TGGLE (toggle) allows the operator to mark portions of the flight for later analysis. Pressing the key once starts the marking process; pressing the key again ends marking. The marks are numeric tags, incrementing automatically. The operator is informed of the numeric value of the tag by text on the display. Marking is only functional while the Data Logger is recording data.

No other inputs or keys are required during normal operations of the Data Logger; however, two more keys are active to control the display functions. See the Operation section for details.

Some additional functions and displays are provided for maintenance purposes; these are discussed in the section Maintenance and Troubleshooting.

Power Converters

The complete Data Logger requires approximately 4.5 amps from the aircraft 12-volt power buss. The aircraft power buss and wiring is protected by a 10-amp circuit breaker in the primary power circuit of the Data Logger. Two switching DC-to-DC converters are required in 12-volt aircraft; only a primary converter is required in 24-volt aircraft (in addition to changes to other components of the Data Logger, see the section Maintenance and Troubleshooting for details).

Primary Converter

The primary DC-to-DC converter is that which converts the aircraft DC power to the voltages required to operate the single board computer and other components that require compatible regulated voltages (the Display/Terminal and the Compass System).

The input of the primary converter (for the Beech Sundowner) is 12 volts DC, the outputs are

- +5 volts DC regulated
- -5 volts DC regulated
- +12 volts DC regulated
- -12 volts DC regulated

The primary DC-to-DC converter used is the Model PD110-40L by International Power Sources, Inc. This unit requires an input of 10 to 20 volts DC and provides the four regulated output voltages listed above. The unit is capable of providing + 5 volts DC @ 10 amps, + 12 volts DC @ 9 amps, –12 volts DC and – 5 volts DC both @ 1 amp (total power output not to exceed 110 watts). The + 5 volt output is over-voltage protected and all outputs are over-current protected.

Secondary Converter

The secondary DC-to-DC converter is required only in aircraft that are equipped with a 12-volt electrical system (such as the model of Beech Sundowner employed in this application).

The Vertical Gyroscope requires 24 volt DC for operation; the secondary converter provides this voltage. This converter is not required if the aircraft electrical system is 24 volt DC since then the aircraft power bus can power the gyroscope directly.

The secondary DC-to-DC converter used is Model VT25-142-10 manufactured by Converter Concepts, Inc. This unit requires an input of 10 to 40 volts DC and provides an output of 28 volts DC @ 1 amp.

3. Software

System Operating Software

The software for the Data Logger was developed using Borland C++ Version 3.1; however, the code is all standard C with no C++ extensions. An asynchronous communication library, Greenleaf CommLib Level 2, was used to provide a more robust serial communication environment than is natively available in the Borland product. Software drivers for the analog-to-digital converter system were provided by the manufacturer, Industrial Computer Source.

The objectives and constrains on the software design are outlined in the following list.

- Simple and easy to use; placing as little additional workload on the operator as possible.
- Self-diagnostics of sub-systems on start-up.
- As immune from operator error as practical.
- Capable of recovery from in-process errors.

The program requires a file called logger.ini to function. This file contains the system identification (A or B, as presently only two systems have been constructed), the path or directory into which the logger data files are to be placed, and calibration data for the analog channels which are hardware dependent (pitch, roll, ball, and airspeed). This allows re-calibration of the system without the need to re-compile the basic program.

Most of the inputs are channeled through hardware interrupt serviced input/output ports to insure that data from the external devices is received without loss of information. A system of flags and semaphores are used to indicate when data is available for each module to process, thus allowing the software to bypass modules which need not be run at that particular instant.

After the initialization of the sub-systems, the program enters the main program loop; each function within the loop performs a specific, relatively short task on the data available to be processed and then passes

control the next task. By these means, an operating system, which was never designed to be multitasking, can be manipulated into a multitasking function. For example, one task reads available characters from the GPS system and places them in a buffer (temporary storage). This routine places each message in a separate buffer and sets a flag if a complete message is available. Later, another task interrupts the buffered message and acts upon the result. In the meantime, other tasks are performed (such as servicing the analog-to-digital converter system, scanning for and acting upon operator keyboard input, processing data, storing data, and updating the LED's and text messages of the terminal). When operating and collecting data, this loop is executed approximately three hundred times per second.

A data record is taken each second and stored to a temporary buffer. Every ten seconds, this buffer is written to the fixed disk and the file is closed. This procedure ensures that if software or hardware failure occurs during a flight logging session, the data recorded (with the possible exception of the last ten seconds) is saved and recoverable.

The logger data is stored to the fixed disk in binary format that minimizes the time and disk space required to store each record. A binary record is only 60 bytes long. One hour of flight data occupies only 211 kilobytes of storage and thus a data file representing more than six hours of flight data can easily be stored on a 3 ½" floppy disk.

When the operator ends a logging session and exits the program, the recorded data file is copied to the floppy disk automatically. If this operation fails for any reason (no disk present, disk not formatted, or some other reason), the file is retained and written to the floppy disk on the next opportunity. In any event, the data files are always retained on the fixed disk and may be retrieved using standard DOS command-line procedures.

The program consists of multiple modules, the source code for which may be found in Appendix 7.

Post Flight Data Conversion Software

As noted above, the flight data files are stored in binary for reasons of minimizing the file writing time and to allow them to be easily transported via floppy disks. Although the binary format uses standard IEEE floating point formats, it was determined that conversion to a standard text (ASCII) format would allow the maximum flexibility in viewing and analyzing these data.

Programs have been written to read the binary data files and convert the records to text format (ASCII). In the converted ASCII file, "tab" characters separate the fields of each record and records are separated by a carriage-return/line feed (newline) character(s).

There are two versions of the conversion program; these differ only in the treatment of the horizontal position information. The standard horizontal position output of the Global Positioning System Receiver is latitude and longitude. The first version of the conversion program (**convert.exe**) directly converts this data to the ASCII format. The second version (**utm-con.exe**) converts the horizontal position data to Universal Transverse Mercator (UTM), in place of latitude and longitude. UTM uses "northing" and "easting" as the coordinates (in addition to a UTM zone number).

The advantage of using UTM coordinates is that UTM is a rectilinear system. This simplifies the process of plotting the aircraft's' course. The "northing" and "easting" coordinates are expressed in meters and are converted from the latitude/longitude data to a resolution of one meter in this application.

The source code for both conversion programs may be found in Appendix 7.

4. Operation

General Operational Procedures

The initial display on the handheld display/control console is a sign-on message indicating the SystemID and software version. This is followed by a check for the presence of a floppy disk in drive A and giving the operator the opportunity to insert one. If a disk is present, an estimate of the flight length (in hours) that can be stored on this floppy is displayed. If there is no disk in the drive, the program continues after a short delay.

The system then displays the magnetic heading to allow the operator to judge if the system compass and aircraft compass agree. Pressing ENTER terminates this display.

As soon as a GPS lock is obtained, the system clock is synchronized to UTC (Zulu) time!

LED's on the terminal are illuminated to indicate:

- GPS position fixes are available [GPS]
- Position data are differentially corrected [DIFF]
- System vertical gyro has erected [GYRO]

Once these three conditions are true (LED's lit), the message "READY" will be displayed and pressing the START/STOP key begins recording data. The REC LED will light; indicating recording is in progress. The top line of the display will indicate the number of records that have been recorded; this number will continue to increment as long as the unit is recording flight data.

After ten seconds, the automatically generated filename will be displayed. The filename format is [SystemID] [day] [hours] [minutes]. [year] [month]; e.g. A072115.985 is the filename of the flight data taken with System "A" beginning at 2115Z on May 7, 1998.

Once recording, the operator may press TGGLE to flag certain critical segments of flight data records. The MARK LED will light and all subsequent records will be marked *until* TGGLE is pressed once again. A mark is an integer recorded in the record, beginning at one (1) and incremented upon each use of the marking function. The bottom line of the display indicates the present state of the marking function and the present or last marking number used.

If the GPS signal or differential correction signal are lost while recording, the recording ***will*** continue with no position or altitude data in the first case or with loss of precision in the second. The appropriate LED will blink rapidly to signal the loss of either function.

Pressing START/STOP once again terminates recording of data.

Pressing the EXIT key will attempt to write the recorded data to the floppy disk. Regardless is the success or failure of this operation, the system will shut down the interfaces to the data systems and inform the operator when it is permissible to shut off the power to the system.

Errors and Recovery

There are many possible fatal (and non-fatal) errors, which will be trapped, and a message displayed on the handheld terminal! There will be, no doubt, other faults in the hardware and software which may just STOP the system with NO displayed error message. If an error message is displayed (or if the logging just stops inexplicably), pressing the "reset" button on the Data Logger or turning the power switch OFF and then back ON will re-initialize the system.

In any event, **if** the system was recording, a process is in place that allows the operator to restart recording data to the original file.

If restart is possible, the sign-on message, check for disk, compass checks, and gyro check will be bypassed. The message "Restart Possible" will be displayed!

The operator may press RSTRT on the handheld terminal to resume recording (if GPS and DIFF LED's are lit).

If it desired that subsequent flight data be recorded to a new file, the aircraft must be flown straight and level until the GYRO Led is lit; then if the GPS and DIFF are also lit, pressing the START/STOP key begins recording to a new file.

Other Features

Calibrate Compass: When NOT recording data, the operator may press CAL COMP to begin a compass calibration (autocompensation) procedure. Messages on the handheld terminal will guide the operator through the series of steps required to do an eight-point ground calibration of the magnetic compass engine. The operator may abort this procedure at any time. The unit displays information on the accuracy of the calibration upon completion. Details on this procedure may be found in the Maintenance and Troubleshooting section.

Display Contrast: By pressing "C" on the keypad, the operator can increase the display contrast on the terminal. Each press increases the contrast until maximum contrast is reached and then "wraps around" to minimum contrast.

Display Backlight: By pressing "B" on the keypad, the operator may toggle the backlighting on the LCD display.

File Recovery: If after a flight the data file is ***not*** copied to the floppy disk for any reason, that file is retained on the hard disk marked as not copied. The next time the system is used, any un-copied data files previously stored will be copied to the floppy disk in addition to the data file just recorded. One floppy disk can contain approximately 6.75 hours of flight data.

By starting the Data Logger and NOT pressing START but pressing EXIT, an operator may copy any previously un-copied data files from the system's fixed disk on a floppy.

Operational Error Codes

The following table contains the Error Codes displayed on the handheld terminal when an unrecoverable (fatal) error occurs during a data logging session. In the event that a fatal error is encountered, the operator should make note of the displayed Error Code to facilitate the remediation of the problem.

If an Error Code is displayed in the course of a recording session, it is recommended that a "reset" followed by a "restart" (as mentioned in the previous section) be attempted. Note that in any event, pressing the "reset" button on the Data Logger will require a minute or so before the system appears to respond! This delay is caused by the necessity of re-loading the operating system followed by the actual program.

If this fails to resolve the problem, the Data Logger should be powered down and the logging session cancelled until the required maintenance can be performed.

Table 1 Data Logger Error Codes

Error Code	Description
A001	Error initializing the analog-to-digital converter!
A002	Error initializing an A/D conversion cycle!
A003	Error starting an A/D conversion cycle!
A004	Error reading data from an A/D conversion!
C001	Magnetic Compass fails to respond to commands!
C002	Failed to obtain magnetic heading!
G001	Could not send command to GPS receiver!
G002	Could not reset the GPS receiver!
G003	Could not set differential mode in GPS receiver!
G004	Could not set navigation mode in GPS receiver!
G005	Could not set up differential input port on the GPS receiver!
G006	Could not request NMEA message GGA from GPS receiver!
G007	Could not request NMEA message POS from GPS receiver!
G008	Could not set the differential time limit of the GPS receiver!
I001	Error initializing 16550 serial UARTs.
I002	Error initialing COM3 serial port (compass).
I003	Error initialing COM1 serial port (GPS receiver).
I004	Error initialing COM2 serial port (terminal).
S001	Failed to find file **logger.ini!** This file must be present for the system to start!
S002	Data in file **logger.ini** is incomplete or corrupt!
W001	Error opening data file!
W002	Error writing to the data file!
W003	Error closing the data file!

Structure and Content of Data Files

Each data file is automatically assigned a unique name when a logging session is started. This is done to minimize the number of steps the operator must do to record a session. The file is named using a combination of the System identifier, the date, and the time (Zulu or Universal Coordinated Time) which the particular logging session was started.

The format is **{SystemID}DDHHMM.YYM** where

- {SystemID} is the character ‘A’ or ‘B’
- DD is the two digit day of the month
- HH is the two digit hour of the day in 24-hour format
- MM is the two digit minute of the hour
- YY is the last two digits of the year
- M is a character representing the month (1-9, A=Oct., B=Nov., and C=Dec.)

As noted previously, the Data Logger files are stored in binary format. The details of the binary storage format is defined by the C ‘structure’ ***record*** which may be found in any of the program listings in Appendix 7. Note that an ‘int’ is a 16-bit and a ‘long (int)’ is a 32-bit integer. A ‘float’ is equivalent to the 32-bit floating point and a ‘double’ is equivalent to the 64-bit floating point representation defined by ANSI/IEEE 754-1985: *IEEE Standard for Binary Floating-Point Arithmetic*.

Since it was never intended that the data files be read directly in binary format, the above is more for informational than practical purposes. The following tables indicate the variables stored in the files. The first is exactly the same variables and in the same order as the raw binary data files described above.

Table 2 Legend for Latitude/Longitude ASCII Conversion

Column Heading	Description	Format and Limits
Time	Universal Coordinated Time	HHMMSS
Mark	Observer Data Mark	Auto incrementing integers
Mode	GPS Operational Mode	0 = none, 2 = non-diff, 3 = diff
Lat	Latitude in WGS-84 Datum	(+ or –) ddmm.mmmmm + indicates North Latitude
Long	Longitude in WGS-84 Datum	(+ or –) dddmm.mmmmm + indicates East Longitude
Alt	Altitude Above MSL	Units of feet
Rate_of_Climb	Vertical Speed	Units of feet/minute
Airspeed	Indicated Airspeed	Units of Knots
MagHeading	Magnetic Heading	Degrees
Pitch	Pitch Attitude	Degrees (+ nose up)
Roll	Roll Attitude	Degrees (+ right)
Ball	Coordination (Yaw)	Units of “Ball Width”
CDI_1	VOR/LOC # 1 Course Deviation	Percent Full Scale (limit at 120) + right
T_F1	#1 To-From Indicator	1 = TO, -1 = FROM, 0 = none
Flag1	VOR/LOC # 1 Flag	1 = GOOD, 0 = FLAGGED
CDI_2	VOR/LOC # 2 – Same as Above	
T_F2		
Flag2		
GSCDI	Glideslope Course Deviation	Same as VOR/LOC CDI’s + up
GS Flag	Glideslope Flag	Same as VOR/LOC Flags
COS	Course Over Ground	Degrees – Derived by GPS
SOG	Speed Over Ground	Knots - Derived by GPS

Table 3 Legend for UTM ASCII Converted Files

Column Heading	Description	Format and Limits
Time	Universal Coordinated Time	HHMMSS
Mark	Observer Data Mark	Auto incrementing integers
Mode	GPS Operational Mode	0 = none, 2 = non-diff, 3 = diff
Zone	UTM Zone	Integers between 1 and 60
Northing	UTM Northing Coordinate	Meters north of the Equator
Easting	UTM Easting Coordinate	Meters East of Central Meridian For this Zone + 500,000
Alt	Altitude Above MSL	Units of feet
Rate_of_Climb	Vertical Speed	Units of feet/minute
Airspeed	Indicated Airspeed	Units of Knots
MagHeading	Magnetic Heading	Degrees
Pitch	Pitch Attitude	Degrees (+ nose up)
Roll	Roll Attitude	Degrees (+ right)
Ball	Coordination (Yaw)	Units of "Ball Width"
CDI_1	VOR/LOC # 1 Course Deviation	Percent Full Scale (limit at 120) + right
T_F1	#1 To-From Indicator	1 = TO, -1 = FROM, 0 = none
Flag1	VOR/LOC # 1 Flag	1 = GOOD, 0 = FLAGGED
CDI_2	VOR/LOC # 2 – Same as Above	
T_F2		
Flag2		
GSCDI	Glideslope Course Deviation	Same as VOR/LOC CDI's + up
GS Flag	Glideslope Flag	Same as VOR/LOC Flags
COS	Course Over Ground	Degrees - Derived by GPS
SOG	Speed Over Ground	Knots - Derived by GPS

Post Processing Procedures

A mentioned above, the Data Logger produces a copy of the data file on a 3½" floppy disk at the end of each logging session. This file is in the binary data format. The Post Flight Data Conversion Software is used to convert these files to ASCII (text) format. The program is used depends on if the horizontal position data is desired in latitude/longitude (convert.exe) or in Universal Transverse Mercator (utm_con.exe) format.

The data file is copied to the directory of the computer that contains the conversion program executable file. The program (either **convert.exe** or **utm_con.exe**) is run and the user must enter the name of the data file to be converted. Each program allows the user to select subsets of the records to be converted. The user may 1) convert all records, 2) convert only "marked" records, or 3) convert only a decimated number of records (with the choice of the decimation factor). Once this selection is made, the program writes the converted file in the same directory with only the "extension" of the file name changed. For example, if the file name to be converted was A111407.98B, the resulting ASCII file will have the name A111407.txt. As a practical matter, if the conversion is being run on a Windows 9x or NT computer, the file is manually renamed including the original extension plus the "txt" extension (A111407.98B.txt). This is a legal file name construct in these operating systems.

These converted data files can then be processed by any of a number of software packages depending on the desired analysis to be performed. In the particular experiment for which the Data Logger was developed, this program is a highly modified Microsoft Excel based application.

5. Maintenance and Troubleshooting

General System Software Configuration

System Start Up

The autoexec.bat file found in the root directory of the fixed disk is configured to change the default directory to that in which the Data Logger software resides and to execute the Data Logger software: **gpstest.exe**.

In the event that the Data Logger system requires maintenance, these lines of the autoexec.bat file may be "commented out" so that the system comes up in the standard MSDOS command-line mode. See the section on General Computer Problems for a procedure that may be used.

The boot sequence, which is configured from the CMOS setup of the single board computer, is also modified to facilitate the operation of the system as a Data Logger. To boot from a floppy disk, the CMOS setup must be changed. See the section on General Computer Problems for details.

Logger Parameter File

A file named **logger.ini** is used to define the identification of the system, certain analog calibration parameters, and the directory to which the generated data files will be stored on the fixed disk. This file must be present in the same directory as the main Data Logger executable file: **gpstest.exe**.

Each line begins with the name of parameter defined by that line and must be exactly as appears in the example below. All ten parameters must appear in the file but may be in any order. Any spaces before and after the "=" sign are ignored.

"SystemID" shall be a single character. "DataDirPath" shall be an ASCII string containing no spaces and having the "back-slash" replaced by a "forward-slash" (contrary to normal MSDOS usage for path specifiers). The last "forward-slash" must be present! "DataDirPath" should never be empty nor should it reference the root directory of a disk drive! The remaining values may be specified in signed integer format or signed floating format (with a decimal point). These parameter (those assigned numerical values) are used to adjust the translation of the outputs of the gyroscope, pendulum, and altitude pressure sensor for minor variations of the transducers.

Typical logger.ini file

```
SystemID = A
PitchOffset = -4.979
PitchGain = 12.27
RollOffset = -5.062
RollGain= 18.01
AltOffset = -1.3
AltGain= 0.32175
BallOffset = 0
BallGain = 1.783
DataDirPath = c:/gpstest/data/
```

General Maintenance and Calibration

Periodic Maintenance

Generally, the Data Logger systems require little maintenance on a regularly scheduled basis. The only item would be the air filter, which should be checked and cleaned as required every six months.

The only limited life components are the backup batteries (for the CMOS memory and real time clock of the single board computer, and for the GPS receiver) and the vertical gyroscope. The batteries should last approximately five years before requiring replacement. The vertical gyroscope has a service life of approximately 300-500 hours according to the manufacturer, Humphrey, Inc.

Calibration

The only components that may require calibration (with the exception of the compass engine, the calibration of which is addressed later in this section) are those associated with the analog systems.

The calibration of the analog-to-digital converter system itself is addressed later in this section and is a rather lengthy procedure, which is described in the respective manuals of the two components (AD12-8 and AT16-P). It should be noted that calibration of these components is the only form of adjustment for correcting errors in the low-level A/D channels (see "Errors in Low Level Channels" later in this section).

The remaining variables (pitch, roll, ball (yaw), and airspeed) may be calibrated by changing the respective gain and offset parameters in the logger.ini file previously mentioned. Each Data Logger has a program (adtest.exe) which may be useful in the adjustment of the gain and offset numbers. This file is located in the same directory as the main Data Logger file (gpstest.exe) and uses the same logger.ini data as the main Data Logger program. "adtest.exe displays on the VGA display all of the above mentioned variables. It does not require the compass engine or the handheld terminal to be attached or functional. "adtest.exe" only requires that the A/D system is operational; i. e. communicating with the single board computer.

Troubleshooting

General Computer Problems

To operate the Data Logger system as a MSDOS computer, a standard PC keyboard and a VGA capable display must be connected. The keyboard connector is located on the side of the card-cage; the 15-pin VGA display connector is located on the connector panel of the Single Board Computer (the only full-length card in the card-cage).

Power the Data Logger system and allow it to start normally. If there were no fatal errors during start-up, the "enter" key on the handheld terminal will have to be pressed to acknowledge the compass heading check; then the "EXIT" key should be pressed. The standard shutdown message should appear on the handheld terminal and the VGA display should provide a standard MSDOS command-line prompt.

In the event that the Data Logger system fails to even boot the MSDOS operating system, a keyboard and display must be attached and a bootable 3 ½" floppy disk must be available and inserted in the drive. When the system is powered, press the Del key on the keyboard when prompted to enter the CMOS setup screens. Once in setup, configure the boot options to allow booting from the floppy disk first, then the fixed disk. Save the CMOS setting and allow the system to re-boot. The single board computer should boot the MSDOS operating system from the floppy disk and allow testing to be performed. Diagnostics

should then be performed to determine the cause of the failure to boot from the fixed disk and this condition remedied.

Before returning the system to service as a Data Logger, restore the boot options back to the original configuration; i.e. boot from the fixed disk only. This setting is chosen so that a user can insert a floppy disk (used to provide a copy of the Logger data file) at any time without having the system attempt to boot from the floppy.

At this point, the autoexec.bat file can be edited to comment out the lines that automatically start the Data Logger software (gpstest.exe). These should be removed before the system id returned to service.

Once the computer is booted and operating in MSDOS, all normal MSDOS functions should be available and the unit should behave as a standard computer using command at the standard DOS prompt. The floppy drive (A) and fixed disk (C) should be accessible for both read and write; serial ports COM1 and COM2 should be available. Note that "COM3" is non-standard and will not be recognized by DOS. Also there are no active parallel ports in the system!

Executing the file gpstest.exe from its home directory will run the actual logger software. The external compass system and the handheld display terminal must be connected for the system to start. Furthermore, if the GPS antenna and the RBS differential correction receiver antenna are not connected and receiving signals, the Data Logger will not be allowed to enter the logging mode.

Compass System Problems

Accuracy

If the Data Logger does not provide an error message related to the compass system (type C) but the data provided by the system appears to be erroneous; the first step would be to perform a new calibration (autocompensation) procedure.

This is accomplished by powering the Data Logger and moving the aircraft to an area free from metal structures and underground electrical power cables. This procedure is most easily accomplished with two operators: one to maneuver the aircraft and one to operate the handheld terminal. The aircraft must be maneuvered to eight (8) distinct headings during this process. The operators will be guided through the procedure by a sequence of messages on the Console. At the end of a successful calibration procedure, two single digit numbers are displayed (0-9): the higher the numbers, the better! The first digit represents the quality of the compensation (a score of "7" or above indicates an accuracy of 2 degrees or better). The second digit represents the quality of the magnetic environment (a score of "5" or better is acceptable). If acceptable scores are not achieved, the procedure should be repeated after moving the aircraft to a different physical location.

If calibration does not correct the problem, the optimum diagnostic procedure would be to substitute a KVH C100 compass from another Data Logger system to verify the problem is the compass engine. If the replacement unit solves the problem, the defective unit should be returned to the manufacturer for repair or replacement[1].

If the substitution of the compass engine does not solve the problem, the difficulty may be associated with the aircraft. Changes in the location of the compass system or additional pieces of equipment recently installed near the compass engine location may effect accuracy. Changes in the aircraft wiring in the area of the compass may also have the same effect. It is also possible that the aircraft's engine or generating

[1] If a new C-100 Compass System is acquired, it must be configured using the software provided by the manufacturer. See Appendix 3 for details.

system may be producing electrical noise that may interfere with proper operation of this electronic compass engine.

Communications

If the Data Logger does display an error message (a C001 or C002 fatal error), first check the cable between the Data Logger and the compass system. If the cable was securely connected, disconnect the cable from the compass system end and measure the voltage between pins 5 and 8 of the 9-pin connector. With the Data Logger turned on, there should be 12 volts DC present; pin 8 being positive.

There are only two items (besides the cable and the lack of DC power) which can cause a communication failure. One is the compass system itself and the other is the SIIG input/output board. Replace these items (with units from another Data Logger) one at a time to isolate the problem[2].

GPS System Problems

The Global Position System receiver (Ashtech G12) and the Differential Correction receiver (DCI RDS-3000) work together to provide the total positioning information for the Data Logger. Since the differential corrections are channeled through the GPS receiver and there is not direct connection between the RDS-3000 and the remainder of the Data Logger system, the GPS system must be functioning correctly before attempting to diagnose any potential problems concerning differential corrections.

GPS Receiver System

If the GPS receiver has a problem, the operator will observe one of the following symptoms,

- A Fatal Error of Type G will be displayed on the console.
- The GPS LED on the console will fail to light.
- Excessive time is required for the GPS LED to light (in excess of two minutes).

The Ashtech G12 GPS receiver has an indicator mounted on the circuit board that contains both red and green LED's. Flashing red indication means the receiver has power (+5 volt DC). The green LED flashes between the red flashes. Each green flash indicates one satellite locked (being received and processed), e.g. four (4) green flashes indicates four satellites locked. The unit must be locked on to a minimum of four satellites for the Data Logger to operate.

If a fatal error of type G was displayed, check the power to the Ashtech G12 receiver. Verify that the 9-pin connector labeled Port A is firmly connected to the COM1 serial port of the single board computer. If neither of the above is the cause of the problem, the COM1 serial port should be checked and/or the Ashtech G12 should be checked for proper operation independent of one another.

One method is to use a program supplied by Ashtech called *Evaluate*. This program can be run on a Windows computer using a serial extension cable to connect the computer serial port to the connector labeled Port A. This program will communicate with and test any number of Ashtech GPS receiver systems. A users guide is available for Evaluate 4.0.

If no fatal errors are displayed but the GPS Led never lights to indicate GPS data is available, then the problem is either in the G12 receiver itself or the GPS antenna system. The LED on the receiver itself can be helpful in this case. If green flashes are never observed, the most likely cause is either the antenna or the

[2] If the C-100 Compass System is replaced, see Appendix 3 for information on software configuration. If the SIIG input/output board is replaced, see Appendix 2 for information on the hardware configuration.

antenna cabling. The most straightforward method of determining the component(s) at fault is to interchange to Ashtech G12 receiver with the receiver in another Data Logger (much easier than interchanging antenna systems).

If excessive time appears to be required for the GPS system to lock onto the required number of satellites, the problem may be that the "keep-alive battery" that retains receiver data may be exhausted. This battery allows the system to retain it's last position, the satellite almanac, and satellite ephemeris data. The battery is located within the silver colored connector near the GPS receiver mounting position. If the battery is functional, the GPS LED on the handheld display should illuminate within one minute after the "STARTING" message is displayed.

Differential Correction System

A problem with the differential correction system will only be evident by the Data Logger never coming out of "STANDBY" and the DIFF LED never being lit.

There is no direct communication between the DCI RDS-3000 Differential Corrections Receiver and the main Data Logger computer. All differential status information is passed through the Ashtech G12 GPS system.

The RDS-3000 has two LED's that provide a visual indication of the state of the differential correction receiver.

- Short random flashing of the red LED indicates power is applied and the receiver is not yet tracking an RDS signal.
- If the red LED is steadily on (except for occasional short flashes), the receiver has found a RDS signal.
- If the green LED flashes at 2-second interval or faster, the system is receiving differential corrections.
- If the green LED turns on for 5 seconds then off for 5 seconds, the system is receiving a DCI broadcast but believes the subscription to the service has lapsed. This should not occur since the subscriptions for these receivers were purchased for an indefinite term. DCI should be contacted to resolve this issue.

If the LED's indicate no RDS signal, check the antenna system and cables. A 20 to 30 inch wire connected to the center contact of the BNC connector on the Data Logger should provide enough signal for troubleshooting purposes.

A/D Problems

Analog-to digital converter problems may be of several levels of severity. Each of these will require a somewhat different approach in troubleshooting. The A/D system itself consists of two discrete circuit boards: the main A/D converter (AD12-8) which is located in the computer card-cage, and the multiplexer board (AT16-P) mounted on the side of the Data Logger enclosure. Each of the multiplexer channels used is wired to one of the internal sensors or to the external radio-navigation outputs of the aircraft. The radio-navigation signals pass through a set of relays used for emergency isolation of the Data Logger and essential navigation displays.

Each of the following paragraphs describes a particular class of A/D problem.

Error Codes Displayed

If an A/D error code is displayed on the handheld terminal (type A), the problem is localized to the two circuit boards mentioned above or the cable, which connects the two boards. Verify that the AD12-8 is properly seated in the card-cage and that the cable is firmly seated to each mating connector. If the

problem persists, replace the AD12-8 and AT16-P one at a time to determine which has failed. The AT16-P can be substituted by merely unplugging the cable from the installed unit and plugging it into the spare; there is no need to remove the original unit nor to connect the inputs to the spare AT16-P used for testing purposes. If this procedure is used, be certain that the replacement AT16-P is placed on an insulating surface before applying power.

Spare AD12-8 and AT16-P are available (already properly configured) in addition to a spare cable used to connect these units.

Operational Checks Using the Terminal

If no errors are flagged but it is suspected that there is a problem with one or more of the analog-to-digital channels, the actual converted data from these channels can be displayed on the handheld terminal to aid in maintenance and troubleshooting.

When the Data Logger is in the recording mode, the actual values being stored in the flight data records for pitch, roll, airspeed, ball (yaw), and radio-navigation course-deviation-indicators (CDI's), and associated flags can be displayed on the third line of the alphanumeric display.

- Pressing "1" displays the pitch and roll in degrees (positive is right or up)
- Pressing "2" displays the airspeed in knots and the ball position in unit of "ball width"
- Pressing "3" displays the VOR/LOC #1 course deviation in percent and the flag status
- Pressing "4" displays the VOR/LOC #2 course deviation in percent and the flag status
- Pressing "5" displays the Glideslope course deviation in percent and the flag status
- Pressing "0" clears the display

Errors in High Level Channels

The high level channels are defined as those for which the gain of the A/D system is less than five. These include:

- pitch data
- roll data
- yaw or ball data
- airspeed data

If ALL high level inputs are exhibiting errors, the common source may be the +10 volt precision reference voltage that is used to excite all of these sensors. This reference voltage is generated on the AD12-8 board, routed to the AT16-P via the interconnecting cable, and is distributed to the sensors via a terminal strip located near the AT16-P board.

If the error is limited to a single high level channel, examine the wiring to between that sensor and the AT16-P. If both the pitch and roll channels are exhibiting errors, either the vertical gyroscope or the "secondary voltage converter" may be at fault. With the exception of the output of the secondary converter, which may be directly measured with a voltmeter, the detection of the fault is most easily accomplished by substitution of components (the vertical gyroscope/pendulum assembly or the differential pressure assembly (in event of an airspeed problem).

Errors in Low Level Channels

The low-level channels are those associated with the radio-navigation instruments. These signals are not "low level" in the strictest sense of the term but these channels are measuring differential voltage inputs in the millivolt range (±200 mv range).

If all of these channels are not responding correctly, examine the external connector between the Data Logger and the aircraft (the larger of the two circular connectors). Secondly, verify that the isolation relays are operating (these relays should be activated when power is applied to the Data Logger system. Another possibility is that the zeroing of the multiplexer and/or analog converter may have drifted to an extent which effects these millivolt range measurements without effecting the apparent accuracy of the high level channels. This occurrence would be rare, but if suspected, the procedure for calibration and zeroing of these components is described in the respective product manuals but is too involved to be included here.

If the errors are restricted to a subset of the level-level inputs or to only those from a particular instrument (VOR#1, VOR#2, or GS), the most likely cause is a wiring fault.

Use in 24-Volt Aircraft

The Data Logger was originally constructed for use in an aircraft with a 12-volt DC power buss. In order to convert the unit to operate in a 24-volt aircraft, a number of component and wiring changes are required. The time required to convert one Data Logger from 12-volt to 24-volt operation is estimated to be less than two hours.

Components Required (for each Data Logger)

- Power Converter - International Power Sources, Inc – Model PD110-40M
- Relays - Potter & Brumfield – Model KHAU17D13 [3] (3 pieces)
- Fan – Papst – Model 4314 or equivalent (24 VDC Brushless, 4.7 inch square mount)

Procedure

1. Remove the International Power Sources PD110-40L Power Converter and install the model PD110-40M in its place. It is the same physical size and is a pin-for-pin replacement (no modifications need be made to the cabling).
2. Remove the three or four P&B relays and replace with the 24 VDC units.
3. Remove the 12 VDC fan assembly and replace with the 24 VDC unit.

Optionally, the Data Logger power switch/circuit breaker may be replaced with a unit rated a 5 amperes.

NOTE: In the event that new Data Logger units are built for use in 24-VDC aircraft; the secondary power converter (Converter Concepts) can be completely eliminated from the construction. This converter is used only to provide power to the gyroscope in 12-VDC aircraft. The gyroscope's motor can be wired directly to the switched A+ power buss of the Data Logger when operated in a 24-VDC aircraft.

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[3] The contacts of the selected relay should be a minimum of gold flashed since the signals passing through are small and any excess contract resistance may effect the accuracy of the radio-navigation data.

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Appendices

Appendix 1 – BIOS Settings for Single Board Computer

In general, most of the settings within the BIOS (CMOS setup) of the SB486PV single board computer remain as configured in the standard factory defaults. In addition to the microprocessor and ISA buss controller, only the hard disk controller, the floppy disk controller, and the serial ports are essential for Data Logger operation.

It should be verified that the two on-board serial ports are configured in the standard manner; i. e. COM1 at port 3f8 hexadecimal and IRQ 4; COM2 at port 2f8 hexadecimal and IRQ 3.

Because both IRQ 5 and IRQ 7 are required for other devices by the Data Logger hardware, the on-board parallel port on the SB486PV must be disabled.

Since it is the normal operating procedure to insert a floppy disk in the Data Logger before applying power, the boot sequence of the SB486PV must be modified. The BIOS must be configured to attempt to boot from only the fixed disk, never the floppy.

Appendix 2 – Configuration of Third Serial Data Port

The SIIG I/O Professional multifunction input/output board, Model IO1809, used in this application requires that only one serial port be active and that the other serial port and the parallel port be disabled.

The board is configured by means of jumpers. There are fifteen sets of three pins each; the sets are labeled JP1 through JP15. Each set may be jumped in three ways,

- H; the center and upper pins jumpered
- L; the center and lower pins jumpered
- Open; no jumper installed

The following table documents the jumper configuration used in the Data Logger.

Table 4 SIIG I/O Board Configuration

Position	Jumper	Position	Jumper
JP1	**H**	JP9	**OPEN**
JP2	**L**	JP10	**OPEN**
JP3	**L**	JP11	**OPEN**
JP4	**L**	JP12	**H**
JP5	**L**	JP13	**OPEN**
JP6	**H**	JP14	**OPEN**
JP7	**L**	JP15	**OPEN**
JP8	**L**		

Appendix 3 – Configuration of the KVH Compass System

The KVH C100 compass system is configured by software supplied by the manufacturer. This is MSDOS program but can be run within the Windows environment. The files **C100USR.EXE** and **CLIST.TXT** must be copied to a directory and the executable run from that directory.

Since the C100 compass system is mounted in separate enclosure and both the RS-232 serial communications and the DC power are routed through the single interconnection cable, the following procedure should be used to run the setup program. Use a serial extension cable to connect the computer running the C100USR program to the cable in the Data Logger which is normally connected to COM3 (the serial port which is associated with the SIIG I/O Professional multifunction input/output board). This allows the Data Logger to supply the 12 VDC to power the compass engine.

The compass engines used in the Data Logger are set to communicate at 9600 baud; however, the default baud rate of a new unit is 4800 baud. The parameters should be set as follows:

- Heading Type: magnetic
- PowerUp Mode: Not Sending
- Baud Rate: 9600
- Message Units: d (degrees)
- Output Type: 0
- Output Format: 0
- Damping Type: 3
- Damping Rate: 0

The Data Logger sends a type "d1" command to the compass engine to read the present heading in degrees and does not expect to see any output from the compass engine except responses from such commands. If the PowerUp Mode is inadvertently set to sending, the Data Logger will flag an error immediately.

Calibration should always be performed using the Data Logger built-in feature with the entire system mounted and configured in the airframe in which the system will operate.

Appendix 4 – Configuration of the A/D System

AD12-8

The AD12-8 is configured for ±5 volt input (bipolar). Analog-to digital conversions are started using the on-board counter/timer. The unit is configured to interrupt the main processor on end-of-conversion (EOC). The base I/O address is 310 hexadecimal and the interrupt output is selected as IRQ 7 (IRQ3-5 are used by the serial ports).

A DIP switch S1 configures the base address; the individual switches are labeled A3 through A9. Switches A3, A4, and A6 are ON and the remainder are OFF to configure the address of 310 hexadecimal.

Jumpers accomplish the remainder of the configuration and these are set as listed below.

- BIP/UNIP jumper set to BIP
- 10V/5V jumper set to 5V
- CLK0 jumper present
- TMR/EXT jumper set to TMR
- EXT/EOC jumper set to EOC
- IRQ jumper set to IRQ7

AT16-P

The AT16-P is configured to use programmable gain settings and is set to output ±5 volts. All other settings and jumpers are on the standard default settings (if present).

A DIP switch S1 on the AT16-P board configures these setting. The individual switches labeled GM0, GM1, and GM2 are set OFF; the remainder (labeled G/2, SHO, GP0, GP1, and GP2) are set ON.

Appendix 5 – Initial Settings for DCI Receiver

The DCI receiver Model RDS-3000 is totally software configured. The manufacturer provides a Windows program named RTCMWIN that allows the user to view the correction messages as they are received and set the configuration of the receiver. The items that can be configured include the RS-232 baud rate, the method of scanning for RDS signals, and a list of frequencies to be used.

The RDS-3000 as used in the Data Logger is configured as follows,

- Baud rate is 9600.
- Signal scan is restricted to a list of station.
- Station frequencies are 93.9, 94.5, 94.9, 102.7, and 103.7 megahertz.

This configuration is stored on the computer as a file called 9600.cfg. This file can be uploaded to the receiver using the RTCMWIN program to restore these settings.

The computer, upon which RTCMWIN is installed, is connected *directly* to the RDS-3000 via a NULL modem cable with 9-pin female connectors on each end. If the computer has more than one serial port, the program must be set to use the serial port to which the RDS-3000 is connected. A previously configured receiver should be communicating at 9600 baud, but if not, the program can automatically try all possible communication rates until the receiver is located.

Once the program locates the receiver, the user can “open” the configuration file (9600.cfg) and “send” it to the receiver. If the baud rate originally in use by the receiver and the baud rate specified in the configuration file were different, communication between the program and the receiver will have to be reestablished.

Note that the receiver does not have to be connected to an antenna to be configured; however, if it is desired to view the received RCTM correction data using the RTCM Monitor portion of the RTCMWIN program, an antenna must be attached and an RDS broadcast received.

Appendix 6 – Initial Settings for Display/Control Console

The QTERM-II is configured via software provided by the manufacturer. The program QSETUP.EXE is used to program the terminal using a “QDATA File.” The QDATA File is an ASCII file provided by the manufacturer in several versions for the various models of the QTERM-II terminal. The particular file appropriate to this unit is QDATA40W.V30.

Several changes were made to this default file in order to utilize the display more conveniently and to simplify the task of communicating with the terminal. Specifically the lines identified below were modified.

- [auto wrap mode] off
- [auto scroll mode] off
- [auto line feed mode] off
- [key repeat mode] off
- <k00>'~5' <k01>'~4' <k02>'~3'
- <k03>'~2' <k04>'~1' <k05>
- <sk00>'~5' <sk01>'~4' <sk02>'~3'
- <sk03>'~2' <sk04>'~1' <sk05>

The result of loading this modified configuration is twofold.

1. All twenty character positions on each of the four lines of the display can be written to without changing the display on any other line in the process, and
2. The data sent when a function key is pressed (START/STOP, EXIT, etc.) starts with the tilde (~) character which is not sent by any other key on the keypad.

Detailed instructions on the use of QSETUP and "QDATA Files" are in Chapter 3 of the *QTERM-II User's Manual*.

The QTERM-II sends and receives data and is supplied +5 VDC power through the single serial cable connected between the Data Logger enclosure and the unit. Pin 5 is the standard ground pin for 9-pin serial connectors but pin 9 is used as the +5 VDC input for the QTERM-II. . Use a serial extension cable to connect the computer running the QSETUP program to the cable in the Data Logger, which is normally connected to COM2 (the lower serial port on the single board computer card). This allows the Data Logger to supply the 5 VDC to power the QTERM-II handheld terminal.

Appendix 7 – Source Code

System Operation Software

The following modules are compiled together and linked with the a12drvc.obj file provided by Industrial Computer Source (ICS) and GCLL.LIB provided by Greenleaf Software. Header files are also provided: a12drvc.h from ICS; ibmkeys.h, asciidef.h, and gsci.h from Greenleaf Software. The memory model required by the ICS module is the "large" and therefore that model has been used the compilation. The entry point of the program (main) is to be found in the file gpstest.c.

```
ADFUNCT.C

#include <stdio.h>
#include <dos.h>
#include <math.h>
#include <ctype.h>
#include <bios.h>
#include <alloc.h>
#include <stdlib.h>
#include <conio.h>
#include "a12drvc.h"

extern float   PitchOffset,
                              PitchGain,
                              RollOffset,
                              RollGain,
```

```
                              AltOffset,
                              AltGain,
                              BallOffset,
                              BallGain;
extern int     GyroFlag;

extern struct record
{
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
  int          CDI1;
  int          CDIT_F1;
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

extern struct record Record;
extern int ADCount;
extern unsigned LoopCounter;
extern int ADInProgressFlag;
extern int ADDataReadyFlag;

void FatalError(char *);
unsigned call_driver(void);
unsigned ADSetup(void);
unsigned ADProcedures(void);
unsigned ADCheckRdy(void);
void QTLed(int,int);

extern unsigned ADPointBuffer[];
extern int      ADStatus,
                       ADTask,
                       ADParameters[],
                       ADDataBuffer[],
                       ADTempBuffer[];

/*********************************************************************/
/*                                                                   */
/*      call_driver is the primitive call to a12drv.obj supplied by */
/*              ICS.                                                 */
/*                                                                   */
/*********************************************************************/

unsigned call_driver()
{
  a12drv(FP_OFF(&ADTask),FP_OFF(ADParameters),FP_OFF(&ADStatus));
  if(ADStatus != 0)
  {
   printf("An A/D error code of %i was detected\n",ADStatus);
   printf("Program terminated.");
  }
  return(ADStatus);
}

/*********************************************************************/
/*                                                                   */
/*      ADSetup sets the AD system parameters.  It assigns point     */
/*              addresses, scaleing and gains to all channels        */
/*                                                                   */
/*********************************************************************/


unsigned ADSetup()
{
  unsigned I,status;
```

```
ADParameters[0] = 1;                        /* manual setup */
ADParameters[1] = 0x310;                    /* address of AD12-8 */
ADParameters[2] = 7;                        /* IRQ 7 */
ADParameters[3] = 5;                        /* five volt range */
ADParameters[4] = 1;                        /* bipolar mode */

ADTask = 0;                                 /* Initialize Board */

status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADTask = 11;                                /* clear task list */
ADParameters[0] = 2;
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADTask = 5;                                 /* assign point addresses */
ADParameters[0] = 0;
ADParameters[1] = 3;                        /* channels 0,1,2, and 3 */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 4;
ADParameters[1] = 6;                        /* channels 4,5, and 6 */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 8;
ADParameters[1] = 10;                       /* channals 8,9, and 10 */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 12;
ADParameters[1] = 13;                       /* channels 12 and 13 */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADTask = 14;                                /* set up timers */
ADParameters[0] = 1;                        /* counter 1 */
ADParameters[1] = 3;                        /* mode 3 */
ADParameters[2] = 2;                        /* period 4.47 usec */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 2;                        /* counter 2 */
ADParameters[2] = 1760;                     /* 1760period 8 millisec */
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADTask = 10;                                /* set scale for point 0*/
ADParameters[0] = 3;
ADParameters[1] = 0;
ADParameters[2] =-10000;
ADParameters[3] = 10000;
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 4;                        /* same for points 1 and 2 */
ADParameters[1] = 0;
ADParameters[2] = 1;
ADParameters[3] = 2;
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 3;
ADParameters[1] = 3;                        /* set scale for point 3 */
ADParameters[2] = -5000;
ADParameters[3] = 5000;
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 3;                        /* set acale for point 4 */
ADParameters[1] = 4;
ADParameters[2] = -1000;
ADParameters[3] = 1000;
status = call_driver();
if (status != 0) FatalError("A001");        /* return on error */

ADParameters[0] = 4;                        /* same for points 4 thru 11 */
ADParameters[1] = 4;
```

```
  ADParameters[2] = 5;
  ADParameters[3] = 13;
  status = call_driver();
  if (status != 0) FatalError("A001");              /* return on error */

  ADTask = 4;                                       /* set gains */
  ADParameters[0] = 0;
  ADParameters[1] = 2;
  ADParameters[2] = 0;
  status = call_driver();
  if (status != 0) FatalError("A001");              /* return on error */

  ADParameters[0] = 3;
  ADParameters[1] = 3;
  ADParameters[2] = 1;
  status = call_driver();
  if (status != 0) FatalError("A001");              /* return on error */

  ADParameters[0] = 4;
  ADParameters[1] = 13;
  ADParameters[2] = 2;
  status = call_driver();
  if (status != 0) FatalError("A001");              /* return on error */


 return(0);
}


/*********************************************************************/
/*                                                                   */
/*      ADProcedures performs two functions:                         */
/*      1) Start a conversion if a conversion is not in progress,    */
/*      2) Read and store the data if a conversion was completed.    */
/*                                                                   */
/*********************************************************************/

unsigned ADProcedures()
{
  static unsigned     channel,gain,I,status,*temp,offpntbuf,offdatbuf;
  double       data,tempx, tempy;
  static int            *temp1;
  int pitch,roll;
  extern int ADCount;

  if(!ADInProgressFlag)
  {
        ADTask = 11;
        ADParameters[0] = 1;
        status = call_driver();
        if (status != 0) FatalError("A002");        /* return on error */

        temp1 = ADDataBuffer;
        offdatbuf = FP_OFF(temp1);
        temp = ADPointBuffer;
        offpntbuf = FP_OFF(temp);

        ADTask = 9;                   /* timer driven interrupt data acquisition */
        ADParameters[0] = 1;
        ADParameters[1] = 12;
        ADParameters[2] = FP_OFF(ADTempBuffer);
        ADParameters[3] = FP_SEG(ADTempBuffer);
        status = call_driver();
        if (status != 0) FatalError("A003");        /* return on error */
        ADInProgressFlag = 1;
        return(0);
  }



  if(ADDataReadyFlag)
  {
        ADCount++;
        ADTask = 9;                                 /* get data from buffer */
        ADParameters[0] = 3;
        ADParameters[1] = offdatbuf;
        ADParameters[2] = offpntbuf;
        ADParameters[3] = 12;
        status = call_driver();
        if (status != 0) FatalError("A004");        /* return on error */
```

```
      for (I = 0; I < ADParameters[3];I++)
      {
        channel = (ADPointBuffer[I] & 0xff00)/256;
        data = ADDataBuffer[I] * 0.001;
        gain = ADPointBuffer[I] & 0x00ff;

        switch(I)
        {
              case 0:
                tempx = data + PitchOffset;        /* pitch */
                tempx *= PitchGain;
                Record.Pitch += pitch = (int)tempx;
                break;

              case 1:                              /* roll */

                tempx = data + RollOffset;
                tempx *= RollGain;
                Record.Roll += roll = (int)tempx;
                break;

              case 2:                              /* airspeed */

                tempx =(data + AltOffset)*AltGain;
                tempx = 142.91*sqrt(fabs(tempx));
                Record.Airspeed += (int)tempx;
                break;

              case 3:                              /* ball */

                tempx = (data + BallOffset)*BallGain;
                Record.Ball += tempx;
                break;

              case 4:                              /* CDI2 L/R */
              case 7:                              /* CDI1 L/R */
              case 10:                             /* GS Dev   */

                tempx = 2000*data/3;
                if(tempx < -120.0) tempx = -120.0;
                if(tempx > +120.0) tempx = +120.0;
                if(I==4) Record.CDI2 -= (int)tempx;
                else
                {
                     if(I==7) Record.CDI1 -= (int)tempx;
                     else Record.GSDev -= (int)tempx;   /* note sign change*/
                }
                break;

              case 5:                              /* CDI2 T/F */
              case 8:                              /* CDI1 T/F */

                tempx = 0;
                if(data > 0.042) tempx = -1;       /* FROM */
                if(data <-0.042) tempx = 1;        /* TO */
                if(I==5) Record.CDIT_F2 = tempx;   /* note sign change */
                else Record.CDIT_F1 = tempx;
                break;

              case 6:                              /* CDI2 Flag */
              case 9:                              /* CDI1 Flag */

                tempx = 0;
                if(data > 0.175) tempx = 1;
                if(I==6) Record.CDIFlag2 = tempx;
                else Record.CDIFlag1 = tempx;
                break;

              case 11:                             /* GS Flag */

                tempx = 0;
                if(data > 0.20) tempx = 1;
                Record.GSFlag = tempx;
                break;

        }
      }
      if(!GyroFlag && (abs(pitch) < 7) && (abs(roll) < 5)) GyroFlag = 1;
      ADInProgressFlag = ADDataReadyFlag = 0;
}
```

```
  return(0);
}

/*********************************************************************/
/*                                                                   */
/*      ADCheckRdy merely checks to see if the interrupt driven      */
/*              conversions are complete and set a flag.             */
/*                                                                   */
/*********************************************************************/

unsigned ADCheckRdy()
{
  int status;
  if(ADInProgressFlag && !ADDataReadyFlag)
  {                                                  /* look for complete flag */
       ADTask = 9;
       ADParameters[0] = 2;
       status = call_driver();
       if(ADParameters[1] == 0) ADDataReadyFlag = 1;
       if (status != 0) FatalError("A003");         /* exit on error */
  }
  return(ADDataReadyFlag);
}

/*********************************************************************/
/*                                                                   */
/*      ADLoop check for a condition wereby the A/D system accepts all*/
/*              commands with no errors but never returns a conversion*/
/*              complete signal.  This condition requires power be removed*/
/*              and the system started cold!                         */
/*                                                                   */
/*********************************************************************/

void ADLoop()
{
  /*printf("%d   %d\n",ADCount,LoopCounter); */
  if(!ADCount && (LoopCounter > 200)) FatalError("A005");
  return;
}
```

COMPASS.C

```
#include       <stdlib.h>
#include       <string.h>
#include       <dos.h>
#include       <bios.h>
#include       <conio.h>
#include       <stdio.h>
#include       "ibmkeys.h"
#include       "asciidef.h"
#include       "gsci.h"

extern int     CalFlag,
                      InitFlag,
                      BannerFlag,
                      GPSFlag,
                      DCIFlag;

extern PORT *KVH;      /* compass system on COM3 */
extern PORT *QT;       /* terminal on COM2 */
extern PORT *GPS;

void FatalError(char * );
void QTBeep(void);
void QTLed(int, int);
void CompassCommand(char *,char *);
void QTClear(void);
void QTWLine(char *, int);
float GetMagHeading(void);
void QTBackLite(void);
void QTReset(void);
void NonFatalError(char*);
void QTContrast(void);
void CalCompass(void);
void QTAudioOn(void);
void QTAudioOff(void);
void DisplayCompass(void);
void GPSDeInit(void);
void GPSInit();
```

```
void CalAbort(char * s)
{
  char * AbortString = "=cez";

  NonFatalError(s);
  WriteString(KVH,AbortString,0x0d);
  CalFlag = BannerFlag = 0;
  GPSInit();
  delay(500);
  ClearRXBuffer(GPS);
  return;
}

void DisplayCompass(void)
{
  float head;
  int test = 0;
  char buffer[10];
  char *msg1 ="Magnetic Heading Chk";
  char *msg2 = "Press Enter to Cont.";

  QTWLine(msg1,1);
  QTWLine(msg2,4);

  do
  {
       head = GetMagHeading();              /* Request heading from compass */
       sprintf(buffer,"       %-4.1f\xdf",head);    /* format for display */
       QTWLine(buffer,2);                   /* write it to line two! */

       delay(1000);
       if(!IsRXEmpty(QT))
       {
         ReadStringTimed(QT,buffer,10,0x00,1);
         if(buffer[0] == 'B' || buffer[0] =='G') QTBackLite();
         if(buffer[0] == 0x0d) test = 1;
         if(buffer[0] == 'C' || buffer[0] =='H') QTContrast();
         ClearRXBuffer(QT);
       }

  }while(!test);
  QTClear();
}


float GetMagHeading(void)
{
  float heading;
  char * HDG = "d1";                 /* command to get heading data */
  char ans[40];
  int ERROR = 0;

  CompassCommand(HDG,ans);              /* call command routine */
  ERROR = !sscanf(ans,"%f",&heading);   /* scan result for heading */
  if(ERROR) FatalError("C002");         /* exec Fatal error routine */
  return(heading);
}


/*********************************************************************/
/*                                                                   */
/*      Prompts User through 8 - point calibration procedure         */
/*              Checks for errors which are considered non-fatal     */
/*                                                                   */
/*********************************************************************/

void CalCompass(void)
{
  char * cal = "=ce1";               /* calibration command */
  char response[40];                    /* return string buffer */
  char * pos = "Position A/C to ";      /* Prompt sub-string */
  char * test = "complete:";            /* SUCCESS sub-string */
  float lastheading = 0.0, heading;
  int  ERROR;
  int status;
  char c = ' ';

  if(!CalFlag) return;

  GPSDeInit();
```

```
  GPSFlag = DCIFlag = 0;
  QTClear();                            /* Clear Display */
  CalFlag = 1;                          /* Set CalFlag, no other ops! */
  QTWLine("Compass Calibration",1);     /* Use Prompt Strings */
  QTWLine("Enter on Positioned",3);
  QTWLine("Press \"A\" to Abort",4);

  do
  {
        printf("line 141\n");               /* for testing only */
        CompassCommand(cal,response);       /* send cal command */
        printf("line 143\n");               /* for testing only */
        ERROR = !sscanf(response,"%5f",&heading);    /* scan for valid response */
        if(heading != lastheading)   ERROR++; /* check 45 degree increment */
        printf("heading %f  %f\n",heading,lastheading);     /* for testing only */
        if(ERROR)
        {
          CalAbort("Calibration");
          return;
        }
        sprintf(response,"%s%#03d\xdf",pos,(int)heading);   /* format prompt */
        QTWLine(response,2);                /* Write to Display */

        lastheading = heading + 45.0;       /* increment lastheading for next */

        do                                  /* wait for response */
        {
          status = ReadCharTimed(QT,30000L);/* wait 30 seconds */
          if(status < 0)
          {
                CalAbort("Cal - Time Out!");
                return;                      /* no response in 30 seconds - abort */
          }
          c = (char)status;                 /* assure returned value is char */
        /* disregard characters which are not valid (A,F, and <CR> are valid */
        }while(!(c == 0x0d || c == 'A' || c == 'F'));

        if(c != 0x0d)
        {
          CalAbort("Cal - User Abort!");
          return;
        }
        /* response other than <CR> - abort! */
  } while(heading !=  315.0);

  /* compass system response changes at this stage; requires modifications
        to procedures */

  CompassCommand(cal,NULL);             /* does not return new heading! */
  if(ReadStringTimed(KVH,response,40,0x0d,10000L) < 0)
  {
        CalAbort("Cal - Time Out!");
        return;
  }
  ERROR = 0;
  if(ReadStringTimed(KVH,response,40,0x0d,2000L) < 0) ERROR++;
  if(strstr(response,test) == NULL) ERROR++;
  if(ERROR)
  {
        CalAbort("Cal - Failed");
        return;
  }
  QTClear();
  QTWLine("Compass Cal'ed",1);
  if(!ReadString(KVH,response,40,0x0d))
        QTWLine(response,2);
  QTBeep();
  delay(3000);
  InitFlag = 1;
  QTClear();
  CalFlag = 0;
  ClearRXBuffer(GPS);
  GPSInit();

}

/*********************************************************************/
/*                                                                   */
/*     Send Command to Compass and return the response               */
/*             Makes five attempts to send command                   */
/*             Fatal Error is Compass Fails to respond               */
```

```
/*                                                                      */
/************************************************************************/

void CompassCommand(char * command, char * response1)
{
  int loop = 0;
  int ERROR = 0;
  char temp[21];

  if(!IsRXEmpty(KVH)) ClearRXBuffer(KVH);           /* assure clear buffer */

  do
  {
        WriteString(KVH,command,0x0d);              /* send the command */
        if(command[0] != '=') delay(60);            /* delay */
        else delay(200);

        if(ReadChar(KVH) == '>') break;      /* check for command accepted! */


        ClearRXBuffer(KVH);                 /* command ignored, clear buffer */
        if(++loop >= 5) ERROR = 1;          /* increment error count, retry */
  } while(loop < 5);
if(ERROR) FatalError("C001");               /* abort with Fatal Error */

  do
  {  temp[0] = ReadChar(KVH);               /* purge remains of first line */
  }while(temp[0] != 0x0d && temp[0] >= 0);

  ReadCharTimed(KVH,100L);              /* wait for first character of next */
  if(command[0] == '=') delay(100);     /* increase delay for "cals" */
  else delay(5);
  if(response1 != NULL) ReadStringTimed(KVH,response1,40,0x0d,100L);

}


ERRHAND.C

#include <stdio.h>
#include <conio.h>
#include <dos.h>
#include <ctype.h>

#define IGNORE 0
#define RETRY 1
#define ABORT 2


#pragma warn -par

int handler(int errval, int ax, int bp, int si)
{
  unsigned  di;
  int drive;
  int errorno;

  di = _DI;

  if(ax < 0)   hardretn(ABORT);

  drive = ax & 0x00ff;
  errorno = di & 0x00ff;
  if(drive != 0)  hardretn(ABORT);

/*  sprintf(msg,"Error: %s on drive %c\r\nA)bort, R)etry, I)gnore: ",
              err_msg[errorno],'A' + drive);
  */
  hardresume(IGNORE);
  return ABORT;
}
#pragma warn +par



GETSYS.C

#include <stdio.h>
#include <string.h>
#include <ctype.h>
```

```
#include <stdlib.h>

extern char SystemID;
extern float   PitchOffset,
                              PitchGain,
                              RollOffset,
                              RollGain,
                              AltOffset,
                              AltGain,
                              BallOffset,
                              BallGain;
extern char DataDirPath[50];

void FatalError(char * n);
void GetChar(char * x, int* y);
float GetFloat(char *);
int GetString(char * buffer, char * path);


/*********************************************************************/
/*                                                                   */
/*            This routine looks for "logger.ini" file and reads the */
/*            gains and offsets for critical analog channels, the system*/
/*            ID and the path in which to store the data files.    */
/*                                                                   */
/*********************************************************************/


void ReadSysParameters()
{
  FILE * in;
  char buffer[80];
  char * marker;
  float temp[8];
  char path[50];
  int ch;
  char c;
  int count = 0,index;
  char keys[10][25] = {"PitchOffset","PitchGain","RollOffset","RollGain",
               "AltOffset","AltGain","BallOffset","BallGain","SystemID",
               "DataDirPath"};
  if((in = fopen("logger.ini","rt")) == NULL) FatalError("S001");
  for(;;)
  {
        if(fgets(buffer,80,in) == NULL)  break;
        for(index=0;index<10;index++)
        {
          if((strstr(buffer,keys[index])) != NULL)
          {
                switch(index)
                {
                  case 8:
                        {
                          GetChar(buffer,&ch);
                    c = ch;
                          if(isalpha(c))
                          {
                                count++;
                                goto next;
                          }
                        }
                  case 9:
                        {
                          if(GetString(buffer,path))
                          {
                                goto next;
                          }
                        }
                  default:
                        {
                          if((temp[index] = GetFloat(buffer)) <9999) count++;
                                goto next;
                        }
                }
          }
        }
        next:
  }
  fclose(in);
  if(count == 9)
  {
```

```
        SystemID = c;
        PitchOffset = temp[0];  PitchGain = temp[1]; RollOffset = temp[2];
        RollGain = temp[3];  AltOffset = temp[4]; AltGain = temp[5];
        BallOffset = temp[6];  BallGain = temp[7];

        if(strlen(path) != 0)  strcpy(DataDirPath,path);
  }
  else
  FatalError("S002");
}

float GetFloat(char * buffer)
{
  char * marker;
  char tempbuffer[80];
  float value;

  if((marker = strstr(buffer,"=")) != NULL)
  {
        strcpy(tempbuffer, marker + 1);
        if(sscanf(tempbuffer,"%f",&value) == 1) return(value);
  }
  return(10000);
}


void GetChar(char * buffer, int* x)
{
  char * marker;
  char tempbuffer[80];

  if((marker = strstr(buffer,"=")) != NULL)
  {
        strcpy(tempbuffer, marker +1);
        if(sscanf(tempbuffer," %c",x) == 1) return;
  }
  x = 0x00;
  return;
}


int GetString(char * buffer, char * path)
{
  char * marker;
  char tempbuffer[80];

  if((marker = strstr(buffer,"=")) != NULL)
  {
        strcpy(tempbuffer,marker + 1);
        if(sscanf(tempbuffer," %s",path)) return(1);
  }
  path[0] = 0x00;
  return(0);
}
```

GPSTEST.C

```
#include <stdio.h>
#include <dos.h>
#include <time.h>
#include <ctype.h>
#include <bios.h>
#include <alloc.h>
#include <stdlib.h>
#include <conio.h>
#include <math.h>
#include <string.h>
#include <dir.h>
#include <io.h>
#include "a12drvc.h"


#include       "ibmkeys.h"
#include       "asciidef.h"
#include       "gsci.h"

time_t WriteTime;
int    PacingFlag=0;
int WriteTimeFlag = 0;
```

```
FILE * restart;
FILE * logfilepointer;
char LogFileName[80];

int  GPSFlag = 0,                          /* GPS Data Available */
        RecFlag = 0,                      /* Recording Data */
        CalFlag = 0,                      /* Calibrating Compass */
        GyroFlag = 0,                      /* Gyro Erect */
        ReStartFlag = 0,                  /* Restart Recording to old file */
        DCIFlag = 0,                      /* Differential Corrections good */
        InitFlag = 0,                      /* Init in progress */
        MarkFlag = 0,                     /* Marking in progress */
        MarkIndex = 0,                    /* Current or last mark index */
        ReStartFileFlag =  0,             /* Valid restart file read */
        ReStartUpdateFlag = 0,            /* Update present restart.ini file */
        ReStartMarkIndex = 0,
        CompassCheckFlag = 0,             /* display compass check */
        LogFileNamed = 0;                  /* valid filename in "logfilename" */
int  WriteRecordFlag = 0;                  /* write a record now! */
int  FlushRecordBufferFlag = 0;            /* recording stopped! flush!*/
int  SetTimeFlag = 1;
int  FloppyFlag = 0;
int  ExitFlag = 0;
int  ADInProgressFlag = 0;
int  ADDataReadyFlag = 0;
int  BannerFlag = 0;
int  DiagnosticFlag = 0;


unsigned char  CurrentContrast = 0x66;

char SystemID;                                    /* logger.ini variables */
float  PitchOffset,
               PitchGain,
               RollOffset,
               RollGain,
               AltOffset,
               AltGain,
               BallOffset,
               BallGain;
char DataDirPath[50];

struct record
{
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
  int          CDI1;
  int          CDIT_F1;
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

struct record Record;
struct record RecordBuffer[10];
int RecordIndex = 0;

int    GPSBufferFlag[2] = {0,0};
char   GPSBuffer[2][130];
unsigned int  LoopCounter = 1000;

unsigned ADPointBuffer[200];               /* Globals for A/D board */
int             ADStatus,
                ADTask,
                ADParameters[5],
                ADDataBuffer[200],
```

```
               ADTempBuffer[100];

int ADCount=10;


PORT    *KVH;   /* compass system on COM3 */
PORT    *QT;    /* terminal on COM2 */
PORT    *GPS;   /* GPS receiver on COM1 */
int     SendGPSCommand(char * p);
void    FatalError(char * p);
void    GPSInit(void);
int     ReadGPS(void);
void    GPSDeInit(void);
void    GPSScan(void);
void    NameFile(void);
void    WriteToFile(void);
void    ReadSysParameters(void);
void    SysTime(long int);
void    WriteToBuffer(void);
int     WriteRestart(void);
void    checkdisk(void);
void     CopyToFloppy(void);
int     handler(int,int,int,int);
void    DisplaySignOn(char,char*);
void    QTClear(void);
void    QTWLine(char*,int);
void    QTBeep(void);
void    LEDUpdate(void);
void    GetKeyboardInput();
void     UpdateCount(char *);
void    ReadRestart(void);
void    QTReset(void);
void    DisplayRestart(void);
unsigned    ADSetup(void);
unsigned       ADProcedures(void);
unsigned       ADCheckRdy(void);
void    GetKeyboardInput(void);
void    Pacing(void);
void    ADLoop(void);
void    SignOff(void);
void    CopyMessage(char *);
void    ReadCompass(void);
float   GetMagHeading(void);
void    DisplayCompass(void);


FILE * in;

int main()
{
  int status;
  ReadSysParameters();
  ReadRestart();
  harderr(handler);                /* error handler subsitute */


  status =  GreenleafSet16550TriggerLevel(TRIGGER_04);
  if(status < 0)
  {
       printf("Error returned on Trigger = %d\n",status);
       FatalError("I001");
       exit(0);
  }
  GreenleafSetPortHardware(COM3,IRQ5,0x2e8);
  KVH = PortOpenGreenleafPolled(COM3,9600L,'N',8,1);
  if(KVH == NULL) FatalError("I002");


  GPS = PortOpenGreenleafFast(COM1,9600L,'N',8,1);
  if(GPS == NULL)
  {
       printf("Port Open Failed\n");
       FatalError("I003");
       exit(0);
  }
  UseRtsCts(GPS,1);

  QT = PortOpenGreenleafPolled(COM2,9600L,'N',8,1);
  if(QT == NULL) FatalError("I004");
  UseXonXoff(QT,1);
  QTReset();
```

```
  if(ReStartFileFlag) DisplayRestart();
  else
  {
        DisplaySignOn(SystemID,"V1.22");
        checkdisk();                                        /* check for floppy */
        DisplayCompass();
        QTWLine("     STARTING",2);
  }

  ADSetup();

  GPSInit();
  ClearRXBuffer(GPS);
  ClearRXBuffer(QT);

  do
  {
        LoopCounter += 1;
        ADProcedures();
        ReadGPS();
        GPSScan();
        if(WriteRecordFlag)
        {
          printf("Time = %ld, Mode = %d, GPSFlag = %d, DCIFlag = %d\n",
                Record.Time,Record.Mode,GPSFlag,DCIFlag);
          printf("Lat = %lf, Long = %lf, Alt = %d, Heading = %d\n",
                Record.Latitude,Record.Longitude,Record.Altitude,Record.MagHeading);
          if(ADCount)
                printf("%d   %d\n\n",Record.Pitch/ADCount,Record.Roll/ADCount);
        }
        WriteToBuffer();
        WriteToFile();
        LEDUpdate();
        CalCompass();
        GetKeyboardInput();
        WriteRestart();
        ADCheckRdy();
        delay(1);
        Pacing();
//      ADLoop();
  }while(!ExitFlag);
  CopyToFloppy();
  SignOff();
  GPSDeInit();
  PortClose(QT);
  PortClose(KVH);
  PortClose(GPS);
  return(0);
}



/*********************************************************************/
/*                                                                   */
/*      GPSInit reset the receiver and then sets up 3-D nav and      */
/*              the differential parameters.  The receiver will return*/
/*              a GGA and POS message each second.  Any error is considered */
/*              fatal!                                               */
/*                                                                   */
/*********************************************************************/

void GPSInit(void)
{
  int status;
  /* Reset GPS to default settings */
  if(!SendGPSCommand("$PASHS,RST")) FatalError("G002");
  /* Set Differential Mode to auto */
  if(!SendGPSCommand("$PASHS,RTC,AUT,Y")) FatalError("G003");
  /* Set GPS Mode to 3-D */
  if(!SendGPSCommand("$PASHS,PMD,0")) FatalError("G004");
  /* Set Up Differential Corrections on Port B */
  if(!SendGPSCommand("$PASHS,RTC,REM,B")) FatalError("G005");
  /* Set message GGA ONLY SENT IF POSITION COMPUTED */
  if(!SendGPSCommand("$PASHS,NME,GGA,A,ON")) FatalError("G006");
  /* Set message POS ALWAYS SENT */
  if(!SendGPSCommand("$PASHS,NME,POS,A,ON")) FatalError("G007");
  /* Set RTCM timeout to fifteen seconds*/
  if(!SendGPSCommand("$PASHS,RTC,MAX,15")) FatalError("G008");

}
```

```
void GPSDeInit(void)
{
  WriteString(GPS,"$PASHS,RST",-2);
/*  SendGPSCommand("$PASHS,RST");*/
}


/*************************************************************************/
/*                                                                       */
/*      SendGPSCommand attempts five times to send the command to the    */
/*              receiver.  It looks at the response of the receiver and scans*/
/*              for "ACK" which indicates the command was accepted.  It will*/
/*              attempt three repeations before returning failure.       */
/*                                                                       */
/*************************************************************************/

int SendGPSCommand(char * buffer)
{
  int status,i;
  int count =0;
  char response[100];
  char * ack = "ACK";

  do
  {
        for(i=0;i<5;i++)
        {
          ClearRXBuffer(GPS);
          if((status = WriteString(GPS,buffer,-2)) == 0) break;
        }
        if(status != 0) FatalError("G001");
        ReadStringTimed(GPS,response,99,-2,1500L);
        if(GPS->status == ASSUCCESS)
        {
          if(strstr(response,ack) != NULL) return(1);
        }
        count++;
  }while(count < 3);
  return(0);
}



int ReadGPS(void)
{
  static int CurrentBuffer = 0;
  static int BufferIndex[2] = {0,0};
  int input;


  while(!IsRXEmpty(GPS))/*(input = getc(in)) != EOF) /* while characters are available */
  {
        input = ReadChar(GPS);               /* get next character */
        if(input >= 0)                              /* valid read */
        {
          if((input != 0x0d) && (input != 0x0a))
          {
                GPSBufferFlag[CurrentBuffer] = 0; /* test of flags */
                GPSBuffer[CurrentBuffer][BufferIndex[CurrentBuffer]++] = (char)input;
                GPSBuffer[CurrentBuffer][BufferIndex[CurrentBuffer]] = 0x00;
          }
          else
          {
                if(input == 0x0d)
                {
                  GPSBuffer[CurrentBuffer][BufferIndex[CurrentBuffer]] = 0x00;
                                                      /* null terminate string */
                  BufferIndex[CurrentBuffer] = 0;     /* reset index */
                  GPSBufferFlag[CurrentBuffer] = 1;   /* indicate buffer ready */
                  CurrentBuffer = (CurrentBuffer) ? 0:1; /* toggle current buffer */
                }
          }
          if(BufferIndex[CurrentBuffer] != 0) GPSBufferFlag[CurrentBuffer] = 0;
          if(input == 0x0d) return(0);
        }
  }
  return(0);
}
```

```
/*********************************************************************/
/*                                                                   */
/*      GPSScan parses the buffers filled by GPSRead.  GPSBufferFlags are  */
/*      used to determine if buffer is complete.                     */
/*                                                                   */
/*      GPSFlag and DCIFlag are set to 10 each time a valid position comp  */
/*      and diff mode usage are determined.  These are decremented at a    */
/*  once per second rate if no computation or non-diff is detected.  */
/*                                                                   */
/*********************************************************************/

void GPSScan(void)
{
  int   index,status;
  char  ns,ew;
  static unsigned long GGATime, POSTime, LastTimeT, LastTimeD;
  static double GLat,GLon,GAlt,PLat,PLon,PAlt,Rate=0,Geoidal=-30;
  static int GFlag,PFlag;
  float COG,SOG;
  double temptime;
  static char * ggaformat =
              "$GPGGA,%lf,%lf,%c,%lf,%c,%1d,%*2d,%*4f,%lf,M,%lf";
  static char * posformat =
              "$PASHR,POS,%d,%*d,%lf,%lf,%c,%lf,%c,%lf,,%f,%f,%lf";

  if(!GPSBufferFlag[0] && !GPSBufferFlag[1])  return;
                                        /* no buffers filled */
  index = GPSBufferFlag[0] ? 0:1;       /* use buffer 0 if filled */

  if(strstr(GPSBuffer[index],"$GPGGA") != NULL)  /* is a GGA message */
  {

       if(sscanf(GPSBuffer[index],ggaformat,&temptime,&GLat,&ns,&GLon,&ew,&GFlag,
              &GAlt,&Geoidal) == 8)       /* if scan good, transfer data */
       {
         GGATime = temptime;
         if(ns == 'S') GLat *= -1.0;
         if(ew == 'W') GLon *= -1.0;
         Record.Time = GGATime;
         Record.Latitude = GLat;
         Record.Longitude = GLon;
         Record.Altitude = 3.2808*(GAlt - Geoidal);
         if(GFlag == 2)                 /* if differential set bit 0 = 1 */
         {
              Record.Mode |= 0x0001;
              DCIFlag = 10;
         }
         else
         {
              Record.Mode &= 0xfffe;    /* if not clear bit 0 */
              if((DCIFlag > 0) && (LastTimeD != POSTime)) DCIFlag--;
              LastTimeD = POSTime;
         }
         Record.Mode |= 0x0002;      /* set bit 1 = 1 */
         GPSFlag = 10;               /* set GPSFlag */
         LastTimeT = POSTime;

       }
       GPSBufferFlag[index] = 0;           /* mark buffer as read */
       return;
  }

  if(strstr(GPSBuffer[index],"$PASHR") != NULL)     /* is a POS message */
  {
       WriteRecordFlag = 1;          /* time to write a record */
       if(sscanf(GPSBuffer[index],posformat,&PFlag,&temptime,&PLat,&ns,&PLon,&ew,
              &PAlt,&COG,&SOG,&Rate) == 10)
       {
         POSTime = temptime;
         if(ns == 'S') PLat *= -1.0;
         if(ew == 'W') PLon *= -1.0;
         if(POSTime <= Record.Time) WriteRecordFlag = 0;
         else Record.Time = POSTime;
         Record.Latitude = PLat;
         Record.Longitude = PLon;
         Record.Altitude= 3.2808*(PAlt - Geoidal);
         Record.RateOfClimb = 0.25*Record.RateOfClimb + 147.636*Rate;
                                       /* m/s to ft/min */
         /* three second time constant added to rate of climb*/
         Record.COG = COG;
```

```
          Record.SOG = SOG;
          if(SetTimeFlag) SysTime(Record.Time);             /* set system time to GPS */
          if(PFlag == 1)
          {
               Record.Mode |= 0x0001;
               DCIFlag = 10;
          }
          else
          {
               Record.Mode &= 0xfffe;
               if((DCIFlag > 0) && (LastTimeD != POSTime)) DCIFlag--;
               LastTimeD = POSTime;
          }
          if((GPSFlag > 0) && ((LastTimeT + 1L) > POSTime))
          {
               Record.Mode &= 0xfffd;
               GPSFlag--;
          }
          PacingFlag = WriteTimeFlag = 0;
        }
        else
        {
          Record.Time++;
          Record.Mode = 0;
          if(GPSFlag >0) GPSFlag--;
          if(GPSFlag == 0) DCIFlag = 0;
          PacingFlag = WriteTimeFlag = 0;
        }
  }
  GPSBufferFlag[index] = 0;
  return;
}

/*********************************************************************/
/*                                                                   */
/*      WriteToFile uses previously defined file name if present or */
/*             generates a new name based on the date and time. Then */
/*       writes the contents of the buffer to this file and closes   */
/*       the file each time.                                         */
/*                                                                   */
/*********************************************************************/

void WriteToFile()
{
  char  directory[80] = {"f:/"};
  char temp1[15],temp2[5], string[20]= "Log File:";

  if((RecordIndex < 10) && !FlushRecordBufferFlag) return; /*not yet and no flush */
  if(RecordIndex == 0)
  {
        FlushRecordBufferFlag = 0;
        return;
  }
  /*  if we get here, there is data to write! */
  if(!LogFileNamed)
  {
        if(!ReStartFlag)
        {
          NameFile();                          /* generate file name from date */
          if(strlen(DataDirPath))              /* If there is a path, add it!*/
                strcpy(directory,DataDirPath);
                strcat(directory,LogFileName); /* add filename */
          strcpy(LogFileName,directory);       /* copy to global */
        }
        LogFileNamed = 1;
        ReStartUpdateFlag = 1;
        fnsplit(LogFileName,NULL,NULL,temp1,temp2);
        strcat(temp1,temp2);
        strcat(string,temp1);
        QTWLine(string,2);
  }
  if((logfilepointer = fopen(LogFileName,"a+b")) == NULL) FatalError("W001");
  if(fwrite(RecordBuffer,sizeof(Record),RecordIndex,logfilepointer)
               != RecordIndex)
        FatalError("W002");
  if(fclose(logfilepointer) != 0) FatalError("W003");
  RecordIndex = 0;
  FlushRecordBufferFlag = 0;
}
```

```
/*********************************************************************/
/*                                                                   */
/*     WriteToBuffer averages summed fields in the data record and   */
/*             writes the resulting record into the buffer.          */
/*                                                                   */
/*********************************************************************/

void WriteToBuffer()
{
  static unsigned int count = 0;
  char s[10];
  float tempy;
  if(WriteRecordFlag)
  {
        printf("Count = %d\n",ADCount);
        printf("Loops = %u\n",LoopCounter);
        LoopCounter=0;
        if(ADCount)
        {
        Record.Airspeed /=ADCount; Record.Pitch /=ADCount;Record.Roll/=ADCount;
        Record.Ball/=ADCount; Record.CDI1/=ADCount; Record.CDI2/=ADCount;
        Record.GSDev/=ADCount; ADCount = 0;
        }
        if (Record.Ball <0) tempy = -1;
                  else tempy = +1;
                  Record.Ball = floor(fabs(Record.Ball*4.0)+ 0.5);
                  Record.Ball = tempy*Record.Ball/4.0;

        if(RecFlag)
        {
          ReadCompass();
          RecordBuffer[RecordIndex++] = Record;
          sprintf(s,"%9u",++count);
          UpdateCount(s);

          /*****************************************************************/
          /*                                                               */
          /*    The following "switch" displays diagnostic informaton      */
          /*    on the A/D system functions.  Displaying the information   */
          /*    on the third line of the terminal.                         */
          /*    1 displays pitch and roll                                  */
          /*    2 displays airspeed and ball position                      */
          /*    3 displays CDI # 1 and its flag                            */
          /*    4 dispalys CDI # 2 and its flag                            */
          /*    5 displays GS Dev and its flag                             */
          /*                                                               */
          /*    0 clears the third line display                            */
          /*                                                               */
          /*****************************************************************/
          switch(DiagnosticFlag)
          {
                case '0':
                  break;

                case '1':
                  PitchRoll(Record.Pitch,Record.Roll);
                  break;

                case '2':
                  ASPend(Record.Airspeed,Record.Ball);
                  break;

                case '3':
                  PitchRoll(Record.CDI1,Record.CDIT_F1);
                  break;

                case '4':
                  PitchRoll(Record.CDI2,Record.CDIT_F2);
                  break;

                case '5':
                  PitchRoll(Record.GSDev,Record.GSFlag);
                  break;
                default:
                  break;
          }
          time(&WriteTime);
          WriteTimeFlag = 1;
        }
        WriteRecordFlag = 0; Record.Airspeed = 0; Record.Pitch = 0;
        Record.Roll = 0; Record.Ball = 0; Record.CDI1 = 0; Record.CDI2 = 0;
```

```
        Record.GSDev =0;
  }
  return;
}


/*****************************************************************/
/*                                                               */
/*      checkdisk checks for the presence of a disk in drive A and if*/
/*              provides an estimate of the length of flight data which can */
/*              be copied to this disk.                          */
/*                                                               */
/*****************************************************************/


void checkdisk(void)
{
  struct diskfree_t free;
  long avail;
  int size;
  float time;
  char line1[22];

  if(_dos_getdiskfree(1,&free) != 0)
  {
        QTClear();
        QTWLine(" Insert a Formatted",1);
        QTWLine(" Disk into Drive A:",2);
        QTWLine("Press ENTER to Cont.",4);
        QTBeep();
        ReadCharTimed(QT,15000L);
        QTClear();
  }

  if(_dos_getdiskfree(1,&free) == 0)
  {
        avail = (long)free.avail_clusters * (long)free.bytes_per_sector
                        * (long)free.sectors_per_cluster;
        size = sizeof(Record);
        time = (float)avail/(float)size;
        time /= 3600.0;
        sprintf(line1,"space for %4.2f hours",time);
        QTClear();
        QTWLine(" This Diskette has",1);
        QTWLine(line1,2);
        QTWLine("   of Flight Data",3);
        QTBeep();
        delay(3000);
        QTClear();
        FloppyFlag = 1;
  }
}

/*****************************************************************/
/*                                                               */
/*      CopyToFloppy copies all data files in the datasave directory to */
/*              the floppy.  It copies only file with are not archived. *
/*      After a successful copy to floppy, the source file is mark as      */
/*              as archived so it will not be copied again.  The source file*/
/*              is retained (not erased).                                */
/*                                                                       */
/*      CopyToFloppy calls FileCopy to perform the disk to disk copy.      */
/*                                                               */
/*****************************************************************/

void CopyToFloppy(void)
{
  char * fname ="*.*";
  char * dest = "a:/";
  char destfile[20];
  char search[80];
  char sourcefile[80];
  struct ffblk block;
  struct diskfree_t free;

  int FileCopy(char*,char*);

  if(_dos_getdiskfree(1,&free) != 0)
  {
        QTReset();
        QTWLine(" No Disk in Drive!",1);
```

```
        QTWLine(" FILE COPY ABORTTED",3);
        QTBeep();
        delay(2000);
        return;
  }

  if(strlen(DataDirPath))
  {
        strcpy(search,DataDirPath);
        strcpy(sourcefile,DataDirPath);
  }
  strcat(search,fname);
  if(findfirst(search,&block,FA_ARCH) != 0) return;
  strcpy(destfile,dest);
  strcat(destfile,block.ff_name);
  strcat(sourcefile,block.ff_name);
  if(_chmod(sourcefile,0) == 0x20)
  {
        CopyMessage(destfile);
        if(FileCopy(destfile,sourcefile))
               _chmod(sourcefile,1,0x00);
  }
  for(;;)
  {
        if(findnext(&block) != 0) return;
        strcpy(sourcefile,DataDirPath);
        strcat(sourcefile,block.ff_name);
        strcpy(destfile,dest);
        strcat(destfile,block.ff_name);
        if(_chmod(sourcefile,0) == 0x20)
        {
          CopyMessage(destfile);
          if(FileCopy(destfile,sourcefile))
                      _chmod(sourcefile,1,0x00);
        }
  }
}


/*********************************************************************/
/*                                                                   */
/*      FileCopy copies source to destination returning "true" if    */
/*              if suuccessful and "false" if not.                   */
/*                                                                   */
/*********************************************************************/


int FileCopy(char * dest, char * source)
{
  FILE * in;
  FILE * out;
  int status, count,size;
  int * buffer;
  int error = 0;

  if((in = fopen(source,"rb")) == NULL) return(0);
  if((out = fopen(dest,"wb")) == NULL) return(0);
  size = sizeof(Record);
  if((buffer = (int *) malloc(100*size)) == NULL) return(0);
  do
  {
        count = fread(buffer,size,100,in);
        if(!count) break;
        status = fwrite(buffer,size,count,out);
        if(status != count) error = 1;
  }while(!error);

  fclose(in);
  fclose(out);
  if(error)
  {
        unlink(dest);
        return(0);
  }
  return(1);
}

/*********************************************************************/
/*                                                                   */
/*      ReadCompass calls GetMagHeading and places the result in the*/
/*              present record.                                      */
```

```
/*                                                                    */
/**********************************************************************/

void ReadCompass(void)
{
  float head;

  head = GetMagHeading();
  Record.MagHeading = (int) head;
  return;
}
```

NAMEFILE.C

```
#include <stdio.h>
#include <dos.h>
#include <time.h>
#include <string.h>

extern char LogFileName[];
extern int LogFileNamed;
extern char SystemID;

/**********************************************************************/
/*                                                                    */
/*             This routine gives the data file a unique name based on the */
/*             System ID, year, month, day, hour, and minute (UTC time).   */
/*                                                                    */
/**********************************************************************/

void NameFile()
{
  /*TZ environmental varible should be TZ=GMT0 and clock should be GMT */
  struct tm *time_now;
  int month;
  time_t secs_now;
  char str[80];
  char tempstr[80];

  sprintf(str,"%c",SystemID);
  time(&secs_now);
  time_now = localtime(&secs_now);
  strftime(tempstr,13,"%d%H%M.%y",time_now);
  strcat(str,tempstr);
  month = time_now->tm_mon + 1;
  sprintf(LogFileName,"%s%X",str,month);
  LogFileNamed = 1;
}
```

PACING.C

```
#include <stdlib.h>
#include <time.h>
#include <dos.h>

extern time_t WriteTime;
extern int PacingFlag;
extern int WriteRecordFlag;
extern int WriteTimeFlag;
extern int RecFlag;
extern int GPSFlag;
extern int DCIFlag;
extern struct record
{
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
  int          CDI1;
  int          CDIT_F1;
```

```
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

extern struct record Record;

/*************************************************************************/
/*                                                                       */
/*     WriteTo Buffer will set WriteTime!  Pacing() will check for loss  */
/*             of 1Hz datarate.  ScanGPS may reset PacingFlag if reacquired.*/
/*                                                                       */
/*************************************************************************/



void SetTimeRecord(void)
{
  struct time now;
  long temp;

  gettime(&now);
  temp = 100*now.ti_hour + now.ti_min;
  temp = 100*temp + now.ti_sec;
  Record.Time = temp;
}


void Pacing(void)
{
  static  time_t  PresentTime;
  time_t       diff;

  if(!RecFlag||!WriteTimeFlag) return;
  if(!PacingFlag)
  {
       if(time(&PresentTime) > WriteTime +2L)
       {
         SetTimeRecord();
         PacingFlag = 1;
         WriteRecordFlag = 1;
      GPSFlag = DCIFlag = 0;
         WriteTime = PresentTime;
       }
  }
  else
  {
       time(&PresentTime);
       if((diff = PresentTime - WriteTime) == 0) return;
       else
       {
         Record.Time += diff;
         WriteTimeFlag = 0;
         WriteRecordFlag = 1;
       }
  }
}
```

QTFUNCT.C

```
#include "gsci.h"
#include "ibmkeys.h"
#include "asciidef.h"
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

extern struct record
{
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
```

```
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
  int          CDI1;
  int          CDIT_F1;
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

extern struct record Record;
extern int DiagnosticFlag;

extern  PORT *QT;
extern  unsigned char  CurrentContrast;
extern  char    SystemID;
extern  int     RecFlag,
                       MarkFlag,
                       MarkIndex,
                       ReStartMarkIndex,
                       ReStartUpdateFlag,
                       ReStartFlag,
                       CalFlag,
                       ReStartFileFlag,
                       GPSFlag,
                       DCIFlag,
                       CompassCheckFlag,
                       GyroFlag,
                       FlushRecordBufferFlag,
                       ExitFlag;
extern int      BannerFlag,
                       PacingFlag;


/*************************************************************************/
/*                                                                       */
/*      Clear Only the Text on Q-Term Terminal                           */
/*                                                                       */
/*************************************************************************/


void QTClear(void)
{
  char str[2]={0x1b,'E'};
  WriteBuffer(QT,str,2);
}

/*************************************************************************/
/*                                                                       */
/*      Writes the null-terminated string "buffer: to designated line      */
/*                                                                       */
/*************************************************************************/

void QTWLine(char * buffer,int line)
{
  char pos[4] = {ESC,'I','@','@'};          /* position to col 1, line 1 */
  char clear[2] ={ESC,'K'};             /* clear to end of line */
  pos[2] += line - 1;                   /* modify line to that selected */
  WriteBuffer(QT,pos,4);                /* exec positioning */
  WriteBuffer(QT,clear,2);              /* exec clear */
  WriteString(QT,buffer,-1);            /* write string */
}

/*************************************************************************/
/*                                                                       */
/*      Control Status of Q-Term LED,s                                   */
/*                                                                       */
/*************************************************************************/

void QTLed(int lamp, int function)
{
  char string[3] = {ESC,'P'};
  unsigned char c;
```

```
  /* lamps numbered 1-5 from right to left */
  /* 0 = off, 1= 0n, 2= blink, 3 = toggle */
  c = 0x40 + lamp + 8*function;
  string[2] = c;
  WriteBuffer(QT,string,3);
 }

/*************************************************************************/
/*                                                                       */
/*      Toggle Backlight on display                                      */
/*                                                                       */
/*************************************************************************/

void QTBackLite(void)
{
  char back[3] = {ESC,'V','B'};
  WriteBuffer(QT,back,3);
}

/*************************************************************************/
/*                                                                       */
/*      Reset QT : Clears dislay, Clears LEDs, resets stored parameters  */
/*                                                                       */
/*************************************************************************/

void QTReset(void)
{
  char rst[2] = {ESC,'M'};
  WriteBuffer(QT,rst,2);
  delay(350);                 /* command requires 300 ms */
}



/*************************************************************************/
/*                                                                       */
/*      Adjust Contrast on Q-Term Screen                                 */
/*                                                                       */
/*************************************************************************/

void QTContrast(void)
{
  char c;
  char msg[3] = {ESC,'L'};

  c = CurrentContrast + 0x04;
  if(c > 0x78) c = 0x60;
  CurrentContrast = msg[2] = (char)c;
/*  printf("Contrast is %x hex\n",c); */
  WriteBuffer(QT,msg,3);
}


/*************************************************************************/
/*                                                                       */
/*      Next three routines control the buzzer of the Q-Term             */
/*                                                                       */
/*************************************************************************/

void QTBeep(void)
{
  char beep[3] ={ESC,'O','B'};
  WriteBuffer(QT,beep,3);
}

void QTAudioOff(void)
{
  char beep[3] = {ESC,'O','@'};
  WriteBuffer(QT,beep,3);
}

void QTAudioOn(void)
{
  char beep[3] = {ESC,'O','A'};
  WriteBuffer(QT,beep,3);
}


/*************************************************************************/
/*                                                                       */
/*      Display and Announces Occurance of a Software Fatal Error        */
```

```
/*                                                                      */
/************************************************************************/

void FatalError(char * message)
{
  char string[20];
  int i;

  sprintf(string,"Fatal Error # %s",message);
  QTClear();
  QTWLine(string,1);
  QTWLine("Record Error Number!",2);
  QTWLine("To Restart, reset or",3);
  QTWLine("cycle power on unit!",4);
  for(i=0;i<3;i++)
  {
    QTBeep();
    delay(1000);
  }
  exit(0);
}


/************************************************************************/
/*                                                                      */
/*     Displays the Sign-On Message and System ID.  Tests LEDs and Beep!   */
/*                                                                      */
/************************************************************************/

void DisplaySignOn(char c, char * st)
{
  char buffer[20];
  int i;

  QTReset();
  QTWLine("  IPC Data Logger",1);
  sprintf(buffer,"     System %c",c);
  QTWLine(buffer,2);
  sprintf(buffer,"       %s",st);
  QTWLine(buffer,3);

  for(i=1;i<6;i++)
  {
       QTLed(i,1);            /* LED's on */
       delay(300);
  }
  QTBeep();
  delay(500);
  for(i=5;i>0;i--)
  {
       QTLed(i,0);            /* LED's off */
       delay(300);
  }
  delay(3000);
}

/************************************************************************/
/*                                                                      */
/*     Looks for KeyPresses on the QT Terminal, scans for valid inputs,    */
/*     sets flags for the various functions to be performed.            */
/*                                                                      */
/************************************************************************/

void GetKeyboardInput(void)
{
  int status;
  char buffer[22];
  char mess1[5] = {ESC,'I','B','@'};
  char mess2[5] = {ESC,'K'};

  if(IsRXEmpty(QT)) return;          /* return immediately if no characters */
  if(PeekChar(QT) != '~')     /* if not tilde, single character command */
  {
       if((status = ReadChar(QT)) < 0) return; /* return on error */
       switch (status)
       {
         case 'B':                  /* Q-Term BackLite */
         case 'G':
              QTBackLite();
              return;
         case 'C':                  /* Q-Term Contrast */
```

```
        case 'H':
             QTContrast();
             return;
        case '0':
        case '1':
        case '2':
        case '3':
        case '4':
        case '5':
             WriteBuffer(QT,mess1,4);
             WriteBuffer(QT,mess2,2);
             DiagnosticFlag = status;
             return;
        default:
             return;
      }
}
else
{
      if((status = ReadChar(QT)) < 0) return;      /* read and discard first */
      if((status = ReadChar(QT)) < 0) return;  /* read and retain second */
      {
        switch (status)
        {
      case '5':                                    /* toggle marking */
             if(!RecFlag) return;                  /* must be recording to toggle */
             if(!MarkFlag)                         /* not presently marking */
             {
               MarkFlag = 1;                       /* set Mark flag */
               QTLed(1,1);                         /* MARK LED on */
                                                   /* increment index */
               sprintf(buffer,"MARKING!  %9d",++MarkIndex);
               Record.Mark = MarkIndex;
               QTWLine(buffer,4);                 /* Display message */
               ReStartUpdateFlag = 1;      /* set flag to indicate the restart.ini file
                                                        should be updated */
               return;
             }
             else                                  /* presently marking */
             {
               MarkFlag = 0;                       /* reset Mark flag */
               Record.Mark = 0;
               sprintf(buffer,"Last MARK was %5d",MarkIndex);
               QTWLine(buffer,4);                /* Display Message */
               QTLed(1,0);                         /* MARK Led off */
               return;
             }

      case '4':                                    /* calibrate compass */
             if(!CalFlag && !ReStartFileFlag && !RecFlag)
             /* if not cal'ing and no possibility of restart and
                not recording data, allow a calibration */
             {
               CalFlag = 1;                        /* set calibration flag */
             }
             return;

      case '3':                                    /* Use Restart */
             if(ReStartFileFlag && !RecFlag && !CalFlag && GPSFlag
                  && DCIFlag)
             {
               ReStartFlag = 1;
               MarkIndex = ReStartMarkIndex;
               RecFlag = GyroFlag = 1;
               QTWLine("Appending",1);
               QTLed(5,1);                         /* REC LED on */
             }
             return;

      case '2':                                    /* exit program */
             if(!RecFlag && !CalFlag && !CompassCheckFlag)
             {
               ExitFlag = 1;
               unlink("restart.ini");
             }
             return;

      case '1':
             if(!RecFlag && !CalFlag && !CompassCheckFlag
                && GPSFlag && DCIFlag && (GyroFlag || ReStartFileFlag))
             {
```

```
                RecFlag = 1;                        /* set RECORD Flag */
                QTLed(5,1);                         /* set REC LED on */
                ReStartUpdateFlag = 1;
                QTClear();
                QTWLine("Recording",1);
                unlink("restart.ini");
                return;
              }
              if(RecFlag)                           /* if recording */
              {
                RecFlag = 0;                        /* reset RECORD Flag */
                QTLed(5,0);                         /* set RECORD LED off */
                QTLed(1,0);
                FlushRecordBufferFlag = 1;
                ReStartUpdateFlag = 0;
                unlink("restart.ini");
                QTWLine("",1);
                QTWLine("Press EXIT to quit",3);
                QTWLine("   START to resume",4);
                return;
              }

       default:
              return;
         }
       }
  }
}


/*************************************************************************/
/*                                                                       */
/*     Display Non - Fatal Error Message; Sound Alert                    */
/*                                                                       */
/*************************************************************************/

void NonFatalError(char * text)
{
  QTClear();
  QTWLine("Error Detected in ",1);
  QTWLine(text,2);
  QTWLine("Procedure Canceled!",3);
  delay(1000);
  QTBeep();
  delay(1000);
  QTBeep();
  delay(1000);
  QTBeep();
  delay(2000);
  QTClear();
}

/*********************************************************************/
/*                                                                   */
/*     UpdateCount writes the current record number to the display */
/*             as an indication of continuing data collection.      */
/*                                                                   */
/*********************************************************************/

void UpdateCount(char * msg)
{
  char pos[5] = {ESC,'I','@','K'};
  WriteBuffer(QT,pos,4);
  WriteString(QT,msg,-1);
}

/*********************************************************************/
/*                                                                   */
/*     SignOff display a message to the operater when the power may*/
/*             safely removed from the system (all file copied and the*/
/*             system is idle).                                      */
/*                                                                   */
/*********************************************************************/

void SignOff(void)
{
  int i;
  QTClear();
  for(i=1;i<6;i++) QTLed(i,0);
  QTWLine(" Program Terminated!",1);
  QTWLine(" You may safely shut",2);
```

```
  QTWLine("  down the system!",3);
  delay(100);
}

/*********************************************************************/
/*                                                                   */
/*      CopyMessage displays during the copy-to-floppy process warning  */
/*              the operator to wait until the process is completed. */
/*                                                                   */
/*********************************************************************/

void CopyMessage(char * s)
{
  int i;

  for(i=1;i<6;i++) QTLed(i,0);
  QTClear();
  QTWLine("    Please Wait!",1);
  QTWLine("Writing File",3);
  QTWLine(s,4);
}

/*********************************************************************/
/*                                                                   */
/*      DisplayRestart informs the operator that a restart.ini file */
/*              was found an data may be appended to that file if desired.*/
/*                                                                   */
/*********************************************************************/

void DisplayRestart(void)
{
  QTClear();
  QTWLine("  RESTART POSSIBLE",1);
  QTBeep();
}

/*********************************************************************/
/*                                                                   */
/*      DisplayReady display either "STANDBY" or "READY" depending  */
/*              on the state of the datalogger.                      */
/*                                                                   */
/*********************************************************************/

void DisplayReady(void)
{
  if(!(BannerFlag == 1) && !RecFlag && GPSFlag &&
                              DCIFlag && GyroFlag /*|| ReStartFileFlag)*/ && !ExitFlag)
  {
        QTWLine("       READY",2);
        QTBeep();
        BannerFlag = 1;
  }
  if(!(BannerFlag == 2) && !RecFlag && (!GPSFlag || !DCIFlag || !GyroFlag))
  {
        QTWLine("      STANDBY!",2);
        BannerFlag = 2;
  }
}


/*********************************************************************/
/*                                                                   */
/*      LEDUpdate controls the state of the LED's depending on the state*/
/*              of the machine and the state of internal flags.      */
/*                                                                   */
/*********************************************************************/

void LEDUpdate()
{
  static int   LastRec,
                       LastGPS,
                       LastDCI;
  int i;

  i = (RecFlag) ? 2:0;
  if((RecFlag != LastRec) || (GPSFlag != LastGPS))
         if(GPSFlag) QTLed(4,1); else {QTLed(4,i);if(i==2) QTBeep();}

  if((RecFlag != LastRec) || (DCIFlag != LastDCI))
         if(DCIFlag) QTLed(3,1); else {QTLed(3,i);if(i==2) QTBeep();}
```

```
  LastRec = RecFlag; LastGPS = GPSFlag; LastDCI = DCIFlag;
  if(GyroFlag) QTLed(2,1);
  if(!PacingFlag) DisplayReady();
}


void PitchRoll(int pitch, int roll)
{
  char str1[5];
  char str2[5];
  char position1[5] ={ESC,'I','B','@'};
  char position2[5] = {ESC,'I','B','K'};

  sprintf(str1,"%3i",pitch);
  sprintf(str2,"%3i",roll);
  WriteBuffer(QT,position1,4);
  WriteString(QT,str1,-1);
  WriteBuffer(QT,position2,4);
  WriteString(QT,str2,-1);
}

void ASPend(int AS,float ball)
{
  char str1[5];
  char str2[5];
  char position1[5] ={ESC,'I','B','@'};
  char position2[5] = {ESC,'I','B','K'};

  sprintf(str1,"%3i",AS);
  sprintf(str2,"%4.2f",ball);
  WriteBuffer(QT,position1,4);
  WriteString(QT,str1,-1);
  WriteBuffer(QT,position2,4);
  WriteString(QT,str2,-1);
}



RESTART.C

#include       <stdio.h>
#include       <stdlib.h>
#include        <dos.h>
#include       <string.h>

/*#include     "logger.h"  */

extern char LogFileName[];
extern int     ReStartMarkIndex,
                    MarkIndex;
int ReadRestart(void);
int WriteRestart(void);
extern FILE * restart;
extern int LogFileNamed;
extern int ReStartFileFlag;
extern int ReStartUpdateFlag;

/*********************************************************************/
/*                                                                   */
/*             This routine looks for the file "restart.ini".  If it is    */
/*             present, and can be read, the operator is given the option  */
/*             to restart data loggong to the same file for which logging  */
/*             was interrupted.                                      */
/*                                                                   */
/*             "restart.ini" will only exist if a failure caused the data  */
/*             to stop in an abnormal manner, i. e. a Fatal Error, etc.    */
/*             Normal termination of the program deletes the restart file. */
/*                                                                   */
/*********************************************************************/

int ReadRestart(void)
{
  extern FILE * restart;
  char * filename = "FileName";
  char * mark = "MarkIndexNumber";
  char * marker;
  char  buffer[80];
  char tempbuffer[80];
  char  localfilename[80];
  int   length;
  int   localmarknumber;
```

```
  int   localfileflag = 0,
        localmarkflag = 0;
  FILE * tempfile;

  if((restart = fopen("restart.ini","rt")) == NULL)
        return(0);            /* restart.ini not found */

  for( ; ; )
  {
        if(fgets(buffer,80,restart) == NULL)  /* if no more lines */
          break;
        if(strstr(buffer,filename) != NULL)         /* if filename line */
        {
          if((marker = strpbrk(buffer,"=")) != NULL)
          {
                strcpy(tempbuffer,marker +2);
                length = strlen(tempbuffer);
                tempbuffer[length -1] = 0x00;
                if((tempfile = fopen(tempbuffer,"rb")) != NULL)
                {
                  fclose(tempfile);
                  localfileflag = 1;
                  strcpy(localfilename,tempbuffer);
                  goto next;
                }
          }
        }
    else
    {
      if(strstr(buffer,mark) != NULL)
      {
                if((marker = strpbrk(buffer,"=")) != NULL)
                {
                  if(sscanf(marker + 1,"%d",&localmarknumber))
                        localmarkflag = 1;
           }
      }
    }

    next:;
  }
  fclose(restart);
  if(localfileflag && localmarkflag)
  {
    ReStartMarkIndex = localmarknumber;      /* if successfull, copy local to globals */
        strcpy(LogFileName,localfilename);
        ReStartFileFlag = 1;
    return(1);                /* indicate success! */
  }

  return(0);                  /* failure */
}
/*****************************************************************/
/*                                                               */
/*             This is the routine which creates and updates the restart*/
/*             file.  The data file name and the last index mark used is*/
/*             recorded in this file for possible append operations.*/
/*                                                               */
/*****************************************************************/

int WriteRestart(void)
{
  extern FILE * restart;
  char * filename = "FileName = ";
  char * mark = "MarkIndexNumber = ";
  char buffer[80];
  int ERROR = 0;

  if(!ReStartUpdateFlag) return(1);
  ReStartUpdateFlag = 0;
  if((restart = fopen("restart.ini","wt")) == NULL)
        return(0);            /* unable to open file */
  if(sprintf(buffer,"%s%s\n",filename,LogFileName) == EOF)
        ERROR++;
  if(fputs(buffer,restart) == EOF)
        ERROR++;
  if(sprintf(buffer,"%s%d",mark,MarkIndex) == EOF)
        ERROR++;
  if(fputs(buffer,restart) == EOF)
        ERROR++;
  fclose(restart);
```

```
  if(ERROR)
  {
       unlink("restart.ini");
       return(0);
  }
  else
  return(1);
}
```

SYSTIME.C

```
#include <stdio.h>
#include <dos.h>
#include <time.h>
extern int SetTimeFlag;

/*********************************************************************/
/*                                                                   */
/*             This routine sets the system time to UTC time as determined */
/*      by the GPS system after acquistion.                          */
/*                                                                   */
/*********************************************************************/

int SysTime(long int GPSTime)
{
  struct time t;
  long int a,b;
  long int x = 10000L;


  a =  (GPSTime/10000L);
  b = a*x;
  GPSTime = GPSTime - b;
  b = (GPSTime/100L);
  GPSTime -= b*100;
  t.ti_min = (unsigned char)b;
  t.ti_hour = (unsigned char)a;
  t.ti_sec = (unsigned char)GPSTime;
  t.ti_hund = 0;
  settime(&t);
  SetTimeFlag = 0;
  return(0);
}
```

Basic Post Flight Software

LATITUDE-LONGITUDE ASCII CONVERSION

```
#include <stdio.h>
#include <dos.h>
#include <ctype.h>
#include <bios.h>
#include <alloc.h>
#include <stdlib.h>
#include <conio.h>
#include <math.h>
#include <string.h>
#include <dir.h>
#include <io.h>


struct record
{
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
```

```
  int          CDI1;
  int          CDIT_F1;
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

struct record Record;


void convert(struct record  rec,char * str)
{

sprintf(str,"%ld\t%d\t%d\t%15.5lf\t%15.5lf\t%d\t%d\t%d\t%d\t%d\t%d\t%5.2f\t%d\t%d\t%d\t%d\t%d
\t%d\t%d\t%d\t%d\t%d\t%d\n",
        rec.Time,
        rec.Mark,
        rec.Mode,
        rec.Latitude,
        rec.Longitude,
        rec.Altitude,
        rec.RateOfClimb,
        rec.Airspeed,
        rec.MagHeading,
        rec.Pitch,
        rec.Roll,
        rec.Ball,
        rec.CDI1,
        rec.CDIT_F1,
        rec.CDIFlag1,
        rec.CDI2,
        rec.CDIT_F2,
        rec.CDIFlag2,
        rec.GSDev,
        rec.GSFlag,
        rec.COG,
        rec.SOG);
}

int main(void)
{
  char InputFile[80],OutputFile[80],temp[10];
  int Res;
  FILE * in;
  FILE * out;
  char StrBuffer[500];
  struct record * Buffer;
  int size,i,count,factor,j;


  printf("Data Logger Conversion Utility\n\n");
  printf("Enter name of File to Convert:  ");
  gets(InputFile);
  printf("\n\nEnter name of File for result:  ");
  gets(OutputFile);
  printf("\n\nPreprocessing:\n\td) decimate?\n\tm) marked only?\n");
  printf("\tn) none?\n\nEnter d, m, or n:  ");
  do
  {
       Res = toupper((char)getch());
  }while(Res != 'D' && Res != 'M' && Res != 'N');

  if(Res == 'D')
  {
       printf("\n\nDecimation Factor?   ");
       gets(temp);
       sscanf(temp,"%d",&factor);
  }

  printf("\n\n");

  size = sizeof(Record);
  if((Buffer = (struct record *) malloc(500*size)) == NULL)
  {
       printf("Storage Allocation Failed!\n");
       printf("Exiting Program!\n");
```

```
        exit(0);
  }
  if((in = fopen(InputFile,"rb")) == NULL)
  {
        printf("%s not Found!\n",InputFile);
        printf("Exiting Program!\n\n");
        exit(0);
  }

  if((out = fopen(OutputFile,"wt")) == NULL)
  {
        printf("Error opening file %s!",OutputFile);
        printf("Exiting Program!\n");
        exit(0);
  }

sprintf(StrBuffer,"Time\tMark\tMode\tLat\tLong\tAlt\tRate_of_Climb\tAirspeed\tMagHeading\
tPitch\tRoll\tBall\tCDI_1\tT_F1\tFlag1\tCDI_2\tT_F2\tFlag2\tGSCDI\tGSFlag\tCOG\tSOG\n");
  fputs(StrBuffer,out);

  j=0;
  do
  {
        count = fread(Buffer,size,500,in);
        if(!count) break;
        for(i=0;i<count;i++)
        {
          if((Res == 'M' && Buffer[i].Mark != 0) || Res != 'M')
          {
                if(j == 0 || Res != 'D')
                {
                  convert(Buffer[i],StrBuffer);
                  fputs(StrBuffer,out);
                  j = factor;
                }
          }
      j--;
        }
  }while(1);
  fclose(in);
  fclose(out);
  return 0;
}
```

UTM Post Flight Software

UNIVERSAL TRANSVERSE MERCATUR ASCII CONVERSION

```
#include <stdio.h>
#include <dos.h>
#include <ctype.h>
#include <bios.h>
#include <alloc.h>
#include <stdlib.h>
#include <conio.h>
#include <math.h>
#include <string.h>
#include <dir.h>
#include <io.h>

long double d_rad = M_PI/180.0;
long double major = 6378137.0L;
long double flat = 1.0L/298.257223563L;
long double recflat;
long double bmajor;
long double eccensqr, eccenbsqr;
long double TN,AP,BP,CP,DP,EP;
long double FE = 500000.0L;
long double OK = 0.9996L;


struct record
{
```

```
  unsigned long Time;
  int          Mark;
  int          Mode;
  double       Latitude;
  double       Longitude;
  int          Altitude;
  int          RateOfClimb;
  int          Airspeed;
  int          MagHeading;
  int          Pitch;
  int          Roll;
  float        Ball;
  int          CDI1;
  int          CDIT_F1;
  int          CDIFlag1;
  int          CDI2;
  int          CDIT_F2;
  int          CDIFlag2;
  int          GSDev;
  int          GSFlag;
  int          COG;
  int          SOG;
};

struct record Record;


void convert(struct record  rec,int zone, char * str)
{

sprintf(str,"%ld\t%d\t%d\t%d\t%15.0lf\t%15.0lf\t%d\t%d\t%d\t%d\t%d\t%d\t%5.2f\t%d\t%d\t%d
\t%d\t%d\t%d\t%d\t%d\t%d\t%d\n",
       rec.Time,
       rec.Mark,
       rec.Mode,
    zone,
       rec.Latitude,
       rec.Longitude,
       rec.Altitude,
       rec.RateOfClimb,
       rec.Airspeed,
       rec.MagHeading,
       rec.Pitch,
       rec.Roll,
       rec.Ball,
       rec.CDI1,
       rec.CDIT_F1,
       rec.CDIFlag1,
       rec.CDI2,
       rec.CDIT_F2,
       rec.CDIFlag2,
       rec.GSDev,
       rec.GSFlag,
       rec.COG,
       rec.SOG);
}

long double dg2rads(long double degrees)
{
  long double temp1, temp2,temp3;
  /* format of geodetic parameters dddmm.mmmmmm */

  temp1 = degrees/100.0L;
  if(temp1>=0L) temp2 = floorl(temp1);
  else temp2 = ceill(temp1);
  temp3 = (temp1-temp2)*100.0L;
  temp2 += temp3/60.0L;
  temp1 = temp2*d_rad;
  return(temp1);
}

void ll2UTM(long double latrad,
        long double longrad, long double * north, long double *east, int * IZONE)
{
  static int status = 0;
  long double cen_meridian,delta_meridian,sinlat,coslat,tanlat,ETA;
  void initialize(void);
  long double rad_cur(long double x, long double y, long double z);
  long double true_mer_dis(long double a, long double b, long double c, long double d,
long double e,
                                          long double f);
```

```
  long double t1,t2,t3,t4,t5,t6,t7,t8,t9,SN,TMD;
  long double delta_2,delta_4,delta_6,coslat_3,coslat_5,coslat_7,ETA_2,ETA_3,
                      ETA_4;
  long double tanlat_2,tanlat_4,tanlat_6;
  long double dg2rads(long double);

  latrad = dg2rads(latrad);
  longrad = dg2rads(longrad);

  if(!status)
  {
       initialize();
       status = 1;
  }

  *IZONE = 31+ floorl(longrad/d_rad/6.0L);
  if(*IZONE > 60) *IZONE = 60;
  if(*IZONE < 1) *IZONE = 1;

  cen_meridian = (long double)(*IZONE*6 -183)*d_rad;
  delta_meridian = longrad -cen_meridian;

  delta_2 = delta_meridian*delta_meridian;
  delta_4 = delta_2*delta_2;
  delta_6 = delta_2*delta_4;

  sinlat = sinl(latrad);
  coslat = cosl(latrad);
  tanlat = tanl(latrad);

  coslat_3 = coslat*coslat*coslat;
  coslat_5 = coslat_3*coslat*coslat;
  coslat_7 = coslat_3*coslat_3*coslat;

  tanlat_2 = tanlat*tanlat;
  tanlat_4 = tanlat_2*tanlat_2;
  tanlat_6 = tanlat_2*tanlat_4;

  ETA = eccenbsqr*coslat*coslat;

  ETA_2 = ETA*ETA;
  ETA_3 = ETA_2*ETA;
  ETA_4 = ETA_2*ETA_2;

  SN = rad_cur(major,eccensqr,sinlat);
  TMD = true_mer_dis(AP,BP,CP,DP,EP,latrad);

  t1 = TMD*OK;
  t2 = SN*sinlat*coslat*OK/2.0L;
  t3 = SN*sinlat*coslat_3*OK*(5.0L -tanlat_2 +9.0L*ETA +4.0L*ETA_2)/24.0L;
  t4 = SN*sinlat*coslat_5*OK*(61.0L -58.0L*tanlat_2 +tanlat_4 +270.0L*ETA
              -330.0L*tanlat_2*ETA +445.0L*ETA_2 +324.0L*ETA_3 -680.0L*tanlat_2*ETA_2
              +88.0L*ETA_4 -600.0L*tanlat_2*ETA_3 -192.0L*tanlat_2*ETA_4)/720.0L;
  t5 = SN*sinlat*coslat_7*OK*(1385.0L -3111.0L*tanlat_2 +543.0L*tanlat_4
              -tanlat_6)/40320.0L;

  if(latrad>= 0.0L) *north = 0L; else *north = 1.0e7L;

  *north += t1 + delta_2*t2 + delta_4*t3 + delta_6*t4 + delta_4*delta_4*t5;

  t6 = SN*coslat*OK;
  t7 = SN*coslat_3*OK*(1.0L - tanlat_2 + ETA)/6.0L;
  t8 = SN*coslat_5*OK*(5.0L -18.0L*tanlat_2 +tanlat_4 +14.0L*ETA
              -58.0L*tanlat_2*ETA +13.0L*ETA_2 +4.0L*ETA_3 -64.0L*tanlat_2*ETA_2
              -24.0L*tanlat_2*ETA_3)/120.0L;
  t9 = SN*coslat_7*OK*(61.0L -479.0L*tanlat_2 +179.0L*tanlat_4
              -tanlat_6)/5040.0L;

  *east = FE +delta_meridian*t6 + delta_2*delta_meridian*t7
              +delta_4*delta_meridian*t8 + delta_6*delta_meridian*t9;

  *north = floorl(*north + 0.5L);
  *east = floorl(*east + 0.5L);
}



void initialize(void)
{
  long double TN2,TN3,TN4,TN5;
```

```
  recflat = 1.0L/flat;
  bmajor = major*(1.0L -flat);
  eccensqr = 1.0L -powl(bmajor/major,2.0L);
  eccenbsqr = powl(major/bmajor,2.0L) -1.0L;

  TN = (major-bmajor)/(major+bmajor);
  TN2 = TN*TN;
  TN3 = TN2*TN;
  TN4 = TN3*TN;
  TN5 = TN4*TN;

  AP = major * (1.0L -TN + 5.0L*(TN2 - TN3)/4.0L + 81.0L*(TN4 - TN5)/64.0L);
  BP = 3.0L * major *(TN -TN2 +7.0L*(TN3 -TN4)/8.0L +55.0L*TN5/64.0L)/2.0L;
  CP = 15.0L*major*(TN2 -TN3 +0.75L*(TN4 -TN5))/16.0L;
  DP = 35.0L*major*(TN3 -TN4 +11.0L*TN5/16.0L)/48.0L;
  EP = 315.0L*major*(TN4 -TN5)/512.0L;
}

long double rad_cur(long double x,long double y, long double z)
{
  long double temp;

  temp = x/sqrtl(1.0L - y*z*z);
  return(temp);
}

long double true_mer_dis(long double a, long double b, long double c, long double d, long
double e,
                                    long double f)
{
  long double temp;

  temp = a*f -b*sinl(2.0L*f) +c*sinl(4.0L*f) -d*sinl(6.0L*f) +e*sinl(8.0L*f);
  return(temp);
}


int main(void)
{
  char InputFile[80],OutputFile[80],temp[10];
  int Res;
  FILE * in;
  FILE * out;
  char StrBuffer[500];
  struct record * Buffer;
  int size,i,count,factor,j;
  char name[MAXFILE], ext[MAXEXT];
  char newext[MAXEXT] = ".txt";
  int zone;
  long double north,east;

  printf("Data Logger Conversion Utility\n\n");
  printf("Enter name of File to Convert:  ");
  gets(InputFile);

/*
  printf("\n\nEnter name of File for result:  ");
  gets(OutputFile);
*/

  fnsplit(InputFile,NULL,NULL,name,ext);
  fnmerge(OutputFile,NULL,NULL,name,newext);

  size = sizeof(Record);
  if((Buffer = (struct record *) malloc(500*size)) == NULL)
  {
        printf("Storage Allocation Failed!\n");
        printf("Exiting Program!\n");
        exit(0);
  }
  if((in = fopen(InputFile,"rb")) == NULL)
  {
        printf("%s not Found!\n",InputFile);
        printf("Exiting Program!\n\n");
        exit(0);
  }

  if((out = fopen(OutputFile,"wt")) == NULL)
  {
        printf("Error opening file %s!",OutputFile);
```

```
      printf("Exiting Program!\n");
      exit(0);
  }


  printf("\n\nPreprocessing:\n\td) decimate?\n\tm) marked only?\n");
  printf("\tn) none?\n\nEnter d, m, or n:  ");



  do
  {
      Res = toupper((char)getch());
  }while(Res != 'D' && Res != 'M' && Res != 'N');

  if(Res == 'D')
  {
      printf("\n\nDecimation Factor?   ");
      gets(temp);
      sscanf(temp,"%d",&factor);
  }

  printf("\n\n");


sprintf(StrBuffer,"Time\tMark\tMode\tZone\tNorthing\tEasting\tAlt\tRate_of_Climb\tAirspee
d\tMagHeading\tPitch\tRoll\tBall\tCDI_1\tT_F1\tFlag1\tCDI_2\tT_F2\tFlag2\tGSCDI\tGSFlag\t
COG\tSOG\n");
  fputs(StrBuffer,out);

  j=0;
  do
  {
      count = fread(Buffer,size,500,in);
      if(!count) break;
      for(i=0;i<count;i++)
      {
        if((Res == 'M' && Buffer[i].Mark != 0) || Res != 'M')
        {
            if(j == 0 || Res != 'D')
            {
              ll2UTM((long double)Buffer[i].Latitude,
                          (long double)Buffer[i].Longitude,&north,&east,&zone);
              Buffer[i].Latitude = (double) north;
       Buffer[i].Longitude = (double) east;
              convert(Buffer[i],zone,StrBuffer);
              fputs(StrBuffer,out);
              j = factor;
            }
        }
    j--;
      }
  }while(1);
  fclose(in);
  fclose(out);
  return 0;
}
```