FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

TECHNICAL SPECIFICATION
FOR IGC-APPROVED
GNSS FLIGHT RECORDERS

First Edition issued 1 Oct 1997
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Including Amendments 1 - 4

AMENDMENT LIST (AL) RECORD

Formal amendments are agreed in accordance with IGC procedures for this document, and are published by FAI via links on the IGC GNSS web page http://www.fai.org/gliding/gnss/ . The full web reference for the complete version of this document, including amendments, is: http://www.fai.org/gliding/gnss/tech_spec_gnss.asp (AL2)

Amendments should be proposed to the Chairman of the IGC GNSS Committee and the Chairman of GFAC either directly or through the FAI Secretariat (for the FAI address, see the Preliminary Remarks page after the contents list that follows), preferably in a form of words suitable for direct incorporation in this document. (AL2)

When holders of hard copies of this document have incorporated an amendment in the main text, they should insert a copy of the amendment list instructions after this page, so that at a later date, the subjects of the amendment may easily be identified.

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PRELIMINARY REMARKS

1 **Title and Status**. This document, abbreviated as FRSpec, contains the rules, procedures, and specifications applying to equipment which is to be IGC-approved for validation of flight performances to FAI criteria. It is published by FAI through a link on the IGC/GNSS web page http://www.fai.org/gliding/gnss/. The full web reference for this document is http://www.fai.org/gliding/gnss/tech_spec_gnss.asp (AL2)

2 **Target Audience**. FRSpec is intended for FR manufacturers and potential manufacturers, IGC, FAI and NAC officials, GFAC members and their advisors, producers of analysis programs for IGC flight data, and any other organisation or individual interested in the detailed specification of IGC GNSS FRs. Other material concerned with validation of flights to IGC criteria is in the FAI Sporting Code Section 3 (Gliders and Motor Gliders) and its annexes, which are Annex A (SC3A, Championships), Annex B (SC3B, Equipment used for flight validation), and Annex C (SC3C, Official Observer and Pilot Guide). These are all public domain documents available in hard copy from FAI or electronically from the FAI/IGC web site http://www.fai.org/gliding/ (AL3)

3 **Amendments**. Proposals for amendments should be sent to the Chairman of the GNSS subcommittee and to the Chairman of GFAC, preferably in the form of draft wording for direct insertion, with reasons for the proposed changes or additions. Amendments may be issued at any time with the agreement of the IGC GNSS and GFA Committees and with the approval of the IGC President. (AL3)

3.1 FAI Office. If you do not have a communications address for the Chairmen of the IGC GNSS and GFA Committees, initially use the FAI Office:

c/o FAI Secretariat, Fédération Aéronautique Internationale,
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IGC web: http://www.fai.org/gliding/
IGC GNSS web: http://www.fai.org/gliding/gnss/

4 **Nomenclature**. In this document the words "must", "shall", and "may not" indicate mandatory requirements; "should" indicates a recommendation; "may" indicates what is permitted; and "will" indicates what is going to happen. Where appropriate, words of the male gender should be taken as generic and include persons of the feminine gender. Advisory notes and guidance are in italic script.

GLOSSARY
OF TERMS AND ABBREVIATIONS

This expands the glossaries in the main volume of Section 3 of the Sporting Code (SC3) including its Annexes, and includes more specialised terms concerned with GNSS. See also the Definitions listed in para 5.0 of Appendix 1 to this document (IGC file structure), and the list of Three-Letter Codes (TLC) given in para 7.0 of Appendix 1 and to be used in the IGC data file.

Numerical

2D Position - A navigational position in terms of plan (horizontal) position (ie lat/long). In GNSS systems, at least three position lines (ie correct data from three satellites) are needed for a 2D fix.

3D Position - A navigational position in terms of plan position and altitude. In GNSS systems, at least four position lines (ie correct data from four satellites) are needed for a 3D fix.

4D Position - A navigational position in terms of plan position, altitude, and time. Since highly accurate time is an integral part of the principle of operation of a GNSS system, it is automatically available with every GNSS fix.

Alphabetical

ACIAS - availability, continuity, integrity, accuracy, and security , for instance of stored data

Analysis - Study of flight data with a view to authentication and verification.

API - Application Programming Interface. A set of functions that an application can call to tell the operating system to perform a task. (AL4)

ARINC - Aeronautical Radio Incorporated, the company which the US FAA uses to develop and publish numbered standards, eg ARINC 510 for avionic interfaces with simulators. Many avionic standards use ARINC protocols.

Authentication - The process of determining whether data originated in a correct manner from a particular FR, or is a faithful copy of original data. Electronic flight data is authenticated by manufacturer's validation software on a PC by using the appropriate VALI-XXX.EXE file (XXX are the manufacturer's identification letters). This checks the Digital Signature that is on the IGC-format file transferred from the FR, indicates that data originates from a particular FR, and has not been altered since initial transfer from the FR.

CEP - Circular Error Probable, or Circular Error of Probability, normally to a 50% level of probability unless stated otherwise.

Constellation - The group of satellites used to determine the GNSS fix. This may be used to verify the validity of the recorded flight data. It is recorded on the IGC file in the form of the F Record (details, Appendix 1)..

CRLF - `Carriage Return' followed by a `Line Feed'. These two characters, represented by the hex numbers 0D and 0A, are usually used to denote the end of a record (category of data) in the IGC file.

Data Analyst - A person knowledgeable in analysis of electronic flight data and authorised by an NAC to carry out analysis on their behalf.

Datum - The GNSS Geodetic Datum (qv). The Sporting Code for gliding states that the WGS 84 Geodetic Datum shall be used for all lat/long co-ordinates that are recorded and transferred from the FR after flight.

Digital Signature (DS) - see under Security.

DLL - Dynamic-Link Library. In Microsoft Windows, a DLL is a small program containing functions that other programs or resources can call or use. Outside MS Windows, DLLs are used in areas such as Distributed Interactive Simulation (DIS) links and other processing. (AL4)

DOP - Dilution of Precision - The reduction of precision in a GNSS fix due to the geometry of the constellation of satellites used for the fix. Computed by a GNSS receiver for each fix, see also EPE.

Download - Not used in this document because of possible ambiguity. Some manufacturers use the term in the sense of "downloading data from the FR into a PC", but others use "upload" for this process in the sense of "uploading data into a PC from the FR". Therefore, the term `Transfer' is used instead.

DSA - Digital Signature Algorithm. In its specialist meaning, an asymmetric system of Public/Private Key Cryptography (PKC) used in the US National Institute of Standards and Technology Digital Signature Standard (DSS). It is comparable in performance and strength to an RSA (qv) signature with the same key length, and uses a protocol called SHA-1 as the message digest algorithm. Signing a message takes about 1/2 the computation of RSA thus reducing data transfer times from FR to PC, and some computation can be done "on the fly" while the recorder is operating normally. However, DSA takes more computation than RSA to verify a signature, the IGC VALI process taking longer than RSA (but the VALI process is not time-critical, whereas data transfer from FR to PC is). More detail on the implementation of DSA can be found via
http://csrc.nist.gov/publications/fips/fips186-2/fips186-2.pdf.
GFAC will give advice as necessary. (AL4)

Ellipsoid - A three-dimensional ellipse, the same as an oblate (flattened) spheroid. The term ellipsoid is preferred compared to spheroid or Geoid (qv) because it is mathematically unambiguous. An ellipsoid is the best simple mathematical model of the overall shape of the Earth and the currently accepted best simple overall earth model, WGS 84, is ellipsoid based, as are other geodetic datums (qv).

EMI - ElectroMagnetic Interference. Interference with the working of equipment (hardware, software or firmware) due to ElectroMagnetic radiation external to the equipment. May be due to Radio Frequency (RF) radiation from radios in the aircraft or glider itself, or from powerful RF sources outside the aircraft such as from radar and other equipment transmitting in the RF bands.

EPE - Estimated Position Error - An estimate by a GNSS receiver of the probability of position error in each fix, taking into account the geometry factors of DOP (qv below) with the addition of factors such as received signal strength. The probability used in the calculation should be stated so that the significance of the size of the resulting shape (frequently a circular error) is known. Probabilities are frequently calculated to a 2-sigma (95.45%) level, implying that there is about a 95% (19 out of 20) chance that the true position is inside the shape concerned. This probability figure applies to a single fix in isolation and is increased by taking into account adjacent fixes and with knowledge of how gliders are flown. The EPE value appears in the IGC file as a three number group in metres through the FXA code. (AL3)

Fix - For IGC flight analysis, a fix is a sample of simultaneous data from GNSS satellites that successfully records the parameters required for assessment. A sample is where the FR is set to record UTC, latitude, longitude, both GNSS and pressure altitude, fix accuracy (EPE/FXA), and any other variable required with each sample and specified by IGC. See 2D, 3D, 4D and the definitions below. A flight log consists of a series of fixes in time order.

> Fix, Spurious - A GNSS fix with a significant error in time or two-dimensional position (Lat/long). Determined by analysing the fix concerned and adjacent fixes; the spurious fix will generally show an anomalous position (a side-step in 2-D position or in altitude, or both) and involve an unlikely groundspeed between it and adjacent correct fixes. It may or may not have a high EPE or DOP (see above). For flight analysis purposes such as proving presence in an Observation Zone, spurious fixes must be rejected. See SC3 Annex C (Pilot and Observer Guide) for examples and diagrams. (AL3)
>
> Fix, Valid. For IGC flight analysis purposes, a valid fix is a fix that successfully records the minimum parameters required for the analysis concerned, and is not assessed as Spurious (see above). For the purpose of assessing presence in an Observation Zone, the geographical position shall be taken as the centre of the co-ordinates of the fix, ignoring any error circles.

FL - Flight Log - any record of all the data recorded on a flight, evidence from which is used in the flight verification process. A FL may exist as information in the FR memory, as data transferred from a FR to a PC or printer, in software form in a PC or on floppy disk or memory card as a file (compressed or in IGC Standard ASCII format). At a minimum a GNSS flight log must contain a complete series of 4-D fixes in time order, plus any other data required by IGC. When transferred to a PC, it becomes the IGC-format file for the time period involved.

FR - Flight Recorder. In IGC terms, a device recording data for the purpose of flight validation to IGC/FAI criteria, such as a GNSS FR. A GNSS FR is a device capable of producing a Flight Log, and includes a GNSS receiver, pressure altitude sensor (IGC requirement), and a memory storage device. It may also include other facilities such as those for detecting operation of the Means of Propulsion (MoP) in a Motor Glider, the input of Way Points and flight declarations, etc.

FR Serial Number - A unique set of three alphanumeric characters allocated by the manufacturer as means of identification of a individual FR, prefixed with the manufacturer's code allocated by IGC. It is used in the heading record of all transferred data from the FR to a computer and appears in the IGC file as part of the A Record. (AL3)

GD - Geodetic Datum, see below

Geodetic Datum (GD) - When a mathematical model of the earth's shape is fixed at a particular orientation and position with respect to the Earth, it constitutes a so-called `Geodetic Datum', over which a grid of latitude and longitude (or other geographic reference system) can be constructed. Most Geodetic Datums are based on the shape of an ellipsoid; WGS 84 is an example. Having fixed a geodetic datum, map projection methods are then used to represent the three-dimensional earth model on a two-dimensional map.

Geoid - The shape of a theoretical equipotential surface due to the gravity effect of the earth's mass and terrain, but without external gravity (ie no spin, no tides). A geoid is therefore a smooth but irregular surface over the whole earth, close to sea level. The maximum differences between the WGS84 Geoid and the WGS84 Ellipsoid are +65m at 60N 030W (S of Iceland, geoid above the ellipsoid) and -102m on the equator at 080E (S of India, geoid below the ellipsoid). The variation depends on the gravity effects of mountains, ocean trenches, crustal thickness and density. It is used in the form of an electronic `look-up table' in many GNSS receiver system to indicate an approximate Sea Level datum for GPS altitude readings, but will not correspond exactly with Above Sea Level (ASL) altitudes given on local maps. It was used in the past in the selection of the ellipsoid (qv) that was the `best fit' for the region concerned. See also Ellipsoid and Spheroid.

GFAC - GNSS FR Approval Committee of IGC. See IGC Approvals and also Chapter 1.

GLONASS - The Russian GNSS system, the initials standing for GLObal NAvigation Satellite System. Unlike the US GPS system, GLONASS alters its system time on the date and time of every leap-second and is inoperative while doing so (see under GNSS, GPS, and UTC). Its system time is based on Moscow time rather than UTC.

GNSS - Global Navigation Satellite System. A system for the determination of position, velocity and time, that includes one or more satellite constellations, receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance. It includes the Russian GLONASS, the US GPS, and the projected European Galileo system. It implies the use of equipment that receives signals from the relevant constellation of Navigational Satellites in earth orbit. Such equipment calculates time delays between signals from different satellites and, by knowing the exact position of the satellites and the exact time to great accuracy, together with an assumed mathematical model of the earth's shape (see Ellipsoid and Geodetic Datum) is able to calculate position information on the earth's surface in four dimensions (4-D, see above) through software programs.

> GNSS equipment for flight verification - includes the GNSS receiver and associated Flight Recorder (FR) system, including the antenna and all associated hardware such as the processing, data storage, cockpit display and keyboard modules, pressure-altitude sensor (IGC requirement), and the MoP sensor for Motor Gliders. It also includes the associated software and firmware (Such as ROM) both in the glider GNSS equipment and also where used for transferring data into and from the glider equipment from PCs. Software processing using PCs includes the analysis and presentation of flight data, and may also include the preparation of data about gliding sites, turn points, time zones, geodetic datums, pilot information, and so forth; for transfer into the glider GNSS equipment, in accordance with the procedures in this code.
>
> GNSS Altitude - Altitude calculated solely from GNSS position lines. In the IGC format file, GNSS altitude must be referenced to the WGS84 ellipsoid (that is, not a Geoid). Where GNSS altitude is not available from GNSS position-lines (2D fix, altitude drop-out), it shall be recorded in the IGC format file as zero so that the situation can be clearly identified during post-flight analysis. Note that in other GNSS systems, GNSS altitude may be set to show approximate altitudes above local sea level by calculating distance above a Geoid (normally through an electronic look-up table giving geoid heights above and below the selected ellipsoid) rather than distance above the ellipsoid appropriate to the selected Geodetic Datum. (AL3)

GPS - Global Positioning System. The US GNSS administered jointly by the Department of Defense (DoD) and the Department of Transportation (DoT). Signals are normally available from 24 out of 27 satellites in six circular orbital planes at 55 degrees to the equator at an altitude of 20,200km and a period of 12 hours. The control segment of GPS consists of five monitor stations, three ground antennas and a master control station. Receiver-processors (GPS units) provide 3-D position and precise timing to the user.

GPS system time - is the continuous and highly accurate time kept by the GPS satellites. It began as UTC for 6 Jan 1980 when the system first became operational, and maintains that time frame. It does not change with the 'leap seconds' additions that are made to UTC to allow for the slowing down of the Earth's rotation (see under UTC). In year 2000, UTC was 13 seconds later than GPS System Time. However, the GPS system keeps track of leap seconds corrections, and these are sent as part of the satellite's message to users. Most receivers use the GPS satellite message automatically to compensate and output UTC rather than GPS time. In some GPS receivers, stored track records do not take leap seconds into account and output in GPS system time, whereas NMEA data outputs generally include leap seconds and times are corrected to UTC. (AL3)

Hard/Soft Data/Storage - Hard data or storage is that which is not lost when the unit concerned is switched off or its battery fails or is removed. Soft data is otherwise.

Horizontal fix accuracy - the best prediction for the horizontal 2-sigma error of the overall position error. Included in the IGC data file in the B (fix) record through the FXA three-letter code. (AL4)

ICAO - International Civil Aviation Organisation with its HQ in Montreal, Canada

IGC Approval - Certain equipment is subject to a special approval process before it can be used in the verification of flight performances to IGC/FAI criteria. GNSS Flight Recorders (FRs) are examples, and the IGC GNSS Flight Recorder Approval (GFA) Committee (GFAC) test and evaluate GNSS FRs and issue approvals on behalf of IGC.

International Standard Atmosphere (ISA) - The ISA to be used for FAI matters is given in ICAO Document 7488 tables 3 and 4. It assumes a temperature and pressure at sea level of 15C and 760 mm of mercury (or 1013.25 mb/hPa). Above sea level, it assumes a constant temperature lapse rate from sea level of 6.5C per 1000 m (1.98C/3.56F per 1000 ft) rise in height, up to an altitude of 11,000 m (-56.5C) . 11,000m is assumed to be the Tropopause, above which constant temperature (-56.5C) is assumed. Pressure figures from this ISA are used in calibration of barographs, because although the real atmosphere varies from day to day, for calibration purposes a set of internationally agreed figures are needed so that all calibrations are to the same datum, whether or not such figures correspond to `true' height on a given day. A similar principle is used in calibrating pressure altimeters for aircraft, so that all aviation activities have a common standard of pressure height indication in the cockpit.

ISA - International Standard Atmosphere

ISO - International Standards Organisation

Latitude - In a GNSS IGC Flight Log data format, this is a seven character numeric group expressed as two figures for the degrees, two figures for the minutes and three figures representing tenths, hundredths and thousandths of minutes followed by the N or S character.

Leap Second - see under UTC

Longitude - In a GNSS IGC Flight Log data format, this is an eight character numeric group expressed as three figures for the degrees, two figures for the minutes and three figures representing tenths, hundredths and thousandths of minutes followed by the E or W character.

MoP - Means of Propulsion, for Motor Gliders. A MoP Recorder is a recorder used in motor gliders which is capable of producing an after-flight record of operation of the Means of Propulsion against a timebase for the flight. The timebase may be that of a barograph or of a GNSS FR. It must be shown that the sensor and its method of operation is such that a record will always be made when the MoP is operated so as to provide a forward thrust force, irrespective of pilot actions in the cockpit.

MoP Inoperative - The MoP is not in a position to generate propulsion, such as when a pylon-mounted engine or propeller is stowed in the fuselage and physically cannot generate propulsion in this position, or a propeller can be shown to be feathered. In the case of the Stemme (patent) retractable propeller, that the nose-cone into which the propeller retracts, is closed.

MoP Operative - The MoP is in a position to generate propulsion, but is not necessarily generating forward thrust. In most aircraft this indicates that the MoP pylon is extended, or that the engine doors are opened, or that the prop is unfeathered, or, in the case of the Stemme (patent) retractable propeller, that the nose-cone into which the propeller retracts, is opened.

MoP On - The MoP starts to, or is generating, forward thrust. Generally by showing in some way that the propeller has started rotating, or that a jet engine has begun giving thrust.

MoP Stop - The MoP stops generating forward thrust. Generally by showing in some way that the propeller has stopped rotating, or that a jet engine has ceased giving thrust.

NMEA - National Marine Electronics Association. NMEA publishes data standards for interfacing marine electronic devices. It is an international body with its HQ in North Carolina, USA. As GNSS was developed for the marine as well as the aviation market, most GNSS manufacturers use NMEA standards to interface GNSS to peripheral devices. NMEA data is divided into groups called "sentences" identified by three-letter codes, the details being given in documents such as NMEA 0813. For instance the sentence GGA gives GPS fix data, GNS gives fix data for all GNSS systems (US GPS, Russian GLONASS, European Galileo and any other systems), GSA gives the satellites in view at any one time. Some GNSS receiver boards output NMEA data directly and others use manufacturer's binary or other output formats. In the latter case, where NMEA data is mentioned in this document the FR manufacturer must show that equivalent data that is acceptable to GFAC is recorded on the IGC data file. (AL4)

OO ID - This is a code known to an Official Observer (OO) that may (or may not) be entered into a FR prior to flight, depending on the terms of IGC-approval for the FR concerned. Where an OO ID is required as part of IGC-approval, four alphanumeric characters should be provided for this purpose. It may be used to identify the individual flight on the recording, and provide an indication that subsequent data was not manufactured beforehand.

OZ - Observation Zone. A volume of airspace within which a valid GNSS fix (or a photo) is required to validate an IGC event such as start, reaching a turn point, and finish of a flight performance. The Sporting Code for gliding defines the shape of such OZ, that for a turn point being a 90 degree area, the bisector of which is opposite the bisector of the two legs making up a turn point, or opposite to the first course leg for a start, and the last course leg for a finish. Start and finish lines are also permitted as well as the 90 degree angle.

PGP - Pretty Good Privacy. A commercial system for electronic security that uses RSA asymmetric keys, first publicised by Philip R Zimmerman in June 1991 through a public Internet bulletin board. The US authorities initially tried to prosecute Zimmerman for a security breach, but after 3 years gave up the attempt. See http://www.pgp.com . The rights of Zimmerman's company PGP, Inc., were later sold to Network Associates, http://www.nai.com . It has been estimated that some over 500 million copies of PGP are in use worldwide, and the `padlock' symbol on a PC screen normally indicates that the PGP system is available. (AL4)

Pilot Event (PEV Code) - The pilot records an event in time and space, generally by pressing an `event button' that takes an additional GNSS fix and marks the time as a pilot-recorded event. It has no significance in the flight verification process for IGC flight performances but may be required in competitions (such as to identify a start), and be useful to the pilot as a reminder of what happened at that time. May also be used to start a sequence of fixes at short time intervals (fast-fix facility).

PKC - Public/private Key Cryptography. A system where the recipient of a message has an encryption system that is not secret (the Public Key) and is used by people sending messages to him. However, the mathematical factors that make up the Public Key are only held by the recipient (the Private Key), and are needed before the message can be de-coded. The PKC principle was discovered in May 1975 by Whitfield Diffie, Martin Helman and Ralph Merkle (DHM) of the Electrical Engineering Department of Stanford University, USA, and previously in 1973 by James Ellis and Clifford Cocks of the classified Government Communications HQ organisation in the UK. The first commonly available practical application of PKC was the RSA system (qv). (AL4)

Pressure Altitude - In a GNSS FR, this is a five numeric group indicating the pressure altitude in metres with respect the International Standard Atmosphere (ISA) used in aviation, to a sea level datum of 1013.25 HPa. The pressure recorded in the *.IGC file may either be "cockpit static" (vented within the FR box), or use a tube connection to the pressure from glider instrument system static tubing. If the pressure altitude signal within the FR is used for other purposes such as cockpit instrument readings which can be set to other datums such as QNH or QFE, a one-way transmission system must be used from the sensor so that the IGC file always records the required ISA to the 1013 sea level datum irrespective of other settings used for flight instruments. The permitted use of instrument-static is intended for a GNSS FR mounted in the instrument panel. With such an installation, an OO as part of the inspection of the FR installation must check the tubing and the pressure connection to the FR to ensure that they will be out-of-reach of the aircrew in flight. This is to prevent alteration to the IGC-file pressure altitude record by any method. (AL4)

Proof Drive or Flight - A method of checking that a Flight Recorder produces a correct flight log. Under the strict control of an OO or other official, the GNSS/FR is taken on a drive in a vehicle or on a flight in a glider or other aircraft, over a course with known co-ordinates. A proof drive in hilly terrain can be used to check appropriate altitude data from the FR, and a proof flight can check not only altitude data but other records such as of the means-of-propulsion in a motor glider. A proof drive including an identifiable turn at a surveyed point can be used to check GNSS fix accuracy and is used by GFAC for this purpose with each FR tested.

RAIM - Receiver Autonomous Integrity Monitoring - A technique whereby a civil GNSS receiver/processor determines the integrity of the GNSS navigation signals without reference to sensors or non-military integrity systems other than the receiver itself. This is achieved by a consistency check among redundant pseudo-range measurements (pseudo-range is the distance from the user to a satellite plus an unknown user clock offset distance). With four satellite signals it is possible to compute position and offset distance, and if the user clock offset is known, three satellite signals suffice to compute a position. RAIM works by automatically comparing the position line obtained from each GNSS satellite with other position lines obtained from the constellation of satellites being received at any one time. Any anomalous (`rogue') position lines are then discarded for the purpose of calculating the 3-D fix for the time concerned. A numeric code is used which indicates 0 if RAIM is satisfied and 5 when not. In theory, RAIM calculations based on four position lines (three good ones and the `rogue') but in practical terms, 6 satellites are normally needed. See also WAAS.

RSA - A system of Public/Private Key Cryptography (PKC), developed by Ronald Rivest, Adi Shamir and Leonard Adelman of the Massachusetts Institute of Technology (MIT), employing an asymmetric system for key exchange. First published in an article in Scientific American in August 1977, and the company RSA Security Inc was formed to apply it commercially. More detail on the implementation of RSA can be found in the book "Applied Cryptography" by Bruce Schneier, 2nd edition, ISBN 0-471-11709-9. An overview of various cryptographic algorithms can be found in http://www.ssh.fi/tech/crypto/algorithms.html. High Speed RSA Implementation (PDF file) is in: ftp://ftp.rsasecurity.com/pub/pdfs/tr201.pdf. Details of the FIPS 180 Secure Hash Standard are in http://www.itl.nist.gov/fipspubs/fip180-1.htm. Cryptographic libraries with source code in C and C++ are in:
http://www.cs.auckland.ac.nz/~pgut001/cryptlib and http://www.eskimo.com/~weidai/cryptlib.html. GFAC will give advice as necessary. (AL4)

Security - Digital Signature (DS) - A Digital Signature (DS) is a set of encrypted data generated by an FR and transferred form the FR with the flight data. Mathematically, the DS corresponds with (matches) the flight data in such a way that any subsequent alteration of any part of the flight data destroys the correspondence (the data match) and so the alteration is detectable. See Chapter 2 para 2.8.3.

Soft/Hard Data - See under Hard Data.

Spheroid - A three-dimensional oblate (flattened) sphere in the form of a three dimensional ellipse (an ellipsoid). The term ellipsoid is preferred to spheroid because it is mathematically unambiguous, whereas `flattening' of a sphere could imply shapes other than an ellipse.

Spurious Fix - see under Fix

Start - The beginning of a task, ie the point from which measurement of the flight performance commences. Usually crossing a start line or exiting a Start Point Observation Zone.

Total Energy Altitude (TEAlt) - The combination of the gliders potential and kinetic energy expressed as a hypothetical `zero-energy' altitude, expressed in metres. eg TAS 300 kph (162 knots) gives a height increment of 354 m (1160 ft) for the purpose of calculating TEAlt, 250 kph (155 knots) gives an altitude increment of 245.5 m (805 ft); 200 kph (124 knots) an increment of 157.6 m (517 ft); 150 kph (81 knots) an increment of 88.4 m (290 ft), and 100 kph (62 knots) an increment of 39.32 m (129 ft).

Track - The true track (continuous sequence of actual 2D positions) on the ground over the over which the aircraft has flown.

Turn or Way Point Confirmation- The indication that the glider has reached the TP/WP to the criteria laid down in the IGC sporting code, for instance by demonstrating presence in the OZ by the use of photography or a GNSS FR. In Sporting Code terminology this is "reaching" the turn point. There is no obligation to actually fly round the point itself.

Upload - Not used in this document because of possible ambiguity. `Transfer' used instead, see under Download.

UTC - Universal Time Co-ordinated. Used to be called Greenwich Mean Time (GMT) and is virtually the same as GMT other than for astronomical purposes. A so-called `leap second' is added at midnight on agreed dates such as 30 Jun or 31 Dec and is used to change UTC by a whole second at a time, to allow for the slowing down of the

Earth's rotation. The period between the addition of the next leap second varies between one and two years, and is agreed internationally. Between 1980 and 2000, 13 leap-seconds were added. The IGC data file requirement (Appendix 1) requires times in data files to be in UTC. See also GLONASS, GNSS and GPS. (AL3)

Vertical fix accuracy - the best prediction for the vertical 2-sigma component of the overall position error. When included in the IGC data file, through the VXA three-letter code. (AL4)

WAAS - Wide-Area Augmentation System. A system made up of an integrity and reference monitoring network, processing facilities, geostationary satellites, and control facilities. Wide area reference stations and integrity monitors are widely dispersed data collection sites that contain GPS/WAAS ranging receivers which monitor all signals from the GPS, as well as the WAAS geostationary satellites. The reference stations collect measurements from the GPS and WAAS satellites so that differential corrections, ionospheric delay information, GPS/WAAS accuracy, WAAS network time, GPS time and UTC time can be determined. The monitored data are forwarded to the central data processing sites for determination of the correction and other data as well as verifying residual error bounds for each satellite. These sites also generate navigation messages for the geostationary satellites and WAAS messages. This information is modulated on the GPS-like signal and broadcast to users from geostationary satellites. See also RAIM.

WGS 84 - World Geodetic System 1984. A co-ordinate system based on a mathematical model of the earth and including many variables such as gravity constants and coefficients, formulas for the Earth's angular velocity, a WGS84 ellipsoid and a WGS84 geoid, with associated constants, conversion factors and co-ordinate systems. For the purpose of GNSS, the ellipsoid model is important, and is the currently accepted best overall simple mathematical model for the earth's shape and upon which all IGC GNSS fixes and calculations are initially based. Fix position and distance calculations can then be transformed to any of over 200 other ellipsoids (local Geodetic Datums). Some similar systems to WGS84 include the International Terrestrial Reference Frame (ITRF, eg ITRF96) and the European Terrestrial Reference System (eg ETRS98) but lat/long differences between these systems are less than 1m with respect to co-ordinates based on WGS84.

WGS84 Ellipsoid. The ellipsoid radii for WGS 84 are as follows:
Major Axis (the Equator), radius = 6378.1370 km
Minor axis (Polar), radius = 6356.7523 km (flattening 21.3847 km)
Orientation The minor axis is between the Earth's centre of mass and the Terrestrial Pole as defined by the Bureau Internationale de l'Heure (BIH). In approximate terms, this is the Earth's spin axis.

WGS84 Geoid. The maximum differences between the WGS84 Geoid and the WGS84 Ellipsoid are +65m at 60N 030W (S of Iceland, geoid above the ellipsoid) and -102m on the equator at 080E (S of India, geoid below the ellipsoid). A table of WGS84 Geoid heights with respect to the WGS84 Ellipsoid is available in MS Excel format from FAI (via the GFAC Chairman). See also under Geoid in this Glossary.

CHAPTER 1

IGC APPROVAL FOR EQUIPMENT USED IN THE FLIGHT VERIFICATION PROCESS

This is based on Chapter 1 of Annex B to the FAI Sporting Code Section 3 (Gliders and Motor Gliders)

1.1 **IGC-APPROVAL OF GNSS FLIGHT RECORDERS (FRs) - GENERAL**. Approval of a GNSS FR unit is achieved following evaluation by the IGC GNSS FR Approval Committee (GFAC), whose terms of reference are given below. GFAC examines GNSS FRs for compliance with IGC rules and guidelines for equipment, software, and data standards. It establishes on behalf of IGC the detailed procedures under which equipment shall be checked, installed, and operated if it is to be acceptable for providing flight verification evidence that contributes to eventual validation of the flight performance to IGC criteria. Approval indicates only that the equipment meets the standards of availability, continuity, integrity, accuracy, and security that is required for FAI sporting purposes.

1.1.1 **FAI disclaimer**. FAI takes no responsibility for, and has no liability for, the use of equipment for other purposes such as navigation, airspace avoidance, terrain avoidance, or any matters concerning flight safety.

1.1.2 **Approval for Specific Equipment**. Operating procedures specified by GFAC may, for example, require an OO's pre-flight inspection of specific items, physical sealing of all or part of the equipment, stowage out of reach of the flight crew, insertion of codes known only to the OO, or other procedures. Such procedures will be an integral part of the IGC-approval for the type of equipment concerned, and will depend on its design (particularly its built-in security) and the results of the evaluation process, before approval is given.

1.2 **IGC GNSS FR APPROVAL COMMITTEE (GFAC)**. A committee of 5 persons shall be appointed by IGC to inspect, test, evaluate, and approve GNSS Flight Recorders (FRs) for the purpose of producing evidence for validation of FAI/IGC flight performances. Members may delegate work to other experts but are responsible for co-ordinating the work and for producing final recommendations.

1.2.1 **Appointment of GFAC Members**. GFAC members will be appointed for a period agreed by IGC, and members will be eligible for re-appointment. Members will select the GFAC chairman from amongst their number. (AL4)

1.2.2 **Working Language**. The English language shall be used for formal communications to and from GFAC, and within GFAC.

1.3 **APPLICATION**. A manufacturer seeking IGC-approval of an FR shall apply in writing to the FAI (through the chairman of GFAC) who will provide the applicant with the current procedures for the approval process, such as a formal application, documentation requirements, the number of units to send, to whom they are to be sent, etc. (see 1.3.3.1 below). The appropriate fee shall be deposited in FAI's IGC account by each applicant when hardware is first sent for evaluation (initially only to the GFAC Chairman, see 1.3.3.1 below). IGC approval will not be given until the appropriate fee is received and all expenses attributable to the manufacturer have been paid to FAI. The fee is varied by IGC from time to time and details are available from the GFAC Chairman. At the time of writing (year 2001) it is 1500 Swiss Francs (ChF) for an application for a new type of GNSS FR, less for modifications to an existing IGC-approved design. The precise method of deposit will be given on the application form available from the GFAC Chairman. The English language must be used for the application and for all documentation and communications sent to GFAC. (AL4)

1.3.1 **Documentation**. Each applicant shall provide documentation to GFAC as to how their unit meets the requirements. Such documentation will be held in confidence by GFAC and their advisors.

1.3.2 **Changes**. The fee for approval of significant changes to an existing approved unit shall be set by FAI up to the fee for a new type of GNSS FR, depending on the complexity of the evaluation as determined by FAI. The term significant means any change which could possibly affect the flight verification process. (AL3)

1.3.3 **Requirements**. Each applicant must:

1.3.3.1 For the submission of any new model of FR - first send details to the GFAC Chairman of the intended design such as draft specifications, drawings, draft manual, commonality with existing models, etc., as soon as a draft is available. The Chairman will send such details to GFAC members and appropriate technical experts and will co-ordinate comments that will be sent back to the manufacturer. Email is the recommended method in the form of text or attached files in word-processed format (such as MS Word). Use jpg (compressed) format for diagrams and pictures at not more than 200kB per graphic unless requested otherwise. As soon as IGC-format files are available from early hardware, send copies to the GFAC chairman so that the exact format can be checked and commented on. Do not send any hardware until GFAC comments have been made on the written Specification and initial IGC files have been produced and sent, unless advised otherwise by the GFAC Chairman. In terms of sending hardware, as soon as a complete prototype or alpha/beta test version is available, send a single example to the GFAC Chairman for initial evaluation and feedback, before the fix-of-design stage is reached. The Chairman's evaluation team will test the hardware and report to GFAC members, relevant technical experts and the FR Manufacturer. When hardware is sent, the FR manufacturer should apply to FAI for IGC-approval and pay the appropriate fee. All GFAC members have a right to ask for hardware for testing themselves. Therefore, after appropriate correspondence between the Chairman and the FR manufacturer, and after any necessary changes have been made to the prototype equipment evaluated, sets of hardware shall then be sent by the manufacturer to those GFAC members notified to the manufacturer by the Chairman. (AL4)

1.3.3.1.1 Fix Error Rates. Recorder systems must show an error rate of fixes better than 1 in 1000 fixes in normal signal propagation conditions. Error rates are taken from the centre of fixes assessed as in excess of 100 metres from a true 2-D (lat/long) position (discounting any errors in GNSS altitude). General accuracy must be to an average of better than 20 metres in lat/long (assuming that the Selective Availability or equivalent error is not applied by the GNSS control authority). (AL4)

1.3.3.1.2 Pressure Altitude Calibration. The pressure altitude recording system in the FR must be calibrated using standard procedures for barograph calibration, and a calibration table and the IGC file for the calibration forwarded with any hardware that is sent.

1.3.3.2 Re-approval after changes. For re-approval of a unit after changes have been made, the other provisions of 1.3.3 apply. (AL3)

1.3.3.3 Integrity and accuracy. A detailed description of how integrity and accuracy are assured for stored data must be provided.

1.3.3.4 Security. A detailed description of security protection must be provided, that is, the design features which prevent deliberate or inadvertent misuse or production of false data.

1.3.3.5 IGC rules and procedures. Other requirements of this Specification and any other FAI or IGC rules or procedures relevant to GNSS FRs must be complied with.

1.4 **EVALUATION**. Upon receipt of all of the formal application material, GFAC will complete their work as soon as practicable and normally within 120 days, except in the case of unforeseen difficulties. The testing carried out by GFAC will be of a non-destructive nature but GFAC or FAI is not liable for any damage to or loss of any equipment. A sample test and evaluation schedule which may be used is at Appendix 2. During the evaluation process, anyone may send opinions, evidence, other test results, etc to GFAC about the proposed unit's suitability or otherwise in meeting IGC requirements. The evaluation period starts when all members of GFAC who have expressed a wish to test the hardware themselves, have received all of the required equipment and documentation in good order and ready to test. The GFAC Chairman will notify the manufacturer of the contact details of individuals to whom hardware should be sent (see 1.3.3.1). If such individuals are not provided by the FR manufacturer with all of the equipment to be evaluated, the target evaluation period does not apply although the evaluation will be completed as soon as practicable in the circumstances prevailing. This will involve equipment being sent from individual to individual. Any excess expenses incurred by individuals (such as postal, excise and tax), shall be paid by the FR manufacturer into the FAI account on request so that individuals can be re-imbursed and do not have to pay these expenses themselves. (AL4)

1.4.1 **Correspondence with GFAC**. This should be carried out through the committee chairman who will inform other members and co-ordinate any responses to an FR manufacturer.

1.5 **APPROVAL**. On behalf of IGC, GFAC shall either approve, conditionally approve, or require modifications to the applicant's unit. Drafts of approval documents will be circulated beforehand to GFAC members and associated experts, also to the FR Manufacturer concerned; but the final version is the responsibility of GFAC alone.

1.5.1 **Conditional Approval.** Conditional approval usually requires some changes and/or additions before full approval can be given, when the factors which led to the conditional approval have been changed. *An example might be where in the initial standard of FR tested, a motor glider Means-of-Propulsion sensor either was not included, or was assessed by GFAC as not being adequate; in this case an IGC-approval might be issued without including the MoP sensor, pending changes to it for later evaluation and approval. Or where security is assessed as not sufficient for operation in the same way as other approved FRs, but where the FR in question can be approved by including specific extra OO checks and inspections, maybe pending improvements in security systems which will enable it to operate like others.*

1.5.2 **Requirement for Modifications**. If the decision is that modifications are required before IGC-approval can be given, GFAC will supply the manufacturer complete details of what is required. If the manufacturer notifies GFAC within 21 days that he wishes the approval process to continue, he will be expected to resubmit a modified FR for further review by GFAC within the next 180 days. GFAC will aim to complete this review within 60 days, subject to not encountering any unforeseen difficulties. *If this procedure is followed, no extra fee will be payable but the initial fee will continue to be held.*

1.6 **CONDITIONS**. When an IGC-approval is issued, an applicant agrees to the following conditions:

1.6.1 To inform FAI through the GFAC Chairman whenever changes (of whatever nature) are made to an approved model of FR. (AL3)

1.6.2 FAI may decide that significant changes have been made based upon reports from other parties.

1.6.3 Where features of an approved-FR are changed, FAI must be notified and may decide that a formal evaluation of such features is required, or if the changes are extensive, that another full approval process is required. This shall require a fee of up to the fee for a new type of GNSS FR. Where a party other than the FR manufacturer has notified FAI of the change concerned (1.6.2) which led to a further approval process, the fee shall be that for a new type of GNSS FR, since the manufacturer was obliged under 1.6.1 to notify FAI earlier. (AL3)

1.6.4 FAI may remove or alter the existing approval of any FR at any time.

1.7 **LABORATORY TESTING**. FAI may decide that a report on the FR (or a particular aspect of the FR and/or its peripherals) from a recognised testing laboratory must be supplied. In this case, the applicant will be responsible for the expense in addition to the application fee. The applicant shall be given the opportunity to withdraw his application prior to incurring this expense.

1.8 **APPROVAL BY NACs**. NACs shall accept the IGC approval as valid for initial use of the equipment in their countries, without further evaluation at a national level. The terms of any IGC-approval will be posted on the Internet newsgroup rec.aviation.soaring (r.a.s.), on the FAI IGC email mailing list, and on the FAI Internet web pages under the IGC GNSS web site: http://www.fai.org/gliding/gnss/. If any problems arise during practical usage, the GFAC Chairman should be notified in the first instance. (AL1)

CHAPTER 2

EQUIPMENT REQUIREMENTS
FOR GNSS FLIGHT RECORDERS

2.1 INTRODUCTION

2.1.1 **IGC Responsibility**. Where GNSS equipment is used for primary evidence of Flight Performance Verification, IGC has a duty to ensure that checks and balances and design requirements are used to preserve the integrity of evidence, such as by taking appropriate action to prevent anomalies or cheating, and also to ensure the use of common data formats wherever possible.

2.1.2 **Role of the IGC GNSS FR Approval Committee (GFAC)**. The GFAC will evaluate GNSS FR equipment on behalf of IGC in accordance with procedures given in Chapter 1 of Annex B to the Sporting Code for Gliding, which is the basis of Chapter 1 of this document.

2.1.2.1 **Requirements which will be closely evaluated** - include appropriate levels of simplicity for pilots, OOs and others; reliability; security of data; the minimisation of anomalies and the elimination of opportunities for cheating; and compliance with standards for the IGC data file and other common IGC file requirements.

2.1.3. **Changes in rules or procedures**. Where changes in rules or procedures are made which affect GNSS FRs, the following timescale applies for the incorporation of such changes in all of a given type of FR, taken from the date of first notification of the change to the FR manufacturer. The date of submission is taken as the date of receipt of the appropriate fee by FAI or the date of receipt of all equipment required for testing by the individuals notified to the manufacturer by the GFAC Chairman who are to receive the hardware (see 1.3.3.1), whichever date is the later. (AL4)

2.1.3.1 FRs not yet submitted to GFAC or FRs under formal evaluation for IGC approval. A change must be incorporated before IGC-approval is given, or within 6 months of notification of the change if this is a later date.

2.1.3.2. FRs already having IGC approval. Changes involving internal alterations to FR units will not normally be required, except for units returned to the manufacturers or agents for other reasons (such as firmware or hardware updates), when changes can be incorporated at the same time. A software change outside the FR unit itself shall be made available within six months of the notification of the change to the manufacturer. (AL2)

2.1.3.3 Exceptions. Where a manufacturer makes a case for a different procedure to the above, this may be agreed by GFAC. Conversely GFAC may believe that a change must be made notwithstanding the above. If in doubt, the President of IGC will arbitrate.

2.2 **FUNCTIONAL REQUIREMENTS**. The following is a list of functions expected to be available or to be calculated from flight data from the FR hardware: Takeoff point/time/altitude, Start point/time/altitude, flight continuity, flight path, reaching declared or other turn points, finish point/time/altitude, distance flown, speed, landing point/time/altitude, and any national requirements such as non-violation of airspace or other altitude restrictions.

2.3 **GENERAL REQUIREMENTS**. Record data during flight in latitude, longitude, altitude and time in such a manner that flight continuity and the flight path are shown; transfer recorded data after flight to a computer for further processing, analysis and flight verification; have a unique FR serial number nominated by the manufacturer and un-modifiable by the user.

2.4 **REQUIREMENTS FOR DATA RECORDING**. Continuous recording in accordance with the Sporting Code for Gliding including its annexes (these give fix time interval settings such as a maximum setting of 60 seconds for establishing flight continuity and recommend settings of 4, 2 or 1 sec when near to Observation Zones); setting of fix-recording frequency (constant or variable time between fixes); a receiver capable of processing data from at least 12 satellites at one time; record satellites used in position determination; initialisation and/or reset of data storage; if required by the terms of the IGC-approval the ability of an OO to input a personal code (OO ID, see glossary) before flight; GNSS clock time recording with correction to and output as UTC (i.e. applying the leap-second correction); position lat/long recording to the WGS 84 Geodetic datum; GNSS-calculated altitude recording; pressure altitude recording with or without GNSS recording, with continuous time clock function (para 2.6.6.1.1); fix validity and accuracy recording; pilot-activated event input (PEV code); retention of recorded data until officially transferred for analysis by the NAC; retention of data validity as battery voltage falls (until final failure causes recording to cease, but previously recorded data must not be lost, see Appendix 1 para 7 for use of the Three Letter Code LOV for low voltage); and recording any other parameter defined as mandatory in the IGC data file standard given in Appendix 1. (AL4)

2.4.1 Creation of IGC data file. After switching on the FR, the subsequent commencement, cessation and rate of recording fixes for transfer after flight may be by automatic or pre-set means; subject to providing a sufficient baseline of valid fixes on the ground both before and after flight in order to establish takeoff and landing altitudes as well as the exact positions and times of takeoff and landing, and satisfying the requirements for demonstration of flight continuity. For baselines and other details, see Appendix 1 para 1.1.1. (AL3)

2.4.2. Standard of signals. Receivers must be able to determine whether ranging signals are marked unhealthy or not, so that the receivers only use ranging signals in the navigation solution which are not marked unhealthy. If in doubt refer to GFAC before the design is fixed (AL3).

2.4.3 Desirable Features: Output-only port for remote in-flight data display with turn point and other information; recording interval variation either automatic near turn points or through fast fix button; automatic activation of recording when movement detected (see Appendix 1 para 1.1.1.1 for movement thresholds and mandatory baselines before takeoff and after landing); flight declaration with date/time of entering (see Appendix 1 para 4.2, the C-record); preservation of flight data in situations of impact, damage or crash; low power consumption.

2.5 **OPERATING PROCEDURES**

2.5 **OPERATING PROCEDURES**. IGC-approvals apply not only to the equipment itself, but may include mandatory operating procedures (such as checks by OOs or others, sealing, stowage, etc) where these relate to the integrity of evidence used for flight verification.

2.6 **PRINCIPLES**

2.6.1 **Date and time**. The Sporting Code requires that there must be proof, independent of the GNSS FR, that the flight data recorded on and transferred from the FR took place on the day and at the times shown on the transferred data. This is to ensure that a FR record cannot be artificially manufactured in advance and used later.

2.6.2 **Data file standard**. The data recorded in the FR and transferred after flight to a PC must be capable of analysis in the form of the IGC data file standard format given in Appendix 1. Data may be transferred from the FR in another form (eg binary code) as long as it can then be transformed into the IGC format through the programs covered in para 2.9.

2.6.3 **Memory used for flight data**. The memory used for storage of the flight data to be used in the flight verification process must be of a type and design so that it cannot be accessed, combined (such as in a storage device with software partitions), altered or corrupted by other data legitimately or otherwise present in the equipment. Any write-access for mandatory flight recording information to the memory, which originates other than from secure or otherwise approved sensors (such as GNSS, pressure transducer, approved MoP sensor) must be detected by the FR and shall invalidate the flight record.

2.6.4 **Identification of corrupt, false, or inaccurate data**. Any flight data that is corrupt, false, or inaccurate, either though inadvertent or deliberate causes should be positively identified and recorded as such wherever possible.

2.6.5 **Integral Pressure-Altitude Sensor**. A GNSS FR used for IGC flight verification evidence shall have an integral altitude sensor capable of producing an output of pressure altitude in the same way as a barograph and having a fixed sea level datum of 1013.25 HPa at 15°C (ie recording Flight Levels rather than height above ground or sea level). The altitude sensor shall be within the FR unit and its primary function is to append accurate pressure altitude data to each fix. If its data is used for other purposes such as a cockpit display, it shall be ensured that the data transmission from the FR is outbound only; it must not be possible to alter the pressure altitude fix record by any inbound data from sources external to the FR. The pressure altitude recording system shall conform to the normal rules on barographs and calibration, and shall continue to operate if the GNSS is inoperative. For calibrations in an altitude chamber it must be possible to produce an IGC-format file of the pressure changes, without the need for any special switching of the FR except to switch it on before starting the calibration. For FRs which do not record continuously after switching on, this may be achieved by ensuring that a small rate of change of pressure altitude is enough to start recording fixes of pressure altitude with time. This will also ensure that pressure-altitude fixes are produced in flight in the absence of any GNSS data. Experience in the past has shown that a suitable trigger value is a pressure change of 1 metre per second for 5 seconds. The FR shall be configured so that it records the pressure altitude at the time of each GNSS fix. This must include an adequate baseline for the take-off and landing (see Appendix 1 para 1.1.1.1), for comparison with any independent measurement of airfield pressure at take-off and after landing. For stand-alone FRs, the pressure recorded in the *.IGC file must be "cockpit static" (vented within the FR box), but for FRs mounted in the instrument panel (for instance, near to other pressure instruments), the pressure recorded may either be "cockpit static", or use a tube connection to the pressure from glider instrument system static tubing. See also the Glossary item on Pressure Altitude. (AL4)

2.6.5.1 **Calibration accuracy**. The IGC FR pressure-altitude sensor and recording system is an electronic barograph in its own right, and is subject to the same rules and procedures. See para 2.10 on calibration accuracy.

2.6.6 **Programming of GNSS Navigational Reference Data**. The GNSS navigational reference data must not be changed in the time between the OO's checks on the FR before flight, and the OO's checks and the transfer of data from the FR after flight. Presentation and manipulation of approved data on cockpit displays by a pilot in flight is not part of programming and is therefore allowed. Programming in this context includes any action which could change the source or method of calculation for 4-D position data during flight. This includes:

2.6.6.1 Any change which could alter the geographic co-ordinates (eg latitude and longitude, or grid), GNSS-altitude, GNSS clock time and its correction to UTC, or the record of satellite constellation (the satellites used in fixes) in a data sample other than by movement of the glider itself, and specifically:

2.6.6.1.1 A continuous time clock function is required during the operation of the FR, in addition to the date and time derived from the GNSS fixes themselves. This is in order to maintain time when GNSS fixing is not occurring, and to give an accurate date/time if the GNSS fails and the FR has to be operated in pure barograph mode. The sustainer battery for the clock may then be used to trash security if the case is opened at any time in an unauthorised manner. This is to ensure that owners of IGC-approved GNSS FRs can use the unit as a pure barograph in the event of complete lack of GNSS fixes (for whatever reason, an example being a fault or damage to the antenna, its cable or connectors). For GNSS boards which do not incorporate a Real-time Clock (RTC) module capable of providing an accurate time base if time from GNSS fixes is not available, a separate RTC similar to that used in a PC must be fitted in order to sustain the time base. (AL3)

2.6.6.2 Any change of Geodetic Datum setting. The Sporting Code for gliding states that the lat/long data in all files transferred from the FR after flight must be to the WGS 84 Geodetic datum. Therefore, any change from this must either be impossible by the design of the FR, or must be recorded on the flight data file.

2.6.7 **Allowed Changes** - Programming of the GNSS navigational reference data does not include the following, which are therefore allowed to be changed, operated or affected in flight, including by flight-crew actions:

2.6.7.1 **Navigational target points**. Controls (eg switches or buttons) accessible to the flight crew may be used which select different preset points as navigational targets or Waypoints. eg Start, Turn and Finish Points, and other points of interest.

2.6.7.2 **Data sampling interval settings**. The settings for the time interval between data samples may be changed, either automatically (for instance at Waypoint Observation Zones) or by manual switching. The maximum time setting for data sampling for the purpose of establishing flight continuity is 1 minute (SC3 para 4.3.1). It must also be possible to set a data sampling interval of less than 5 sec for use near Observation Zones, so that pilots can use this shorter interval when near and in the OZ, as recommended in Annex C to the Code (SC3C) para 9.2. (AL3)

2.6.7.3 **Pilot event marker**. This is where an extra fix is recorded and the code PEV (Pilot Event) appears in the flight data for the fix concerned, following a specific pilot action such as pressing a button. The PEV code on the flight data must only appear as a result of this pilot action and not as a result of any other action or function. It is recommended that a series of fixes at a shorter interval than usual (fast fix function) follow a PEV event, but the PEV code must only appear on the fix for the time at which the pilot took the action. Where the action is pressing a button or switch, not more than one button or switch shall need to be pressed to obtain the PEV event. (AL2)

2.6.7.4 **Camera connection**. A connection to a camera may be used which takes an additional GNSS data sample on shutter press, marking the event with the appropriate three-letter code (Codes, Appendix 1 para 7, PHO for photo).

2.6.7.5 **Motor glider MoP record**. Before IGC-approval for a Motor Glider Means of Propulsion (MoP) recording system in the FR, the operation of the MoP itself or other functions associated with operating the MoP, must be recorded in a specific and unambiguous way. Systems which have a microphone inside the FR and record cockpit noise with every fix using the ENL code are preferred; a low but positive ENL value in normal gliding flight shall be recorded so that the system is self-validating with each fix. Systems that depend on wiring which cannot be inspected for its whole run, and the use of types of microswitch that could be held open or closed (for instance by a magnet) in order to avoid engine running being detected, will not be approved by IGC. In the case of microswitch- or vibration- based systems that are IGC-approved after testing, the normal procedure (specified in the IGC-approval document) will be for an OO to carry out a MoP test both before and after flight, the FR having to run continuously between the MoP tests in order to show that the MoP recording system is still operative. Microswitches can be used to detect functions such as engine bay doors open/closed, pylon up/down, nose cone propeller cover extended/retracted (for designs such as the Stemme), etc.

2.6.7.5.1 Fix sampling time for MoP record. The prime method used for showing MoP activation (a condition in which it would be possible to generate forward thrust) must record a fix immediately if the MoP activation condition is detected, irrespective of the fix sample rate setting.

2.6.7.6 **Other functions**. Other functions may be operated in flight that can be shown not to affect the GNSS navigational reference data or the integrity of other evidence for flight validation. This will be evaluated by GFAC and incorporated in the IGC-approval document for the type of FR concerned.

2.7 EQUIPMENT REQUIREMENTS

2.7.1 **GNSS FR Equipment Requirements**. In order to achieve the general conditions of the previous paras, the equipment requirements and procedures in the following paras shall be followed, and other provisions of the Sporting Code for Gliding (SC3) and its Annexes complied with, subject to the terms of the IGC-approval.

2.7.2 **Security of Data between GNSS Receiver and the FR Memory**. The user, and particularly the flight crew, must be denied access to the line carrying the inbound signal containing the data to be used in the flight verification process (eg the NMEA protocol inbound signal), to the FR memory (the ingoing data line). See 2.7.3 for the principles to be adopted. The GNSS receiver and the flight data memory module of the Flight Recorder must either be in a sealable enclosure with the connections between them entirely within the enclosure, or the GNSS receiver and flight data memory modules must be in separate sealable enclosures with positive security protection being included for data being transferred between them.

2.7.2.1 **Type of seal**. The enclosure may either be specially sealed by an OO before flight, or may have a manufacturer's permanent physical seal, or an electronic seal, subject to convincing GFAC that the integrity of data used for flight validation can be preserved by the particular design.

2.7.2.2 **Wiring**. Only the following wires may pass through the boundaries of the sealed enclosure:

2.7.2.2.1 Electrical power. Wires carrying electrical power to the GNSS receiver and FR.

2.7.2.2.2 Antenna. The GNSS receiver antenna (aerial) cable. The antenna connector must be a type designed and specified for low energy antenna signals, including the GPS frequencies around 1.5 GHz. Such as the BNC bayonet or TNC threaded antenna connectors. Where the antenna connector on the FR case is not the 9mm diameter BNC bayonet type, for GFAC testing a short interface cable must be provided so that antennas with BNC connectors can be used for test purposes. Since antennas with BNC connectors are commonly available, in the case of FRs not having a BNC connector on the FR case, it is recommended that production equipment includes an interface cable so that a BNC antenna connection can be used if the original antenna has to be replaced (such as during a competition). (AL4)

2.7.2.2.3 Data cable. Where the equipment is configured as a receiver module and a separate recorder unit, the cable and its connections used for transmitting data to the recorder unit must be specially designed so that alteration of GNSS fixes, the flight log or the Geodetic Datum is not possible; except as signalled by genuine fix and other data from the receiver module. See 2.8.1 and 2.8.2 on data security for conditions where a separate GNSS module may be used.

2.7.2.2.4 Cable to cockpit navigation display. A cable for transmitting data to a cockpit display for approved navigation information, with appropriate controls for switching the display information in an approved manner. The cable is to be buffered by the manufacturer such that no alteration to GNSS fixes, the flight log or geodetic datum in the FR is possible through this cable.

2.7.2.2.5 Cables for approved functions. A cable or cables for the approved functions provided that no alteration of GNSS fixes, the flight log or the Geodetic Datum, is possible by signals sent through these cables. These functions include an Event Marker, Camera connection, and Motor Glider MoP sensor.

2.7.2.2.6 Connector cable to the PC. The IGC standard cable for data transfer to a PC has 9-pin D Subminature RS232 connectors, male on the FR end and female on the PC end, with straight through wiring (for instance, female pin 2 is connected to male pin 2, etc). If a different connector is used on the FR (see 2.7.2.2.7 below), the FR manufacturer shall either provide a cable which connects to the FR and has a female 9-pin RS232 connector for the PC connection, or provide an adapter which connects the FR connector to the 9-pin male end of the IGC standard 1:1 connector cable. 'Cross-Over', 'Null Modem' Gender Changer or Manufacturer-Specific cables may not be used. (AL2)

2.7.2.2.7 Connectors to the FR for data transfer. There are three IGC-approved options for connecting a PC to the FR, one of which shall be available on the outer case of stand-alone FRs. In the cases of panel-mounted FRs an interface connector may be used so that one of the IGC-approved connectors is readily available (such as on the end of a short cable connector from the FR itself) at the back of the instrument panel (or in another convenient place) for data transfer purposes. (AL4)

2.7.2.2.7.1 Option 1 - 9-pin RS232 connector. This is a 9-way D Subminiature female connector with RS232 standard pin assignments, as used in existing systems such as Cambridge, Print Technik and Zander. Pin 2 is for RXD (data from FR to PC), pin 3 for TXD (data from PC to FR), and pin 5 for GND (signal ground). Other pins may be used (for example to implement Hardware Flow Control), provided that they conform to the RS232 standard pin assignments as implemented on PCs, and allow connection of the FR to a PC using a Standard 1:1 cable. If other pins are used then they must be to the PC standard, and not free for any purpose (such as Voltage Supply) unless this is agreed by GFAC. (AL1)

2.7.2.2.7.2 Option 2 - RJ11 6-pin connector. This is a female 9 x 6 mm RJ11 socket with 6 connections, as used for some modems and telephones. Pin assignments are as follows:

1 +v
2 Spare (For future application (FFA) with GFAC approval.
The Colibri FR uses this for an external LCD)
3 Spare (remarks as for pin 2)
4 Rx
5 Tx
6 Ground

2.7.2.2.7.3 Option 3 - RJ-45 8-pin connector. This is a female 12 x 6 mm RJ-45 socket with 8 connections, as used on ISDN and Ethernet connections. Pins are numbered from left to right, with the male plug held towards the observer with the pins uppermost and the cable running away from the observer (AL3).

Pins	Function
1&2	Volts +
3&4	Spare, for future application with GFAC approval
5	TX
6	RX
7&8	Earth (Volts -ve)

2.7.2.2.8 Antenna connector - this must be a type designed and specified for low energy antenna signals, including the GPS frequencies around 1.5 GHz. Such as the BNC bayonet or TNC threaded antenna connectors.

2.7.3 **Non-Accessibility to Flight Crew**. Any switches, buttons, electrical plugs and sockets associated with the GNSS receiver unit and its associated FR must be inaccessible to the crew in flight, except where the IGC-approval for the equipment concerned specifically allows it. Antennas may be separate from the main unit in order that they can be placed in the glider in the best position for reception of signals.

2.7.3.1 **Possibility of re-programming in flight**. It must be shown that any in-flight transfer of data to or from the FR, or the use of an un-approved connection for data transfer, will either be apparent on the after-flight data or can be shown to be impossible because of the design. If this is detected, the flight data shall then be invalid for IGC purposes.

2.7.3.2 **Stowage out of reach of flight crew**. The equipment design may be such that stowage out of reach of the flight crew is required. Such stowage may be to the rear of the crew in an compartment inaccessible in flight (similar to a barograph stowage), or mounted in or behind the instrument panel. In the case of instrument panel mounting, the crew must not be able to gain access in flight to wiring, plugs, data ports, or hardware, except that which is part of the specific IGC-approval for the equipment.

2.7.3.3 **Geodetic datum**. The Geodetic Datum is recorded in the IGC file header (H) record, and the Sporting Code (SC3) states that the WGS 84 Geodetic Datum shall be used for all lat/long co-ordinates that are recorded and transferred from the FR after flight. Any changes to it must be recorded in the output data, unless it can be shown that the equipment is such that it is physically impossible to change the Geodetic Datum between the OO's checks before and after flight. This can be achieved by fixing the design to WGS84, or by physical sealing after setting WGS84 by a method allowed in the IGC-approval for the equipment.

2.7.3.4 **Connecting cables**. If the design of the FR includes separate units connected by cable (not including the antenna), the whole run of any cables used to transfer data on fixes outside any sealed units must be continuous between the units without any other breaks or connectors. The cables must be shielded against electronic interference. The cables must be connected in such a way that any disconnection is positively shown; this may be by a physical seal or by an electronic device which records automatically after the initial connection if the cable becomes disconnected. It is recommended that, for ease of inspection by the OO, the cable should be installed so that it is clearly visible throughout its whole length.

2.7.4 **Identification of Corrupt, False, or Inaccurate Data**. A method should be included to positively identify any corrupt, false or inaccurate data and to record it as such, whether such data originates from inadvertent or deliberate causes. This may be achieved at various stages in the process such as: by a program within the FR marking suspect fixes such as any with a high EPE/FXA or where the components of the fix are not consistent with each other; or after flight by using a PC-based approved analysis program which calculates the groundspeed between the centre of each fix and highlights (for further manual analysis) any fixes between which calculated groundspeeds are unlikely.

2.7.4.1 **Averaging Algorithms**. Most commercial GPS boards used in FRs include averaging or dead-reckoning algorithms that, when the vehicle carrying the FR is moving above a low speed threshold, reduce short-term variations of fix position and produce straighter series of fixes which correspond more closely to real positions. If the system employed has a forward-prediction effect (sometimes called "DEDuced" or "dead reckoning", where fixes are not derived from GNSS lines-of-position but are predicted from past velocity), it has been shown that a glider running in to a Turn Point at high speed and losing GNSS lock can "throw forward" a series of predicted fixes and so be able to record fixes in an Observation Zone when the glider has not reached the Zone. It is recognised that GPS receiver board manufacturers are reluctant to divulge details of their programs, but IGC-approval will not be given if testing shows that a high-speed run followed by a sharp turn, can throw fixes forward of the true position of the glider. FR manufacturers must ensure that any such averaging programs in the GPS board they use, operate only over short time periods and cannot be used by pilots to produce false fix records, particularly close to Observation Zones. Fixes recorded on the IGC data file must be based on real GNSS position-lines. Predicted fixes must not be recorded such as those from so-called Dead Reckoning (DR) and other forward-prediction algorithms designed for use on the ground if signal is lost due to terrain masking. If such a system is available on the GNSS board, it must either be permanently disabled or set at a time constant of less than 5 seconds if it is to be used for fixes recorded in an IGC flight data file. (AL3)

2.7.5 **Unique Serial and Version Numbers**. Each FR shall have three-character alphanumeric Serial Number (S/N) unique to that manufacturer, marked physically and also in the electronic memory so that it is included on all output data. Output data must include the S/N, the version number of the hardware and firmware (or software) standard, and details of the GPS board and Pressure Altitude sensor inside the FR concerned (details are in Appendix 1 in the H (Header) record). The S/N must also be available either by being permanently imprinted by engraving or die-stamping on the outer case of the FR, or having an easily accessible display that shows it for long enough for an OO to note it down.

2.8. **SECURITY - PRINCIPLES**. Security procedures and hardware, firmware and software standards must be used so that no alteration of data may occur without such alteration being detectable. The method of ensuring that GNSS FR flight data is secure is through the generation of a digital signature (DS) in the FR, which becomes part of all flight data transferred from the FR. PCs, transfer software, email, and portable storage media such as a diskette may be used to transmit data taken from the FR to the validating authority (NAC or FAI). Regardless of the level of physical control used in handling and transmitting data between the FR and the validating authority, the DS must enable detection of any alteration of data throughout the transfer process from the FR and at any time afterwards. Individual FRs must have different security keys to others, so that if the key for one FR is broken, the rest of the product range will still be secure. (AL4)

2.8.1. **All flights including World Records and 1000/2000 km Flights to IGC criteria**. For IGC-approval of FRs for all flights, it is normally expected that the FR will be a single sealed unit with security protection to the full standard of this Specification. However, if it is intended to use a GNSS unit that is separate from the FR unit itself, the security of electronic flight data from the GNSS unit to the FR must be to a similar standard as that required for such data which is transferred from the FR unit itself to storage media. This applies where a stand-alone GNSS unit is connected to the FR by cable rather than a FR which has both GNSS receiver and recorder together in a secure container. A separate receiver must be securely physically sealed, and the data stream from the GNSS receiver to an FR unit must contain both an electronic identification of the individual receiver unit (so that in the event of a query on the data, it can be identified and inspected), and also a digital signature (DS) system no less secure than that required for data from the FR unit itself.

2.8.2 **Badge Flights up to Diamond, use of Separate GNSS and FR Units**. For use in Silver, Gold and Diamond Badge flights, IGC will permit the use of systems using a separate GNSS receiver unit connected to the FR unit by cable. This is subject to the other provisions of the Sporting Code Section 3 and this Specification, in particular the ability to generate the IGC format flight data file and conform with requirements for security of data (see 2.8.3.1 on the Message Digest and Appendix 1on the IGC file structure).

2.8.3 **Digital Signature**. A Digital Signature (DS) is generated by the GNSS FR and must be transferred to the PC at the same time as the flight data. The DS will be used as a check that the data originated correctly from an individual FR and that there has been no change in the data between the initial data transfer from the FR to the PC, and the data used for final flight validation.

2.8.3.1 **Message Digest**. The Message Digest (MD) is essentially a hashing value (a mathematical function) of the content of the IGC format file (the flight data itself with the alphabetical records), and represents an image of the whole file. The MD is encrypted using the private key of the FR, and once encrypted becomes the Digital Signature (DS) that is added to the file to be transferred to the PC and appears in the G record of the IGC file format. The flight data (the Message) is not encrypted. A MD is generated with an algorithm of the FR manufacturer's choice. Knowledge of the private key used to encrypt the MD must be restricted to as few a number of people as possible, and the manufacturer must keep a register of people with this knowledge. Flights made by any persons using an individual FR for which they have this knowledge will not be validated for IGC purposes. It must not be possible to access the security algorithms by dis-assembly of the FR, for instance through an EPROM reader. FRs approved for all flights (2.8.1) must have an asymmetric algorithm such as RSA, or have a system providing equivalent security as decided by GFAC. FRs for flights up to and including lower levels approved by IGC (currently Diamonds and below) must have algorithms which are complex enough to discourage malpractice but need not be to the same level of security as FRs for all flights. GFAC may require the FR manufacturer to present and defend the design of the signature-generating algorithm, but knowledge of details will be kept to a small number of experts in data security who will be under an agreement of confidentiality.

2.8.3.1.1 RSA, DSA and data transfer times. In the case of RSA (for meaning, see the Glossary), a key of at least 512 bits will be required, and, for non-RSA systems, a key length giving equivalent security as decided by GFAC. With progress in computing and the possibility of even asymmetric cryptographic systems being broken, such key lengths and other security aspects will be kept under review and revised from time to time. It is expected that new designs of GNSS FRs will have more capable processors and more memory than earlier designs, so that larger key sizes should not present a problem. The DSA system (see Glossary) is a permissible alternative to RSA and may give shorter times for data transfer from the GNSS FR to a PC. With the DSA system it may be possible to make security calculations while the FR is recording data, which may save time during data transfer to a PC after the flight. A 100kB IGC data file is expected to transfer with full security encoding from the FR to a typical PC used by gliding competition organisers (typically a low range Pentium {P100, for instance}, but this level will be kept under review), in 1 minute or less. The time to execute the VALI-XX.EXE program is considered to be less critical. For more information on RSA and DSA, see the Glossary, and for advice on these matters, consult GFAC, initially through its Chairman. (AL4)

2.8.3.2. **Checking at the NAC**. When the IGC-format flight data file is checked later at the NAC, a correct DS check ensures that the file has been transmitted to the NAC with no errors, and it also ensures that the file has not been modified in any way since the original transfer from the FR. The DS from the G record is decrypted in order to get the original MD using a public key (related to the private key) which is stored independently of the FR. This public key is in the FR manufacturer's VALIDATE program file (VALI-XXX.EXE, where XXX is the manufacturer's identification, see 2.9.3.4). The VALI program at the NAC will check that the MD recomputed from the received file is correct. If the VALI check is successful, this shows that the file content is an exact copy of the file transferred from the FR, and that the FR output conforms to the manufacturer's criteria which are checked by the (same manufacturer's) VALI program. The system is similar to that used for encrypting and checking files and mail on the Internet. For further advice, contact the GFAC Chairman who will refer questions to appropriate experts in software security for flight data files.

2.8.4. **Unauthorised Interference**. If a FR is opened or otherwise interfered with (such as electronically), a mechanism must exist so that any subsequent data from that FR will be detected as not having the correct DS. This can be achieved by a microswitch that operates if the FR case is opened and deletes the security algorithms and keys, also any data in the memory. This system may only be re-set to normal after being returned to the manufacturer or his authorised agent for re-initialisation. Knowledge of the method of re-initialisation must be restricted to the minimum number of persons and controlled so that unauthorised persons cannot gain the knowledge. See above on validation (VALI-XXX) programs.

2.8.5 **Use of Computers with a FR.** There must be security devices (sometimes called a "firewall") which prevent a computer that is connected to the FR being used for unauthorised changes to the internal programming of the FR or of data stored in the FR, both on the ground and in flight. Although current IGC-approvals normally state that a portable PC shall not be connected in flight (except where specifically tested and approved for a particular FR such as the use of small Palmtops for display and other purposes), there is no way of preventing this, particularly in a two-seat glider. The worst-case in terms of security, which must be taken into account, is that a powerful portable is connected to the FR, unsupervised by an OO, with the intention of breaking security or injecting false data either on the ground or in flight. How this is prevented by design features, should be stated when applications are made for IGC-approval. This will also be tested by GFAC. (AL2)

2.8.6 **Changes and upgrades - maintenance of security**. Changes and upgrades may involve replacement of components, including GPS receivers, processors, boards, ROMs of various types, and microchips. These may only be carried out at the FR Manufacturer's facility or that of an authorised agent, so that the physical and electronic security of the updated FR is re-set to the standards required by this document and of the IGC-approval for the FR concerned. Where firmware can be re-programmed without component replacement by using tools external to the FR (such as where EEPROMs, flash PROMs are used, and any equivalent systems), manufacturers must restrict the knowledge of such tools/firmware to a minimum number of persons. Any security codes (including Private Keys) embedded in such tools/firmware must be known to as few a number of people at the manufacturer's facility as possible. This is to reduce the possibility of reverse engineering of such tools/firmware by unauthorised persons such as potential "hackers". It is expected that the secret Private Key (PK) for the Asymmetric Algorithm will be stored in RAM, so that opening of a cover or the FR case removes the maintaining supply to the RAM, thus erasing the PK. Where components have to be physically replaced, the PK is trashed as above when the cover or FR case is opened to gain access to the component to be replaced, and the PK then has to be re-entered. Where external reprogramming of the Firmware is possible using EEPROM or Flash Prom (or any future system), it must not be possible to replace the firmware without the PK being made invalid. The manufacturer's reprogramming process may re-enter the PK and for this reason, only the minimum number of people should have knowledge of the manufacturer's process of external programming. It may be possible for unauthorised persons to reprogram the EEPROM or Flash Memory, but without the PK, this must not result in a working recorder that will pass future VALI-XXX.EXE checks. (AL2)

2.9 DATA FORMAT, TRANSFER, CONVERSION, AND VALIDATION PROGRAMS

2.9.1 Format of transferred data from the FR. The data transferred from the FR may be either in a manufacturer's proprietary file format (such as binary), or in the IGC file format described in Appendix 1. The IGC format is preferred so that later conversion to it is avoided. In the IGC file format, whether obtained on transfer from the FR or on later conversion, the source of the G-record (security record) must be from the FR itself. In all cases, data transferred from the FR shall be checked against the VALI-XXX program by the NAC before a flight achievement is validated.

2.9.2 Conversion of Data to the IGC Format. Where the transferred data is in a different file format to the IGC format (such as binary), it must be possible to convert the original to a separate IGC-format file so that the NAC can use standard IGC files with their analysis program(s).

2.9.3 Short Program Files for Transfer and Conversion to the IGC File Format. Short electronic program files shall be produced by a FR Manufacturer solely for the transfer of data from each type of FR and conversion to the IGC data format given in Appendix 1. These program files must be capable of fitting, uncompressed, and executing their programs on a 1.4 Mb floppy diskette, with enough spare room for flight files to be transferred from the FR, and must work without other requiring other files or programs except the operating system of the PC. They may be used by pilots and OOs either through a floppy diskette (which may be self-booting) or through the hard disk of a PC. The program file names include the letters XXX, which is the individual manufacturer's three letter code given in Appendix 1. These files are in addition to the FR Manufacturer's main software program (if any) and are to help pilots, OOs and others who wish to have the simplest and quickest method of data transfer from the FR, and conversion for the IGC format for later analysis. This includes officials at competitions responsible for transferring data from many FRs each day to a PC for analysis and scoring. There is no obligation for a FR manufacturer to have any further software programs, because analysis and flight validation can be carried out from the IGC format file using one of the many programs developed independently for this purpose and listed on the IGC web pages. Parameters (switches) passed to short program files are listed below. To denote the switch, either a forward slash (/) or a minus sign (-) may be used, with a space between the filename and the / or - symbol. However, there is no space between the switch and its parameter, eg space-p2 or /p2 = COM2 port, spaceb19200 or /b19200 = baud 19.2k, space-d[path] or /d[path] = path for files created (no brackets needed, just the path), space-nXYZ01AUG or /nXYZ01AUG for flight by glider XYZ on 1 August. Approved switches are as follows: (AL3)

-p1, -p2 = COM ports (default COM1)
-b19200 Baud rate (default 19200)
-d [path] defines path where the file(s) will be created. A Null parameter defines current path (which is also the default).
-q Quiet mode i.e. non-interactive, for use in batch processing. Transfers all flights not on disk unless-o is also used, in which case all available flights are transferred. Default is the use of the interactive menu.
-o Overwrite existing files. Default is do not overwrite.
-x = manufacturer's proprietary. This is to allow manufacturers to have their own specific parameters without compromising switches IGC may define at a later date. e.g. /xh to define Hardware Flow Control.
-v = Version number of file, display
-b = Baud, if absent, defaults to FR's natural baud rate.
-i = DATA file does not also convert to IGC file format (ie needs separate action with CONV file)
-? = Help/instruction menu. How to operate the program, description of switches, etc.
-n [file] Define a filename to be used other than the IGC default, for instance for ease of identification of a glider flight file in a large competition. In a comp the glider registration or pilot's name will be more useful than the normal file name. All details in the normal file name are in secure parts of the file, and the file name itself is not secure (that is, protected by the digital signature system) and can be changed by any PC operator. In the case where more than one file is transferred, second and subsequent files will have -2, -3, etc. appended to the filename. After -n is used, in the IGC format the IGC suffix must be retained so that it will be recognised by analysis programs designed for this format, and in any binary format the file name should be converted to the new one but the manufacturer's binary suffix retained (AL2)

Exit code = 00 means transfer program is satisfactory.
Exit code = 04 means transfer program found minor errors.
Exit code = 16 means transfer program found fatal errors.

An example, for instance for use in a competition: DATA-XXX -q -nEE25JUL

In this case, the transfer program of the manufacturer XXX will transfer the last flights, without questioning to the user (quiet), and it will create the file EE25JUL.IGC in the current directory for the glider Echo Echo in a competition on 25 July. This format will be more useful to the competition organisers than the conventional IGC filename that is designed for records and badge flights under OO supervision. (AL2)

2.9.3.1 Data transfer from FR to PC - the DATA file. The program file DATA-XXX.EXE shall transfer the flight data from the FR memory to a PC and shall also convert transferred data to the *.IGC file format at the same time. This file should be as small as possible, must work alone (not depending on any other files or programs), and is not expected to exceed 200 kb. Similar programs which will work on Mac computers may also be produced, but evidence submitted to NACs and FAI must be in PC format. On executing the DATA-XXX program file, the data from the last flight must automatically be transferred to the PC to the same directory as the DATA file, without needing special switching or keyboard actions, Afterwards, options must be offered through a simple menu for transferring data from other flights in the FR memory, and the system should recognise and indicate if these other flights are already in the selected directory of the PC concerned. Transfer of the data on the last flight should be as quick as possible (at competitions up to 100 FRs may be involved). Appendix 1 para 1.1.1 gives the conditions for which this program must produce a separate IGC flight data file. Menus should be as simple as possible and designed so that they can be used by people who are not computer experts. The DATA-XXX program file must transfer data when executed and connected to an FR which is switched on. No special setting up of the FR itself should be required before data transfers, although a timeout function of at least 30 seconds is acceptable after the FR is switched on during which contact from a PC may be made. The DATA-XXX program must be capable of downloading via serial COM ports 1 and 2, and manufacturers should include compatibility with other COM ports, LTP ports, USB ports, and any future commonly-available ports. For COM ports, only the port number is required; for other ports the three-letter designation of the port type plus the port number is required. For Example: DATA-XXX -pLPT1, or /pUSB2. (note the space between the file name and the switch). The DATA, COM and VALI files will be made available as freeware on FAI internet reference: ftp://www.fai.org/gliding/software/gps/pc/ (also through a link from http://www.fai.org/gliding/gnss/), and manufacturers should check from time to time that their program files are up to date. FR manufacturers must also distribute them as part of their normal software package to customers. The DATA program file is the shortest software program which can transfer data for the FR to a PC and can help to ensure that data is in the hands of an OO at the earliest possible time after flight. Many DATA programs for different FRs can be held on a PC (or on a floppy diskette) at the gliding club or other organisation at the airfield. For those FRs which have a more comprehensive manufacturer's software program in addition to the three short program files, the DATA file provides a free and rapid option for data transfer on the field in the absence of the other program. (AL4)

2.9.3.2 Conversion to .IGC Format - the CONV file. Unless data is always produced from the FR in the IGC file format, a separate program file CONV-XXX.EXE shall be provided for use on the same diskette as the DATA-XXX program. This shall produce an individual IGC file either for each time that the FR was switched off for more than 5 minutes, or for each flight recorded (detail, Appendix 1 para 1.1.1). For conversion of a flight data file, a short menu may be provided, otherwise type "CONV-XXX" followed by a space and the name of the file to be converted, then "enter". The file is not expected to exceed 100kb in size.

2.9.3.3. Programs. The DATA and CONV programs should not need high PC speeds and large amounts of RAM to work, and must, when used for data transfer after flight, be capable of being used on a 1.4 Mb diskette (including a self-booting diskette) without any interaction with the PC Hard Disk or any other files. The DATA and CONV programs may be copyright but must be freeware and will be placed on the IGC GNSS web page for general access. FR manufacturers' programs which insert extra data into the FR (such as pilot and glider data, and lists of turn points), and/or conduct flight analysis, are not affected and are a matter between customers and the FR manufacturer. It must be possible to transfer data from the secure storage medium of the FR directly to the serial port of a low-specification PC (such as at the glider on the field, using a 486/33 laptop PC) and to create the IGC file for the flight on the PC hard disk or a standard 1.4MB floppy disk (which may be self-booting), by use of the DATA-XXX.EXE program. For this data transfer, the connector fitted to the body of the FR storage device must be one of the options specified in para 2.7.2.2.7, or, for FRs that are permanently mounted in an instrument panel, through a short interface cable ending in one of the IGC-approved connector options. This is so that pilots, OOs and competition organisers only have to provide facilities for the connectors specified rather than a larger number of other types. In addition to this basic method of transferring flight data from the FR storage to a PC, other methods of creating and storing the IGC file are permissible as long as the resulting IGC file is identical to that produced by the basic method, and satisfies any later checks made against the VALI-XXX.EXE program. Other methods include the use of separate software programs which include data transfer (such as part of a manufacturer's integrated program for setup, transfer and analysis), also the use of PalmPCs and

PC cards for data transfer from the FR storage so that storage of secure IGC files is ensured before the analysis and validation process. If in doubt about a particular type of device, consult GFAC beforehand. Such methods and devices will be tested by GFAC during the evaluation of the FR and any storage devices, to ensure that the IGC data file produced is identical to that produced after the basic process using the DATA-XXX program file on a low-range PC. (AL4)

2.9.3.4 Digital Signature (DS) Check Program - the VALI file. The program file VALI-XXX.EXE shall be produced by an FR manufacturer for authenticating (validating) the DS of the IGC-format file. There may be more than one type of program for different types of FR from a particular manufacturer, see the next sub-para. If there is an intermediate format (such as binary) which is transferred from the FR before conversion to the IGC format, it must be ensured that DS data is transferred to the IGC file during conversion, so that when using the VALI program with the IGC file, the check is a genuine one based on the data transferred from the FR. The VALI program may be copyright but must be freeware and will be placed on the IGC GNSS web page for general access. It is not expected to exceed 100kb in size, but this is not critical, a high level security check is the primary aim. It must work without requiring other files or programs other than the flight data file it is checking and the PC operating system. For authentication of a flight data file, a short menu may be provided, otherwise type "VALI-XXX" followed by a space and the name of the file to be authenticated, then "enter". It should be assumed that anyone attempting to produce false flight data has access to the VALI file, and the complexity of the Digital Signature adjusted appropriately.

2.9.3.5 Multiple Programs - File Names. If a manufacturer needs more than one *.EXE program for different types of FRs, first the hyphen shall be deleted and a number added (DATA-XXX becomes DATAXXX2). After XXX9, the alphabetical code shall be used, that is, A=10, B=11, etc.

2.9.3.6. Other ways of producing the short program file functions. It is a requirement that the three short self-executing program files DATA, CONV and VALI are produced, for placing on the IGC GNSS web pages for general use. In addition, other versions may be produced which fulfil the same functions, for instance as part of a manufacturer's more comprehensive program for the FR, as long as the resulting IGC flight data file continues to pass the VALI check for electronic security when this is carried out later at the NAC or FAI using the latest version of the VALI-XXX.EXE program file. (AL3)

2.9.3.6.1. Windows equivalents of the DATA, CONV and VALI program files. FR Manufacturers may also provide direct Windows equivalents to the DATA, CONV and VALI DOS program files, following the protocols given in Appendix 3. These will be placed on the IGC GNSS web pages for general use, together with the required DOS program files. This is likely to become a mandatory requirement if the DOS requirement is ever dropped or operation under DOS becomes impractical. Windows versions of the DATA, CONV and VALI short programs conforming to the above will be added to those available for general use through the IGC GNSS web pages. Any manufacturer intending to provide these should first contact GFAC. Also see below on long file names. (AL4)

2.10 **Calibration accuracy of Pressure Altitude Sensor**. An IGC-approved FR must have a pressure-altitude sensor and is an electronic barograph in its own right. Electronic sensors used inside electronic barographs and FRs have settings which can be adjusted by the manufacturer for sea level pressure and also a gain setting for the rest of the altitude range. These must be set by the manufacturer so that the output corresponds closely to the FAI pressure altitude criteria (the ICAO International Standard Atmosphere, Document 7488 tables 3 and 4). Large corrections must be reduced by adjustment. On set-up and calibration before or immediately after initial sale, it is expected that the sea level setting will correspond to the required ISA (1013.25 mb) within 1 millibar; up to an altitude of 2000 metres within 3 millibars; and above this, within one percent of altitude (Source: Annex B to Sporting Code, Chapter 2).

2.11 **Means of Propulsion (MoP) detection systems.** Although the ENL system is preferred, a number of types of MoP detection and recording systems have been IGC-approved for GNSS FRs. Tests will be carried out by GFAC and requirements for individual types of FRs will be given in the IGC-approval documents. Manufacturers must ensure that production standards and settings are the same as those in the FR which was tested and approved by GFAC, or the guidance which is published in the IGC-approval and other documents will not be valid. (AL2)

2.11.1 Engine Noise Level (ENL) systems. These record a three-number ENL value with each fix, between 000 and 999. ENL is the preferred method for recording MoP operation, because no wiring external to the FR is needed, nor any special mounting of the FR in the cockpit, nor, for IGC-approved ENL systems, is a specific engine-run needed on each flight to "prove" the system. However, in design, careful processing (filtering and weighting) of the raw noise signal is required so that a MoP developing forward thrust always gives a characteristically high ENL value, whereas ENL values associated with normal gliding flight, are significantly lower, including aerodynamically noisy flight regimes such as high speed and flight with canopy panels open under sideslip conditions. (AL3)

2.11.1.1 Default settings. Where a motor glider Engine Noise (ENL) function is incorporated, the default setting of the FR should ensure that the ENL function is enabled. For FRs where it is possible to disable the ENL function, this should require a positive action to do so, because in gliders without a motor an ENL record has still been found useful as additional evidence during post-flight analysis. (AL3)

2.11.1.2 Recorded ENL values. Figures at or close to the maximum ENL value of 999 should be recorded in the IGC file as a result of loud noises such as the running of 2-stroke engines under high power and with the GNSS FR placed in a typical position in a glider cockpit. It is accepted that less noisy engines (4-stroke and Wankel (rotary) engines) may not produce ENLs close to 999 even when at high power, but must still result in ENL values over 750 (and preferably 800) so that engine- or propeller-running can be clearly identified. At the other end of the scale, quiet gliding flight should result in low but positive ENL readings so that the system is seen to be self-checking with each fix. Periods showing 000 are not acceptable and figures varying around 020 should be achieved in quiet flight in a well-sealed sailplane.

2.11.1.3 Covering the FR. In the event of the FR being covered either inadvertently or deliberately with noise-insulating material, the design must ensure that ENL levels are maintained as far as possible; this is also intended to cover the case of quieter engines such as those which are electrically-powered. (AL3)

2.11.2 Vibration sensors. This is where vibration is recorded instead of noise levels, the results being shown as a three digit number in the IGC file in the same way as ENL values. Similar tests will be carried out to those for ENL systems, and similar readings are expected which must distinguish clearly between MoP generation of thrust, and gliding flight. However, correct vibration levels recorded will depend on firm mounting of the FR to the airframe, and soft mounting has been shown to result in no reading at all even when a powerful engine was in operation. To ensure that the FR mounting is transmitting the required vibration, the IGC-approval will normally require that an engine-run is carried out on each flight before the soaring performance, and that the FR cannot be moved during flight to a less-sensitive position. The FR unit must be firmly attached to a part of the glider structure which is capable of transmitting the vibration caused by the MoP to the case of the FR. The FR must be sealed to the glider unless the FR is out of reach of the flight crew and an engine run is carried out during the flight to prove the recording system. Where the FR is sealed by an OO to the glider structure, the engine-run which proves the system may be carried out at any time between sealing and unsealing the FR. (AL2)

2.11.3 Microswitch-based systems. These involve cabling external to the FR which runs to a microswitch which is permanently attached to a MoP function such as engine-bay doors, pylon erect or retract, etc. Operation of the microswitch causes a three-letter code to be generated and added to the IGC file for the appropriate time, signifying that the appropriate engine function has operated (for instance, EOF, EON, EUP, see para 7 of Appendix 1). The system must be fail-safe in the sense that failure gives indication as if the MoP had operated. To ensure that the FR and cable are correctly connected and have remained connected during flight, the IGC-approval will normally require that the cable to the microswitch must be easy for an OO to inspect along its complete length to ensure that there are no breaks in it (unless they are sealed by an OO) and that other functions such as unauthorised switches are not attached to it. The motor sensor must be operated both before and after the flight performance with continuous operation of the FR in between, so as to mark the flight data file with the appropriate codes. (AL2)

APPENDIX 1
TO IGC SPECIFICATION FOR GNSS FRs

DATA FILE STANDARD FOR GNSS FLIGHT RECORDERS - - THE IGC DATA FILE FORMAT

1. INTRODUCTION

1.1 Background, and IGC file production. The IGC Data File Standard was initially developed by a group consisting of representatives of IGC, glider FR manufacturers and a number of independent software developers mainly concerned with flight data analysis programs. After discussion and development during 1993 and 1994 it was initially defined in December 1994 and became part of official IGC/FAI documents after approval by IGC in March 1995. It has been refined and developed since through regular amendments. It provides a common world standard data format for the verification of badge, record, and competition flights to FAI/IGC criteria. The Standard may also be used by other FAI sports and activities.

1.1.1 Production of Flight Data File. It must be possible to produce a separate and complete IGC flight data file for each flight including all record types (para 2.2 following) relevant to the flight such as header records, flight declaration, etc. Two ways of achieving this are by continuous recording of fixes between the times that the FR was switched on and off, or, for FRs that have a "standby" state on switch-on, only recording fixes after preset movement and pressure thresholds are exceeded and ceasing recording when changes are below the thresholds (but see 1.1.1.2 on short periods without external power). (AL3)

1.1.1.1 FRs that do not start recording fixes immediately after switch-on. The following thresholds before fixes are recorded have been found suitable in the past: lat/long change, 10-15 km/hr; pressure altitude change, 1 metre per second for 5 seconds. Pre-takeoff and after-landing baselines of at least 20 fixes must be provided. After landing, this can be achieved by a time delay before stopping fix recording. For the pre-takeoff baseline, a small memory circuit can be used that continuously stores the appropriate number of previous fixes and, when movement is detected, puts them into the flight data record. (AL3)

1.1.1.2 Loss of external power for short periods. To allow for events such as changing or switching batteries in flight, a period of 5 minutes with no external power should be allowed to elapse before a new Flight Data File is created on powering up again. After this period has elapsed a new IGC file must be produced, so that if several flights are made on one day, each has a complete IGC data file of its own. (AL3)

1.1.1.3 Data transfer to a PC. If the data for several flights is held in the FR memory, it must be ensured that when the data is transferred, all record types in IGC files that are subsequent to the first file are those relevant to each subsequent individual flight. If any record types are changed between flights (such as declaration, pilot name, etc.) the changes must be included in the subsequent (but not previous) flight data files. (AL3)

1.2 **REVISION CONTROL**. The IGC flight data file format is revised through the normal amendment process for this document. See amendment procedures and list of amendment on page (i).

2. GENERAL

2.1 **FILE STRUCTURE**. An IGC-format file consists of lines of characters, each line giving a set of data such as for a GNSS fix. Each line starts with an upper-case letter denoting one of the Record types listed in para 2.2., and ends with CRLF (Carriage Return Line Feed). Each line is limited to 76 characters in length, excluding the CRLF which is hidden and does not appear in text form. Some Record types take up only one line, some such as task and header take up several lines. For instance, the task/declaration (C) Record includes a line for each Waypoint, and the Header (H) Record includes separate lines for GNSS FR type, pilot's name, glider identification, etc. The order of Record types within an IGC file is given in para 2.3. Some Record types occur only in only one place in the file (single instance Records), others such as fixes re-occur as time progresses (multiple instance Records). Only characters listed as valid in para 6 shall be used in the file. If others such as accented characters (acutes, hatcheks, umlauts, etc) in names of airfields and turn points, are used in a manufacturer's proprietary (original) file format, such characters shall be converted to a valid character as part of the conversion to the IGC format. This is so that analysis programs designed for the IGC format do not have to recognise non-standard characters.

2.2 **RECORD TYPES**. The Record types are prefixed by upper case letters as follows:

IGC DATA FILE FORMAT - RECORD TYPE IDENTIFICATION LETTERS	
A - FR manufacturer and identification B - Fix C - Task/declaration D - Differential GPS E - Event F - Constellation G - Security	H - File header I - List of extension data included at end of each fix (B) Record J - List of data included in each extension (K) Record K - Extension data L - Logbook/comments M, N, etc. - Spare

2.3 **RECORD ORDER**. The FR I/D (A) Record is always the first in the file and the last is the Security (G) Record. After the single-line A record is the multi-line Header (H) Record, followed by the I and J Records that list extension data which applies to later Record types in the file. These are followed by other Record types indicating that certain data is recorded in the file, including the task/declaration (C) Record, and the initial Satellite Constellation (F). Time-specific Records follow, placed in the file in time order using either GNSS fix-time (if the GNSS is locked on) or the FR's Real Time Clock (RTC); these are B (fix), E (event), F (constellation change) & K (extension data). The logbook/comments (L) Record data may be placed anywhere after the H, I and J Records and can have several lines throughout the file depending on the nature of the comments included.

The following sequence of Record types is typical, although in a real flight data file there will be many more fix (B) record lines than shown here:

IGC DATA FILE FORMAT - ORDER OF RECORD TYPES IN AN IGC FILE	
A - FR manufacturer and identification (always first) H - File header I - Fix extension list, of data added at end of each B record J - Extension list of data in each K record line C - Task/declaration (if used) L - Logbook/comments (if used) D - Differential GPS (if used) F - Initial Satellite Constellation B - Fix plus any extension data listed in I Record B - Fix plus any extension data listed in I Record E - Pilot Event (PEV) B - Fix plus any extension data listed in I Record K - Extension data as defined in J Record	B - Fix plus any extension data listed in I Record B - Fix plus any extension data listed in I Record F - Constellation change B - Fix plus any extension data listed in I Record K - Extension data as defined in J Record B - Fix plus any extension data listed in I Record E - Pilot Event (PEV) B - Fix plus any extension data listed in I Record B - Fix plus any extension data listed in I Record B - Fix plus any extension data listed in I Record K - Extension data as defined in J Record L - Logbook/comments (if used) G - Security record (always last)

2.4 **UNITS**. Data in the flight log shall use the following unit system:

Time - UTC (ie <u>not</u> GPS internal system time which is different by 13 `leap seconds' in 2000 (AL3))
Distance - Kilometres and decimal kilometres
Speed - Kilometres per hour
Date - UTC DDMMYY (day, month, year)
Direction - True
Lat/Long - Degrees, minutes and decimal minutes with N,S,E,W designators
Altitude - Metres, separate GNSS and pressure values.
Pressure - Hectopascals (the same as millibars) to two decimal places, for instance altimeter subscale setting, but see * below under PPPPpp

The above items shall be recorded in the flight log as follows:

Time - HHMMSSsss (UTC)
HH - Hours fixed to 2 digits with leading 0 where necessary
MM - Minutes fixed to 2 digits with leading 0 where necessary
SS - Seconds fixed to 2 digits with leading 0 whre necessary
sss - number of direction decimals (the number of fields recorded are those available for direction in the Record concerned, less fields already used for HHNNSS)

Distance - DDDDddd, kilometres up to 9999 with leading zeros as required and then three decimal places (that is, the last figure is metres)

Speed - SSSsss
SSS - fixed to 3 digits with leading 0
sss - number of speed decimals (the number of fields recorded are those available for speed in the Record concerned, less fields already used for SSS)

Date - DDMMYY
DD - number of the day in the month, fixed to 2 digits with leading 0 where necessary
MM - number of the month in year, fixed to 2 digits with leading 0 where necessary
YY - number of the year modulo 100, fixed to 2 digits with leading 0 where necessary

Direction DDDddd
DDD - fixed to 3 digits with leading 0 where necessary
ddd - number of direction decimals (the number of fields recorded are those available for direction in the Record concerned, less fields already used for DDD)

Lat/Long - D D M M m m m N D D D M M m m m E
DD - Latitude degrees with leading 0 where necessary
DDD - Longitude degrees with leading 0 or 00 where necessary
MMmmmNSEW - Lat/Long minutes with leading 0 where necessary, 3 decimal places of minutes (mandatory, not optional), followed by North, South, East or West letter as appropriate

Altitude - AAAAAaaa
AAAAA - fixed to 5 digits with leading 0
aaa - number of altitude decimals (the number of fields recorded are those available for altitude in the Record concerned, less fields already used for AAAAA)

PPPPpp - Pressure in hPa (mb) with two decimal places, PPPPpp fixed to 6 digits with leading zero for settings in the 900 range). For altimeter subscale settings, 1013.25 mb (ISA Sea Level) has an PPPPpp code of 101325, and 980 mb has a code of 098000.
* An altimeter setting (and any change to it) may be recorded, for instance where the FR feeds a cockpit display (three-letter code ATS, see para 7). However, it must not be used to change the pressure altitude recorded with each fix in the IGC file, which must remain with respect to the ISA sea level datum (1013.25 mb) at all times.

GNSS Altitude. Where GNSS altitude is not available from GNSS position-lines such as in the case of a 2D fix (altitude drop-out), it shall be recorded in the IGC format file as zero so that the lack of valid GNSS altitude can be clearly seen during post-flight analysis. (AL3)

2.5 FILE NAMING

2.5.1 Short file name style: YMDCXXXF.IGC
Y = Year; value 0 to 9, cycling every 10 years
M = Month; value 1 to 9 then A for 10, B=11, C=12.
D = Day; value 1 to 9 then A=10, B=11, C=12, D=13, E=14, F=15, G=16, H=17, I=18, J=19, K=20, L=21, M=22, N=23, O=24, P=25, Q=26, R=27, S=28, T=29, U=30, V=31.
C = manufacturer's IGC code letter (see table below)
XXX = unique FR Serial Number (S/N); 3 alphanumeric characters
F = Flight number of the day; 1 to 9 then, if needed, A=10 through to Z=35

2.5.2 Long file name style. This uses a full set of characters in each field, a hyphen separating each field. For instance, if the short name for a file from manufacturer X is 36HXABC2.IGC, the equivalent long file name is 2003-06-17-XXX-ABC-02.IGC. Long file names may be generated by software that is compatible with long file names, although the DOS versions of the DATA, CONV and VALI programs must continue to generate and use short file names. (AL3)

2.5.3 FR Serial Number (S/N). The three-character FR S/N must be used in the A-record and be imprinted on the case of the recorder unless there is an easily-accessible electronic display which includes the S/N.

2.5.3.1 Existing FRs using serial numbers with coded systems where the XXX translates to a different five-number numerical code which is used in the A-record, have "Grandfather Rights" and do not need to be changed. New FRs must use the three-alphanumeric system described above.

2.5.4. Date of flight - the date used in the file name and in the H-record (DTE code) is the UTC date of the first valid fix in the flight log transferred after flight.

2.5.5. Security of file name. The file name is not protected by the electronic security system, which only applies to data within the file itself (see chapter 2, para 2.8). File names may be changed for specific purposes such as competitions, where it may be found more convenient to change from the IGC name system in which the file is originally transferred from the FR (para 2.5), to a system using glider competition number or pilot name. No loss of data or security occurs, since all of the data in the IGC file name is repeated in the file itself in the A and H records. (AL2) Example:
16AFXYZ2.IGC = 10 June 2001, Filser FR number XYZ, Flight 2 of the day.

2.5.6 Manufacturer codes. Single-letter and three-letter codes are tabulated below. Potential manufacturers not listed should apply to the Chairman of GFAC for allocation of codes:

IGC DATA FILE FORMAT - CODES FOR FLIGHT RECORDER MANUFACTURERS		
A - Garrecht - GCS (AL1) B - Borgelt - BOR C - Cambridge - CAM D - Delver - DEL E - EW - EWA F - Filser - FIL G - Griffin - GRI H - Scheffel - SCH (AL3) I - Ilec - IEC J - K - L - LX Navigation - LXN (AL1) M -	N - O - P - Peschges - PES Q - R - Print Technik - PRT S - Streamline Digital Instruments - SDI (AL1) T - U - V - Ball Variometer Inc - BVI (AL2) W - Westerboer - WES (AL4) X - Manufacturers not yet allocated - XXX - see note below Y - Z - Zander - ZAN	0 - 1 - 2 - 3 - 4 - Garmin - GAR 5 - 6 - 7 - 8 - 9 -
Note: X - XXX is a "wild card" designation for IGC format files but from sources which are not yet IGC-approved. These FRs will not have been evaluated by GFAC or be IGC-approved, and there is no guarantee that the file will be of orthodox IGC format. However, the details of the manufacturer and FR model concerned should be identifiable because (if the file conforms to the IGC standard) they will be in the H (Header) record, see below. (AL1)		

3 **SINGLE INSTANCE DATA RECORDS**. These records only occur once in each IGC-format data file, but each record type may contain several lines prefixed with its type letter.

3.1 **A RECORD - FR ID NUMBER**. The A Record must be the first record in an FR Data File, and includes the three-character GNSS FR Serial Number (S/N) unique to the manufacturer of the FR that recorded the flight (AL3). Format of the A Record:

A M M M N N N T E X T S T R I N G CR LF

A record - Description	Size	Element	Remarks
Manufacturer	3 bytes	MMM	Alphanumeric, see para 2.5.6
Unique ID	3 bytes	NNN	Valid characters alphanumeric (AL3)
ID extension	Optional	TEXT STRING	Valid characters alphanumeric

3.2 **G RECORD - SECURITY**. The G Record verifies that the data has not been altered during or following the flight. The FR manufacturer must provide a VALI-XXX.EXE program file (see para 2.9.3.4 in the main bidy of this document) to check the integrity of the file with the security code. The security code must be generated by the FR, not by the computer extracting the flight data. Flight analysis software from sources other than the manufacturer should ignore the detailed data in this record, but can use the G record as a marker for the position of other data and records in the IGC file. All records must be included in the security mechanism, except the H records which have the O or P source, and any L records which do not have the Manufacturer ID (because some L records may be put in by the pilot).

Format of G Record:
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR LF
etc

G record - Description	Size	Element	Remarks
Security code	Up to 75 bytes per line	SSSSS	Valid characters alphanumeric, see Chapter 2, para 2.8.3.1 on security key length. (AL3)

The G Record must not use any non-printing character, because whitespace is often removed when ASCII files are transmitted across data communication networks.

3.3 **H RECORD - FILE HEADER** The H-Record is used to store data such as the day of a flight, the name of the pilot, glider, the type of FR used, the type of GNSS receiver and pressure altitude sensor, amongst other things. There are several different subtypes of the H-Record which are recorded on separate lines prefixed H. All Three Letter Codes (CCC) that bear the H flag in section 7 are possible subtypes of the H-Record.

The line entries in the H-record may be created by the FR (source code F), or, for items such as pilot and glider names, by the Pilot or OO (P and O source records) either before or after flight. Only H-Record data with source code F is covered by the security code and VALI check system.

The general format of the H-Record is: record identifier, source of information (S), record subtype identifer (CCC), long name of the record subtype, colon, actual information (TEXTSTRING). The long name is intended as an aid for people reading the file. For official purposes only the source of information, the record subtype (CCC) and the actual information are definitive.

GNSS Geodetic Datum. The long name, a colon and the name of the Geodetic Datum set (WGS84 = IGC number 100, see para 8) come after the IGC-assigned number for the GPS-Datum, which is located directly behind the record subtype identifer DTM.

3.3.1 Required records. The following H records are required, in the order given below:

HFDTEDDMMYY CRLF
HFFXAAAAAA CRLF
HPPLTPILOT:TEXTSTRING CRLF

HPGTYGLIDERTYPE:TEXTSTRING CRLF
HPGIDGLIDERID:TEXTSTRING CRLF
HFDTMNNNGPSDATUM:TEXTSTRING CRLF
HFRFWFIRMWAREVERSION:TEXTSTRING CRLF
HFRHWHARDWAREVERSION:TEXTSTRING CRLF
HFFTYFRTYPE:MANUFACTURERSNAME,FRMODELNUMBER CRLF
HFGPS:MANUFACTURERSNAME,MODEL,CHANNELS,MAXALT CRLF (AL3)
HFPRSPRESSALTSENSOR:MANUFACTURERSNAME,MODEL,MAXALT CR LF (AL3)

H record - Description	**Size**	**Element**	**Remarks**
Data source	1 byte	F, O or P	Placed after leading H: F=FR,O=OO, P=Pilot
Record subtype	3 bytes	CCC	Alphanumeric, placed after data source, see para 7 for TLCs
UTC Date	6 bytes	DDMMYY	Valid characters 0-9
FXA accuracy category, metres	3 bytes	AAA	Valid characters 0-9 (Default 500)
Lines on Glider and Pilot	As required	Text String	After relevant TLC (eg PLT for Pilot name)
GPS Datum	3 bytes	NNN	WGS 84 must be used, 100 =WGS84 (see para 8)
Lines on FR name, firmware, hardware	As required	Text String	After relevant TLC (eg FTY for FR type)
HFGPS line	As required	Text String	Gives the GPS engine manufacturer and type, number of channels, and the maximum GNSS altitude in metres that could be recorded in the IGC file. Use comma separators between each piece of information. For the Russian GLONASS system use the code GLO instead of GPS (listed in para 7). If another GNSS system is used, apply to GFAC for an appropriate three-letter code. (AL3)
HFPRS line	As required	Text String	Gives the pressure altitude sensor (Manufacturer and type) and maximum pressure altitude in metres that could be recorded in the IGC file. Use comma separators between each piece of information. (AL3)

3.3.2 Additional H records. These are optional. Additional data may be appended after the mandatory records. Two additional records (Comp ID and class) are shown below.
H S C I D C O M P E T I T I O N I D : T E X T S T R I N G CR LF
H S C C L C O M P E T I T I O N C L A S S : T E X T S T R I N G CR LF

3.3.3 Names and identifications.

Similar names. Where there may be people with names which are similar or the same (Smith/Schmidt), full initials or other names should be used. In addition, a TLC of DOB for Date-of-Birth is available, and if used, this must be in the line following the pilot's name in the format DDMMYY (the same format as used for date of flight in the H record).

Name of any second crew member (code SCM), family name first then other names or initials without punctuation but separated by spaces (for instance, SMITH B S, or SMITH BERNALD)

Sufficient characters should be made available to allow for long names and identifications. Such as, for glider registration, allow for a registration such as XXXX-AAAA (where XXXX is the designator of the Nation or National Airsport Body), requiring at least 9 characters to be available in this field. Manufacturers should provide for more rather than less characters in these fields so that flight declarations are easily made in full (AL3).

Club or organisation from which flown or operated (code CLB), with nation (for instance LASHAM UK, ELMIRA US). Where there is not space to put the Nation in full, the two-letter codes from the ISO 3166 list of National designators should be used (these are also used for Nations in Internet addresses). Some ISO 3166 two-letter National Codes are as follows (AL3):

ISO 3166 TWO-LETTER NATIONAL CODES		
AR - ARGENTINA	FI - FINLAND	NL - NETHERLANDS
AT - AUSTRIA	FR - FRANCE	NO - NORWAY
AU - AUSTRALIA	GR - GREECE	NZ - NEW ZEALAND
BE - BELGIUM	HR - CROATIA (HRVATSKA)	PL - POLAND
BR - BRAZIL	HU - HUNGARY	PT - PORTUGAL
CA - CANADA	ID - INDONESIA	RU - RUSSIA
CH - SWITZERLAND	IE - IRELAND	SE - SWEDEN
CL - CHILE	IL - ISRAEL	SI - SLOVENIA
CN - CHINA	IN - INDIA	SK - SLOVAKIA
CO - COLOMBIA	IS - ICELAND	TR - TURKEY
CZ - CZECH REPUBLIC	IT - ITALY	TW - TAIWAN
DE - GERMANY	JP - JAPAN	UK - UNITED KINGDOM
DK - DENMARK	KR - KOREA (S)	US - UNITED STATES
EC - ECUADOR	LT - LITHUANIA	UY - URUGUAY
EE - ESTONIA	LV - LATVIA	VE - VENEZUELA
EG - EGYPT	MX - MEXICO	ZA - SOUTH AFRICA
ES - SPAIN	MY - MALAYSIA	

3.4 **I RECORD - EXTENSIONS TO THE FIX (B) RECORD**. The I record defines any extensions to the fix (B) Record in the form of a list of the appropriate Three-Letter Codes (CCC), data for which will appear at the end of subsequent B Records. Only one I-Record line is included in each file, located after the H record and before the first B Record. Fix Accuracy (FXA) must be included, followed by SIU and ENL if these are recorded in the FR concerned. The format of the I Record is as follows: I N N S S F F C C C S S F F C C C CR LF

I Record - Description	Size	Element	Remarks
Number of extensions	2 bytes	NN	Valid characters 0-9
Start byte number	2 bytes	SS	Valid characters 0-9
Finish byte number	2 bytes	FF	Valid characters 0-9
3-letter Code	3 bytes	CCC	Alphanumeric, see para 7 for list of codes

The byte count starts from the beginning of the B Record, taking the first B in the line as byte one. Example:
I 01 36 40 FXA CR LF
This shows that Fix Accuracy (FXA) is recorded between bytes 36 and 40 on each B-record line. And, for a device that also records Satellites In Use (SIU) and Engine Noise Level (ENL):
I 03 36 38 FXA 39 40 SIU 41 43 ENL CR LF
This shows that on each B-record line, Fix Accuracy (FXA) is recorded between bytes 36 and 38, Satellites In Use (SIU) between bytes 39 and 40, and Engine Noise Level (ENL) between bytes 41 and 43. To aid clarity, some spaces have been inserted in the example line above, these should not be used in the actual B record in the IGC file.

3.5 **J RECORD - EXTENSIONS TO THE K RECORD**. The K record is used for data that needs to be updated as a flight progresses but is not required as often as fix (B) Records. The J record is a single line that defines what data will be in subsequent K-record lines. It fulfils the same function for the K Record as the I Record (3.4 above) does for the fix (B) record, and operates in the same way. It is placed in the file immediately after the I record line, before the first B Record. The format of the J Record is as follows: J N N S S F F C C C S S F F C C C CR LF

Description	Size	Element	Remarks
Number of extensions	2 bytes	NN	Valid characters 0-9
Start byte number	2 bytes	SS	Valid characters 0-9 (from start of K Record)
Finish byte number	2 bytes	FF	Valid characters 0-9
3-letter Code	3 bytes	CCC	Alphanumeric, see para 7

Example: J 0 1 0 8 1 2 H D T CR LF
This shows that True Heading (HDT) is recorded between bytes 8 and 12 on each K-record line.

3.6 **C RECORD - TASK**. The C Record is used to specify tasks and to make flight declarations. It is placed in the IGC file before the first fix (B) record and after the H, I and J records. The first line contains the UTC-date and UTC-time of the declaration, the local date of the intended day of flight, the task ID, the number of turn points of the task and a textstring which can be used to describe the task (500k triangle, etc). Pilot input of intended flight date must be the flight date in local time, not the UTC date which will be different in countries with large time offsets from UTC (The Three-Letter Code for Time Zone Offset is TZN, see the list in para 7).

The other lines contain the WGS84 lat/long coordinates and a textstring for the place or point concerned. These include the take-off field, start point, turn points, finish point and landing field. The format of C Record is as follows, using N latitude and E longitude:

C D D M M Y Y H H M M S S F D F M F Y I I I I T T T E X T S T R I N G CR LF
C D D M M M M M N D D D M M M M M E TAKEOFF FIELD CR LF
C D D M M M M M N D D D M M M M M E START POINT CR LF
C D D M M M M M N D D D M M M M M E TURN POINT CR LF
C D D M M M M M N D D D M M M M M E TURN POINT CR LF
C D D M M M M M N D D D M M M M M E FINISH POINT CR LF
C D D M M M M M N D D D M M M M M E LANDING FIELD CR LF

<table>
<tr><th>C record - Description</th><th>Size</th><th>Element</th><th>Remarks</th></tr>
<tr><td>Date UTC</td><td>6 bytes</td><td>DDMMYY</td><td>Valid characters 0-9</td></tr>
<tr><td>Time UTC</td><td>6 bytes</td><td>HHMMSS</td><td>Valid characters 0-9</td></tr>
<tr><td>Flight date</td><td>6 bytes</td><td>FDFMFY</td><td>Valid characters 0-9, taken from the FR, if not used, fill with zeros (AL2)</td></tr>
<tr><td>Task number on the day</td><td>4 bytes</td><td>IIII</td><td>Valid characters alphanumeric, may be an ID reference or a 1-2-3 sequence. The last declaration before takeoff is the definitive declaration (a task need not be declared on the day of the flight, an electronic declaration is valid until superseded by another valid declaration).</td></tr>
<tr><td>Number of Task TPs</td><td>2 bytes</td><td>TT</td><td>Valid characters 0-9. 1 for an out-and-return, two for a triangle, etc.</td></tr>
<tr><td>TO or A/F LatLon</td><td rowspan="6">17 bytes</td><td rowspan="6">DDMMmmmN
DDDMMmmmE
to the WGS84 Geodetic Datum</td><td rowspan="6">Plus textstring for any local turn point code numbers, letters, name or brief description, but the latitude and longitude is definitive. The declared start point, turn points, and the finish point with their Latitude and Longitude are mandatory; the takeoff/landing or airfield data are not part of the IGC declaration requirement given in the Sporting Code for Gliding (SC3) but are useful extra data particularly where remote starts or finishes are used. If the coordinates of a point which is not part of the official task are difficult to include beforehand (such as takeoff, landing, or the fields for takeoff and landing), they should be set to 00000000N000000000E.</td></tr>
<tr><td>Start LatLon</td></tr>
<tr><td>T/P LatLon</td></tr>
<tr><td>T/P LatLon</td></tr>
<tr><td>Finish LatLon</td></tr>
<tr><td>Land or A/F LatLon</td></tr>
</table>

3.7 **D RECORD - DIFFERENTIAL GPS**. This indicates that differential GPS is being used. It is placed in the IGC file before the first fix (B) record after the H, I, J and C records. The format of the D Record is as follows:

D Q S S S S CR LF

Description	Size	Element	Remarks
GPS Qualifier	1 byte	Q	Use 1=GPS, 2=DGPS
DGPS Station ID	4 bytes	SSSS	

These parameters correspond to the NMEA GGA GPS quality indication. The absence of a D Record indicates that differential GPS was not used. Any use of DGPS is subject to GFAC approval, and it must be shown that the use of GPS preserves the integrity of basic lat/long and other flight data.

4. **MULTIPLE INSTANCE DATA RECORDS.** These are Record types that can re-occur at different times in the course of the IGC file, unlike single instance Records which occur in each file only in one place.

4.1 **B RECORD - FIX**. Not counting the last CRLF, this includes 35 bytes for its basic data plus those for extra characters that are defined in the I Record such as Fix Accuracy (FXA, mandatory after AL4), Satellites In Use (SIU, optional) and Engine Noise Level (ENL, optional). The basic data is: UTC, WGS84latitude, WGS84 longitude, fix validity, pressure altitude and GNSS-altitude. All of the information within each B-record must have a data issue

time within 0.1 seconds of the time given in the B-record. Where NMEA data is used within the FR, fix data should be taken either from the GGA or GNS sentences. GGA is specific to the US GPS system. GNS is intended for all GNSS systems (GPS, GLONASS, Galileo and future systems), and should be used if it is available from the GNSS board installed. The three characters for FXA and two for satellites in use (SIU), should be derived from parts of the fix sentence used and are described in both the NMEA GGA and GNS as `Horizontal DOP' and `number of satellites in use'. In the B Record FXA (HDOP) should be recorded as a three-figure group in metres and SIU as a two group number. SIU is an optional record and may be used to back up the more detailed satellite data in the mandatory F-record. Leading zeros should be included as necessary. Because earlier IGC-approved GNSS FRs may not have FXA and SIU in their B-records, the position of this data in each B record line must be indicated (for instance to analysis programs) by including them in the I record which designates the positions of additional fields in the B record. FXA should be placed after the two groups for altitude, followed by optional fields such as SIU and then ENL for Motor Gliders. In each B-record line, FXA would therefore normally occupy bytes 36, 37 and 38, SIU bytes 39 and 40, ENL either 39-41 or 41-43 depending whether SIU is used. The format of the basic data is:
(AL4)

B H H M M S S D D M M M M M N D D D M M M M M E V P P P P P G G G G G CR LF

B record - Description	Size	Element	Remarks
Time UTC	6 bytes	HHMMSS	Valid characters 0-9
Latitude	8 bytes	DDMMmmmN/S	Valid characters N, S, 0-9
Longitude	9 bytes	DDDMMmmmE/W	Valid characters E,W, 0-9
Fix validity	1 byte.	A or V	Use A in the IGC file to denote a 3-D fix and V for a 2-D fix. Where data in NMEA format is used within the FR, in the GSA sentence (DOP and active satellites), put A in the IGC file for GSA mode 3, and V for GSA mode 2. In the future, other characters may be used in this field in the B record to denote other meanings, and will be notified in future amendments. (AL4).
Press Alt.	5 bytes	PPPPP	Altitude to the ICAO ISA above the 1013.25 HPa sea level datum, valid characters 0-9
GNSS Alt.	5 bytes	GGGGG	Altitude above the WGS84 ellipsoid, valid characters 0-9

To append the Fix Accuracy (FXA, mandatory), Satellites in Use (SIU, optional) and Engine Noise Level (ENL, optional) or any other variable to each fix, these have to be defined earlier in the I Record (so that, for instance, they will be recognised by analysis programs). For instance:

I 0 3 3 6 3 8 F X A 3 9 4 0 S I U 4 1 4 3 E N L CR LF

and the resulting B Record becomes:

B H H M M S S D D M M M M M N D D D M M M M M E V P P P P P
G G G G G A A A S S N N N CR LF

B record - Description	Code	Size	Element	Remarks
Fix Accuracy	FXA	3 bytes	AAA	Valid characters 0-9, metres, mandatory parameter after Amendment 4
Satellites in Use	SIU	2 bytes	S S	Valid characters 0-9
Engine noise	ENL	3 bytes	NNN	Valid characters 0-9

4.2 **E RECORD - EVENTS**. The E-record records specific events on the IGC file, typically a pilot-initiated event (PEV code). It is placed before the individual fix (B) Record for the same time that records where and when the event occurred. Events must have a Three Letter Code (TLC) from section 7. More than one event record may be used at the same time, but Events initiated within the FR (as opposed to by the pilot) are only expected to be occasional in the time-history of the flight file and should not be used for making additional records with every fix. This may confuse the analysis programs designed for use with this file format, which often search for and highlight event records. If a FR manufacturer wishes to insert additional information with each fix, this should be through an extension to the B record, first listing the information Code (CCC) in the I-record.

If a manufacturer wants to add a new type of event, a new Three Letter Code (para 7) should be requested from GFAC. The manufacturer must provide an exact definition of the event and a proposed coding. GFAC may decide that the proposal should not be treated as an event but that the information should be incorporated into the B- or K-record in the normal way for these records by listing in the I and J records.

The form of the E-Record is record identifer, time, TLC, textstring. Some examples follow:

E 1 0 4 5 3 3 P E V CR LF
B 1 0 4 5 3 3 4 9 4 5 3 3 3 N 0 1 1 3 2 4 4 4 E A 0 1 3 5 7 0 1 5 0 1 105 CR LF
This indicates a pilot initiated event (PEV) at 10:45:33 UTC, and the associated B record shows the location 49:45.333 N 11:32.444 E, at the pressure altitude 1357 metres, GNSS altitude 1501 metres, and fix accuracy (FXA) 105m.

Some events require more than just the TLC for interpretation:
E 1 0 4 5 4 4 A T S 1 0 2 3 1 2 CR LF
The altimeter setting in a display device connected to the FR was changed to 1023.12 hPa at the time 10:45:44

E 1 0 4 5 5 5 E O N CR LF
B 1 0 4 5 5 5 4 9 4 5 3 3 3 N 0 1 1 3 2 4 4 4 E A 0 1 3 3 7 0 1 5 6 7 095 CR LF
The engine was turned on (EON) at 10:45:55 UTC, and the B record shows the location 49:45.333 N 11:32.444 E, at the pressure altitude 1337 metres, GNSS altitude 1567 metres, and fix accuracy (FXA) 095m

E 1 0 4 7 3 3 C G D 1 0 3 CR LF
The geodetic datum was changed to Bessel (IGC number 103, see para 8) at 10:47:33 UTC.
This would invalidate the recording for IGC purposes, for which WGS84 must be used.

4.3 **F RECORD - SATELLITE CONSTELLATION**.

This is a mandatory record. For the US GPS system, the satellite ID for each satellite is the PRN of the satellite in question, for other satellite systems the ID will be assigned by GFAC as the need arises. Where NMEA data is used within the FR, the ID should be taken from the GSA sentence that lists the IDs of those satellites used in the fixes that are recorded in the B record. The F Record is not recorded continuously but at the start of fixing and then only when a change in satellites used is detected. (AL4)

Format of F Record:
F HH MM SS AA BB CC DD EE FF GG CR LF

Description	**Size**	**Element**	**Remarks**
Time UTC	6 bytes	HHMMSS	Valid characters 0-9
Satellite ID	2 bytes for each satellite used	AABBCC or 01, 02 etc	Valid characters alphanumeric

4.4 **K RECORD - DATA NEEDED LESS FREQUENTLY THAN FIXES**. The K record is for data that may be needed less frequently than fix (B) records. The K record should have a default interval of 20 seconds. As an example, if the B-record records every 5 seconds, the K-record could be set to record every 20 seconds, for instance containing true heading (HDT). The contents of the K record are listed in the J record. The following J Record specifies the information in the K Record in the next line:

J 0 8 1 2 H D T CR LF

K H H M M S S 0 0 0 9 0 CR LF
This K Record states that the true heading (TLC = HDT) is 090 (East).

4.5 **L RECORD - LOG BOOK/COMMENTS**. L-Records can be placed anywhere in the file after H, I and J records but before the G-record. The L-Record allows multiple free format text lines to be added to the flight data records at any time in the time-sequence, although this record is not itself time-stamped. It can be initiated by a program in the FR, by pilots or official observers, and the term "comment record" may be more descriptive rather than "logbook". The FR Manufacturer three-letter ID (para 2.5) should be used in the case of data initiated by the FR, and in this case the manufacturer should state how to interpret this type of L-Record for the benefit of writers of software for the IGC format. In other cases this field (MMM below) will also be three spaces, initiated by the pilot (code PLT) or OO (OOI) as required. The format of the L Record is as follows:

L MMM T E X T S T R I N G CR LF
L PLT T E X T S T R I N G CR LF

Description	Size	Element	Remarks
Manufacturer input	3 bytes	MMM	Manufacturer's code, see para 2.5
Pilot input	3 bytes	PLT	Text string after PLT
OO input	3 bytes	OOI	Text string after OOI

The L records which have the FR Manufacturer's ID MMM must be included in the digital signature (security system) for the file. Other L records (eg those put in by the pilot (PLT) or an OO (OOI)) will not be covered by the digital signature for the file, see para 3.2. Examples of pilot inputs:

LPLT This flight was my second 1000km attempt
LPLT from Eagle Field

5**. DEFINITIONS**

Airspeed - The true airspeed of the aircraft in kph, for systems with air data input.
Alphanumeric - Valid alpha and/or numeric character from the list of valid characters (para 6).
Competition Class - The IGC/FAI competition class of the aircraft.
Constellation - The precise satellites from which data was used to determine the GNSS fix. This may be used to verify the validity of the flight data.
Course - The direction between two points expressed as degrees magnetic or true.
Datum - The GNSS datum (co-ordinate system) in use.
Engine Down - The Means of Propulsion (MoP) (eg engine and propeller) is stowed and not in a position to generate thrust.
Engine Noise Level (ENL) - Ambient noise at the FR expressed as three numbers, maximum 999. This continuously-recorded active parameter registers a positive baseline level (ie not a zero level) even when the MoP is not in operation, and so produces a continuous check of the integrity of the MoP-recording system.
Engine Off - The Means of Propulsion (MoP) is in a condition where thrust cannot be generated.
Engine On - The Means of Propulsion (MoP) is in a condition when thrust could be generated.
Engine RPM - This is a parameter related to engine RPM so that true RPM may be derived if necessary.
Engine Up - The propulsion unit pylon is extended or the engine or propeller doors are open, in a condition in which thrust can be generated on starting the engine.
Equipment Events - These are events generated solely by the FR (such as detecting takeoff), as opposed to events generated after flight by the analysis of the FR flight data (such as establishing presence in a Turn Point Observation Zone or crossing a start or finish line).
Finish - The end of a task, such as crossing a finish line, entering a finish observation zone, or (for some distance flights) landing. Definitions, Sporting Code (SC3) main volume.
Fix Accuracy - The accuracy of the fix concerned expressed as EPE in metres, normally to a 2-sigma probability. See EPE in the Glossary.
FR Serial Number - a three-character alphanumeric which is unique within all FRs of all types from that manufacturer, and is allocated by the manufacturer to identify an individual FR. It is used in the first (A) record (see

this appendix, para 3.1) and in the IGC file name (para 2.5). For complete and unique identification of an FR, the S/N should be preceded by the Manufacturer's name or code. See para 2.5 for one and three-letter versions of manufacturer's codes, the one-letter version being used in the file title and the three-letter version in the A record. (AL2)

Glider ID - The unique registration alphanumeric of the individual aircraft.

Glider Type - The manufacturer and precise model number of the aircraft.

GNSS Altitude - A five numeric character group indicating the GNSS altitude in metres above the ellipsoid.

GNSS Connect - Where a separate GNSS unit is used, indicates GNSS connection to the FR module

GNSS Disconnect - Where a separate GNSS unit is used, indicates GNSS disconnection from the FR module.

Ground Speed - The ground speed in kph.

Heading - The direction in which the aircraft is pointed (the longitudinal axis) in degrees true or magnetic.

Latitude - A seven character alphanumeric group expressed as two figures for the degrees, two figures for the minutes and three figures representing tenths, hundredths and thousandths of minutes followed by the N or S character. Where this is inserted into a FR such as part of a flight declaration, the N/S character must be capable of being entered in either upper or lower case. For IGC purposes lat/long must be referenced to the WGS84 Geodetic Datum.

Longitude - An eight character alphanumeric group expressed as three figures for the degrees, two figures for the minutes and three figures representing tenths, hundredths and thousandths of minutes followed by the E or W character. Where this is inserted into a FR such as part of a flight declaration, the N/S character must be capable of being entered in either upper or lower case. For IGC purposes lat/long must be referenced to the WGS84 Geodetic Datum.

On Task - The pilot is attempting a Task.

OO ID - This is a series of alphanumerics that is entered by an OO into the FR before flight. It consists of a minimum of four characters and is confidential to the OO.

Photo - A photograph has been taken, such as of a turn point.

Pilot Event (PEV code) - The pilot has marked a particular time. This may represent a number of different occurrences or events such as crossing a start line (or marking the intention to cross shortly) or arriving at a point.

Pressure Altitude - This is a five numeric group indicating the pressure altitude in metres above the 1013.25 HPa sea level datum and the ICAO ISA above.

RAIM - Receiver Autonomous Integrity Monitoring (when used) - This is used to indicate the quality of GNSS navigation data, see the Glossary section.

Record Extension - This allows extra information to be added to the fix (B) and extension (K) data records.

Security data (Digital Signature) - This is used to verify that the flight data has not be altered during or since the flight.

Start - The start of an official soaring performance. For definitions, see the Sporting Code (SC3).

Supplemental Data Fix - The use of external non-satellite data to assist the GNSS unit determine the position, such as a ground.-based beacon

Task - The main points of an intended flight. Normally an intended start, turn points and finish.

Total Energy Altitude - The combination of the gliders potential and kinetic energy expressed in metres of effective altitude.

Track - The true track (flight path) over the ground that the aircraft has achieved.

Turn point Validation - Proof of presence in the relevant Observation Zone for the point concerned.

6. **VALID CHARACTERS**. These consist of all printable ASCII characters from Hex 20 to Hex 7E, except those tabulated below as reserved. A text string is a sequence of valid characters. The following table shows the character first and then the hexadecimal code, and the second table presents the same information in hex order:

<table>
<tr><th rowspan="2">NUMBERS</th><th colspan="4">LETTERS</th><th colspan="2" rowspan="2">SYMBOLS
Res = reserved</th><th rowspan="2">RESERVED CHARACTERS</th></tr>
<tr><th colspan="2">Upper Case</th><th colspan="2">Lower Case</th></tr>
<tr>
<td>0 = Hex 30
1 = 31
2 = 32
3 = 33
4 = 34
5 = 35
6 = 36
7 = 37
8 = 38
9 = 39</td>
<td>A = Hex 41
B = 42
C = 43
D = 44
E = 45
F = 46
G = 47
H = 48
I = 49
J = 4A
K = 4B
L = 4C
M = 4D</td>
<td>N = 4E
O = 4F
P = 50
Q = 51
R = 52
S = 53
T = 54
U = 55
V = 56
W = 57
X = 58
Y = 59
Z = 5A</td>
<td>a = Hex 61
b = 62
c = 63
d = 64
e = 65
f = 66
g = 67
h = 68
i = 69
j = 6A
k = 6B
l = 6C
m = 6D</td>
<td>n = 6E
o = 6F
p = 70
q = 71
r = 72
s = 73
t = 74
u = 75
v = 76
w = 77
x = 78
y = 79
z = 7A</td>
<td>space= Hex 20
Res = 21
" = 22
# = 23
Res = 24
% = 25
& = 26
' = 27
(= 28
) = 29
@ = 40
` = 60
Res = 2A
+ = 2B
Res = 2C
- = 2D
. = 2E</td>
<td>/ = 2F
: = 3A
; = 3B
< = 3C
= = 3D
> = 3E
? = 3F
[= 5B
Res = 5C
] = 5D
Res = 5E
_ = 5F
{ = 7B
| = 7C
} = 7D
Res = 7E</td>
<td>CR = 0D
LF = 0A
$ = 24
* = 2A
, = 2C
! = 21
\ = 5C
^ = 5E
~ = 7E</td>
</tr>
</table>

And the same information in hex order:

<table>
<tr><th colspan="4">VALID CHARACTERS IN HEX ORDER

Res = reserved</th><th>RESERVED CHARACTERS</th></tr>
<tr>
<td>20 = space
21 = Res
22 = "
23 = #
24 = Res
25 = %
26 = &
27 = '
28 = (
29 =)
2A = Res
2B = +
2C = Res
2D = -
2E = .
2F = /
30 = 0
31 = 1
32 = 2
33 = 3
34 = 4
35 = 5
36 = 6
37 = 7</td>
<td>38 = 8
39 = 9
3A = :
3B = ;
3C = <
3D = =
3E = >
3F = ?
40 = @
41 = A
42 = B
43 = C
44 = D
45 = E
46 = F
47 = G
48 = H
49 = I
4A = J
4B = K
4C =L
4D = M
4E =N
4F =O</td>
<td>50 = P
51 = Q
52 = R
53 = S
54 = T
55 = U
56 = V
57 = W
58 = X
59 = Y
5A = Z
5B = [
5C = Res
5D =]
5E = Res
5F = _
60 = `
61 = a
62 = b
63 = c
64 = d
65 = e
66 = f
67 = g</td>
<td>68 = h
69 = i
6A = j
6B = k
6C = l
6D = m
6E = n
6F = o
70 = p
71 = q
72 = r
73 = s
74 = t
75 = u
76 = v
77 = w
78 = x
79 = y
7A = z
7B = {
7C = |
7D = }
7E = Res</td>
<td>0D = CR
0A = LF
24 = $
2A = *
2C = ,
21 = !
5C = \
5E = ^
7E = ~

These characters are reserved (not to be used) because they could be confusing if used in a text string, for instance due to other meanings or alternative keystrokes</td>
</tr>
</table>

7. **THREE-LETTER CODES (TLC)** These are shown as CCC in the formats earlier in this appendix. Their meanings are listed below together with the Records in which they can be used. If a manufacturer wants to add a new type of event, a new TLC should be requested from GFAC. The manufacturer should provide an exact definition of the event and a proposed coding. GFAC may decide that the proposal should not be treated as an event but that the information should be incorporated into the B- or K-record.

TLC	Record Type Used with	TLC meaning, and notes on how it is to be used
ATS	H E	Altimeter Pressure Setting. Although an altimeter pressure setting may be recorded (for instance where the FR feeds a cockpit display), it must not be used to change the pressure altitude recorded with each fix, which must remain with respect to the ISA sea level datum of 1013.25 mb at all times
CCL	H	Competition class
CCN	E	Camera Connect
CDC	E	Camera Disconnect
CGD	E	Change of geodetic datum
CID	H	Competition ID
CLB	H	Club or organisation, and country, from which flown or operated (eg Elmira US, Lasham UK). For Nation, use the ISO 3166 two-letter codes, some of which are given in para 3.3.3 of Appendix A
DAE	I, B, J, K	Displacement east, metres
DAN	I, B, J, K	Displacement north, metres
DOB	H	Date of Birth of the pilot in the previous line of the H record (DDMMYY)
DTE	H	Date, expressed as DDMMYY
DTM	H	Geodetic Datum in use for lat/long records (for IGC purposes this must be set to WGS84)
EDN	E	Engine down. See note on line for EON
ENL	I, B	Engine Noise Level, recorded from 000 to 999. This is the preferred MoP recording method because it requires no cables or sensors external to the FR, and is self-validating, recording a positive value with each fix.
EOF	E	Engine off. See note on line for EON
EON	E	Engine on. Note: Where ENL or RPM are not used as the primary indicator of MoP operation, event records and the EON/EOF or EUP/EDN codes shall be used. A combination of the two methods may be used, eg EON/EOF based on a parameter such as ignition ON/OFF, a minimum generator output, EUP/EDN for engine bay doors open/closed or pylon up/down; plus RPM based on prop or engine rpm, or ENL for noise level at the FR.
EUP	E	Engine up. See note on line for EON
FIN	E	Finish
FTY	H	FR Type (Manufacturer's name, FR Model Number)
FXA	B, I, J, K	Fix accuracy. When used in the B (fix) record, this is the EPE (Estimated Position Error) figure in metres (MMMM) for the individual fix concerned, to the 2-Sigma (95.45%) level unless specified differently (AL3)
FXA	H	Fix Data Accuracy Category. When used in the header record, this is a general indication of potential fix accuracy and indicates a category of receiver capability rather than an exact figure such as applies to each recorded fix in the B, I, J or K records, see above. If in doubt, use a three figure group in metres that refers to a typical EPE radius achieved by the receiver in good reception conditions. (AL3)

GCN	E	GNSS (Separate module) Connect
GDC	E	GNSS (Separate module) Disconnect
GID	H	Glider ID
GLO	H	GLONASS, the Russian GNSS system, manufacturer, model, etc. (AL3)
GPS	H	GPS Receiver Type & Version letter/number
GSP	I, B, J, K	Ground speed, give units (kt, kph, etc.)
GTY	H	Glider type, manufacturer, model
HDM	I, B, J, K	Heading Magnetic
HDT	I, B, J, K	Heading True
IAS	I, B, J, K	Airspeed Indicated (IAS), give units (kt, kph, etc.)
LOV	E	Low voltage. Must be set for each FR at the lowest voltage at which the FR will operate without the possibility of recorded data being degraded by the voltage level. Not to be used to invalidate a flight if the flight data appears correct when checked in the normal way, but a warning to check fix data particularly carefully. (AL1)
ONT	E	On Task - attempting task
OOI	H	OO ID - OO equipment observation
PEV	E	Pilot EVent - Pilot initiated action such as pressing a button
PHO	E	Photo taken (shutter-press)
PLT	H	Pilot, name, add DOB if any ambiguity
PRS	H	Pressure Altitude Sensor, manufacturer, model, etc. (AL3)
RAI	I, B, J, K	RAIM - GPS Parameter, see Glossary
REX	I, B, J, K	Record extension - Manufacturer defined data defined in the I or J record as appropriate, normally in the form of a TLC (which, if a new variable is agreed, may be a new TLC allocated by GFAC at the time). Any use must be approved by GFAC, and published so that there will be no doubt on how it is being used. (AL4)
RFW	H	Firmware Revision Version of FR
RHW	H	Hardware Revision Version of FR
RPM	I, B	Engine rpm, or another MoP parameter that varies in a similar way.
SCM	H	Second Crew Member's Name
SEC	G	Security - Log security data
SIT	H	Site, Name, region, nation etc.
SIU	I, B	Satellites in use. A two-character field from the NMEA GGA or GNS sentences, as appropriate, or equivalent data agreed by GFAC. (AL4)
STA	E	Start event
SUP		Supplemental data fix - External data input as required
TAS	I, B, J, K	Airspeed True, give units (kt, kph, etc.)
TEN	I, B, J, K	Total Energy Altitude in metres
TPC	E	Turn point confirmation - Equipment generated event (not valid for flight validation which requires independent checking of fixes and relevant Observation Zones)
TPL		Turn point list as required

TRM	I, B, J, K	Track Magnetic
TRT	I, B, J, K	Track True
TZN	H	Time Zone Offset, hours from UTC to local time.
UNT	H	Units of Measure
VXA	I, B, J, K	Vertical Fix Accuracy, Three characters in metres from the VDOP part of the NMEA GSA sentence, or equivalent data agreed by GFAC. (AL4)
WDI	I, B, J, K	Wind Direction
WVE	I, B, J, K	Wind Velocity

8. **GNSS GEODETIC DATUMS** Geodetic Datums have been numbered by IGC as follows. The Sporting Code for gliding states that the WGS 84 Geodetic Datum (serial 100 below) shall be used for all lat/long co-ordinates that are recorded and transferred from the FR after flight.

Name - Locations in which used	Name - Locations in which used
000 ADINDAN - Ethiopia, Mali, Senegal, Sudan 001 AFGOOYE - Somalia 002 AIN EL ABD 1970 - Bahrain Island, Saudi Arabia 003 ANNA 1 ASTRO 1965 - Cocos Island 004 ARC 1950 - Botswana, Lesotho, Malawi, Zaire, Zambia, Zimbabwe 005 ARC 1960 - Kenya, Tanzania 006 ASCENSION ISLAND 1958 - Ascension Island 007 ASTRO BEACON "E" - Iwo Jima Island 008 AUSTRALIAN GEODETIC 1966 - Australia, Tasmania Island 009 AUSTRALIAN GEODETIC 1984 - Australia, Tasmania Island 010 ASTRO DOS 71/4 - St. Helena Island 011 ASTRONOMIC STATION 1952 - Marcus Island 012 ASTRO B4 SOROL ATOLL - Tern Island 013 BELLEVUE (IGN) - Efate and Erromango Islands 014 BERMUDA 1957 - Bermuda Islands 015 BOGOTA OBSERVATORY - Colombia 016 CAMPO INCHAUSPE - Argentina 017 CANTON ASTRO 1966 - Phoenix Islands 018 CAPE CANAVERAL - Florida, Bahama Islands 019 CAPE - South Africa 020 CARTHAGE - Tunisia 021 CHATHAM 1971 - Chatham Island (New Zealand) 022 CHUA ASTRO - Paraguay 023 CORREGO ALEGRE - Brazil 024 DJAKARTA (BATAVIA) - Sumatra Island (Indonesia) 025 DOS 1968 - Gizo Island (New Georgia Islands) 026 EASTER ISLAND 1967 - Easter Island 027 EUROPEAN 1950 (ED50) - Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland 028 EUROPEAN 1979 (ED79) - Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland 029 FINLAND HAYFORD 1910 - Finland 030 GANDAJIKA BASE - Republic of Maldives 031 GEODETIC DATUM 1949 - New Zealand 032 Ordnance Survey of Great Britain 1936 (OSGB36) - UK 033 GUAM 1963 - Guam Island 034 GUX 1 ASTRO - Guadalcanal Island035 HJOESEY 1955 - Iceland 036 HONG KONG 1963 - Hong Kong 037 INDIAN - Bangladesh, India, Nepal 038 INDIAN - Thailand, Vietnam 039 IRELAND 1965 - Ireland 040 ISTS 073 ASTRO 1969 - Diego Garcia 041 JOHNSTON ISLAND 1961 - Johnston Island 042 KANDAWALA - Sri Lanka 043 KERGUELEN ISLAND - Kerguelen Island 044 KERTAU 1948 - West Malaysia, Singapore 045 L.C. 5 ASTRO - Cayman Brac Island 046 LIBERIA 1964 - Liberia 047 LUZON - Mindanao Island 048 LUZON - Philippines (excluding Mindanao Island) 049 MAHE 1971 - Mahe Island 050 MARCO ASTRO - Salvage Islands 051 MASSAWA - Eritrea(Ethiopia)	052 MERCHICH - Morocco 053 MIDWAY ASTRO 1961 - Midway Island 054 MINNA - Nigeria 055 North American 1927 (NA27) - Alaska 056 NA27 - Bahamas (excluding San Salvador Island) 057 NA27 - Central America 058 NA27 - Canal Zone 059 NA27 - Canada (including Newfoundland Island) 060 NA27 - Caribbean 061 NA27 - Mean Value (CONUS) 062 NA27 - Cuba 063 NA27 - Greenland (Haynes Peninsula) 064 NA27 - Mexico 065 NA27 - San Salvador Island 066 NA83 - Alaska, Canada, Central America, CONUS, Mexico 067 NAPARIMA, BWI -Trinidad and Tobago 068 NAHRWAN - Masirah Island (Oman) 069 NAHRWAN - Saudi Arabia 070 NAHRWAN - United Arab Emirates 071 OBSERVATORIO 1966 - Corvo and Flores Islands (Azores) 072 OLD EGYPTIAN - Egypt 073 OLD HAWAIIAN - Mean Value 074 OMAN - Oman 075 PICO DE LAS NIEVES - Canary Islands 076 PITCAIRN ASTRO 1967 - Pitcairn Island 077 PUERTO RICO - Puerto Rico, Virgin Islands 078 QATAR NATIONAL - Qatar 079 QORNOQ - South Greenland 080 REUNION - Mascarene Island 081 ROME 1940 - Sardinia Island 082 RT 90 - Sweden 083 SOUTH AMERICAN 1956 - Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela 084 SOUTH AMERICAN 1956 - Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad, Tobago 085 SOUTH ASIA - Singapore 086 PROVISIONAL SOUTH CHILEAN 1963 - South Chile 087 SANTO (DOS) - Espirito Santo Island088 SAO BRAZ - Sao Miguel, Santa Maria Islands (Azores) 089 SAPPER HILL 1943 - East Falkland Island 090 SCHWARZECK - Namibia 091 SOUTHEAST BASE - Porto Santo and Madeira Islands 092 SOUTHWEST BASE - Faial, Graciosa, Pico, Sao Jorge, Terceira Islands 093 TIMBALI 1948 - Brunei and East Malaysia (Sarawak and Sabah) 094 TOKYO - Japan, Korea, Okinawa 095 TRISTAN ASTRO 1968 - Tristan da Cunha 096 Reserved For Future Use 097 VITI LEVU 1916 - Viti Levu Island (Fiji Islands) 098 WAKE-ENIWETOK 1960 - Marshall Islands 099 World Geodetic System 1972 (WGS72) 100 World Geodetic System 1984 (WGS84) 101 ZANDERIJ - Surinam 102 CH-1903 - Switzerland 103 Bessel 1847 - Austria

9. **<u>EXAMPLE IGC-FORMAT FILE</u>**

9.1 The IGC file format starts with the A Record and is followed by the H (header) and other records. The record letter is always at the start of the appropriate line in the file when it is viewed in text format. For more details of formats for individual records, see the relevant paragraphs earlier in this Appendix.

9.2 In this example, spaces have been used between subject fields to make the layout and sequence clearer to a reader. In a real IGC-format file there should be no spaces in any record except within a text string as a word separator.

9.3 CRLF = line terminator, not flight data.

9.4 In a real file there would be many more B records at the preset fix intervals for cruise and fast fix rates.

9.5 In the example below, some notes appear in brackets. These are not part of the file format itself. Also, for clarity, some spaces are used in B-record lines between different variables that are recorded, but no spaces should be used in the IGC file itself.

A XXX ABC FLIGHT:1
HFFXA 035
HFDTE 160701
HFPLT PILOT: Bill Bloggs
HFGTY GLIDERTYPE: Schleicher ASH-25
HFGID GLIDERID: ABCD-1234
HFDTM100 GPSDATUM: WGS-1984
HFRFW FIRMWAREVERSION:6.4
HFRHW HARDWAREVERSION:3.0
HFFTY FRTYPE: Manufacturer, Model
HFGPS MarconiCanada: Superstar,12ch, max10000m CR LF
HFPRS PRESSALTSENSOR: Sensyn, XYZ1111, max11000m CR LF
HFCID COMPETITIONID: XYZ-78910
HFCCL COMPETITIONCLASS:15m Motor Glider
HFSCM SECONDCREW: John Smith
I 02 36 38 FXA 39 41 ENL CRLF
J 01 08 12 HDT CRLF
(The following example of a C record is for a 500 km triangle to be flown from Lasham gliding centre in the UK)
C 150701 213841 160701 0001 02 500K Tri
C 5111359N 00101899W Lasham Clubhouse
C 5110179N 00102644W Lasham Start S, Start
C 5209092N 00255227W Sarnesfield, TP1
C 5230147N 00017612W Norman Cross, TP2
C 5110179N 00102644W Lasham Start S, Finish
C 5111359N 00101899W Lasham Clubhouse
(The following example starts with the F record of 9 satellite IDs, then the B (fix) record starts with altitudes of 280m (pressure), 421m (GPS) and FXA (HDOP radius) 95m, SIU 09 and ENL 950:)
F160240 04 06 09 12 36 24 22 18 21 CRLF
B160240 5407121N 00249342W A 00280 00421 095 09 950 CRLF
D 20331 CRLF
E160245 PEV CRLF
B160245 5107126N 00149300W A 00288 00429 095 09 020 CRLF
B160250 5107134N 00149283W A 00290 00432 095 09 015 CRLF
B160255 5107140N 00149221W A 00290 00430 095 09 012 CRLF
F160300 06 09 12 36 24 22 18 21 CRLF
(satellites in use reduce from 9 to 8 as ID 04 is no longer received, FXA increases to 110m)
B160300 5107150N 00149202W A 00291 00432 110 08 009 CRLF
E160305 PEV CRLF
B160305 5107180N 00149185W A 00291 00435 110 08 015 CRLF
B160310 5107212N 00149174W A 00293 00435 110 08 024 CRLF
K160248 090 CRLF
(note that this is specified in the J record as being HDT, true heading in the above K record HDT is 090 (East))
B160248 5107220N 00149150W A 00494 00436 110 08 018 CRLF

B160252 5107330N 00149127W A 00496 00439 110 08 015 CRLF
L XXX RURITANIAN STANDARD NATIONALS DAY 1 CRLF
L XXX FLIGHT TIME: 4:14:25, TASK SPEED:58.48KTS CRLF
G REJNGJERJKNJKRE31895478537H43982FJN9248F942389T433T CRLF
G JNJK2489IERGNV3089IVJE9GO398535J3894N358954983O0934 CRLF
G SKTO5427FGTNUT5621WKTC6714FT8957FGMKJ134527FGTR6751 CRLF
G K2489IERGNV3089IVJE39GO398535J3894N358954983FTGY546 CRLF
G 12560DJUWT28719GTAOL5628FGWNIST78154INWTOLP7815FITN CRLF

-------------- Appendix 1 ends -------------

APPENDIX 2 TO GNSS FR SPECIFICATION

SAMPLE TEST AND EVALUATION SCHEDULE

The following tests may be carried out under the auspices of each member of the GFAC. Members may delegate detailed testing and assessment to other experts who are bound by the same confidentiality as GFAC itself. Results, assessments and opinions will be confidential to GFAC members, their advisors and to IGC or FAI officials who may be involved if IGC or FAI policy may be affected. These tests are not necessarily all and GFAC reserve the right to carry out any other non-destructive testing where it is deemed relevant to assessing the probable validity of flight data.

1 **GENERAL REQUIREMENTS.** The following aspects will be evaluated: ease of operation in an air sport environment from badge and record flights to large competitions, integrity of data, fix accuracy, recording of errors and anomalies, security against unauthorised input and changes to data, failure recovery, and standard IGC file structure.

2 **EVALUATION AND ANALYSIS**. The following aspects will be evaluated through an analysis program independent of the FR manufacturer, using the IGC file format: presenting all and selected segments of the flight path in graphical plan views, also vertical views of GNSS and pressure altitude with time. Including checks on required data such as fix accuracy (FXA) and Pilot Event (PEV), and checks on indications of Means of Propulsion operation, such as ENL recording.

3 **PHYSICAL INSPECTION OF THE EQUIPMENT**

3.1 Quality of construction and components.

3.2 Layout and type of components. Susceptibility to inadvertent or deliberate production of invalid flight data. Sealing, shielding, access, construction of the recorded flight data processor memory and relation to other components, data streams and memories. Crashworthiness aspects including preservation of flight data after impact or damage.

4 **SYSTEM ACCURACY AND RECORDING CAPABILITY**

4.1 Ground Tests. Several ground runs of the equipment will be made. Runs of up to 12 hours may be undertaken in order to check, amongst other things, memory capacity for long flights. Some runs will be made with the equipment mounted in a vehicle driven over a test course recorded in position, height and time (the Proof Drive mentioned in the Definitions section). Accuracy will be recorded over surveyed ground positions. These will include tests for any "throw forward" dead-reckoning fixes not based on actual satellite lines-of-position. Tests will be made first with the antenna connected and then with the antenna disconnected on arriving at the point. Fix records must closely compare with those from any control equipment.

4.1.1 The pressure-altitude recording system will be calibrated using standard procedures for barograph calibration, and a calibration chart will be produced. The sea level setting must correspond to the required ISA (1013.25 mb) within 1 millibar; up to an altitude of 2000 metres within 3 millibars; and above this, within one percent of altitude. The FAI pressure altitude criteria will be used (the ICAO International Standard Atmosphere, Document 7488 tables 3 and 4). See also Chapter 2, para 2.10, and Chapter 3 of Annex B to the Sporting Code (SC3B).

4.1.2 Temperature of the equipment may be varied during the test runs between +40C and -20C, depending on facilities available to the tester.

4.2 Flight Tests. Flight data should closely compare with that from any control equipment. See Chapter 1, para 1.3.3.1.1 on fix accuracy and error rates.

5 **ANTI-TAMPERING PROTECTION**

5.1 Tests will be made to assess the susceptibility of the equipment as a whole to corruption of the recorded flight data by inadvertent or deliberate means.

5.2 The minimum standard is a positive and recorded identification on every occasion that false data is produced or introduced into the recorded flight data store.

6 **POWER SOURCE.** Measurements of power consumption will be made, and, where relevant, of battery characteristics under different conditions of charge and temperature. Misleading results must not be produced as voltage falls and the LOV code must be generated before results become inaccurate. (AL3)

7 **ELECTROMAGNETIC INTERFERENCE**. Susceptibility to ElectroMagnetic Interference (EMI) will be assessed to the current European JAA and US FAA requirements. FR data memories must be resistant to levels of EMI that could be experienced in flight, so that the integrity of flight data is preserved. Also, some GNSS equipment designed primarily for ground use, may cease to operate or produce spurious results when in the presence of high-powered EM radiation such as from powerful ground-based transmitters. Tests will be made with hand-held radios (as frequently used in gliders) using VHF transmissions at up to 1 watt RMS. Transmission distances tested will be down to 1 foot for FR units designed for mounting close to the pilot's head, and 3 feet for panel-mounted units. No adverse effects should be shown on the FR, its GPS board, data memory, its security devices, and its output data.

8 **FLIGHT TESTS**. Flight tests will be made in several types of glider or motor glider, or, during periods of poor weather, in light aircraft.

8.1 Accuracy. Flights will take place either on accurately-recorded routes or over accurately-surveyed points, or in aircraft fitted with known GNSS FR equipment used as a "control". Flight data will be compared between the control GNSS and the output of the equipment under test.

8.2 Security. Security protection and procedures before and after flight, and the role of OOs, will be assessed. The effect of mis-switching will be investigated, and deliberate attempts will be made to insert false data after the pre-flight OO inspection. The possibility of transferring false data after flight will also be assessed.

8.3. Manoeuvring flight. Tests will be carried out in manoeuvring flight to check for anomalies. FRs will be tested under rapid pitch, roll and turn, and also at extreme attitudes and in high-G situations. The possibility of "throwing forward" fixes by turning rapidly after a high speed run, will also be assessed.

8.4. Pressure altitude recording. Tests will be made on the barograph (pressure-altitude recording) function. On flight tests it will be ensured: that the barograph function continues if GPS signal is lost; that re-lock occurs quickly once signal is restored; and that in the event of total GPS failure, the FR functions as a barograph after switching on. These tests will involve disconnecting and re-connecting the antenna, or, for FRs with fixed antennas, covering up the antenna with material impervious to RF signals (such as metal sheet or foil).

8.5 Means-of-Propulsion (MoP) recording system. Tests will be made on any system for recording the operation of the Means of Propulsion for motor gliders. Where Engine Noise Level (ENL) or vibration sensors are used, tests will be made with the FR in a number of types of glider and motor glider. These will include glass-construction machines with low aerodynamic cockpit noise, also machines with higher cockpit noise in gliding flight. Conditions will include speed and other variations, and sideslipping flight with cockpit panel(s) open (producing the so-called `organ-pipe' effect in some gliders). Operation of both two-stroke and four-stroke engines will be tested at all available power settings. Results will be analysed to ensure that a clear difference in the IGC file data is shown between all types of gliding flight, and any engine running at positive thrust settings. If these conditions are not shown, modifications to the ENL system will be required until they are. (AL4)

---------------- end of Appendix 2 ----------------

APPENDIX 3 TO GNSS FR SPECIFICATION

Windows-based short programs for data transfer and conversion to IGC format, and validation of data

1. INTRODUCTION

1.1 General. This appendix describes an IGC standard for Manufacturer-supplied Windows Dynamic Link Libraries (DLLs) in a 32-bit Windows environment, for the DATA, CONV and VALI functions that are described in para 2.9 of the main part of this Specification.

1.2 Availability on the IGC GNSS web site. The DLLs shall be freeware and be made available through links from the IGC/GNSS web site http://www.fai.org/gliding/gnss/. IGC will supply a sample control program, in both source and executable form. This will load a DLL and call each of the Application Programming Interface (API) functions specified below. This control program will also be available through links from the IGC web site.

1.3 Functions supported. All such DLLs shall support the functions described in the API below.

1.4 Control program. The Control Program will check responses from the DLLs and also perform checks for the existence of a file before calling on a DLL to open it for reading (e.g. ConvertLog or ValidateLog) and to query overwriting an existing file (e.g. DownloadLog and ConvertLog). The Control Program will also select the COM port to be used.

1.5 DLL Naming. The name shall be of the form IGC-XXXy.DLL where XXX is the Manufacturer's three Letter Code as defined in Appendix 1 para 2.5.6. It is expected that a manufacturer's basic DLL will be able to handle all GNS FRs in the product range. In case this cannot be achieved, the symbol "y" above is an optional alphanumeric for other DLLs from a given manufacturer.

2. APPLICATION PROGRAMMING INTERFACE (API) FOR MANUFACTURER-SUPPLIED DLLs

2.1 General. A standard API is described later in para 3. It includes the functions mentioned in para 1.1 for the operating systems Windows 95/98/ME, NT/2000, and subsequent releases. The API shall be implemented by a DLL supplied by each flight recorder manufacturer, which exports a defined set of functions for use by control programs. These control programs may include third-party flight evaluation applications, competition scoring software, and minimal generic programs for the use of pilots, official observers and contest directors.

2.2 Control programs. The DLLs will be stored in a common directory on the computer of the end-user. A control program will use the Win32 *LoadLibrary* or *LoadLibraryEx* functions to load a DLL using run-time linking. The control program will then query it for the entry point of each API function by name, using the Win32 *GetProcAddress* function.

2.3 Functions and descriptions. Some of the functions described below are designated optional. If a function is not implemented by a particular DLL, *GetProcAddress* will return NULL. In the API descriptions below, DWORD, BOOL, TCHAR, LPTSTR, and LPCTSTR are standard Win32 API types defined as long, bool, char, char *, and const char *, respectively, for the required ANSI (as opposed to UNICODE) DLL build. HWND is a 32 bit window handle. FALSE is integer 0, TRUE is any non-zero integer value.

2.3.1 Icons. In addition to these functions, each DLL is to provide a unique 32x32x4 (16 color) icon, with the fixed resource identifier IDI_IGCICON (defined to be 101). Control programs may use the Win32 *LoadImage* call to obtain the icon, and display it in a listbox or other context.

3 **API SUB-ROUTINE DESCRIPTIONS**. The standard API follows. Titles of main sub-routines appear as sub-paras, and end in the letters DLL, FR or LOG. They are followed by relevant data such as parameters, return values, and remarks. Para and sub-para numbers are included only as a reference in this document and are not relevant when API sub-routines are used in practice.

3.1 API Sub-routine: IdentifyDLL

DWORD IdentifyDLL(LPTSTR value, DWORD size)

The *IdentifyDLL* function obtains an identifying string, which the control program will enter in a listbox used to select the appropriate DLL.

3.1.1 Parameters
value: [out] pointer to buffer that will receive string.
size: [in] size of the buffer pointed to by *value*.

3.1.2 Return Values. Function returns number of bytes in returned string, if actual length of string exceeds *size*, the string will be truncated to *size* -1 bytes.

3.1.3. Remarks. The string consists of five fields, separated by the "pipe" character ("|", 0x7C), the manufacturer name, supported FR name(s), DLL software revision number, and two comma separated lists of zero or more file extensions. The first list of extensions identifies manufacturer proprietary log files, if any, which can be converted to IGC format using the *ConvertLog* function. The second list identifies log files (possibly including IGC format) that can be authenticated by the *ValidateLog* function. A terminating NUL character is always appended to the string (but not included in the returned count). Maximum permitted length of the string (excluding the terminating NUL character) is 127 characters. Example:

Acme Instruments|XL 100, 200|2.0|XL1,XL2|XL1,XL2,IGC

3.2 API Sub-routine: InitializeDLL

void: InitializeDLL(HWND mainWindow)

InitializeDLL is an initialization function that must be called before any of the other functions, with the exception of *IdentifyDLL*.

3.2.1 Parameters
mainWindow
Handle for the control programs main window, or NULL if there is none.

3.2.2. Remarks. The window handle should be stored in the DLL, and used as the parent handle for any dialog boxes displayed by DLL functions. These dialogs should be centered within the main window.

3.3 API Sub-routine: KeepAwakeIntervalDLL

DWORD KeepAwakeIntervalDLL()

The *KeepAwakeIntervalDLL* function is used to obtain the nominal time interval between calls to *KeepAwakeFR.*

3.3.1 Return Values. Returns the interval in milliseconds. If 0 is returned, *KeepAwakeFR* calls are not required (and will be ignored).

3.3.2 API Sub-routine: SerialOptionsDLL

DWORD SerialOptionsDLL(LPTSTR options, DWORD size)

[OPTIONAL] The *SerialOptionsDLL function* displays a modal dialog box requesting any user settable connection options (line speed, flow control, etc.) needed to configure a serial port for use with the manufacturers FRs.

3.3.3. Parameters
options: [out] pointer to buffer which will receive the connection options.
size: [in] size of the buffer pointed to by *options* in bytes.

3.3.4 Return Values. Function returns number of bytes in returned string, if actual length of string exceeds *size*, the string will be truncated to *size* -1 bytes.

3.3.5 Remarks. This dialog should not include selection of the serial communication device. Maximum permitted length of the returned string (excluding the terminating NUL character) is 63 characters. The string is intended for use in a subsequent call to *SerialConnectFR*, the actual format of the string is determined by the manufacturer. The control program may choose to store this string in the registry or a file for use in future sessions. This is an optional function, and should only be exported by the DLL if there are user settable connection options.

3.4 **API Sub-routine: SerialConnectFR**

BOOL SerialConnectFR(LPCTSTR device, LPCTSTR options)

The *SerialConnectFR* function is used to establish communication with a FR connected through a serial port. Must be called prior to using *KeepAwakeFR, IdentifyFR, IdentifyLogFR, DownloadLogFR,* and/or *DisconnectFR*.

3.4.1 Parameters
device: [in] name of the serial communication device device ("COM1", etc.).
options: [in] string returned by a previous call to *SerialOptionsDLL*, or NULL to use the default device options. The format of this string is determined by the manufacturer.

3.4.2 Return Values. Returns TRUE if connection established, FALSE otherwise.

3.4.3 Remarks. If a connection cannot be established, the function should display a modal dialog box detailing the problem.

3.5 **API Sub-routine: KeepAwakeFR**

BOOL KeepAwakeFR()

The *KeepAwakeFR* function is used to prevent the FR from disconnecting during idle periods between calls to *ConnectFR* and *DisconnectFR*. If *KeepAwakeIntervalDLL* returns a non-zero value, the control program must call *KeepAwakeFR* each time that interval elapses.

3.5.1 Return Values. Returns TRUE if the FR still connected or FALSE if connection has been broken.

3.6 **API Sub-routine: IdentifyFR**

DWORD IdentifyFR(LPTSTR value, DWORD size)

The *IdentifyFR* function is used to obtain the manufacturer id/serial number, the FR model name/number, and the FR sealed status for the connected FR.

3.6.1 Parameters
value: [out] pointer to a buffer which will receive the string result.
size: [in] size of the buffer pointed to by *value* in bytes.

3.6.2 Returned Values. Function returns number of bytes in returned string, if actual length of string exceeds *size*, the string will be truncated to *size* -1 bytes.

3.6.3 Remarks. The string consists of three fields, separated by the "pipe" character ("|", 0x7C), the manufacturer id/serial number (formatted MMMNNN, where MMM is the manufacturer id, and NNN is the serial number), the FR model name/number, and the FR sealed status (ASEALED@ if sealed, AUNSEALED@ if not). Maximum permitted length of the string (excluding the terminating NUL character) is 63 characters. Example:

AXL01F|XL 100|SEALED

3.7 **API Sub-routine: IdentifyLogFR**

DWORD IdentifyLogFR(DWORD index, LPSTR value, DWORD size)

The *IdentifyLogFR* function is used to obtain information on a log stored in the currently connected FR.

3.7.1 Parameters
index: [in] index of the desired log, starting with 0.
value: [out] pointer to the buffer which will received the returned string.
size: [in] size of the buffer pointed to by *value*.

3.7.2 Return Values. *IdentifyLogFR* returns number of bytes in the returned string, if actual length of string exceeds *size*, the string will be truncated to *size* -1 bytes. If the value specified for *index* exceeds the number of logs present in the FR (minus 1, as indexing starts with 0), *IdentifyLogFR* will return 0.

3.7.3 Remarks. The returned string consists of seven fields, separated by the "pipe" character ("|", 0x7C), the default log file name (including extension), log start UTC date (formatted YYYY-MM-DD, example "2000-05-12", zero padding required), log start UTC time (formatted HH:MM:SS, example "17:09:22", zero padding required), log end UTC time (formatted HH:MM:SS), pilot name, competition id, and competition class. Maximum permitted length of the returned string (excluding the terminating NUL character) is 127 characters. Example:

0B8X01F1.XL1|2000-11-08|20:05:21|01:21:09|J. Doe|XYZ|15M

Logs are indexed in descending start date/time order, the log at index 0 is the most recent log. When retrieving information on all of the logs stored within the FR, a control program should start by calling *IdentifyLogFR* with *index* 0, incrementing *index* by 1 until *IdentifyLogFR* returns 0.

3.8 **API Sub-routine: DownloadLogFR**

BOOL DownloadLogFR(DWORD index, LPCTSTR fileName, BOOL progress)

The *DownloadLogFR* function is used to download a log file from the currently connected FR.

3.8.1 Parameters
index: [in] the index of the desired log, starting with 0.
fileName: [in] a null terminated string containing the name of the file (which may include a path) to which the log will be downloaded. If NULL, the default file name will be used in the current working directory.
progress: [in] if TRUE, while the download is in progress, *DownloadLogFR* will display a modal dialog box with a progress indicator and a cancel download button. If FALSE, the download will occur silently, without a progress dialog box being displayed.

3.8.2 Return Values. *DownloadLogFR* returns TRUE if successful, FALSE if there was an error.

3.8.3 Remarks. If a file with the specified name and path already existed, it will be overwritten. If there is an error, *DownloadLogFR* should display a modal dialog box giving the details.

3.9 **API Sub-routine: DisconnectFR**

VOID DisconnectFR()

DisconnectFR is called after the control program has completed interaction with the FR, to close the communication device.

3.10 **API Sub-routine: ConvertLog**

BOOL ConvertLog(LPCTSTR fileName, LPCTSTR igcFileName)

[OPTIONAL] *ConvertLog* converts the log file specified by *fileName* to an IGC format file specified by *igcFileName*.

3.10.1 Parameters
fileName: [in] a null terminated string containing the name of an existing log file (which may include a path) in the manufacturer proprietary format.
igcFileName: [in] a null terminated string containing the name of the IGC file (which may include a path) to be created.

3.10.2 Return Values. Returns TRUE if successful, FALSE if there is an error.

3.10.3 Remarks. This is an optional function, and should only be exported by the DLL if log files are downloaded in a non-IGC proprietary format. If a file with the specified *igcFileName* already exists, it will be overwritten. If there is an error, the function should display a modal dialog with the details.

3.11 **API Sub-routine: ValidateLog**

BOOL ValidateLog(LPCTSTR fileName)
ValidateLog is called to authenticate the digital signature on a specified log file.

3.11.1 Parameters
fileName: [in] a null terminated string containing the name of an existing log file (which may include a path) to be validated.

3.11.2 Return Values. Returns TRUE if file can be validated, FALSE otherwise.

3.11.3 Remarks. If the log was not produced by a supported flight recorder, is in an unsupported format, or the digital signature is invalid, the function should display a modal dialog detailing the problem, then return FALSE.

4. PROGRAMMING FRAMEWORK FOR CONTROL PROGRAMS

To be added later.

--------------- Appendix 3 ends ---------------