FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

TECHNICAL SPECIFICATION
FOR
GNSS FLIGHT RECORDERS
TO
IGC STANDARDS

Second Edition
20 December 2010

AMENDMENT LIST (AL) RECORD

Amendments are published by FAI via links from the IGC GNSS web page www.fai.org/gliding/gnss. The full web reference for the complete version of this document is: www.fai.org/gliding/gnss/tech_spec_gnss.asp

Amendments should be proposed to the Chairman of the IGC ANDS or GFA Committees (ANDS = Air traffic, Navigation and Display Systems , GFAC = GNSS Flight Recorder Approval Committee). This can be done either by direct contact or through the FAI Secretariat. For the FAI address, see the Preliminary Remarks page after the contents list that follows. The proposal should include the reason for the change and a form of words suitable for direct incorporation in this document.

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PRELIMINARY REMARKS

1. **Title and Status**. This document contains the rules, procedures and specifications applying mainly to equipment that is to be IGC-approved for validation of flight performances to FAI/IGC criteria using Flight Recorders based on GNSS systems, and is also for use by other FAI Airsports. It is published by FAI at web reference: www.fai.org/gliding/gnss/tech_spec_gnss.asp

2. **Target Audience**. This document is intended for Flight Recorder manufacturers, potential manufacturers, and any other organisation or individual interested in the detailed specification of GNSS Flight Recorders and their outputs in the IGC flight data file format. This includes officials who deal with GNSS recording matters in IGC and other FAI airsports, NACs, members of the IGC ANDS and GFA committees and their advisors, also producers of analysis programs for the IGC format for flight data. 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 on championships (SC3A); Annex B on equipment used for flight validation, including GNSS Flight Recorders (SC3B); Annex C, the Official Observer and Pilot Guide (SC3C); and Annex D rules for the IGC Ranking List (SC3D). These are available from the web site www.fai.org/gliding

   2.1 Recorder types not for IGC-approval. Where a type of recording device is not to be submitted for IGC-approval, all of the details in this document need not apply in full, and any differences are the responsibility of the Authority that will validate the flights concerned. However, the output data should be as close as possible to the IGC file structure so that analysis programs designed to work with this format will operate correctly. Where such recorders are mentioned in this document, the term "Non-IGC FR" is used. IGC and its agents have no responsibility for, or liability for, the design or use of such devices.

3. **Amendments**. Proposals for amendments should be sent to the Chairman of the IGC ANDS and GFA Committees, 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 after the agreement of the IGC ANDS and GFA Committees.

   3.1 FAI Office. If you do not have a communications address for the Chairmen of the IGC ANDS and GFA Committees, initially contact the FAI Office who will forward your message:

c/o FAI Secretariat, Fédération Aéronautique Internationale,
Avenue Mon Repos 24, 1005 Lausanne, Switzerland
   (## this address will change in about April 2011and this page will be updated)

   Tel: +41 21 345 1070
   Fax: +41 21 345 1077
   Email: sec@fai.org
   Web: www.fai.org

4. **Meaning of key words**. 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 the context is 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*.

5. **Legal Entity**. FAI is the legal entity and Swiss law applies. FAI Commissions such as IGC are agents of FAI; GFAC and its advisors are agents of IGC.

6. **Confidentiality of proprietary data**. The evaluation of equipment on behalf of IGC will require that manufacturers reveal some proprietary and security data so that compliance with this specification can be assessed. Such data will be kept in confidence to GFAC members and appropriate technical experts.

GLOSSARY
OF
TERMS AND ABBREVIATIONS

This expands the glossaries in the main volume of the Sporting Code for Gliding (SC3) including its Annexes, and includes more specialised terms concerned with GNSS position recording. See also the terms and abbreviations listed in Appendix A to this document (the IGC file structure), particularly para A5 (Definitions), and para A7 which list the Three-Letter Codes (TLC) that can be used in the IGC data file. There is also a Glossary of Terms on the web site of the FAI Commission on Airspace and Navigation Systems (FAI CANS), see: www.fai.org/system/files/cans_glossary_20090413.pdf Another Glossary of more general FAI terms is in the General Section of the Sporting Code at: www.fai.org/system/files/GS_2010.pdf

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. The geometry of the lines-of-position between the satellites and the surface of the earth is such that errors in recorded GPS altitude are between 1.8 and 2.2 times those in latitude and longitude. In addition, further significant short-term inaccuracies in GPS altitudes have been recorded in IGC files, including GPS altitude unlocks and short-term (occasionally major) variations compared to pressure altitude. This is probably because of less-than-ideal installations in gliders. Source: GFAC report to IGC in 2001, posted on the fai.org/gliding web site.

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 available with every GNSS fix.

Alphabetical

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

ADS-B (Automatic Dependent Surveillance - Broadcast). The ADS-B system uses Global Navigation Satellite System (GNSS) position data and relatively simple broadcast communications links. It is Automatic, in that it is always live and requires no operator action. It is Dependent, in that it depends on a GNSS system for position data. Surveillance, in that it provides 4D position data to ground controllers and other aircraft. Broadcast, in that it broadcasts data on pre-set radio frequencies to any ADS-B-equipped aircraft or ground station that is receiving. The ADS-B system is the basis for the European SESAR and U.S. NextGen future Air Traffic Management systems.

Analysis - Study of flight data with a view to authentication and verification of a flight. In addition, other flight characteristics may be analysed such as navigational accuracy, speed in various parts of the flight, proximity to controlled airspace and so forth.

ANDS Committee - The Air traffic, Navigation and Display Systems committee of IGC, previously called the GNSS Committee.

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

ARINC - Aeronautical Radio Incorporated, the company that 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 - see under Validation.

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. Where this is recorded in the IGC file, it may be used to help to verify the validity of the recorded flight data. In the IGC file it appears in the F Record (details, Appendix A under F-record).

CRLF - `Carriage Return' followed by a `Line Feed'. These 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.

Datum - The GNSS Geodetic Datum (qv). The Sporting Code for gliding (SC3) states that the WGS 84 Geodetic Datum shall be used for all lat/long co-ordinates that are recorded in and downloaded from the FR after flight. This assumes that the shape of the Earth is a three-dimensional ellipse ("ellipsoid"), the dimensions of which are defined by the WGS84 system (see later under WGS84). The WGS84 ellipsoid is an FAI-approved earth model for measuring flight distances, see the General Section of the FAI Sporting Code (FAI GS), at: www.fai.org/system/files/GS_2010.pdf.

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.

DOP - Dilution of Precision - The reduction of precision in a GNSS fix due to the geometry of the satellites, computed by a GNSS receiver for each fix. See also Estimated Position Error (EPE). DOP can be estimated in various ways, including, HDOP (Horizontal position), GDOP (Geometric), PDOP (Position, overall), TDOP (Time) and VDOP (Vertical position). EPE also varies with constellation position. Some definitions from RTCA sources are given below (for RTCA, see below).

GDOP - Geometric Dilution of Position - The ratio of position error of a multilateration system (see definition of Multilateration). More precisely, it is the ratio of the Standard Deviation (SD) of the position error to the SD of the measurement errors, assuming all measurement errors are statistically independent, have a zero mean (average) and the same standard distribution. GDOP is the measure of the quality (sometimes, "goodness") of the geometry of the multilateration sources as seen by the observer. A low GDOP is desirable, a high GDOP undesirable. (See also PDOP, HDOP and VDOP.)

HDOP - Horizontal Dilution of Position - The ratio of user-referenced horizontal position error to measurement error of a multilateration system. (See GDOP for a more detailed description.)

PDOP - Position Dilution of Position - The ratio of user-referenced 3D position error to measurement error of a multilateration system. PDOP is the root-sum-square of HDOP and VDOP.

VDOP - Vertical Dilution of Position - The ratio of user-referenced vertical position error to measurement error of a multilateration system (see GDOP for a more detailed description).

Download - Where used in this document, it refers to the transfer of data from the GNSS Flight Recorder either by cable to a PC or directly to a memory device attached to the recorder. This terminology follows normal usage in avionics where "download" refers to data being transferred from an aircraft module such as a flight recorder to a separate ground storage device for later analysis. The term "upload" is the reverse process where data is transferred into the recorder from a PC or other system.

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 half of the computation of RSA thus reducing download 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 download from FR to PC is, particularly in competitions with many entrants). 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.

ECC - Elliptic Curve Cryptography. A patented second-generation Public/Private Key-based Cryptographic (PKC) system. It has a smaller private key length compared to systems such as RSA and DSA for the equivalent level of electronic security. For IGC flight recorder purposes, ECC with a 160 bit private key is accepted as equivalent to RSA with a 512 bit key. See also in this Glossary under DSA, PKC, RSA and also: www.nsa.gov/ia/industry/crypto_elliptic_curve.cfm.

EGNOS - European Geostationary Navigation Overlay Service. EGNOS is a GPS-enhancement system that makes the same kind of corrections in the European area as the North American WAAS (see below). It reduces position errors to about one quarter those of un-enhanced GPS systems. EGNOS has a series of Ranging and Integrity Monitoring Stations (RIMS) which receive GPS signals. Master Control Centres (MCC) process RIMS data and calculate corrections based on the known positions of the RIMS stations. The correction data is then sent to three EGNOS satellites that are geostationary over the equator. GPS users on the ground in the area of EGNOS cover can receive data from the EGNOS satellites so that the corrections for the European area can be applied to raw GPS positions. EGNOS became operational in July 2005.

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. 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. It may be due to Radio Frequency (RF) radiation from radios or other emitters 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.

Enhancement systems, for GNSS - This term is generally used for Satellite-Based Augmentation Systems (SBAS) that apply corrections to GPS receivers over a specified area. These systems increase accuracy by monitoring errors over their area and making corrections available to compatible receivers. More detail is under SBAS below.

ENL – Environmental Noise Level. A three-letter code used in an IGC file associated with three numbers between 000 and 999 placed in the fix record of the file, indicating the noise level at a Recorder and intended to differentiate between engine-on and engine-off flight. See Chapter 5 for more details.

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 above) 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 under the FXA code.

EUROCAE - European Organisation for Civil Aviation Equipment. The Regulatory agency for certifying aviation equipment in Europe. It is a non-profit organisation formed from manufacturers of aircraft, airborne equipment, Air Traffic Management (ATM) systems and ground equipment, Service Providers, National and International Aviation Authorities and Users (Airlines, Airports, operators) from Europe and elsewhere. EUROCAE develops performance specifications and other documents that are referenced as a means of compliance to European Technical Standard Orders (ETSOs) and other regulatory documents. EUROCAE works with US standardisation bodies, including RTCA (see later) and SAE, to produce harmonised specifications where possible. EUROCAE documents also take into account ICAO standards and ARINC specifications.

Fix - For IGC flight analysis, a fix is a sample of near-simultaneous data from GNSS satellites that 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), satellite constellation and any other variable required with each sample and specified by IGC. See 2D, 3D, 4D and the definitions below. Fixes are recorded as individual lines in the B record in the IGC file, separated by CRLF.

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.

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.

FR - Flight Recorder. In this document, a device recording GNSS fix and other data for the purpose of flight validation to IGC/FAI criteria. An IGC-approved GNSS FR is a device capable of producing an IGC flight data file, and includes a GNSS receiver, pressure altitude sensor, a memory storage device and both physical and electronic security to ensure validity of the flight data in an IGC file. A GNSS FR may also include other facilities such as those for detecting operation of the Means of Propulsion (MoP) in a Motor Glider, the input of Waypoints, flight declarations, etc. See also non-IGC FR.

FR Serial Number (S/N) - For an IGC FR, a set of three alphanumeric characters allocated by the manufacturer (unique to that manufacturer), identifying an individual FR. The S/N appears in the first line of the IGC file. If identification of an individual FR is required, the S/N should be prefixed by the manufacturer's name and followed by the FR model and type.

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, a three-dimensional ellipse; 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. A document describing a Geodetic Datum system may have additional elements, for an example see under WGS84.

Geoid - Sometimes used loosely to mean an earth model (an assumed shape for the earth). In the WGS 84 specification document it has a more precise meaning, 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). In this more precise meaning, 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 some GNSS receiver systems 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 Altitude - Altitude calculated solely from GNSS position lines. In the IGC format file, GNSS altitude must be referenced to the WGS84 ellipsoid. Where GNSS altitude is not available from GNSS position-lines (altitude drop-out leading to 2D fixes), it shall be recorded in the IGC file as zero so that the situation can be clearly identified during post-flight analysis. Note that in commercial GNSS systems, GNSS altitude may be set to show approximate altitudes above local sea level rather than distance above the ellipsoid appropriate to the selected Geodetic Datum.

GPS - Global Positioning System, the U.S. 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. GPS receivers 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" that are added to UTC to allow for the slowing down of the Earth's rotation (see under UTC).   In 2011, UTC was 15 seconds later than GPS System Time. However, the GPS system is programmed with the leap second corrections, and this is made available to users. Most receivers automatically output UTC rather than GPS system time. However, 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.

Grandfather rights. This term is used for a situation where the approval or certification of a type of equipment is continued unaltered, although the Specification conditions have changed with time (generally, increased).   Detail on its application to IGC-approved GNSS Flight Recorders is in para 1.1.4.5.

GS. The General Section of the FAI Sporting code, with which other Sporting Codes must conform.
See www.fai.org/documents/sportingcode/GeneralSection_download

Hard/Soft Data/Storage - Hard data or storage is that which is retained 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 (95.45% probability) error of the overall position error. Included in the IGC data file in the B (fix) record through the FXA three-letter code.

ICAO - International Civil Aviation Organisation. Detail: www.icao.int

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 the ICAO ISA. Details are in ICAO Document 7488 tables 3 and 4. At sea level, this assumes a temperature of 15C and a pressure equivalent to 760 mm of mercury (1013.25 mb/hPa). Above sea level, it assumes a constant temperature lapse rate of 6.5C per 1000 m rise in height (1.98C/3.56F per 1000 ft), up to an altitude of 11km (-56.5C) . 11km is assumed to be the Tropopause, above which constant temperature (-56.5C) is assumed until 20km, thereafter increasing by about 1 degree per kilometre. 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, see also under ICAO

ISO - International Standards Organisation

Kph – Kilometres per Hour

Latitude - In a GNSS IGC flight data format, this is a seven number group with two figures for degrees, two figures for minutes and three figures for tenths, hundredths and thousandths of minutes followed by the N or S character.

Leap Second - see under GPS and UTC

Longitude - In an IGC file, 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.

Meaning of specific words. See later under Words, meaning.

MoP - Means of Propulsion, for Motor Gliders or, for non-IGC FR devices, other aircraft. A MoP Recorder is used in motor gliders and produces an after-flight record of operation against a timebase for the flight. 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. See under ENL and MOP

MOP – A three-letter code used in an IGC file associated with three numbers between 000 and 999 placed in the fix record of the file, indicating operation of a Means of Propulsion. See Chapter 5 for more details.

Multilateration   - literally, having many sides, the shape of such a geometric figure. Therefore, in navigation systems, the obtaining of a fix from multiple lines of position which, if plotted out on a map, would form a multi-sided figure (sometimes called a "cocked hat" by navigators), the centre of which is the "Most Probable Position" or MPP.

NMEA - National Marine Electronics Association. NMEA is an international body (www.nmea.org) that publishes data and interface standards for marine and other electronic devices. 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 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.

Non-IGC FR. A device that that records GNSS fixes in the form of the basic IGC file structure but is not designed with a view to IGC-approval. Where a type of recorder is not to be put forward for IGC-approval and is to be used for non-IGC purposes, all of the details included in this document need not apply. However, the output data from such a recorder should be as close as possible to the IGC file structure so that analysis programs designed to work with this structure will work with the non-IGC Recorder. Such devices could be, for example, a flight instrument designed for the purpose, a stand-alone GNSS unit or a portable device that receives and stores GNSS data. Where FAI Airsports other then gliding are concerned, the type of device, method of data storage and security considerations (for data storage and post-flight download), should be approved by the appropriate FAI Air Sport Commission for flights within its jurisdiction.

OZ - Observation Zone. A volume of airspace within which a valid GNSS fix is required to validate an IGC event such as start, reaching a turn point, and the finish of a flight performance. The Sporting Code for Gliding (SC3) defines the shape of these Observation Zones. For a turn point this is a 90 degree area, the bisector of which is opposite the bisector of the two legs making up a turn point. For start and finish points, the 90 degree OZ is 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. Circular OZ are also permitted, but in this case the radius of the various OZ must be subtracted from the distance calculated from the Wayoints themselves.

PGP - Pretty Good Privacy. A commercial system for electronic security that uses RSA (qv) asymmetric keys, and the "padlock" symbol on a PC screen normally indicates that the PGP system is available.

Pilot Event (PEV Code) - This is where a pilot presses an event button or equivalent that takes an additional GNSS fix and marks the fix with the PEV code. 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. After the fix with the PEV code, a series of fixes at short time intervals is generated (the 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 first commonly available practical application of PKC was the RSA system of Rivest, Shamir and Adelman (qv under RSA).

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. See also 1.1.4 and Chapter 4.

Proof Drive or Flight - A method of checking that a Flight Recorder produces a correct IGC flight data file. Under the 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

Pseudorange / Pseudo-Range - a measure of the apparent propagation time from a navigational satellite to the receiver antenna, expressed as a distance. The distance from the user to a ranging source (for instance a satellite) plus an unknown user clock offset distance. With four ranging source signals it is possible to compute position and offset distance. If the user clock offset is known, three ranging source signals would suffice to compute a position.

qv - quod vide, Latin for "which see". Where this abbreviation is used, the reader is invited to look up the reference.

RAIM - Receiver Autonomous Integrity Monitoring. A system inside a GPS receiver that automatically compares the position-line obtained from each satellite with other position-lines being received at any one time. Any anomalous ("rogue") position lines are then discarded for the purpose of calculating the fix. A numeric code is used which indicates 0 if RAIM is satisfied and 5 when not. In theory, RAIM calculations can be based on a minimum of four position lines (three good ones and the "rogue") but in practice, six satellite position-lines are needed for the system to operate properly. With a 12- or 16-Channel receiver and the antenna in a good position, this is not normally a problem. See also SBAS.

RSA - A system of Public/Private Key Cryptography (PKC) with an asymmetric system for key exchange. The initials are from the names of the three developers Ronald Rivest, Adi Shamir and Leonard Adelman of MIT. For FR man ufacturers, more detail implementing RSA is in "Applied Cryptography" by Bruce Schneier, ISBN 0-471-11709-9. An overview of various cryptographic algorithms is at www.ssh.fi/tech/crypto/algorithms.html. A PDF file on High Speed RSA Implementation is at: ftp://ftp.rsasecurity.com/pub/pdfs/tr201.pdf. Details of the FIPS 180 Secure Hash Standard are in www.itl.nist.gov/fipspubs/fip180-1.htm. Cryptographic libraries with source code in C and C++ are in: www.cs.auckland.ac.nz/~pgut001/cryptlib and www.eskimo.com/~weidai/cryptlib.html. GFAC will give advice as required.

RTCA Inc - a US not-for-profit corporation concerned with aviation and aviation electronic systems, see www.rtca.org. It functions as a US Federal Advisory Committee and develops recommendations on aviation issues based on consensus. Some 300 organizations are members, about one-quarter being non-US, including FAI. The initials RTCA originally stood for Radio Technical Commission for Aeronautics, a previous government body which was discontinued. The initials RTCA no longer have a longer official form, but its letter pages have the words: "Requirements, Technology and Concepts for Aviation ".

SBAS - Satellite-Based Augmentation System. A system that increases GNSS accuracy by monitoring errors at ground stations in the area concerned and making corrections and other data available to compatible receivers. For GPS, systems in service include WAAS (North America) and EGNOS (Europe). Other future SBAS systems include GAGAN (India) and MSAS (Japan). A Ground-Based Augmentation System (GBAS) is being developed in Australia.

SC3 - Section 3 of the FAI Sporting Code, for FAI Class D (gliders) including Class DM (motor gliders), administered by IGC, including annexes A-D, which are SC3A (championships), SC3B (equipment), SC3C (OO Guide), SC3D (ranking list). For a table of the full list of FAI Sporting Codes, see Chapter 1 of the General Section of the FAI Sporting Code, also the FAI web page: www.fai.org/documents/sportingcode

Security - Digital Signature (DS) - A Digital Signature (DS) is a set of encrypted data generated by an FR and downloaded 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 para 6.1 and Appendix G.

Serial Number (S/N) – The three-character Alphanumeric identifier for an individual IGC Flight Recorder. This appears as a three-character group in the name of IGC files and also in the first line of the IGC file. Although the word "number" is used, a more accurate term would be "numbers and letters". Non-IGC recorders may have different S/N systems.

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.

TLC – Three-Letter Code. One of the Codes listed in para A7 of this document and used in the IGC file as a prefix for the information relevant to the TLC and its description in A7.

Total Energy Altitude (TEAlt) - The combination of potential and kinetic energy expressed as a hypothetical `zero-energy' altitude 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 joined-up sequence of a series of 2D positions on the ground (such as GNSS fixes) over which the aircraft has flown or a vehicle has driven.

Turn or Waypoint Confirmation- The indication that the glider has reached the TP/WP to the criteria laid down in the appropriate FAI Sporting Code, for instance by demonstrating presence in the OZ by the use of photography, a GNSS FR, or Observation from the ground. In IGC Sporting Code terminology this is "reaching" the turn point, and there is no obligation to actually fly round the point itself.

Upload - The opposite of Download, see under Download.

UTC - Universal Time Co-ordinated. A world standard time datum used in many areas of activity including aviation, navigation and science. It used to be called Greenwich Mean Time (GMT), based on the Greenwich meridian (zero longitude), a north/south line at the historic Observatory at Greenwich (pronounced Gren-Itch) in East London, UK. UTC is virtually the same as GMT except for astronomical purposes. To allow for the slowing down of the Earth's rotation, by international agreement a so-called "leap second" is added at midnight on dates such as 30 Jun or 31 Dec and is used to change UTC by a whole second at a time. The period between the addition of the next leap second varies between one and two years, and is agreed internationally. The IGC data file requirement (Appendix A) requires times in data files to be in UTC. See above under GLONASS, GNSS, GPS, Leap second.

<u>Validation, VALI check</u>. The IGC electronic validation system may be used to check an IGC file at any time and ensures that the flight data in the file has the integrity to be used in the process of approving a flight performance to IGC standards. The IGC validation system checks that the file has originated correctly from a serviceable IGC-approved recorder and ensures that the flight data in the file is identical to that originally downloaded. For more detail, see para 1.1.10.1 and para G2 in Annex G. The Validation programs for all IGC-approved recorders are available on the IGC/GNSS web pages.

<u>Vertical fix accuracy</u> - the best prediction for the vertical 2-sigma (95.45% probability) component of the overall position error. When included in the IGC data file, through the VXA three-letter code.

<u>WAAS - Wide-Area Augmentation System</u>. A system that corrects GPS positions based on the actual position of monitoring stations in North America. It consists of an integrity and reference monitoring network, processing and control facilities, and special WAAS geostationary satellites above the equator. Reference stations receive data from the GPS and WAAS satellites and measure differential corrections, ionospheric delay information, GPS/WAAS accuracy, WAAS network time, GPS system time and UTC time. These measurements are sent to Data Processing sites for calculation of corrections for the area of WAAS cover. In addition, residual errors can be calculated for data from each satellite. The Data Processing sites also generate navigation messages. This information is broadcast to users from the WAAS geostationary satellites and the resulting GPS/WAAS fixes are more accurate than those using GPS alone. See also EGNOS and RAIM.

<u>Waypoint, way point (WP)</u>. Either (a) A precisely specified point or point feature on the surface of the earth using a word description and/or a set of coordinates, or (b) a set of prec ise coordinates not represented by any specific earth feature. A waypoint may be a start point, a turn point, or a finish point and for IGC purposes has an associated Observation Zone (IGC Sporting Code, definitions, para 1.1.2). It may also be used as a reference point for defining an area that is to be reached as part of a task. The area concerned is within the clockwise angle between two radials originating from the point and a minimum and maximum distance from the WP. (Based on IGC Sporting Code Annex A Part 7, description of Assigned Areas).

<u>WGS 84 = World Geodetic System 1984.</u> A Geodetic Datum and 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 (an equipotential surface approximating to local sea levels) with associated constants, conversion factors and co-ordinate systems. The WGS84 System Definition Document is Technical Report 8350, obtainable from the US National Geospatial-Intelligence Agency (NGA) (ex National Imagery and Mapping Agency (NIMA) and before that, the Defense Mapping Agency (DMA)). An ellipsoid model is the currently accepted best overall simple mathematical model for the earth's shape and in the case of the US GPS system, all IGC GNSS fixes and calculations are initially based on the WGS84 earth model. Fix position and distance calculations can then be transformed to any of over 200 other ellipsoids (local Geodetic Datums). Some earth models very close to WGS84 include the International Terrain Reference Frame (ITRF) and the European Terrestrial Reference Frame (ETRF) that allows for tectonic plate movement in the European area. However, lat/long differences between these systems are generally less than 1m with respect to WGS84.

The radii of the WGS 84 Ellipsoid 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 (an equipotential (equal gravity) surface approximately equivalent to local Mean 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). 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.

<u>Words, meaning</u>, 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 the context is 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*.

CHAPTER 1

GNSS FLIGHT RECORDERS
IGC-APPROVAL AND OTHER PROCEDURES

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

1.1 **IGC FLIGHT RECORDERS - POLICY AND GENERAL**. IGC-approval of a particular type of GNSS Flight Recorder is achieved after Test and Evaluation (T&E) by the IGC GNSS Flight Recorder Approval Committee (GFAC), whose terms of reference are given below. GFAC and its advisors are agents of IGC, FAI Commissions such as IGC are agents of FAI; the legal entity is FAI and Swiss law applies. When a Flight Recorder system is submitted for IGC-approval, GFAC examines it for compliance with IGC rules and procedures for hardware, firmware, software, output data in the standard IGC data file format, and security of the Flight Recorder system both physical and electronic. The full level of IGC-approval indicates that the equipment meets the standards of availability, continuity, integrity, accuracy, and security that are required for the certification of flights for FAI/IGC World Records, all FAI/IGC Badges and Diplomas, Championships and Competitions. Other aspects are matters between customers and manufacturers, including the presentation on cockpit displays, navigational features, and post-flight analysis systems. See 1.1.4 for levels of approval for types of IGC flights for which a Flight Recorder may be used, also 1.1.7 for the position of associated displays in the cockpit.

1.1.1 **FAI Liability**. FAI has no liability for the consequences of the use of Flight Recorders covered by this document for purposes other than validation and certification of flights to FAI/IGC procedures. Such other purposes include, but are not limited to, navigation, airspace avoidance, terrain avoidance, traffic alert, proximity-warning and/or anti-collision functions, any other matters concerning flight safety; and uses outside IGC such as by other FAI Airsports.

1.1.2 **IGC Flight Recorder Operating Procedures**. Operating procedures for each type of Flight Recorder will be specified by GFAC in the IGC-approval document. The IGC-approval process has the objective of making procedures on the day of flight as simple as possible. This is particularly important before flight when the time available for carrying out extra independent checks may be short. Also, after flight it must be quick and easy to download secure flight data to a PC in the IGC flight data format. GFAC will specify procedures that minimise the possibility that either one Flight Recorder could be substituted in the glider by another that was not carried on the flight in question, or that the data in the Flight Recorder that was in the glider could be interfered with without this being detected. This may require either continuous observation of the glider before takeoff and/or after landing, or the physical sealing of the Flight Recorder unit to the glider by an OO at any time or date beforehand, to avoid the need for extra OO observation of the installation before takeoff. Such a seal must be applied and marked in a manner such that there is incontrovertible proof after the flight that it has not been broken. This can be achieved by marking it with the glider registration, the date, time and OO's name, signature, and the OO identification number. Other procedures specific to the type of Flight Recorder concerned may be required, such as stowage of certain modules out of reach of the flight crew, or limitations on the types of flight for which the recorder may be used. Such procedures and limitations will be an integral part of the IGC-approval document for the type of equipment concerned, and will depend on the Flight Recorder design and the results of the evaluation process. *(Amplification of SC3C para 1.7)*

1.1.3 **IGC-Approval Documents for Flight Recorders**. The IGC-approval document for each type of Flight Recorder is produced by GFAC on behalf of IGC. Before the approval document is finalised, it will be circulated in successive drafts to GFAC members, other technical experts and consultants, and the manufacturer concerned. When finally issued, the IGC-approval document will give the detailed procedures under which equipment must be checked, installed in the glider, and operated for flights that are to be validated and certificated to FAI/IGC criteria. The definitive version of the IGC-approval document for a particular type of flight recorder is that which is currently available on the IGC GNSS web page.

    1.1.3.1 Format of IGC-approval documents. These documents have a standard format which consists of an introduction (including legal disclaimers agreed by FAI on matters such as flight safety and intellectual property); manufacturer details; details on hardware (including the type of GPS receiver and pressure transducer); firmware and software; connections to the Flight Recorder; and a list of Conditions of Approval. There are two annexes. Annex A contains notes and recommendations for pilots and Annex B contains notes and recommendations for Official Observers and bodies validating flight performances such as National Airsport Control authorities (NACs). Annex B includes checks that apply to that type and model of Flight Recorder, how to download flight data to a PC, procedures for checking the validity of the IGC file data, and pressure altitude calibrations. Also, for those Flight Recorders fitted with an Environmental Noise Level or a Means-of-Propulsion recording system under the codes ENL and MOP, Annex B contains details of ENL and MOP figures recorded during GFAC testing and to be expected in various phases of flight.

1.1.3.1.1 <u>Checks on individual recorders</u>. It is the responsibility of owners of recorders and pilots using them, to check that the characteristics of the recorder correspond to those in the IGC-approval document. If they do not, the recorder should be returned to the manufacturer or his authorised agent, to be re-set to the characteristics in the IGC-approval. This particularly applies to ENL and MOP figures recorded in IGC files which must be similar to those given in Annex B to the IGC-approval document, and to pressure altitude calibrations which must be to the ICAO International Standard Atmosphere (ISA). For the critical cases in ENL and MOP recording, see 1.4.2. and 5.6.

OOs shall inspect recorder installations before and after flight in accordance with the provisions of Annex B to the IGC-approval document for the type of recorder concerned. Where the FR uses instrument static pressure (rather than "cockpit static"), the tubing and the pressure connection to the FR shall also be checked to ensure that they are out-of-reach of the aircrew in flight so that no unauthorised adjustments to static pressure can be made.

1.1.3.2 <u>IGC-approval document kept with the Flight Recorder</u>. It is recommended that an up-to-date copy of the approval document including its two annexes is kept with each unit of the equipment, so that it can be consulted by pilots and OOs as required. A copy of the current IGC-approval document in either written of electronic form must be included with each recorder sold or updated.

1.1.3.2.1 <u>Valid versions of the IGC-approval and program files</u>. The latest versions of IGC-approvals and the FR Manufacturers DLL files (or the earlier short progam files) are posted on the IGC web site, and only these versions are valid for use with IGC/FAI claims. Earlier versions of the IGC-approval and DLL/program files must not be used in the validation of flights to FAI/IGC criteria.

1.1.4 **Levels of IGC-approval**. The IGC-approval document for individual types of Flight Recorders will specify procedures to be used and any limitations on types of flights for which the approval is valid. Reduced levels of approval apply to types of Flight Recorders that do not meet the requirements for full approval at the time that the approval is given, and will be determined by GFAC. Reduced levels also apply where the security of a type of recorder has either been compromised or is below the requirements of the current Specification, or where other features do not meet the current Specification. The following levels of IGC-approval apply:

1.1.4.1 <u>IGC-approval for all flights</u>. This applies to Flight Recorders that may be used for evidence for all flights up to and including FAI/IGC world records. For new types of recorders, compliance with the current Specification is required. For types with existing IGC-approvals to this level, "Grandfather Rights" (1.1.4.5 below) apply unless there are major differences compared to the current Specification, as assessed by GFAC.

1.1.4.2 <u>IGC-approval for IGC/FAI badge and Diploma flights</u>. This applies to Flight Recorders that may be used for evidence for all IGC/FAI badge and distance Diploma flights, but must not be used for IGC/FAI world record flights. For competition flights, see 1.1.4.6. This level may be used for new recorders that do not meet the current Specification in some areas. For types of recorder that are already IGC-approved, this level may be used for those whose characteristics are now significantly below the current Specification standard, particularly on security or accuracy of data, as assessed by GFAC.

1.1.4.3 <u>IGC-approval for badge flights up to Diamonds</u>. This applies to Flight Recorders that may be used only for evidence for FAI/IGC Silver, Gold and Diamond badge flights, although for competition flights, see 1.1.4.6. This level may be used for recording systems that have significantly lower standards of security and other characteristics compared to those for higher levels of approval, as assessed by GFAC.

1.1.4.4 <u>No IGC-approval/non-IGC-approved Recorders</u>. This applies to types of Flight Recorders that have either not been tested and approved by GFAC to IGC standards, or to recorders that were previously IGC-approved but where a major security or other problem has been shown to exist which could compromise the integrity of flight data. It also includes FRs used in other FAI Airsports that output in the basic IGC file format where such recorders are not to be submitted for IGC-approval.

1.1.4.5 <u>Grandfather rights and approval levels</u>. The term "Grandfather Rights" is used for a situation where the conditions of an original IGC-approval are continued with time, even though the provisions of the IGC Specification or Sporting Code have changed. That is, the recorder would be subject to additional limitations or would not be approved at its existing approval level, if it were submitted for IGC approval as a new model. Continuity of the original approval is so that owners and manufacturers are not constantly required to carry out updates as the Specification or Sporting Code changes with time, unless a major difference exists in the type of recorder compared to the current Specification or Sporting Code. A similar policy is adopted in civil aviation by other aviation organisations such as the FAA and JAA with regard to already-certificated designs. However, GFAC reserves the right to change the conditions of an approval document where it considers that the current Specification or Sporting Code is sufficiently different to those under which the original approval was issued.

1.1.4.6 <u>Competitions</u>. The above sub paras apply to record, badge and distance diploma flights to be validated to FAI/IGC rules and procedures. For IGC competition flights, the types of recorders that may be accepted are (a) at the discretion of the competition organisers and (b) subject to any higher level rules and procedures that may apply to the organisers. For instance, Regional or National competition rules or Sporting Code Annex A procedures for World and other Championships that use Annex A rules.

1.1.5 **Changes of approval level.** If GFAC proposes to lower the approval level of a type of IGC-approved recorder, this will be discussed in confidence, first with the IGC ANDS committee and then with the manufacturer (approval levels, para 1.1.4). A recommendation will be made to the IGC Bureau at an appropriate stage. Further procedures, Appendix E.

1.1.6 **World Records**. Evidence for the verification of an IGC World Record must be from a Flight Recorder that is IGC-approved for World Record flights (SC3 para 3.0.3). See 1.1.4 on approval levels.

1.1.7 **Cockpit displays**. IGC is concerned by the potential risk of collision between gliders, due to over-concentration on cockpit displays, where the pilot would be better advised to be visually scanning outside the cockpit. Displays and instruments that need regular checking should not be mounted in instrument panels in positions away from external view, but should be in prominent positions close to the view of the outside world. Although IGC cannot control the layout of instrument panels, it can draw attention to the potential dangers. Particularly in single-seat gliders and other FAI aircraft, the position of displays connected to a Flight Recorder should not be remote from sight lines used for pilot lookout and scan for other aircraft. Displays should not be positioned so as to obstruct potential sight lines that might be needed for lookout.

1.1.8 **Antenna Positioning**. If the GNSS antenna is accessible to the crew in flight, no attempt must be made to inject any data that would alter that from the GNSS system concerned. Any abuse of this may lead to a future IGC requirement to place the antenna out of reach of the flight crew.

1.1.9 **Sealing of data ports and plugs**. Wherever possible, IGC-approval will not involve sealing of ports and plugs before flight, but no attempt must be made by users to pass unauthorised data into the Flight Recorder. Any abuse of this may lead to a requirement for sealing.

1.1.10 **IGC Standard of Security for the Flight Recorder and the IGC Flight Data File**. For IGC-approval to be given, the type of Flight Recorder must be protected by both physical and electronic security. A manufacturer's physical seal must be fitted to the recorder case in such a way that it will be broken if the case is opened. Also, a system must be incorporated that makes the internal electronic security system inoperative if the recorder case is opened or otherwise becomes insecure. Flights made after any such event must continue to produce IGC files, but such files must be clearly marked as insecure and must fail the IGC Validate check of the IGC file (see 1.1.10.1 below). Re-set of a recorder to a secure state must only be through the manufacturer or his authorised agent, and the knowledge of confidential details that are part of any re-set procedure (such as private keys) must be restricted to the absolute minimum number of people.

1.1.10.1 Electronic Validation of IGC Flight Data Files. The IGC electronic Validation system checks the security and validity of data in an IGC file, and can be used at any time to check a file. To use the IGC Shell program, the manufacturer's IGC-XXX.DLL file must be in the IGC Shell directory (XXX = manufacturer identification letters). Having executed IGC-Shell.exe, select the FR manufacturer in the box at the top of the display, press the display's Validate button, highlight the IGC file to be checked and click "Open". The result of the validation check will then be shown in a box in the middle of the display. Older recorders for which the manufacturer has not provided a DLL file for the IGC Shell program have a VALI-XXX.EXE program file instead. The IGC Shell program, DLL and VALI files are available at: http://www.fai.org/gliding/gnss/freeware.asp

If an IGC file passes the IGC electronic validation check, it shows (1) that the IGC file has originated correctly from a serviceable FR that has not been opened or been modified in an unauthorised way, and (2) that the flight data in the IGC file is identical to that which was originally downloaded immediately after flight. The IGC validation program will reject an IGC file if only one character in the flight data is not the same as originally downloaded This can be checked by copying an IGC file that passes the Validation check, and, on the copied file, using a text editor to change one character (such as one figure in a Lat/long, ENL or other flight data). The resulting IGC file should fail the IGC validation check. Then, restore the original character and the IGC Validation program should once again pass the file.

1.1.11 **Proof of presence of the Flight Recorder in the aircraft**. There must be incontrovertible evidence that the particular Flight Recorder was present and recording in the particular aircraft for the flight concerned. The procedures given in the IGC-approval document shall ensure this as far as possible. This is particularly important because, unlike other elements in the verification process, a FR and its IGC file contain virtually all the evidence for the flight. Proof of presence is particularly important with small, lightweight types of FR that can easily be transferred from one aircraft to another. Two methods are employed: (1) OO inspection of the FR installation, and (2) independent evidence of takeoff, landing and other evidence for the claimed flight (independent of the FR and its IGC file). These two methods are amplified below:

1.1.11.1 OO inspection and/or sealing to the glider. If an OO is not present to witness and to check the Flight Recorder installation at takeoff or landing or immediately before and after these times, the FR that is to be used for flight validation must be sealed to the glider structure by an OO. This may be carried out at any time or date before flight as long as the sealing is timed, dated and with the OO's identification clearly marked so that the OO can identify it later if necessary.

1.1.11.2 <u>Check of takeoff and landing , independent of the Flight Recorder data</u>. The times and points of takeoff and landing, shall be recorded either by an OO, other reliable witnesses, or by other means such as an Air Traffic Control or official Club log of takeoffs and landings. This shall be compared to the Flight Recorder takeoff and landing data (SC3 para 11.3). This is intended as a simple independent check of these aspects of the FR data. Following this, the rest of the data may be accepted as valid evidence for the claim, subject to (1) any anomalies being satisfactorily explained, (2) compatibility of the data with independently-known conditions for the flight and (3) the IGC file for the claim passing the IGC Electronic Validate check (see 1.1.10.1 above). Known conditions that can be independently checked include: (1) Wind observations at relevant altitudes (including those recorded officially by local meteorological offices and airfields) compared to thermal and other drift from the IGC file data. (2) conditions experienced by other aircraft and gliders in the same area and at similar time, including those available on other IGC files for comparison, and (3) direct observation of the aircraft by other pilots, witnesses, etc.

1.1.12 **Anomalies in evidence.** Any anomalies in evidence for a claim under IGC rules from an IGC-approved GNSS Flight Recorder should be referred to the GFAC Chairman for further investigation and to obtain an opinion from GFAC and its technical experts on whether the flight data can be accepted for an IGC claim. This should be done as soon as an anomaly is discovered, by the OO concerned or by the body that will validate the flight (such as the NAC) so that other supporting evidence is not lost due to the passage of time. It is important that the recorder is kept in its original state and is not re-set or modified until the investigation is completed.

1.2 **IGC GNSS FLIGHT RECORDER APPROVAL COMMITTEE (GFAC)**. A committee of at least five persons shall be appointed by IGC to test, evaluate, and approve individual types of GNSS Flight Recorders in accordance with para 1.1. GFAC members may delegate specialist work to other experts but are responsible for co-ordinating the work and for producing final recommendations. The detail of the work and any opinions expressed within GFAC discussion are confidential to GFAC and any other experts and IGC officials who may be involved.

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

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

1.3 **NOTIFICATION BY MANUFACTURERS**. Manufacturers who may apply for IGC-approval for their equipment should make contact with the GFAC Chairman as early as practicable during the design process. In the manufacturer's own interest, this should be before any design-fix is made, and before any commitment to large-scale purchase of specialised components. This is because initial discussion with GFAC on the intended design may reveal that changes have to be made before IGC-approval can be considered. The GFAC Chairman will provide the applicant with the current procedures for the approval process, such as the application form and documentation requirements.

1.3.1 **Correspondence with GFAC**. Manufacturers applying for IGC-approval must correspond with GFAC through its chairman who will inform other members and technical advisors, and co-ordinate any responses to the manufacturer. In cases where specialist matters are being discussed, the Chairman may authorise direct correspondence with an appropriate specialist GFAC advisor (such as on the detail of GNSS systems, electronic security and recording technology), but the GFAC Chairman must be copied with all correspondence so that he is aware of progress and of the issues involved.

1.3.2 **Submission of a new model of IGC Flight Recorder**. Details of the intended design should be sent to the GFAC Chairman as soon as available. These should include a brief specification, drawings, draft manual (if it exists at this stage), commonality with any existing models, etc. Manufacturers should not wait until these documents are final, drafts should be sent as soon as they are available. The Chairman will circulate such details to GFAC members and appropriate technical advisors and will co-ordinate comments that will be sent to the manufacturer. For communication, email is recommended with attached files in common formats such as MS Word, Excel etc. For diagrams and pictures, use a format such as JPEG, compressed to not more than 200kB per graphic unless requested otherwise. Details sent by the manufacturer will be treated as confidential to GFAC and its advisors.

1.3.2.1. <u>IGC flight data files</u>. As soon as IGC-format files are available from early Flight Recorder hardware, email copies to the GFAC chairman so that the exact format can be checked for compliance with the IGC standard.

1.3.2.2. <u>When recorder hardware is available</u>. Recorders should not be sent until GFAC comments have been made on the specification of the type of FR concerned, and IGC files have been produced and sent. When a complete or beta test version is available, and <u>before the fix-of-design stage is reached</u>, notify the GFAC Chairman. When the Chairman requests, send an example of the appropriate equipment for initial evaluation and feedback. The Chairman's evaluation team will test the hardware and report to GFAC members, relevant technical experts and to the Flight Recorder manufacturer.

1.3.2.3 <u>Fee to FAI</u>. When hardware is sent, the Flight Recorder manufacturer must apply to FAI on the forms provided and pay the appropriate fee to FAI, unless this has been done earlier. See also para 1.3.5.

1.3.2.4 <u>Sending Further Hardware</u>. All individual GFAC members have the right to ask for hardware for testing themselves. Therefore, after appropriate correspondence between the Chairman and the Flight Recorder manufacturer, and after any necessary changes have been made to the prototype equipment already evaluated, the chairman will notify the manufacturer of those GFAC members who wish to receive equipment to the latest standard for testing. Further detail, para 1.4.

1.3.3 **Re-approval after changes to a recorder**. For re-approval or continued- approval of a type of Flight Recorder after changes have been made to its design, the provisions of 1.3.2 that are relevant to the changes, apply.

1.3.4 **Documentation**. The recorder manufacturer or applicant for IGC-approval shall provide information to GFAC on how the particular model of Flight Recorder is intended to meet the IGC Specification.

1.3.4.1 <u>Security Protection</u>. A detailed description of security protection must be provided, including the design features that prevent deliberate or inadvertent misuse or production of false data. GFAC members and their advisors will keep such information confidential.

1.3.4.2 <u>Pressure Altitude Calibration</u>. The pressure altitude recording system in the Flight Recorder must be calibrated to the ICAO ISA using IGC/FAI procedures for barograph calibration. A calibration table and the IGC file for the calibration from which the figures in the table were obtained, must be forwarded with any hardware that is sent. For more detail on the accuracy of calibrations, see para 4.4.5.

1.3.5 **Fees and expenses for IGC-approval**. The appropriate fee must be deposited by the applicant in the FAI account (for the IGC Sub-account) when hardware is sent to the GFAC Chairman for evaluation. Expenses such as customs duties and national taxes for postage of recorder hardware must be paid by the applicant and not be an expense on GFAC members, IGC or FAI. If the receipt of payment is delayed, IGC-approval will not be given until the fee is received and all expenses attributable to the manufacturer have been paid. The fee is adjusted by IGC from time to time and details are available from the Chairmen of the IGC ANDS and GFA Committees. At the time of writing (year 2010) the fee is 1000 Euros (€) for an application for testing a new type of GNSS Flight Recorder for IGC-approval. For changes or modifications to an existing IGC-approved design, the fee depends on the complexity of the required evaluation as determined by GFAC, and may be the same or less. The current scale of fees is on the application form available from the GFAC Chairman.

1.4 **TEST AND EVALUATION FOR IGC-APPROVAL**. GFAC will complete Test and Evaluation (T&E) as soon as practicable on receipt of all of the appropriate material, normally within 120 days, unless there are unforeseen difficulties. The testing carried out by GFAC will be of a non-destructive nature but GFAC, IGC or FAI is not liable for any damage to, or loss of, any equipment. A sample test and evaluation schedule is at Appendix 2 of this document. 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 the GFAC persons to whom hardware should be sent. If the Flight Recorder manufacturer is not able to send equipment to all persons at the same time, equipment will be sent from person to person. In this case, the target evaluation period does not apply although the evaluation will be completed as soon as practicable. Any excess expenses incurred by individuals (such as postal, excise and tax), shall be paid by the Flight Recorder manufacturer into the FAI account on request so that individuals can be re-imbursed and do not have to pay these expenses themselves.

1.4.1 **Laboratory Testing**. GFAC may decide that a report on the Flight Recorder (or a particular aspect of the FR and/or its peripherals) is needed from a recognised independent testing laboratory. In this case, the applicant will be responsible for the expense of this report in addition to the application fee. The applicant shall be given the opportunity to withdraw the application before incurring this expense. Such requirements may arise if test or evaluation is required that is outside the expertise or facilities available to GFAC members and their advisers.

1.4.2 **ENL System - General**. The IGC Environmental Noise Level (ENL) system is designed to differentiate between any engine running that generates forward thrust, and any flight condition encountered in normal soaring flight without the use of engine. Pilots and OOs should note that the critical engine-on case with all motor gliders is not when the engine is run at high power. Also, the critical engine-off case is not a quiet glide with a well-sealed cockpit. These cases are covered below, and are particularly important with low-noise engines such as those using electric power, and low-ENL engines such as jets, see 1.4.2.4. Pilots flying such motor gliders should ensure that engine-recording systems have been provided in accordance with Sporting Code requirements so that their flights can be validated to IGC standards.

1.4.2.1 <u>High Engine Power</u>. A combination of engine and propellor noise at high power are expected to give ENL figures over 800 out of 999, the maximum ENL number in the IGC file. Most two-stroke systems produce ENL values over 900 and some give the maximum of 999. Four-stroke and Wankel (rotary) engines give lower figures but normally enough to differentiate between power-on and power-off. Some electric and jet engines at high power have also been shown to give moderate ENL values; however, high power is not the critical case in terms of differentiating between power-on and power-off flight, see below.

1.4.2.2 <u>Critical ENL Cases</u>

1.4.2.2.1 <u>Power - on</u>. The critical power-on case that is used for testing ENL is not full power, it is when any positive forward thrust is generated by the engine (SC3C para 12.1 and FAI GS 2.2.1.4). Under such conditions, recorded ENL must be high enough to differentiate from the Power-Off cases below; if it is not (such as with electric and small jet engines), an extra system operating under the MOP code must be fitted (see 1.4.2.4 and chapter 5).

1.4.2.2.2 <u>Power - off</u>. The critical ENL power-off case is not a quiet, well-sealed cockpit. It is a noisy cockpit, typically thermalling with air vents and cockpit panels open. This can produce ENL figures up to 300, more if sideslip is present and 400 has been seen. Another high-noise case is high speed flight with the cockpit panel(s) open, but this is not as realistic as thermalling with panels open because in this case the glider will be climbing and could be more easily be mistaken for use of engine.

1.4.2.3 <u>ENL numbers</u>. The three ENL numbers as recorded in IGC files must therefore differentiate between the "quiet engine" and the "noisy cockpit" cases. This is done by carefully selecting the frequency and gain at which the ENL system is most sensitive. The ENL system is then tested by GFAC in a range of motor gliders, gliders and powered aircraft. Experience has shown that peak sensitivity between about 70 and 300Hz with a typical "bell curve" (the statistical "normal distribution") either side of the peak frequency, gives a good ENL response to engine and propeller noise and less response to other cockpit noises.

1.4.2.4 <u>Low-ENL Motor Gliders</u>. Where an engine system produces low ENL values that make it difficult to differentiate between power-on and power-off flight (as assessed by GFAC using the criteria in 1.4.2), an additional system shall be provided in the motor glider concerned. This system must produce a signal that is shown in the IGC file under the three-letter code "MOP" (see Chapter 5), as an indication of forward thrust generated by the engine system. This applies to quiet engines such as those with electrical power, and others such as jets for which the frequency response or direction of noise does not register highly enough on ENL systems in cockpit-mounted recorders. This will be subject to GFAC evaluation and decision on the type of motor glider concerned.

1.5 **IGC-APPROVAL**. GFAC shall either approve, conditionally approve, or require modifications to the applicant's unit before IGC-approval to the appropriate level can be given (see 1.1.4 for levels). Drafts of approval documents will be circulated to GFAC members and associated experts, and to the Flight Recorder Manufacturer concerned. The final version is the responsibility of GFAC, which has the status of an agent of IGC and FAI (see para 1.1).

1.5.1 **Limitations before IGC-approval**. If GFAC decides that IGC-approval cannot be given to the appropriate level without changes being made (see 1.1.4 for IGC-approval levels), GFAC will inform the manufacturer of what is required in order to gain IGC-approval. This may involve an approval with limitations, such as an approval level other than "all flights" or an approval without an ENL system. If the manufacturer notifies GFAC within one month that the approval process should continue, the manufacturer will be expected to resubmit a modified Flight Recorder for further review by GFAC within the next six months. GFAC will aim to complete this review within three months, subject to not meeting any unforeseen difficulties. If this procedure is followed, no extra fee will be payable but the initial fee will continue to be held. An example might be where a motor glider Means-of-Propulsion (MoP) sensor system either was not included, or was assessed by GFAC as not being adequate. In this case an IGC-approval might be issued without the MoP sensor system, pending the development of a system which satisfies the IGC Specification, which would then be added to the Approval by amendment.

1.6 **APPLICANT'S AGREEMENT**. When an IGC-approval is issued, the applicant agrees to the following conditions:

1.6.1 **Changes to an IGC-approved Flight Recorder**. Notification of any intended change to hardware, firmware or software must be made by the manufacturer or applicant to the Chairman of GFAC so that a decision can be made on any further testing which may be required. This includes changes of any sort, large or small.

1.6.2 **Action on Changes**. GFAC may decide that a formal evaluation of such changed features is required, or, if the changes are extensive, that another full approval process is needed. This shall require a fee of up to that for a new type of FR.

1.6.3 **Changes in IGC-approvals**. IGC may remove or alter an existing IGC-approval document at any time.

1.6.4. **Manufacturer's details**. An IGC-approval is for the named product or products manufactured by (or under the control of) the Organisation whose details are given in the approval document in the paragraph headed "Manufacturer". Any changes to these details shall be sent to GFAC without delay, so that the approval document can be updated.

1.6.4.1 Transfer to another Organisation. An IGC-approval will only be transferred to another Organisation after consultation by GFAC with the previous and future Organisations, followed by amendment of the approval document.

1.6.4.2 Significant changes. If significant changes have been made in the Organisation listed in the IGC-approval document under "Manufacturer", FAI reserves the right to require a new IGC-approval process for the types of flight recorder concerned. In this context, the approval process will require the signature or re-signature of an approval application and GFAC may wish to test recorder equipment produced by the changed Organisation. What changes are considered significant will be as assessed by GFAC and include transfer of manufacturing responsibility to a different Organisation, acquisition of a name by another Organisation, or a change of structure or of key personnel within the same Organisation.

1.6.4.3 Cease of Manufacture and/or Support. Where a manufacturer ceases to make a particular type of recorder, GFAC shall be informed. The manufacturer shall state whether support for the type will continue such as updates and/or repairs to existing recorders.

1.6.4.3.1 Pilot aspects. Pilots should be aware that if they are using a recorder for which there is no manufacturer support, in the event of anomalies in the electronic data (IGC file) without manufacturer support to reduce any anomalies in IGC files, it may not be possible to validate such flights.

1.6.4.4 Exclusions. FAI, and their agents IGC and GFAC have no responsibility for, matters related to: (1) Intellectual Property (IP) and Intellectual Property Rights (IPR) or, (2) the relations of the Organisation with any others except with FAI and its agents or as they affect FAI, its agents and the IGC approval and others issued by IGC Air Sport Commissions.

1.7 **USE OF IGC FLIGHT RECORDERS WITHIN NATIONS**. A GNSS Flight Recorder operated in accordance with its IGC-approval document shall be used for all flights that require validation to FAI/IGC criteria including World Records (SC3, para 3.0.3) and World Championships (SC3 Annex A). An IGC-approved Flight Recorder must also be used for evidence for FAI/IGC Badge and Diploma Flights except that, for Silver and Gold badge flights only, evidence from a Position Recorder may be used under special Sporting Code rules (see the Glossary under "Position Recorder" for definition and SC3 references). For the different levels of IGC-approval from world records to badges, see para 1.1.4. IGC-approved FRs may also be used by NACs for flights under their jurisdiction, where FAI/IGC standards are specified such as for national and regional records, and com petitions. Where flight validation is not required to FAI/IGC criteria, the choice of criteria is at the discretion of those responsible for validating the flight.

1.7.1 **IGC File Format**. For the format of the IGC Flight Data file, see Chapter 3 and Appendix A. These references give the normal sequence of data in the IGC file and the detail on how it is to be shown. In the case of older types of recorder with Grandfather Rights (para 1.1.3.4.5), there may be some differences compared to the current IGC file format, but for a performance to be validated to IGC standards, in all cases the file must pass the IGC electronic Validation check (para 1.1.10.1).

1.7.2 **Non-IGC FRs**. Where flight validation is not required to FAI/IGC standards, the choice of criteria is at the discretion of those responsible for validating the flight, such as competition officials or, for non-IGC FRs, other FAI Air Sport Commissions.

1.8 **NOTIFICATION AND ISSUE OF IGC-APPROVAL DOCUMENTS AND FILES**. Notification of issue of a new or amended IGC-approval document will be posted on the Internet newsgroup rec.aviation.soaring (r.a.s.) and also on the FAI IGC-discuss list. The complete IGC-approval document will be posted on the web site www.fai.org/gliding/IGC_approved_frs. In addition, the FR Manufacturers DLL file (or, for older types of recorder, the short program files) for downloading IGC files, and for validating the integrity of such files, will also be posted for free access on www.fai.org/gliding/gnss/freeware.asp .

1.9 **PRODUCTION STANDARDS**. IGC reserves the right to inspect and test examples of products covered by IGC-approvals, for the purpose of checking compliance with the standards and conditions of their approval.

1.9.1 **Testing production equipment**. Such testing will be carried out by GFAC and may be at any time and without prior notice. GFAC may obtain recorder units under its own arrangements such as from owners or sales outlets, but, if requested by GFAC, the Organisation listed in the IGC-approval document under "Manufacturer" shall supply one set of hardware required for such testing.

1.9.2 **Results of testing**. If any problems are found or questions are raised, GFAC will correspond with the manufacturer. If this cannot be done to the satisfaction of GFAC, the terms of the IGC-approval may be altered under the authority of para 1.6.3 above.

1.10 **PROBLEMS OR QUESTIONS IN USE**. If any problems or questions arise during use of IGC-approved Flight Recorders, the GFAC Chairman should be notified in the first instance. See also para 1.1.12.

CHAPTER 2
GENERAL PRINCIPLES AND REQUIREMENTS

2.1 **IGC RESPONSIBILITY**. IGC has a duty to ensure that checks and design requirements are used to preserve the integrity of evidence, including that from GNSS Flight Recorders. This includes taking appropriate action to prevent and detect anomalies, loose practice, poor supervision, malpractice, even cheating, and also to ensure the use of common standards and data formats wherever possible.

2.1.1 **IGC disclaimer**. Where modules and sub-systems are used by a recorder manufacturer in a particular design and do not originate from that manufacturer, it is the responsibility of the recorder manufacturer to ensure that any Intellectual Property Rights (IPR) are properly covered where they relate to the module or sub-system concerned. This includes compliance with patent and similar requirements. Such modules or sub-systems may consist of hardware, firmware, software, a mixture, or intellectual ideas and principles. FAI and IGC have no responsibility for such rights and agreements as part of the IGC-approval process and recorder manufacturer are required to have obtained them for the use of the recorder internationally.

2.1.2 **Role of the IGC GNSS FR Approval Committee (GFAC)**. The IGC GFA Committee 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 (SC3B), which is the basis of Chapter 1 of this document.

    2.1.2.1 Factors to be evaluated . These include simplicity of operation for pilots, OOs and others during initial set-up, during recording in flight, and downloading and validation of data after flight. Also security of flight data; minimisation of opportunities for malpractice or cheating; compliance with the IGC data file format; other requirements from IGC and, for non-IGC FRs, from other FAI Air Sport Commissions.

2.2 PRINCIPLES FOR IGC-APPROVAL

2.2.1 **Operating Procedures**. IGC-approvals apply not only to the equipment itself, and may include both recommended and mandatory operating procedures. These include pre-and after-flight checks by OOs or others, sealing, stowage, etc., where these relate to the integrity of the IGC file that is downloaded after flight.

2.2.2 **Downloaded Data**. Although downloading in the IGC format is preferred, data initially downloaded may be in an intermediate format such as binary. Any intermediate format must be able to be converted into a separate file in IGC format either at the time or later, preserving the full security of the data in the resulting IGC file.

2.2.3 **References for GNSS Data in the IGC file**. For IGC-approval, the Earth Model to which recorded latitudes and longitudes are referenced, must be the WGS84 ellipsoid. The time datum is UTC. For more detail, see the Glossary under UTC and WGS84).

    2.2.3.1 Position data including Altitude. It must not be possible to change position and other data that will be used in the IGC file that is downloaded after flight other than by movement itself. However, manipulation of data outside the FR memory for presenting on cockpit displays is allowed, such as to show altitude above sea level or above ground rather than to the 1013.35 mB datum of the ICAO ISA. Also, controls, switches or buttons may be used in flight to change fix intervals or to select geographic points as navigational targets (for instance Waypoints or other points of interest to the pilot).

    2.2.3.2 Continuity of Time Data - the RTC. In addition to the date and time derived from the GNSS fixes themselves, a continuous Real Time Clock (RTC) function is required to maintain accurate time if GNSS fixing is not occurring. During any periods where GNSS data is not available, fixes must continue with the other data including pressure altitude and an accurate timebase.

2.2.4 **Pressure-Altitude Recording**. An IGC FR shall include a sensor producing an output of pressure altitude, calibrated to the ICAO ISA. The pressure altitude system must be compensated for temperature changes and the sensor must be of a type that is acceptable to GFAC. Such an FR also has the status of an IGC-approved electronic barograph. Fixes must continue to be recorded if the GNSS is inoperative for all or part of the flight (less the GNSS data fields). The pressure altitude system will be tested by GFAC for accuracy and compliance with this Specification. For further details on pressure altitude, see chapter 4.

2.2.5 **Motor glider Means of Propulsion (MoP) recording**. For self-launching and self-sustaining motor gliders, an IGC-approved system that records operation of the Means of Propulsion must be available. Such a system may also be required in non-IGC recorders. Inside the FR itself, the Environmental Noise Level (ENL) operates completely within the recorder case, and is mandatory for IGC FRs designed for use in motor gliders. For types of engine installations for which ENL does

not differentiate enough between engine running and gliding flight (as judged by GFAC, bearing in mind the critical cases given in para 1.4.2 and 5.6), an additional sensor operating under the MOP code must be used. Tests on engine-on and gliding conditions will be carried out by GFAC and conditions for the use of ENL and MOP systems will be given in the IGC-approval document for the type of FR concerned. This will include typical numbers between 000 and 999 that were found in GFAC tests for ENL and MOP. For further details on MOP recording, see chapter 5.

2.2.5.1 <u>Production standards</u>. FR manufacturers must ensure that production standards and settings for ENL and MOP detection systems are the same as those in the FR that was tested and approved by GFAC. Individual recorders must be tested before sale to ensure that the detection system(s) produce results similar to those described in Annex B of the IGC approval document for that type of recorder.

2.2.6 **The Recorder case**. The connections between GNSS receiver and the flight data memory module of an IGC FR must be entirely within a secure case, unless GFAC agrees otherwise. In all cases security must be demonstrated, particularly resistance to the injection of spurious or false data. For further details on security matters, see chapter 6.

2.2.6.1 <u>Identification Markings</u>. The case of an IGC recorder must be permanently marked with the name of the recorder manufacturer, the type and version and the three-character alphanumeric serial number (S/N) of that recorder. Where a display is available, the recorder make, type, S/N and version must be shown on that display for at least 10 seconds before it changes to another presentation, so that it can easily be written down by an OO before flight. Other details on the display are optional because many are included in the IGC file header record. Where a recorder is designed to be mounted in an instrument panel, the above data must be easy to see and record from the cockpit without having to access the back of the panel.

2.2.7 **Memory for flight data**. The memory used for storage of the flight data 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. When the memory is full, flight data shall continue to be recorded, for instance by over-writing the earliest data previously recorded.

2.2.7.1 <u>Preservation of memory data</u>. The design shall preserve flight data so that it can be downloaded after flight and also at later dates. The design should take into account conditions of impact (for instance, accidental dropping of the recorder), damage, and crash. Wherever possible, non-volatile memory should be used that does not depend on a sustainer battery for retention of data. If a sustainer battery is used, its position and wiring to the memory unit should be made as secure as possible with respect to impact or other damage. An individual recorder must have a system for maintaining its internal security for at least one year without application of external power and either be re-charged on application of external power or be capable of sustaining the security system for at least 2 years.

2.2.8 **Recorder functions within an Overall System**. Where the flight recorder is part of a larger system with other functions as well as the recording of flight data, the recorder functions and their security devices must be kept separate (in design terms) from other, wider functions of the design. This also applies to a recorder design that includes modules inside it that have functions other than the recording of IGC flight data. The manufacturer must be able to show that the design is such that there can be no interference with the recording functions, the security of their output and the download of data.

2.2.9 **Units and Conversion Factors**. Where conversions have to be made, the following shall be used, and are in accordance with international agreements:

Feet to metric distances:	1 inch = 1/12 foot = 2.54 centimetres exactly
Miles:	International Statute Mile = 5280 feet exactly
	International Nautical Mile = 1852 metres exactly
Speed:	Knots are Nautical Miles per hour
	"mph" refers to Statute Miles per hour

2.2.10 **Changes in IGC Rules or Procedures**. Where changes in IGC rules or procedures are made which affect a type of GNSS FR, the following timescale applies:

2.2.10.1 <u>FRs not yet submitted to GFAC or FRs under formal evaluation for IGC approval</u>. 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.

2.2.10.2. <u>FRs already having IGC approval</u>. 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 important changes must 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.

CHAPTER 3

IGC FLIGHT DATA FILES - PRINCIPLES

Detail on the format of the IGC file is in Appendix A, this chapter contains the main principles

3.1 **Earth Model**. Lat/long figures must be with respect to the WGS 84 ellipsoid (see WGS84 in the Glossary).

3.2 **Altitude**. Both GNSS altitude and pressure altitude to the ICAO ISA must be recorded.

3.3 **GNSS Receiver and Satellite capability**. The type of GPS receiver will be tested for accuracy and freedom from anomalies in recording lat/long and altitude. For IGC-approval, it must be of a type that is acceptable to GFAC, and must have the ability to receive data from at least 12 satellites at one time.

3.4 **Time**. The time datum is UTC. For fixes in the IGC file the UTC time must be derived from the same data package in which the lat/long and other material in the fix was derived, or, if GPS is not locked on, from the Real-Time Clock (RTC) in the recorder.

3.5 **Start of an IGC flight data file**. After switching on the FR, fixes may either be recorded in the IGC file as soon as GNSS lock-on has occurred, or the recorder may be configured to wait until movement is detected. Recommended thresholds for movement detection are a speed of 15 kph or a pressure altitude change of 1 metre per second for 5 seconds. Starting an IGC file when pressure change is detected is also important where pressure altitude calibrations are made in a sealed chamber in which GNSS lock-on is not possible.

    3.5.1 Pre-takeoff Baseline. To establish an accurate takeoff position and pressure altitude, a baseline of at least 20 valid fixes on the ground must be provided before takeoff. For more detail on how this can be achieved where recording starts when movement is detected, see Appendix A para A1.1.1.

3.6 **IGC file - fix Intervals**. The Sporting Code for Gliding (SC3) requires a fix interval of not more than 60 seconds for establishing flight continuity. For an IGC-approved FR, the maximum fix interval setting for use in cruising fight between waypoints shall therefore not be greater than 60 seconds, and must also allow for pilot choice of intermediate intervals such as 10 and 20 seconds for fixes to be recorded in the IGC file. A Pilot Event (PEV)/fast-fixing facility must also be included. After a Pilot Event (PEV) has been selected, a fix must be made immediately to which the PEV code is attached, followed by at least 30 seconds at a fix interval of 1 or 2 seconds. The Pilot Event must be easy to initiate and not require more than one switch action or button-press, after which the pilot must receive a positive alert (for instance, an audio tone or a clear indication on a display). Fast fixing may also be automatic such as when near Observation Zones of Waypoints whose positions have been stored in the Recorder and selected for the flight.

    3.6.1 Other data in Fixes. For IGC-approval, the following are required: recording of fix validity; error circle; and IDs of satellites used in position calculations. Signals marked "unhealthy" must not be used in fixes included in IGC files. For non-IGC FRs, these are recommendations rather than requirements.

3.7 **End of an IGC file**. The IGC file must not be ended until one of the following three conditions apply: (1) if no horizontal or vertical movement has been detected for 10 minutes (thresholds as in 3.5 above); (2) after the recorder is switched off by deliberate action, or; (3) if the recorder is still powered after the flight, when the user establishes a connection for downloading from the recorder. The 10 minute period is so that the IGC file does not end prematurely during a period in wave or ridge lift without much movement. A delay before ending the IGC file is also needed for barograph calibrations so that a new file is not produced while the calibrator is making small adjustments to the pressure at each level of the calibration.

3.8 **Low Voltage**. For IGC-approval of recorders working at a nominal 12 Volts DC, correct data recording must continue in the range 10-16 volts. If recording fails due to lower voltage, data up to that point must not be lost. See Appendix A para A7 for use of the Three Letter Code LOV for low voltage.

3.9 **Task declarations**.

    3.9.1 Pre-flight Declarations. The C-record in an IGC file is for a pre-flight declaration. For World records, the Sporting Code for gliding (SC3) requires an electronic declaration; a paper declaration is not valid. Many other flight claims need an electronic declaration. Therefore, for IGC-approval of a Recorder at the "all flights" level, an electronic declaration facility is required and is desirable at other approval levels.

    3.9.2 Electronic declarations. Where an electronic declaration facility is included (at any IGC-approval level) the FR manufacturer must include setup software that allows the user to create the declaration data that is required by the

Sporting Code for Gliding (SC3). The software must be easy to use and must allow inputs of the data required by SC3 to appear in the C-record (for Waypoint co-ordinates) and the H-record (for pilot, glider etc). There must be an option to input lat/long in degrees and decimal minutes, to three decimal places of minutes. The software should allow declared Points to be extracted from Waypoint lists in at least one of the common formats that are available internationally through web sites as the Worldwide Soaring Turnpoint Exchange (http://soaringweb.org/TP).

3.9.3 Post-Flight Declarations. For "Free Flights" under SC3 rules, a pilot may select waypoints after flight based on where the glider is recorded to have flown and the type of flight to be claimed. If these are to be added to the IGC file (compared to being nominated separately), the Logbook Record (L-Record) shall be used, using the same format as the pre-flight declaration but with the letters LP for Post-Flight instead of C at the beginning of each line. The use of the L-Record is to ensure that adding these details after the flight, does not invalidate the electronic security of the IGC file because the L-Record is not included in the IGC electronic Validation check.

3.10 **First lines of IGC files - Serial and Version Numbers**. The first line of the IGC file contains a manufacturer identification and a three-character alphanumeric Serial Number (S/N) unique to that Recorder. The H- (header) record of the IGC file must also include the version number of hardware, firmware, and details of the GPS receiver and Pressure Altitude sensor (see Appendix A paras 3.1 and 3.2).

3.11 **Download, Conversion, and Validation of Flight Data**. For new types of recorder for IGC-approval, manufacturers must produce the appropriate DLL file to enable the IGC Shell system (see Appendix C) to perform the download, conversion (from binary to the IGC format, if initial download is in binary) and validation functions. Before the IGC Shell system was produced, self-executing DOS-based short program files DATA, CONV and VALI were used for these functions but these now only apply to IGC-approved recorders operating under "Grandfather rights" where the manufacturer has not produced an IGC Shell DLL file, although manufacturers producing a DLL may also produce the DOS files if they wish. The structure of the DOS-based files is given in Appendix D. This software is made available by IGC as freeware on:

www.fai.org/gliding/software/gps/pc , also through: www.fai.org/gliding/gnss

FR manufacturers must check from time to time that their DLL and other files included on these web references are up to date. Manufacturer's manuals should remind customers to check the web site above from time to time in case updated versions have been made available.

3.11.1 Format of downloaded data from the FR. In accordance with para 2.2.2, the data downloaded from the FR may be either in a manufacturer's proprietary file format (such as binary), or directly in the IGC file format described in this Chapter and in more detail in Appendix A. For IGC FRs, in the IGC file format, whether obtained on initial download or on later conversion, the source of the G- (security) record must be from the FR itself and not, for instance, from the program used for downloading or conversion. In all cases, the IGC-format file shall be able to be checked by the IGC Shell program (or the earlier VALI short program file) by the NAC or other validation body before an overall flight performance may be validated to the standards of IGC.

3.11.2 Retention of Originally Downloaded file. Where the data initially downloaded is in a different format (such as binary) this file must be retained so that the conversion may be repeated later if required.

3.12 **Fix Accuracy - Averaging Algorithms**. Some commercial GPS receivers 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. FR manufacturers must ensure that any such averaging programs operate only over short time periods and do not produce false fixes, particularly close to Observation Zones. The principle is that Fixes recorded on the IGC data file must be based on the processing of real position-lines from GNSS satellites.

3.12.1 Throw-forward of fixes. Some GNSS systems have a forward-prediction system (sometimes called "DEDuced -" or "dead - reckoning"), where fixes are not derived from GNSS lines-of-position but, if GNSS lock is temporarily lost, fixes are predicted based on past velocity. With such systems, it has been shown that a glider approaching 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. **For IGC-approval, such systems must be disabled**. GFAC ground testing will include approaching a turn point, disconnecting the GNSS antenna followed by a sharp turn; and no fixes must be thrown forward of the true position when the antenna was disconnected.

CHAPTER 4
PRESSURE ALTITUDE RECORDING

This chapter amplifies the basic requirement given in 2.2.4

4. **PRESSURE-ALTITUDE RECORDING – BASIC PRINCIPLES**. An IGC FR shall include a sensor producing an output of pressure altitude, calibrated to the ICAO ISA. Fixes must continue to be recorded (less the GNSS data fields) if the GNSS is inoperative for all or part of the flight. Reference: para 2.2.4

4.1 **Other uses of pressure altitude data**. Data may be used for other purposes such as cockpit displays, and in these cases another zero datum such as Sea Level or Ground Level may be used instead of 1013.25mB of the ICAO ISA that must always be used in the IGC file. It must not be possible to alter the pressure altitude figures in the IGC file from outside the secure case of the FR.

4.2 **Baselines for Takeoff and Landing**. In accordance with 3.5.1, a baseline must be recorded before take-off for comparison with any independent measurement of airfield pressure. Similarly for landing under 3.7.

4.3 **Cockpit or instrument static sources**. For stand-alone FRs, the pressure recorded in the IGC file must be "cockpit static" (vented within the FR box). For FRs mounted in an instrument panel, the pressure recorded may either be "cockpit static", or use a tube connection to the instrument static pressure system.

4.4 **Pressure Altitude Calibration**

4.4.1 Sensor adjustments. Electronic sensors have settings that can be adjusted by the FR manufacturer (1) for sea level pressure and (2) a gain setting for the rest of the altitude range. The output from the sensor system will be converted to digital altitudes through an Analogue-to-Digital converter and these digital altitudes will be used as the pressure altitude element in the IGC data file. The capability of the A-to-D converter (10-bit, 16-bit, etc) will govern the size of any steps (altitude resolution) in the altitude output to the IGC file, for which a limiting value is given below.

4.4.1.1 Resolution. The maximum permissible step in digital recording of altitude in the IGC file is one third of a hectoPascal (millibar) throughout the height range of the FR. On the ICAO ISA at sea level, one hPa is 27.0 ft (8.23m) in altitude. Therefore, 1/3 hPa is 9 feet or 2.74m, and the height difference for 1/3 hPa increases with altitude in accordance with the ICAO ISA.

4.4.2 Start of recording and calibrations. 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 that 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 and a suitable trigger value for starting recording is given in para 3.5.

4.4.3 Fix interval during Calibrations. A short fix interval is required so that the pressure level in the altitude chamber, once set, does not have to be held for an extended period. It should be possible to set a 1 or 2 second fix interval before the calibration starts. For recorders with non-variable fix rates in excess of 2 seconds, this may be set through a special calibration mode. Any such special calibration mode should be easy to set by the pilot or owner of the recorder and subsequently be continued until re-set to flight mode later. This is so that a calibration centre only has to switch the recorder on and carry out the calibration without any extra switching.

4.4.5 Calibration - correction tolerances. The pressure altitude sensor adjustments must be set by the manufacturer so that the output in the IGC file corresponds closely to IGC/FAI pressure altitude (the ICAO International Standard Atmosphere, Document 7488 tables 3 and 4). Large corrections must be reduced by adjustment so that, for instance in competitions, constant reference to calibration tables for individual FRs can be avoided. If larger calibration corrections are found due to drift with elapsed time, it must be possible to re-set the altitude sensor to the above criteria by returning the FR either to the manufacturer or his authorised agent. Such agent must also be qualified to re-set security on re-sealing the FR. The following tolerances are copied from Chapter 2 to Annex B to the Sporting Code for Gliding (SC3B), and apply on set-up and calibration before or immediately after initial sale:

4.4.5.1 The sea level setting must correspond to the required ISA (1013.25 mb) within 1 millibar; (1mb at SL = 26.9 feet (8.2m))

4.4.5.2 Up to an altitude of 2000 metres, calibration correction must be within 3 millibars;
   3mb at 1000ft (304.8m) = 83.2 feet (25.4m)
   3mb at 2000ft (609.6m) = 85.5 feet (26.1m)
   3mb at 3000ft (914.4m) = 88.2 feet (26.9m)
   3mb at 4000ft (1219.2m) = 90.9 feet (27.7m)
   3mb at 5000ft (1524.0m) = 93.8 feet (28.6m)
   3mb at 6000ft (1828.8m) = 96.5 feet (29.4m)
   3mb at 7000ft (2133.6m) = 99.7 feet (30.4m)

4.4.5.3 Above 2000m, calibration correction must be within one percent of altitude..

CHAPTER 5
MEANS OF PROPULSION RECORDING

This chapter amplifies the general provisions of 2.2.5

5.1 **GENERAL**. For self-launching and self-sustaining motor gliders, an IGC-approved system that records operation of the Means of Propulsion must be available in the FR. Such a system may also be required in non-IGC recorders. Inside the FR itself, the Environmental Noise Level (ENL) system operates completely within the recorder case, and is mandatory for IGC FRs designed for use in motor gliders. For types of engine installations for which ENL does not differentiate enough between engine running and gliding flight (as judged by GFAC, bearing in mind the critical cases given in para 5.6), an additional sensor under the MOP code must be used. (The above is an extract from 2.2.5). Where the term "MoP" is used in this chapter, it is an abbreviation for "Means of Propulsion", a term used in the Sporting Code for Gliding to mean "engine". Where "MOP" is capitalized it refers to the specific recording system described in this chapter in 5.4 under the MOP three-letter code in an IGC file.

5.2 **Fix recording**. 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. In the case of systems under the ENL and MOP codes, a fix must be recorded immediately the ENL or MOP value exceeds 500 (out of the maximum of 999) for the first time, subsequent fixes being at the selected fix interval.

5.3 **Environmental Noise Level (ENL) systems**. For IGC FRs designed for use with motor gliders, an ENL system is mandatory (paras 2.5 and 5 refer). This is where acoustic noise is recorded using a microphone and signal processing, all within the case of the Recorder. A three-number ENL value is added to each fix in the IGC file, utilising all of the whole numbers between 010 and 999 (for 000, see 5.3.1). For IGC-approved ENL systems, no specific engine-run is needed on each flight to "prove" the system. ENL systems using peak frequency sensitivities in the range 100-300 Hz have been shown to work well with piston engines in motor gliders. However, in design, careful processing of the raw noise signal is required (frequency filtering and weighting) so that a high ENL value is always placed on the IGC file when forward thrust is generated by the MoP. ENL values associated with gliding flight must be significantly lower, see 5.3.1. Where an ENL function is incorporated it must not be possible to disable it, because if used in aircraft without a MoP, an ENL record has been found useful as additional evidence during post-flight analysis.

5.3.1 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 FR in a typical position in a glider cockpit. Less noisy engines such as 4-stroke and Wankel (rotary) engines, may not produce such high figures, but must still result in ENL values over 600 when forward thrust is being produced, so that any engine and/or propeller running can be clearly identified. At the other end of the scale, quiet gliding flight must result in low but positive ENL readings so that the system is seen to be self-checking with each fix. For new types of IGC FRs, periods showing 000 are not acceptable and figures between 010 and 020 must be achieved in quiet flight in a well-sealed sailplane. Other cockpit noise levels such as in gliding flight with cockpit ventilation and other panels open (with and without sideslip) must be recorded at sufficiently low values so that they cannot be mistaken for use of engine. In the case of sideslip with cockpit panels open at thermalling speeds, ENL should be less than 300 and preferably 200. See also para 5.6 on critical ENL conditions and Appendix B para B8.5 on flight testing of ENL systems.

5.3.2 Covering the FR. Although the FR should be mounted in the cockpit without any objects placed on top, in the event of the FR being covered with material that may be noise-insulating, the design must ensure that ENL levels are maintained as far as possible, such as by using an Automatic Gain Control (AGC) system.

5.3.3 GFAC ENL system testing. In the case of a type of ENL system that is not yet IGC-approved, it is recommended that the recorder that is sent for initial GFAC testing has special facilities so that the frequency of peak sensitivity and also the ENL gain settings (and any other variables relevant to the ENL system), can be adjusted by the GFAC tester. This is so that recorders for which the initial ENL settings are found unsatisfactory for IGC-approval, do not have to be returned to the manufacturer for adjustments that could easily have been made during testing. Experience has shown that a peak frequency sensitivity between 75 and 300 Hz discriminates between the noise of 2-stroke, 4-stroke and Rotary (Wankel) engines, and cockpit noise during gliding flight. Tests will also be made with quieter motor glider engines and in glide conditions of high cockpit noise such as with canopy panels open. GFAC tests on ENL systems include using an acoustic generator to test sensitivity (the ENL numbers on the IGC file) with frequency, and these tests normally produce a typical "bell curve" (the "normal distribution" curve). For more detail on ENL tests, see Appendix B para B8.5.

5.4 **Sensors external to the FR – the MOP three-letter code**. For types of MoP where GFAC assesses the ENL values as being too low to differentiate between engine-on flight and some conditions in normal soaring flight, an additional sensor system shall be required that operates under the Three-Letter Code MOP. This records an engine function approved by GFAC (in addition to the ENL system within the FR) that is supplied to the recorder by an appropriate signal or sensor, for which three numbers between 000 and 999 are available in the IGC file under the MOP code. At maximum engine power, a MOP value over 900 is required, and at power for level flight, a value of over 600. See also Appendix A (the IGC file structure) under MOP in para A5 (Definitions) and para A7 (Three-Letter Codes).

5.4.1 Positioning of the Sensor. The sensor may be connected by a cable to the FR (see below for security aspects) and, if required, be positioned close to the engine and/or propeller so that it receives a strong signal when the engine is running. An example is an acoustic system with its sensitivity matched to the frequency of sound produced by the engine or propeller system. In the case of an electric engine using a propeller, sound is produced in the plane of the propeller at frequencies related to the blade-rate. For jet engines, RPM (and frequency produced) is much higher than the piston engines for which existing ENL systems are designed, and high sound/noise values are produced near and to the rear of the jet pipe.

5.4.2 Type of Sensor. The nature of the sensor and how its signal is processed shall be approved by GFAC and will be assessed during the testing process before IGC-approval. See above for acoustic (sound/noise) sensors, others could use fuel flow, engine RPM, jet pipe or other temperature, and so forth, at the discretion of the recorder manufacturer. Because GFAC may approve different sensor systems, in the IGC file a description of the type of sensor shall be given in the H (Header) record in the form HFMOPSENSOR Text String.

5.4.3 Integrity of the system. When the system is not sensing any signal and otherwise an MOP value of 000 would be recorded, an MOP value of 010 shall be used to indicate (1) continuity of any wire leading to the sensor or supplying the signal, and (2) serviceability of the sensor or signal itself (where 000 would otherwise be recorded. One (but not the only) solution is for the Recorder to generate a coded pulse that is sent at regular intervals down the wire, the return of which indicates the two conditions above and causes the number 010 to be placed on the IGC file for the fix concerned. Such systems will be assessed by GFAC during the testing process before IGC-approval.

5.5. **Other Engine Sensors**. In early IGC FR designs, two other types of sensor were used and still have Grandfather Rights, within the levels and other terms of the IGC-approval for the types of recorder concerned.

5.5.1 Vibration sensor. 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. 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 requires that an engine-run is carried out on each flight before the soaring performance, and that it must be shown 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 that 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 must be 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.

5.5.2 Microswitch-based systems. These involve cabling external to the FR which runs to a microswitch or equivalent 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 (TLC) 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 A7). These systems have the disadvantage that there is no positive and continuous signal on the IGC file when the engine is running, and missing one microswitch operation would cause the indications on the IGC file to be misleading. The system must be fail-safe in the sense that failure must give an 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 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.

5.6 **Critical ENL and MOP Recording Cases**. Based on 1.4.2.

5.6.1 Power-on. The critical power-on case that is used for testing ENL and MOP systems is power for low-speed cruise, that is, just sufficient power for level flight in still air. At this condition, recorded ENL must be high enough to differentiate from the Power-Off cases below; if it is not (such as with electric and small jet engines), the extra MOP system must be fitted.

5.6.2 Power-off. The critical ENL and MOP power-off case is not a quiet, well-sealed cockpit. It is a noisy cockpit, typically thermalling with air vents and cockpit panels open. This can produce ENL figures up to 300, more if sideslip is present and 400 has been seen on some recorders. Another high noise case is high speed with the cockpit panel(s) open, but this is not as realistic as thermalling with panels open because in the latter case the glider will be climbing and could be more easily be mistaken for use of engine.

5.6.3 ENL and MOP numbers. The three ENL and MOP numbers as recorded in IGC files must therefore differentiate between the "quiet engine" and the "noisy cockpit" cases. This is done by carefully selecting the frequency and gain at which the ENL system is most sensitive, and in the case of MOP systems, testing the sensor provided by the FR manufacturer, which could be acoustic, RPM, fuel flow, temperature (for instance Jet Pipe Temperature). The ENL and MOP system is then tested by GFAC in a range of motor gliders, gliders and powered aircraft.

5.7 **Production standards**. FR manufacturers must ensure that, at the point of sale, the MoP detection system of a recorder produces figures results similar to those described in Annex B of the IGC-approval document for that type of recorder.

CHAPTER 6

SECURITY OF RECORDERS AND DATA

This chapter gives the broad principles, detail is in Appendix F

6.1 **IGC Security - General**. Security procedures related to hardware, firmware and software must be used so that no alteration of recorded flight data may occur without such alteration being detectable. For the IGC file, this is achieved by a system where a digital signature (DS) is generated by the FR. This system creates the G- (security) record at the end of the file, which enables the flight data to be checked for validity through the IGC electronic validation program. More detail is in this chapter and in Appendix F. Regardless of the level of physical control used in handling and transmitting data between the FR and the authority validating the flight, the DS system must enable detection of any alteration of data from that initially download from the FR and at any time afterwards.

6.1.1 Security Keys. Individual FRs must have different security keys to those for other recorders from that manufacturer, so that if the key for one FR is broken, the rest of the product range will still be secure.

6.1.2 Levels of IGC-approval. Security aspects are important factors in the types of flights for which a recorder is given IGC-approval, the highest approval level being for "all flights". The list of different approval levels is in para 1.1.4 of this Specification, copied from the same para in Annex B to the Sporting Code for Gliding (SC3B).

6.2 **Physical Seal**. Unless the construction of the recorded case is permanently sealed to the satisfaction of GFAC, the case must have a tamper-proof physical seal across at least two joints or screws, so that the seal will be broken if the case is opened. The type of seal must be approved by GFAC and must have markings unique to the recorder that are difficult to replicate. Seals with holographic symbols are preferred. The seal material must be such that it breaks when it is peeled off and it must not be possible to remove intact in the presence of heat or solvents, so that it could be re-fitted.

6.3 **Wires passing through the FR Case**. Only the following wires may pass through the boundaries of the recorder case, or the secure recorder module within the case of a system with wider capabilities.

6.3.1 Electrical power. Wires carrying electrical power to the GNSS receiver and FR. Unless the recorder has an internal battery capable of running the recorder for at least 10 hours, it must be designed for use with an external 12V DC battery system unless agreed otherwise by GFAC. For input voltage tolerance, see para 3.8. Recorders with internal batteries should also be able to operate on external power, to allow for very long flights and also for low charge on the internal battery.

6.3.2 The GNSS receiver antenna cable. The antenna, its wiring and connection to the FR are critical parts of the system without which GNSS fixes will not be obtained. In case of a defect, the components external to the FR case must be easy to replace with serviceable ones. Therefore, for FRs with external antenna connections, any antenna connector on the FR case must be to a type of antenna cable connector that is commonly-available worldwide, be separate from other connectors and be designed and specified for low energy antenna signals, including GPS frequencies around 1.5 GHz. It is recognised that some FR designs have antennas that are integral with the recorder case and an external connector does not apply.

6.3.2.1 Antenna connectors. The IGC standard external antenna connectors on the FR case are the 9mm BNC bayonet, and, where a smaller connector is desired, the SMC (Sub-Miniature type C) screw fitting with 4mm female and 3.5mm male components. Where a screw fitting is used in a glider installation, it is recommended that it is prevented from un-screwing by the use of locking agent that will hold it firm but allow it to be unscrewed later if required. For new types of IGC Recorders, push-pull antenna connectors will not be IGC-approved because they can become disconnected in a glider installation if the wire is inadvertently put under tension (push-pull connectors are those that can be disconnected solely by a pull-action rather than by a turn or screw action).

6.3.3 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 must be buffered by the manufacturer such that no alteration to GNSS fixes or the geodetic datum/earth model used for IGC files is possible through this cable.

6.3.4 Cables for approved functions. A cable for other functions approved by GFAC, provided that no alteration to GNSS fixes or the geodetic datum/earth model used for IGC files is possible through this cable. These functions include a Pilot Event (PEV) marker and a Motor Glider sensor system under the MOP code.

6.3.5 <u>Connector cable for data download from FR to PC</u>. The types of IGC-approved connectors on the FR case for download of flight data are specified in Appendix E.

6.3.6 <u>Separate GPS Receiver Unit - Data Cable to Recorder</u>. If 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 or the geodetic datum/earth model used for IGC files is not possible; except as signalled by genuine fix and other data from the receiver module.

6.3.7 <u>Connectors and fittings for data download from FR to PC</u>. The types of IGC-approved connectors or fittings on the FR case for download of flight data are specified in Appendix E. Some fittings such as memory cards and USB memory sticks do not need a PC to be connected to the recorder for downloading flight data.

6.4 **Connectors and Fittings for downloading Flight Data**. IGC-approved types of connectors for downloading flight data are listed in Appendix E. Where a PC is used for downloading, either the RJ45 or the USB type of connector is recommended because standard wiring to these types includes both power and data download facilities. The IGC standard connections for the RJ45 are given in Appendix E and the USB connections are to the international standard. For panel-mounted recorders, it is recommended that an industry-standard memory fitting is on the front face (such as an SD card or USB connector); if the connector for downloading is elsewhere, an extension cable should be supplied so that there is no need to gain access to the back of the instrument for routine downloading.

6.5 **Identification of Inaccurate Data**. A method must 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 that marks 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.

APPENDIX A

THE IGC DATA FILE FORMAT

A1. **INTRODUCTION**

A1.1 **The IGC File**. 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 through regular amendments. It provides a common world standard data format for the verification of flights to FAI/IGC criteria. It may also be used by other FAI sports and activities, but in this case the exact format may not be followed precisely.

A1.1.1 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 relevant to the flight such as header records, flight declaration, fixes, security record, etc (see para A2.2 for list of record types in an IGC file). Fixes in the IGC file (B-record lines) may be recorded continuously between the times that the FR was switched on and off. Alternatively, the FR may have a "standby" state after switch-on, see para 3.5 in the main body of this document for the thresholds for starting recording of fixes.

A1.1.1.1 Pre-takeoff Baseline. For FRs that only start recording fixes in the IGC file after movement is detected, a pre-takeoff baseline must be provided (see para 3.5.1 in the main body). For this, a memory circuit can be used that continuously stores the appropriate number of previous fixes and, when movement is detected, uses them for the first B-record lines in the IGC file.

A1.1.1.2 Ending recording. Under flight conditions of little horizontal or vertical movement, the IGC file must continue to record data and must not be ended while flight continues. See para 3.7 in the main body of this document for the criteria for ending an IGC file.

A1.1.1.3 Data download to a PC. If the data for several flights is held in the FR memory, it must be ensured that when the data is downloaded, 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.

A1.2 **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).

A2. **GENERAL**

A2.1 **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 A2.2., 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 Header and Flight Declaration take several lines. For instance, the Header (H-) Record includes separate lines for GNSS FR type, type of GNSS receiver and Pressure altitude sensor, pilot name, glider identification, etc., and the Flight Declaration (C) Record includes lines for the co-ordinates of each Waypoint. The order of Record types within an IGC file is given in para A2.3. 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 A6 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.

A2.2 **Record Types**. Each record types is prefixed by an upper case letter that appears in the IGC file as the first character on the line concerned:

IGC DATA FILE FORMAT - RECORD TYPE IDENTIFICATION LETTERS	
A - FR manufacturer and identification	H - File header
B - Fix	I - List of additional data included at end of each B-record
C - Task/declaration	J - List of additional data included at end of each K-record
D - Differential GPS	K - Frequent data, additional to the B-record
E - Event	L - Logbook/comments
F - Satellite constellation	M, N, etc. - Spare
G - Security	

A2.3 **Record Order**. The 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 identify data included in B and K record lines later in the file. These are followed by other Record types 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 time from the recorder's Real Time Clock (RTC); these are B (fix), E (event), F (constellation change) & K (additonal 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.

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:

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

A2.4 **Units**. Data in the IGC file shall use the following unit system. For international conversion factors to be used, see para 2.2.9 in the main body of this document.

Altitude - Metres, separate records for GNSS and pressure altitudes.
Date (of the first line in the B record) - UTC DDMMYY (day, month, year).
Latitude and Longitude - Degrees, minutes and decimal minutes to three decimal places, with N,S,E,W designators
Pressure - Hectopascals (the same as millibars) to two decimal places, for instance altimeter subscale setting, but see * below under PPPPpp
Time - UTC, for source, see para 3.4 in the main body in this document. Note that UTC is not the same as the internal system time in the U.S. GPS system, see under "GPS system time" in the Glossary.

And, where calculations are made from successive fixes:

Direction - degrees True, clockwise from 000 (North)
Distance - Kilometres and decimal kilometres. For conversions from feet and miles, see para 2.2.9.
Speed - Kilometres per hour. For conversions from knots and mph, see para 2.2.9.

The previous items shall be recorded as follows:

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

> Altitude, GNSS. 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.

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, fixed to 2 digits with leading 0 where necessary

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

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

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

Pressure - 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 (ICAO 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 (three-letter code ATS), for instance where the FR feeds a cockpit display. However, this must not be used to change the pressure altitude recorded in the IGC file, which must remain with respect to the ICAO ISA with its fixed sea level datum of 1013.25 mb.

Speed (where calculated from successive fixes) - 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)

Time - HHMMSS (UTC) - for optional decimal seconds see "s" below
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 where necessary
s - number of decimal seconds (if used), placed after seconds (SS above). If the recorder uses fix intervals of less than one second, the extra number(s) are added in the B-record line, their position on the line being identified in the I-record under the Three Letter Code TDS (Time Decimal Seconds, see the codes in para A7). One number "s" indicates tenths of seconds and "ss" is tenths and hundredths, and so forth. If tenths are used at, for instance, character number 49 in the B-record (after other codes such as FXA, SIU, ENL), this is indicated in the I record as: "4949TDS".

A2.5 **FILE NAMING**

A2.5.1 <u>Short file name style</u>:   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 on next page)
   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

A2.5.2 <u>Long file name style</u>. This uses a full set of characters in each field, a hyphen separating each field, the field order being the same as in the short file name. For instance:

Short file name: 36HXABC2.IGC
Long file name: 2003-06-17-XXX-ABC-02.IGC
                where XXX is the manufacturer's three-letter IGC identifier
                ABC is the IGC serial number/letters of the individual recorder.

In the long file name, the ABC field is not limited in the number of characters but by the hyphens at the start and end of the field. This can be used by a manufacturer to differentiate between different types of recorder, such as by having a different first serial number/letter for each recorder type. Long file names may be generated by appropriate software, although the (now obsolete) DOS versions of the DATA, CONV and VALI programs (See Appendix D) will continue to generate and use short file names.

A2.5.3 <u>FR Serial Number (S/N)</u>. For IGC FRs, the three-character S/N must be used in the A-record and be imprinted on the case of the recorder unless the case includes a display which includes the S/N. See the definition of Serial Number in the Glossary.

A2.5.4. <u>Date of flight</u> - 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 B-record of the IGC file downloaded after flight. This in not necessarily the date at the time of switching on, or of take-off. This distinction is particularly important in time zones where a recorder is switched on close to midnight UTC.

A2.5.5. <u>Security of file name</u>. The file name is not protected by the electronic security system, which applies to flight data within the file itself. File names may be changed for specific purposes such as competitions, where it may be found more convenient to change from the IGC name 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.
Example: 968EXYZ2.IGC = 8 June 2009, EW FR serial XYZ, Flight 2 of the day.

A2.5.6 <u>Manufacturer codes</u>. Single- and three-character codes are tabulated below. Manufacturers applying for IGC-approval who are not listed should apply to the Chairman of GFAC for allocation of codes. Manufacturers using the IGC file format but not applying for IGC-approval should use the X and XYY codes, see note 2 at the end of the table.

A2.5.6.1 <u>Name of Intermediate Format file</u>. If a manufacturer chooses a system where data is download from the recorder in an intermediate format such as binary, the file name for the intermediate format shall be as for the IGC file but with the Manufacturer's three letter code used instead of "IGC" after the dot. It shall then be possible to convert the intermediate format to the IGC format through the Conversion utility that is part of the manufacturer's IGC-XXX.DLL file and the IGC Shell program (see Appendix C) or, for earlier systems, through the CONV-XXX.EXE program file (see Appendix D).

Single Char. Code	Three Char. Code	Manufacturer's Name	Single Char. Code	Three Char. Code	Manufacturer's Name
A	GCS	Garrecht	S	SDI	Streamline Data Instruments
B			T	TRI	Triadis Engineering GmbH
C	CAM	Cambridge Aero Instruments	U		
D	DSX	Data Swan/DSX	V	LXV	LXNAV d.o.o.
E	EWA	EW Avionics	W	WES	Westerboer
F	FIL	Filser	X	XYY	Other manufacturers, see note below
G	FLA	Flarm (Flight Alarm)	Y		
H	SCH	Scheffel	Z	ZAN	Zander
I	ACT	Aircotec	0		
J			1		
K	NKL	Nielsen Kellerman	2		
L	LXN	LX Navigation	3		
M	IMI	IMI Gliding Equipment	4		
N	NTE	New Technologies s.r.l.	5		
O			6		
P	PES	Peschges	7		
Q			8		
R	PRT	Print Technik	9		

IGC DATA FILE FORMAT - CODES FOR MANUFACTURERS OF IGC-APPROVED FLIGHT RECORDERS

Notes to the table: 1. Where possible, the initial letter of a manufacturer's name will be allocated for the single-character code. Where this letter is already allocated, generally the next letter in the manufacturer's name will be used, etc.

2. X and XYY are general designations for IGC files for devices where IGC-approval does not apply. The use of the prefix X designates that the device is not IGC-approved, and the letters YY may be replaced by characters that identify the manufacturer of the device. Such devices will not have been evaluated by GFAC and may not comply with some aspects of the IGC Specification such as security protection, recording of pressure altitude, ENL, MOP or other variables. There is no guarantee that the file will conform exactly to the IGC format, although specimen files will be checked if emailed to the GFAC chairman for evaluation. It should be noted that although the file name will not contain the information, the details of the manufacturer and the recorder model concerned will be identifiable (if the file conforms to the IGC standard) because they will be included in the H (Header) record, see below under H Record in the line (with extra spaces for clarity):

    HF FTY FR TYPE : MANUFACTURERS NAME, FR MODEL NUMBER CRLF.

    Some other FAI air sports have their own systems for non-IGC recorders:
    For instance, for Hang Gliding (FAI Commission CIVL), see: http://wxc.fai.org/module.php?id=10

3. The codes PFC, PLT and OOI will not be used since they could cause confusion in the L record.

A2.5.7 <u>Mandatory Records</u>. The following records are mandatory for an IGC file from an IGC-approved FR:

Record type in file order	Appendix A reference	Remarks
A	3.1	Manufacturer and unique ID for FR
H	3.2	Header record
I	3.3	FXA addition to B-record, ENL for motor gliders
B	4.1	Fix record (lat/long/alt etc.)
F	4.2	Satellites used in B record fixes
G	3.6	Security record

A3 <u>**SINGLE INSTANCE DATA RECORDS**</u>.

These records only occur once in each IGC-format data file, but each record type may contain several lines prefixed with its type letter. The order below is the sequence in which they normally appear in the IGC file.

A3.1 <u>**A RECORD - FR ID NUMBER**</u>. 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 . Format of the A Record, with extra spaces for clarity:

A MMM NNN TEXT STRING CR LF

A record - Description	Size	Element	Remarks
Manufacturer	3 bytes	MMM	Alphanumeric, see para A2.5.6. For Non-IGC FRs this will be XYY (see 2.5.6 table). Note that the full manufacturer name will be in the Header record in the form: HFFTYFRTYPE:MANUFACTURERSNAME,FRMODEL
Unique ID	3 bytes	NNN	Valid characters alphanumeric. For IGC FRs this is three alphanumeric characters. Non-IGC FRs may have an ID of three or more characters, or may not have an individual ID (in which case this field should be blank).
Additional data	Optional	Text String	Valid characters alphanumeric. If used, start with a comma separator to distinguish it from the earlier characters for Unique ID (because some non-IGC recorders may have S/Ns more than 3 characters). Short data may be added such as more complete identification of the recorder maker, type & number (unless this is not already covered, for example the HFFTYFRTYPE line in the Header record), or the number of the IGC file produced by this recorder on the date concerned (this will be the Flight Number if all files refer to flights).

A3.2 **H RECORD - FILE HEADER**

The H- (Header) Record is used to store data such as the date, pilot's name, glider type and registration, the type of FR used, 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.

A3.2.1 Source Codes. The line entries in the H-record may be created by the FR (source code F), or by the OO or Other origin allowed by this Specification (O source record) after flight. See the line "Data Source" in the table below. The H-Record data with source code F is covered by the security code and the VALI check system.

A3.2.2 General format. The general format of the H-Record is: H, data source (S), subtype (CCC), subtype long name, colon, text string. The long name and text string are intended as an aid for people reading the file.

A3.2.3 Earth Model. GNSS Geodetic Datum/Earth Model. The long name, a colon and the name of the Geodetic Datum /Earth Model (WGS84 = IGC number 100, see para A8) come after the IGC-assigned number for the GPS-Datum, which is located directly behind the record subtype identifer DTM.

A3.2.4 Required records. The following H records are required. Extra spaces between fields are added for clarity:

    H F DTE DD MM YY CRLF
    H F FXA AAA CRLF
    H F PLT PILOT IN CHARGE: TEXT STRING CRLF
    H F CM2 CREW 2: TEXT STRING CRLF
    H F GTY GLIDER TYPE:TEXT STRING CRLF
    H F GID GLIDER ID: TEXT STRING CRLF
    H F DTM NNN GPS DATUM: TEXT STRING CRLF
    H F RFW FIRMWARE VERSION: TEXT STRING CRLF
    H F RHW HARDWARE VERSION:TEXT STRING CRLF
    H F FTY FR TYPE: MANUFACTURERS NAME,FR MODEL NUMBER CRLF
    H F GPS MANUFACTURERS NAME, MODEL, CHANNELS, MAX ALT CRLF
    H F PRS PRESS ALT SENSOR: MANUFACTURERS NAME, MODEL, MAXALT CR LF

A3.2.5 A table follows with more detail:

H record – Description	Size	Element	Remarks
Data source	1 byte	F or O	Placed after leading H: F=FR, O = Official observer or Other source allowed by this Specification. F must be used if the data is downloaded from the FR even though it was originally entered by a pilot or OO. This is to ensure that data entered before flight is protected by the security system and if it is changed after flight it will fail the VALI check.
Record subtype	3 bytes	CCC	Alphanumeric, placed after data source, see para A7 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 Pilot in Charge and Crew Member 2	At least 30 characters	Text String	After relevant TLC. PLT for name of Pilot in Charge, CM2 for name of Crew Member 2, if any
GPS Datum	3 bytes	NNN	WGS 84 must be used, 100 =WGS84 (see para A8)
Lines on FR name, firmware, hardware	As required	Text String	After relevant TLC (eg RHW for FR Hardware version)
FR Type line	As required	F	Includes model data including sub-types. For instance, not only Model XXX 1 but 1a,1b, etc.
HFGPS line	As required	Text String	Gives the GPS receiver 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 and for the European Galileo system use GAL (GLO and GAL are listed in para A7). For equipment that receives data from more than one GNSS system, use the data sequence above for one system followed by the sequence for the other.
HFPRS line	As required	Text String	Gives the pressure altitude sensor Manufacturer and type; maximum pressure altitude in metres that could be recorded in the IGC file. Use comma separators between each element.
HF FRS line	As required	Text String	Format: HF FRS SECURITY SUSPECT USE VALI PROGRAM: TEXTSTRING CRLF Must be used where security is suspect, for instance if the recorder's physical security system (microswitch) has operated. The words before the colon are mandatory. The reason for referring to the VALI program is that this carries out a security check on the IGC file. The text string should be a description of the likely fault, such as: "Security Microswitch operated, recorder needs to be re-set"

For non-IGC FRs, see extra H-records in the table in para A3.2.7.5

A3.2.6 Additional H records. These are optional and are identified by the appropriate Three Letter Codes given in para A7. Additional data may be appended after the mandatory records. Two additional records (Competition ID and class) are shown below, with extra spaces for clarity.
    H S CID COMPETITION ID : TEXT STRING CR LF
    H S CCL COMPETITION CLASS : TEXT STRING CR LF

A3.2.7 Names and identifications.

A3.2.7.1 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 (format as for date of flight in the H record).

A3.2.7.2 Name of Crew Member 2 (code CM2), family name first then other names or initials without punctuation but separated by spaces (for instance, SMITH B S, or SMITH BERNALD)

A3.2.7.3 Long names. 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 .

A3.2.7.4 Country, 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:

ISO 3166 TWO-LETTER NATIONAL CODES

www.iso.org/iso/country_codes.htm

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

A3.2.7.5 Non-IGC FRs. For Non-IGC FRs, the following H-records apply. If others would be useful to non-IGC Airsports, contact the GFAC Chairman for these to be considered:

Non-IGC-FRs: TLC & Description	Size	Element	Remarks
HO SOF	As required. To describe software name, version and date/time of download	Text string	This is download software external to the Recorder other than the IGC Shell program or the earlier IGC DATA short program file. The text string gives the program name, program version and the date/time of the download (Format: DDMMYYHHMM). Use comma separators between each piece of information. The date/time uses the B-record format up to minutes of time (no need for seconds). For example: GpsDump,4.53,1907102039
HF FSP (Variant on the IGC File Specification). Or, if not embedded in the Recorder, HO FSP	Up to 30 characters	Text string	For instance CIMA 1a, GAC 2b together with other useful details
HF ALG (GPS Altitude)	Three characters	TLC in Remarks column	ELL for WGS84 Ellipsoid GEO for WGS84 Geoid (approx Sea Level datum) NKN = GPS altitude datum not known NIL = GPS altitude not recorded, In which case B records must have V for the fix validity and 00000 for GPS altitude
HF ALP (Pressure Altitude)	Three characters	TLC in Remarks column	ISA = ICAO ISA MSL = Above Mean Sea Level NKN = Pressure altitude datum not known NIL = Pressure Alt not recorded, 00000 to appear in IGC file

A3.3 **I RECORD - ADDITIONS TO THE FIX (B) RECORD**. The I record defines any additions to the fix (B) Record as a list of the appropriate Three-Letter Codes (CCC), data for which will appear in subsequent B Records. Only one I-Record line is included in each file, located after the H record and before the first B Record. For IGC FRs, Fix Accuracy (FXA) must be included, in the form of the Estimated Position Error figure (see Glossary under EPE). This shall be followed by SIU, ENL and MOP, if these are recorded in the FR. Note that although the SIU number is optional in the B record, the F Record (satellite constellation used) is mandatory, see para A4.3. The format of the I Record with extra spaces for clarity, is:

I NN SS FF CCC SS FF CCC CR LF

I Record – Description	Size	Element	Remarks
Number of additions	2 bytes	NN	Valid characters 0-9
Start byte number	2 bytes	SS	Valid characters 0-9, start byte on each B-record line
Finish byte number	2 bytes	FF	Valid characters 0-9, finish byte on each B-record line
3-letter Code	3 bytes	CCC	Alphanumeric subject, see para A7 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

The above line 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 Environmental Noise Level (ENL):

I 04 3638 FXA 3940 SIU 4143 ENL 4446 MOP CR LF

The above line 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, Environmental Noise Level (ENL) between bytes 41 and 43 and MOP between bytes 44 and 46. To aid clarity, some spaces have been inserted in the example line.

A3.4 **J RECORD - ADDITIONS TO THE K RECORD**. The J record is a single line that defines what data will be in subsequent K-record lines, the K record being used for data that is updated as a flight progresses but is not required as often as fix (B-) Records.   The J-record fulfils the same function for the K Record as the I Record (3.3 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 with extra spaces for clarity, is:

J NN SS FF CCC SS FF CCC CR LF

Description	Size	Element	Remarks
Number of additions	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 A7

Example, with extra spaces for clarity:
J 01 08 12 HDT CR LF
This shows that True Heading (HDT) is calculated and recorded between bytes 8 and 12 on each K-record line.

A3.5 **C RECORD - TASK. (Pre-flight Declaration)** The C Record is used to make pre-flight declarations. It is placed in the IGC file before the first fix (B-) record and after the Header, I and J records.

A3.5.1 <u>Lines in the C Record</u>. The first line contains the UTC-date and 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 text string which can be used to describe the task ("500k triangle", etc). Optionally, the recorder may be configured so that a pilot can enter the intended flight date in the local time zone, 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 A7). The other lines contain the WGS84 lat/long coordinates and a text string describing the place or point concerned. These include the take-off airfield, start point, turn points, finish point and landing airfield. The text describing the type of point (see example below) is so that the nature of the points can be clearly seen by viewing the IGC file.

A3.5.2 <u>IGC terminology</u>. In IGC terminology, "Waypoint" refers to a either a start point, turn point or finish point. The term "Turn Point" refers to a point in a measured course between a start and finish point. The points that must be specified exactly in an official IGC flight declaration are the start-, turn- and finish-points either declared before the flight, or, for IGC "Free Flights", selected after flight. The number of turn points will be nil for a straight goal flight, one for an out-and-return, two for a triangle, three for 3-TP distance, more for some polygon competition tasks.

A3.5.3 <u>Takeoff and Landing</u>. Two lines in the C-record of the IGC file are for the takeoff airfield and landing airfield and are for general information rather than being part of an IGC Flight Declaration. They can be entered approximately or, if the co-ordinates are difficult to obtain, the recorder shall default to 00000000N000000000E for these two lines.

A3.5.4 <u>Area Tasks</u>. The incorporation of this facility in an IGC FR is optional. In some competitions, an area to be reached is specified with respect to a Waypoint in terms of distances and true bearings (radials) from the point. If a recorder has a facility to enter this in the C record, the following system shall be followed in the IGC file: At the end of the relevant Waypoint line in the C record, minimum and maximum distances follow in kilometers from the WP, followed by bearing

1 and bearing 2 in degrees true from the WP and then the word AREA after the type of point. In the case of competitions using units other than kilometres (such as statute or international nautical miles), a conversion must be made so that the IGC file continues to be in kilometres (and decimal kilometres as necessary). The area is clockwise from bearing 1 to 2. In the case of circular areas round a point the two bearings used shall be 000 to 360 and the minimum distance will be zero. Where an area referenced to a Waypoint is to be specified, after the C record line that defines the Waypoint but before CRLF at the end of the line, add: "DDDDdddDDDDdddBBBbbbBBBbbbAREA"

The two distances Dd are first minimum distance from the WP in km and decimal kilometres, then maximum distance.

The two bearings Bb are in degrees and decimal degrees true from the WP, the task area extending clockwise from bearing 1 to 2.

For instance: "C....0012000 0032000 122000 182000TURN AREA" would be an area from 12 to 32 km from the WP between the bearings 122 and 182 from the Point.

The format of C Record is as follows, using N latitude and E longitude for the example:

    C DD MM YY HH MM SS F D F M F Y IIII TT TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E TAKEOFF TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E START TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E TURN TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E TURN TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E FINISH TEXT STRING CR LF
    C DD MM MMM N DDD MM MMM E LANDING TEXT STRING CR LF

Spaces have been added between data fields in this example to aid clarity.
The Text String is intended to be the name and short description of the Point

For an area referenced to a Turn Point:
    C DD MMMMMN DDD MMMMME 0012000 0032000 122000 182000TURN AREA CR LF

C record – Description	Size	Element	Remarks
Date UTC	6 bytes	DDMMYY	Valid characters 0-9
Time UTC	6 bytes	HHMMSS	Valid characters 0-9
Flight date	6 bytes	FDFMFY	Valid characters 0-9. If not used, fill with zeros
Task number on the day	4 bytes	IIII	Valid characters alphanumeric, may be an ID reference or a 1-2-3 sequence. ; if not used, the default is 0001. 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).
Number of Task TPs	2 bytes	TT	Valid characters 0-9. 1 for an out-and-return, two for a triangle, etc.
TO or A/F LatLon			The exact declared point is defined by the latitude and longitude. Plus textstring for any local turn point code numbers, letters, name or brief description. The declared start point, turn points, and the finish point with their Latitude and Longitude are mandatory; the takeoff and landing data are not part of the IGC declaration requirement given in the Sporting Code for Gliding (SC3) but are useful, particularly where remote starts or finishes are used. If the coordinates of a point which is not part of the official task is difficult to include beforehand (such as takeoff and landing), it should be set to 00000000N000000000E
Start LatLon			
T/P LatLon	17 bytes	DDMMmmmN DDDMMmmmE to the WGS84 Geodetic Datum	
T/P LatLon			
Finish LatLon			
Land or A/F LatLon			

A3.6 **G RECORD - SECURITY**. The G Record is a coded sequence of characters placed at the end of the IGC file and is used to verifiy that flight data originally recorded in the IGC file has not been altered after the flight, using the Public/Private Key system described in Annex G para G2. For IGC FRs, the FR manufacturer must provide a VALI program (see Annex D para D3) to check the integrity of the file with the security code, which 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 IGC Validation check, except H records with the O source, and any L (Logbook) records put in after flight by the pilot or OO (O or P source letter). Only L records with the Manufacturer FR ID (F source letter) will be included in the Validation check.

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 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 CR LF   etc

G record - Description	Size	Element	Remarks
Security code	Up to 75 bytes per line	SSSSS	Valid characters alphanumeric, see Annex G para G2.1.2 on security key length.

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

A4. **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 that occur in each file only in one place.

A4.1 **B RECORD - FIXES**. 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, in the form of the figure for Estimated Position Error, see the Glossary under EPE), Satellites In Use (SIU), Environmental Noise Level (ENL for all motor gliders), MOP (required for motor gliders with engines giving low ENL). The required basic data is: UTC, WGS84latitude, WGS84 longitude, fix validity, Fix Accuracy, 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 receiver. In the B Record FXA 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.

4.1.1 The format of the basic data, with extra spaces for clarity, is:

B HHMMSS DDMMM MmmmN DDDMMmmm E V PPPPP GGGGG CR LF

4.1.2 In tabular form, with notes:

B record – Description	Size	Element	Remarks
Time UTC	6 bytes	HHMMSS	Valid characters 0-9. The leap-second correction must be applied to all recorded fixes so that UTC always appears in the B-record. When a GPS system initially locks on, in the short period before the current leap-second data is available from the ephemeris data of the GPS system, the leap-second correction that was used when that recorder was last locked on should be used
Latitude	8 bytes	DDMMmmmN/S	Valid characters N, S, 0-9. Obtained directly from the same GPS data package that was the source of the UTC time that is recorded in the same B-record line. If no latitude is obtained from satellite data, pressure altitude fixing must continue, using times from the RTC. In this case, in B record lines must repeat the last latitude that was obtained from satellite data, until GPS fixing is regained.
Longitude	9 bytes	DDDMMmmmE/W	Valid characters E,W, 0-9. Obtained directly from the same GPS data package that was the source of UTC time that is recorded in the same B-record line. If no longitude is obtained from satellite data, pressure altitude fixing must continue, using times from the RTC. In this case, in B record lines must repeat the last longitude that was obtained from satellite data, until GPS fixing is regained.
Fix validity	1 byte.	A or V	Use A for a 3D fix and V for a 2D fix (no GPS altitude) or for no GPS data (pressure altitude data must continue to be recorded using UTC times from the RTC)
Press Alt.	5 bytes	PPPPP	Altitude to the ICAO ISA above the 1013.25 HPa sea level datum, valid characters 0-9 and negative sign "-". Negative values to have negative sign instead of leading zero
GNSS Alt.	5 bytes	GGGGG	Altitude above the WGS84 ellipsoid, valid characters 0-9

4.1.3 <u>Other data in Fix lines</u>. To append the Fix Accuracy (FXA, mandatory), Satellites in Use (SIU), Environmental Noise Level (ENL) and MOP or any other variable to each fix, these have to be defined earlier in the IGC file. This is done in the I Record (so that the data will be recognised by analysis programs). For instance, with extra spaces for clarity:

I 04 3638 FXA 3940 SIU 4143 ENL 4446 RPM CR LF

This shows that on each B-record line, Fix Accuracy is recorded between bytes 36 and 38, Satellites In Use between bytes 39 and 40, Environmental Noise Level between bytes 41 and 43, and engine RPM between bytes 44 and 46.

The resulting B Record becomes (with extra spaces for clarity):

BHH MM SS DD MMMMM N DDD MMMMM E V PPPPP GGGGG AAA SS NNN RRR 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
Environmental Noise	ENL	3 bytes	NNN	Valid characters 0-9

A4.2 **E RECORD - EVENTS**. The E-record is used to record specific events on the IGC file that occur at irregular intervals. Such events include a pilot-initiated event (PEV code) or, for recorders fitted with proximity sensing devices, a proximity event using one of the appropriate Three-Letter Codes as defined in para A7. The E Record is placed before the individual fix (B) Record for the same time that shows 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 analysis programs, 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 addition to the B record, first listing the description Code (CCC) in the I-record.

If a manufacturer or analysis programmer wants to add a new type of event, a new Three Letter Code (para A7) 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, with extra spaces for clarity:

    E 104533 PEV CR LF
    B 104533 49 45 333 N 011 32 444 E A 01357 01501 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 and GNSS altitude 1501 metres.

Some events require more than just the TLC for interpretation (with extra spaces for clarity):
    E 104544 ATS 102312 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

A4.3 **F RECORD - SATELLITE CONSTELLATION**.

For IGC FRs, this is a mandatory record. However, there is no requirement to update the F-record at intervals of less than 5 minutes, so that transient changes of satellites received due to changing angles of bank, flying in valleys, etc do not lead to frequent F-record lines. 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 which 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.

    Format of F Record (with extra spaces for clarity):
    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

A4.4 **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 (with extra spaces for clarity):
    J 08 12 HDT CR LF
    K HHMMSS 00090 CR LF
    This K Record shows that the true heading (TLC = HDT) is 090 (East).

A4.5 **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 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". If the data is not from the FR (F source letter), the Element field in the table below will also be three characters, initiated by the pilot (code PLT), Official Observer Input (code OOI), or by other sources allowed by this Specification such as external Download Software (code SOF).

A4.5.1 <u>Validation check</u>. L-records with the Manufacturer's ID (MMM) must be included in the Validation check, L-records from other sources must not be.

A4.5.2 <u>Free Flights</u>. In the case of Free Flights where waypoints are claimed post-flight by the pilot, the PFC (Post-Flight Claim) code shall be used followed by the Waypoints in the same format as the C Record (Pre-flight declaration). It is expected that this data will be inserted by a software program (for instance, after download of the flight data to a PC immediately after flight, by a program outside the FR) rather than added manually, so that it is in the correct format and can be recognised by analysis programs that are designed to read Post-Flight Claim data and present the flight on screen together with the PFC waypoints.

A4.5.3 <u>Length</u>. This record in the IGC file should not be taken as encouragement or permission to include long entries. L-record data should be restricted to data that is best placed inside the IGC file itself and is difficult to cover elsewhere. To reduce the length of L-record entries, where appropriate, a brief cross-reference should be included (to web, other documents etc) rather than be included in full inside the IGC-file itself.

The format of the L Record is as follows (with extra spaces for clarity):

L MMM TEXTSTRING CR LF
L PLT TEXTSTRING CR LF
L PFC TEXT FORMAT AS C RECORD CR LF

Description	Size	Element	Remarks
Manufacturer input	3 bytes	MMM	Manufacturer's code, see para A2.5
Pilot input	3 bytes	PLT	Text string after PLT
OO input	3 bytes	OOI	Text string after OOI
After flight pilot input	3 bytes	PFC	For free flight after-flight choice of course

Examples of pilot inputs:
L PLT This flight was my second 1000km attempt
L PLT from Eagle Field

A4.6 **D RECORD - DIFFERENTIAL GPS**. This indicates that differential GPS is being used and can be a multiple-instance record if, during the flight, more than one differential beacon is 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 (with extra spaces for clarity):

D Q SSSS CRLF

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.

A5. **DEFINITIONS**   These relate to usage in the IGC file. Also see the Glossary of Terms at the start of this Specification.

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 A6).

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.

Environmental 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 – Covered under the MOP code, see below

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 (95.45%) 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 para A3.1) and in the IGC file name (para A2.5).

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 speed over the ground 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.

MOP = Means of Propulsion. When the Three-Letter Code MOP is used in an IGC file, this refers to an engine (MOP) function (in addition to ENL) supplied to the recorder by an appropriate signal or sensor, for which three numbers between 000 and 999 are available in the IGC file for each fix, their position being defined in the I-record. At maximum RPM a value over 900 is required, and at power for level flight, a value of over 600. The sensor may be connected by a cable to the FR and, if required, be positioned close to the engine so as to receive a strong signal when the engine is running (such as an acoustic system matched to the sound frequency of the engine or propeller system concerned). The nature of the sensor and how its signal is processed shall be approved by GFAC. A description of the type of sensor shall be given in the H (Header) record in the form HFMOPSENSOR Text String. An MOP value of 010 shall be used to indicate (1) continuity of any wire leading to the sensor or supplying the signal, and (2) serviceability of the sensor or signal itself (where 000 would otherwise be recorded, one solution is for the Recorder to generate a coded pulse that is sent at regular intervals down the wire, the return of which indicates the two conditions and causes the number 010 to be placed on the IGC file for the fix concerned).

On Task - The pilot is attempting a Task.

OO ID - 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.

Pilot Event (PEV code) – Where 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. A sequence of fast fixes follows (see para 3.6 in the main body of this document).

Pressure Altitude - 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 Addition - This allows extra information to be added to the fix (B) and extra data (K) 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.

A6. **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:

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

And the same information in hex order:

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

A7. **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 the IGC file 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.

TLC	Record Letter(s) TLC used with	TLC meaning, notes on how it is to be used
ACX ACY ACZ	I,B	Linear accelerations in X, Y and Z axes, for aerobatic aircraft equipped with appropriate sensors feeding to the recorder and IGC file. X = longitudinal, Y = lateral, Z = vertical (so-called "G")
ANX ANY ABZ	I,B	Angular accelerations in X, Y and Z axes, for aerobatic aircraft equipped with appropriate sensors feeding to the recorder and IGC file. Pitch = X, roll = Y, yaw = Z.
ATS	H E	Altimeter pressure setting in hectoPascals (the same as Millibars) with 4 numbers and one decimal point (for instance, 1013.2, 0995.7). 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
CCO	J,K	Compass course (from the aircraft compass sensor). Three numbers based on degrees clockwise from 000 for north.
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 A3.3.3
CM2	H	Second Crew Member's Name, family name first then given name(s) as required (same format as PLT for pilot-in-charge). For aircraft with more than two crew, use CM3 and so forth if required.
DAE	I, B, J, K	Displacement east, metres. For West use negative sign
DAN	I, B, J, K	Displacement north, metres. For South use negative sign
DB1	H	Date of Birth of the pilot-in-charge (aircraft commander) in the previous line of the H record (DDMMYY)
DB2	H	Date of Birth of second crew member in format DDMMYY. For aircraft with more than two crew, use DB3 and so forth if required.
DOB	H	Obsolete code, now use DB1. Was 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	Environmental 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
FLP	E	Flap position, three characters such as FLP060 for 60 degrees of positive flap. If negative, use a negative sign before the numbers, such as FLP-20 for minus 20 degrees flap.

FRS	H	Flight Recorder Security. To be used where a security fault has been detected such as the recorder internal security system (microswitch) having operated.
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 a 2-Sigma (95.45%) probability
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.
GAL	H	Galileo (European GNSS system), followed by receiver maker, type & version letter/number. See 3.3.1 above.
GCN	E	GNSS (Separate module) Connect
GDC	E	GNSS (Separate module) Disconnect
GID	H	Glider ID
GLO	H	GLONASS (Russian GNSS system), followed by receiver maker, type & version letter/number. See 3.3.1 above
GPS	H	GPS (US GNSS system), followed by receiver maker, type & version letter/number. See 3.3.1 above.
GSP	I, B, J, K	Groundspeed, three numbers in kilometres per hour
GTY	H	Glider type, manufacturer, model
HDM	I, B, J, K	Heading Magnetic, three numbers based on degrees clockwise from 000 for north
HDT	I, B, J, K	Heading True, three numbers based on degrees clockwise from 000 for north
IAS	I, B, J, K	Airspeed, three numbers in kilometres per hour
LAD	I, B	The last places of decimal minutes of latitude, where latitude is recorded to a greater precision than the three decimal minutes that are in the main body of the B-record. The fourth and any further decimal places of minutes are recorded as an addition to the B-record, their position in each B-record line being specified in the I-record.
LOD	I, B	The last places of decimal minutes of longitude, where longitude is recorded to a greater precision than the three decimal minutes that are in the main body of the B-record. The fourth and any further decimal places of minutes are recorded as an addition to the B-record, their position in each B-record line being specified in the I-record.
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.
MAC	E	MacCready setting for rate of climb/speed-to-fly (m/sec)
MOP	B, I	Means of Propulsion. A signal from an engine-related function approved by GFAC and placed on the IGC file in the fix record. For details, see the definition of MOP above in Para A5.
OA1 OA2 OA3 Etc	E	Position of other aircraft (if this is recorded by the system), data fields after the Codes being separated by colons. Format after the Three Letter Code is the identification of the aircraft concerned (if this is recorded by the system, otherwise insert NK for not known) followed by a colon, letter P for polar or C for Cartesian followed by the co-ordinates. Polar co-ordinates are with respect to the recorder. Format is numbers for horizontal distance in metres from the recorder followed by a colon, followed by 3 numbers of degrees clockwise from 000 for north, followed by a colon and vertical distance in metres from the recorder, a negative sign before the numbers meaning negative vertical distance. After the numbers for vertical distance, the letter G should be used for GNSS data and P for Pressure Altitude, both can be used if the data is available. Alternatively, Cartesian co-ordinates can be used for the 3D position of the Other Aircraft (for instance from ADS-B and similar position reporting systems). Format is lat/long followed by pressure and GPS altitudes (if these are recorded by the system) in the same order and format as for the B record (para A4.1), omitting the fix validity character. Where a type of altitude is not recorded, zeros should be substituted.
OAT	J,K	Outside air temperature (Celsius). If negative, use negative sign before the numbers.
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. A sequence of fast fixes follows (see para 3.6 in the main body of this document).
PFC	L	Post-Flight Claim. For Free Flights where waypoints are claimed post-flight.
PHO	E	Photo taken (shutter-press)
PLT	H	Pilot-in-charge (aircraft commander), family name first then given name(s) as required
PRS	H	Pressure Altitude Sensor, manufacturer, model, etc.
RAI	I, B, J, K	RAIM - GPS Parameter, see Glossary
REX	I, B, J, K	Record addition - 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.
RFW	H	Firmware Revision Version of FR
RHW	H	Hardware Revision Version of FR
SCM	H	Obsolete code, now use CM2. Was 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.
STA	E	Start event
TAS	I, B, J, K	Airspeed True, give units (kt, kph, etc.)
TDS	I, B, J, K	Decimal seconds of UTC time, for use with systems recording time to this accuracy. Time in seconds is recorded in the main body of the B-record and decimal seconds are recorded as an addition to the B-record, their position in each B-record line being specified in the I-record. Similarly with the K and J-records. For an example see A2.4 under Time.
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)
TRM	I, B, J, K	Track Magnetic. Three numbers based on degrees clockwise from 000 for north
TRT	I, B, J, K	Track True. Three numbers based on degrees clockwise from 000 for north
TZN	H	Time Zone Offset, hours from UTC to local time.
UND	E	Undercarriage (landing gear), recorded as UP or DN, in the format UNDUP or UNDDN.
UNT	H	Units of Measure
VAR	J, K	Uncompensated variometer (non-total energy) vertical speed in metres per second and tenths of metres per second with leading zero and no dot (".") separator between metres and tenths. Valid characters 0-9 and negative sign "-". Negative values to have negative sign instead of leading zero
VAT	J, K	Compensated variometer (total energy/NETTO) vertical speed in metres per second and tenths of metres per second with leading zero and no dot (".") separator between metres and tenths. Valid characters 0-9 and negative sign "-". Negative values to have negative sign instead of leading zero
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.
WDI	I, B, J, K	Wind Direction (the direction the wind is coming from). Three numbers based on degrees clockwise from 000 for north
WSP	I, B, J, K	Wind speed, three numbers in kilometres per hour
XN*	As Appropriate	A manufacturer-selected code where N is the manufacturer's single-character IGC name (para A3.5.6) and * can be any character. The manufacturer must specify its meaning and usage in the documentation for the recorder and its use must be approved by GFAC before IGC-approval. The X prefix is intended to allow a trial with a provisional new code before deciding whether it is worthwhile adding to the full list.

A8. **GNSS GEODETIC DATUMS** The Sporting Code for Gliding (SC3) states that the WGS 84 Geodetic Datum (serial 100 below) shall be used for all lat/long co-ordinates in the IGC file. Other Geodetic Datums have been numbered by IGC as follows because some early IGC recorders had the capability to select different Earth Models.

ID Name Locations in which used	ID Name Locations in which used
000 ADINDAN – Ethiopia, Mali, Senegal, Sudan	050 MARCO ASTRO - Salvage Islands
001 AFGOOYE – Somalia	051 MASSAWA - Eritrea(Ethiopia)
002 AIN EL ABD 1970 - Bahrain Island, Saudi Arabia	052 MERCHICH - Morocco
003 ANNA 1 ASTRO 1965 - Cocos Island	053 MIDWAY ASTRO 1961 - Midway Island
004 ARC 1950 – Botswana, Lesotho, Malawi, Zaire, Zambia, Zimbabwe	054 MINNA - Nigeria
005 ARC 1960 – Kenya, Tanzania	055 North American 1927 (NA27) - Alaska
006 ASCENSION ISLAND 1958 - Ascension Island	056 NA27 - Bahamas (excluding San Salvador Island)
007 ASTRO BEACON "E" - Iwo Jima Island	057 NA27 - Central America
008 AUSTRALIAN GEODETIC 1966 - Australia, Tasmania Island	058 NA27 - Canal Zone
009 AUSTRALIAN GEODETIC 1984 - Australia, Tasmania Island	059 NA27 - Canada (including Newfoundland Island)
010 ASTRO DOS 71/4 - St. Helena Island	060 NA27 - Caribbean
011 ASTRONOMIC STATION 1952 - Marcus Island	061 NA27 - Mean Value (CONUS)
012 ASTRO B4 SOROL ATOLL - Tern Island	062 NA27 - Cuba
013 BELLEVUE (IGN) - Efate and Erromango Islands	063 NA27 - Greenland (Haynes Peninsula)
014 BERMUDA 1957 - Bermuda Islands	064 NA27 - Mexico
015 BOGOTA OBSERVATORY – Colombia	065 NA27 - San Salvador Island
016 CAMPO INCHAUSPE – Argentina	066 NA83 - Alaska, Canada, Central America, CONUS, Mexico
017 CANTON ASTRO 1966 - Phoenix Islands	067 NAPARIMA, BWI -Trinidad and Tobago
018 CAPE CANAVERAL - Florida, Bahama Islands	068 NAHRWAN - Masirah Island (Oman)
019 CAPE - South Africa	069 NAHRWAN - Saudi Arabia
020 CARTHAGE – Tunisia	070 NAHRWAN - United Arab Emirates
021 CHATHAM 1971 - Chatham Island (New Zealand)	071 OBSERVATORIO 1966 - Corvo and Flores Islands (Azores)
022 CHUA ASTRO – Paraguay	072 OLD EGYPTIAN - Egypt
023 CORREGO ALEGRE – Brazil	073 OLD HAWAIIAN - Mean Value
024 DJAKARTA (BATAVIA) - Sumatra Island (Indonesia)	074 OMAN - Oman
025 DOS 1968 - Gizo Island (New Georgia Islands)	075 PICO DE LAS NIEVES - Canary Islands
026 EASTER ISLAND 1967 - Easter Island	076 PITCAIRN ASTRO 1967 - Pitcairn Island
027 EUROPEAN 1950 (ED50) - Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland	077 PUERTO RICO - Puerto Rico, Virgin Islands
	078 QATAR NATIONAL - Qatar
	079 QORNOQ - South Greenland
028 EUROPEAN 1979 (ED79) - Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland	080 REUNION - Mascarene Island
	081 ROME 1940 - Sardinia Island
029 FINLAND HAYFORD 1910 - Finland	082 RT 90 - Sweden
030 GANDAJIKA BASE - Republic of Maldives	083 SOUTH AMERICAN 1956 - Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela
031 GEODETIC DATUM 1949 - New Zealand	
032 Ordnance Survey of Great Britain 1936 (OSGB36) - UK	084 SOUTH AMERICAN 1956 - Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad, Tobago
033 GUAM 1963 - Guam Island	
034 GUX 1 ASTRO - Guadalcanal Island	085 SOUTH ASIA - Singapore
035 HJOESEY 1955 - Iceland	086 PROVISIONAL SOUTH CHILEAN 1963 - South Chile
036 HONG KONG 1963 - Hong Kong	087 SANTO (DOS) - Espirito Santo Island
037 INDIAN - Bangladesh, India, Nepal	088 SAO BRAZ - Sao Miguel, Santa Maria Islands (Azores)
038 INDIAN - Thailand, Vietnam	089 SAPPER HILL 1943 - East Falkland Island
039 IRELAND 1965 - Ireland	090 SCHWARZECK - Namibia
040 ISTS 073 ASTRO 1969 - Diego Garcia	091 SOUTHEAST BASE - Porto Santo and Madeira Islands
041 JOHNSTON ISLAND 1961 - Johnston Island	092 SOUTHWEST BASE - Faial, Graciosa, Pico, Sao Jorge, Terceira Islands
042 KANDAWALA - Sri Lanka	093 TIMBALI 1948 - Brunei and East Malaysia (Sarawak and Sabah)
043 KERGUELEN ISLAND - Kerguelen Island	
044 KERTAU 1948 - West Malaysia, Singapore	094 TOKYO - Japan, Korea, Okinawa
045 L.C. 5 ASTRO - Cayman Brac Island	095 TRISTAN ASTRO 1968 - Tristan da Cunha
046 LIBERIA 1964 - Liberia	096 Reserved For Future Use
047 LUZON - Mindanao Island	097 VITI LEVU 1916 - Viti Levu Island (Fiji Islands)
048 LUZON - Philippines (excluding Mindanao Island)	098 WAKE-ENIWETOK 1960 - Marshall Islands
049 MAHE 1971 - Mahe Island	099 World Geodetic System 1972 (WGS72)
	100 World Geodetic System 1984 (WGS84)
	101 ZANDERIJ - Surinam
	102 CH-1903 - Switzerland
	103 Bessel 1847 - Austria

A9. **EXAMPLE IGC-FORMAT FILE**

A9.1 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.

A9.2 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.

A9.3 CRLF = line terminator, not flight data.

A9.4 In a real file there would be many more B records at the preset fix intervals for cruise and fast fix rates.

A9.5 In the example below, some notes appear in *brackets and italics*. These are not part of the file format itself. Also, for clarity, some spaces are used in B-record lines between different eleents, but no spaces should be used in the IGC file itself.

```
A XXX ABC FLIGHT:1
HFFXA 035
HFDTE 160709
HFPLT PILOTINCHARGE: Bloggs Bill D
HFGTY GLIDERTYPE: Schempp Ventus2cxa
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
HFMOPSENSOR Microphone near jet pipe
I 03 36 38 FXA 39 40 SIU 41 43 ENL 44 46 MOP CRLF
J 01 08 12 HDT CRLF
```
(The following example of a C (Declaration) record is for a 500 km triangle to be flown from Lasham gliding centre, 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) 205m, SIU 09 and ENL 950:)
```
F160240 04 06 09 12 36 24 22 18 21 CRLF
B160240 5407121N 00249342W A 00280 00421 205 09 950 CRLF
D 20331 CRLF
E160245 PEV CRLF
B160245 5107126N 00149300W A 00288 00429 195 09 020 CRLF
B160250 5107134N 00149283W A 00290 00432 210 09 015 CRLF
B160255 5107140N 00149221W A 00290 00430 200 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)
```
B160300 5107150N 00149202W A 00291 00432 256 08 009 CRLF
E160305 PEV CRLF
B160305 5107180N 00149185W A 00291 00435 210 08 015 CRLF
B160310 5107212N 00149174W A 00293 00435 196 08 024 CRLF
K160248 00090 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 190 08 018 CRLF
B160252 5107330N 00149127W A 00496 00439 195 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 A ends -------------

APPENDIX B

GFAC TEST AND EVALUATION

The following tests may be carried out by members of 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 are confidential to GFAC members, their advisors and to any IGC or FAI officials who may be involved if IGC or FAI policy may be affected. The tests in this Appendix 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 recorder and the validity and security of flight data.

B1 **GENERAL REQUIREMENTS**. The following aspects will be evaluated: ease of operation in an air sport environment from badge and record flights (up to World Records) and large competitions. This will include 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 including flight declarations.

B2 **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. This will include checks on required data such as fix accuracy (FXA), Pilot Event (PEV) and fast fixing, and checks on Means of Propulsion operation, such as ENL recording (and engine RPM for quiet Motor Gliders, where fitted).

B3 **PHYSICAL INSPECTION OF THE EQUIPMENT**

B3.1 Construction. Quality and robustness of construction and components.

B3.2 Layout and type of components. Susceptibility to 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. Preservation of flight data after impact or damage.

B4 **SYSTEM ACCURACY AND RECORDING CAPABILITY**

B4.1 Ground Tests. Several ground runs of the equipment will be made. Runs of up to several hours may be made to check memory capacity for long flights and the ability to hold exact UTC in fix data. Tests will normally start with the equipment mounted in a ground vehicle driven over a test course that is 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" of 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.

B4.1.1 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 4 of this document, and Chapter 3 of Annex B to the Sporting Code (SC3B).

B4.1.2 Temperature of the equipment may be varied during the test runs between +40C and -20C, depending on facilities available to the tester.

B4.2 Flight Tests. Flight data should closely compare with that from any control equipment.

B5 **ANTI-TAMPERING PROTECTION**

B5.1 General. 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.

B5.2 Minimum standard. The minimum standard is a positive and recorded identification on every occasion that false data is produced or introduced.

B5.3 Evaluation and tests. Tests of the electronic and physical security of the FR will be made to ensure that a determined attempt to bypass the security features will normally fail. For instance, any security microswitch must be fitted in such a position (for instance with shields or guards where necessary) to protect against the insertion of a specially shaped tool into the case of the recorder which might hold down the microswitch while the case is being opened, thereby allowing unauthorised design changes to be made without the security mechanism being activated. GFAC will open the cases of types of recorders that are under test, evaluate these features and require changes where these are these are deemed to be necessary to preserve security in subsequent worldwide operation of the type.

B6 **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.

B7 **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.

B8 **FLIGHT TESTS**. Flight tests will be made in several types of glider or motor glider, or, during periods of poor weather, in light aircraft.

B8.1 Accuracy. Flights will take place 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.

B8.2 Security. Security protection and procedures before and after flight, will be assessed. The effect of mis-switching will be investigated, and deliberate attempts will be made to insert false data. The possibility of adding false data after flight will also be assessed.

B8.3. Manoeuvring flight. Tests will be carried out in manoeuvring flight to check for anomalies. Recorders will be tested at high angles of bank to check for any GNSS anomalies. under rapid pitch, roll and turn. The possibility of "throwing forward" fixes by pulling up and turning rapidly after a high speed run, will also be assessed.

B8.4. Pressure altitude recording. Tests will be made on the pressure-altitude recording function. Pressure altitude recording must continue if GNSS signal is lost; re-lock must occur quickly once signal is restored. These tests will involve disconnecting and re-connecting the antenna, or, for Recorders with fixed antennas, covering up the antenna with RF shielding (such as metal foil), and checking that fixes continue to be recorded, less the GNSS functions.

B8.5 Means-of-Propulsion (MoP) recording system. Tests will be made on recording systems for the Means of Propulsion for motor gliders. Such systems include those under Three-Letter Codes ENL and MOP. The critical cases are described in para 5.6 of the main body of this Specification. Tests will be made with the Recorder in a number of types of glider and motor glider. These will include gliders with low aerodynamic cockpit noise, also those with higher cockpit noise in gliding flight. If the required results are not shown, modifications to the ENL system must be made until they are, or an additional sensor added under the MOP three-letter code (para 5.4 in the main body of this document). For other aspects of ENL systems, see Chapter 5 of the main body of this Specification.

B8.5.1 Tests with MoP running. Operation of both two-stroke and four-stroke engines will be tested at power settings from maximum power to power for level flight at slow speeds. 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. A critical test will be with a relatively quiet engine, typically a 4-stroke engine in a motor glider at power for level flight.

B8.5.2 Tests without MoP running. For gliding flight, tests will be made with the cockpit ventilation and other panels open, both straight at high speed and during turns. In many gliders an "organ pipe" noise can be heard in the cockpit and ENL will be recorded for this condition. A particular test that will be made is turning at typical thermalling speeds with cockpit panels open, because this is often done when it is hot, and if the ENL is too high under this condition it could be mistaken for a climb under power.

---------------- end of Appendix B ----------------

APPENDIX C

WINDOWS-BASED IGC SHELL PROGRAM

for data download and conversion to IGC format, and validation of IGC file data

C1. __INTRODUCTION__.

C1.1 General. This appendix describes an IGC standard for Manufacturer-supplied Windows Dynamic Link Libraries (DLLs) in a 32-bit Windows environment, for the download, conversion and validation functions that are described in para 3.11 of the main part of this Specification. The DLLs must work with 32-bit MS Windows Operating Systems used in types of PCs commonly used for downloading flight data shortly after flight. This includes, but is not exclusive to, Windows XP, Vista and 7, home and professional editions. If an IGC file fails the VALI check, a display must be generated that includes the likely reason for the failure. This shall be made available before a return to the main IGC Shell screen.

C1.2 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/freeware.asp. 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.

C1.3 Functions supported. All such DLLs shall support the functions described in the API below.

C1.4 Control program. A Control Program must 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 shall also select the COM port to be used.

C1.5 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 A para A2.5.7. A manufacturer's DLL shall be able to handle all GNS FRs in the product range concerned. In case this cannot be achieved, the symbol "y" above is an optional alphanumeric for other DLLs from a given manufacturer.

C1.6 History. The provision of these Windows-based DLLs became mandatory on 1 July 2004. This is to allow for problems encountered running the non-Windows 'Short DOS programs' on some PCs.

C2. APPLICATION PROGRAMMING INTERFACE (API) FOR MANUFACTURER's DLLs

C2.1 General. A standard API is described below in para C3. It includes the functions mentioned in para C1.1 for the operating systems Windows XP Home and Professional and subsequent releases of the XP system. 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 generic programs for the use of pilots, official observers and contest directors. (modifed AL9)

C2.2..Control programs. The DLLs shall be designed to be stored in a common directory on the computer of the end-user. The control program shall use the Win32 *LoadLibrary* or *LoadLibraryEx* functions to load a DLL using run-time linking. The control program shall then query it for the entry point of each API function by name, using the Win32 *GetProcAddress* function.

C2.3 Functions and descriptions. 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.

C3 __API SUB-ROUTINE DESCRIPTIONS.__ The standard API follows. Titles of main sub-routines are in bold, underlined, and end in the letters DLL, FR or LOG. They are followed by relevant data such as parameters, return values, and remarks.

C3.1 **IdentifyDLL**

DWORD IdentifyDLL(LPTSTR value, DWORD size)

The IdentifyDLL function obtains an identifying string, which the control program shall enter in a listbox used to select the appropriate DLL.
Parameters
value
[out] pointer to buffer to receive string.
size
 [in] size of the buffer pointed to by *value*.
Return Values
Function returns number of bytes in returned string, if actual length of string exceeds size, the string shall be truncated to size -1 bytes.

Remarks
The string consists of six fields, separated by the "pipe" character ("|", 0x7C) , the manufacturer three letter code and optional alphanumeric, the manufacturer name, supported FR name(s), DLL software revision number, and two comma separated lists of zero or more file additions. The first list of additions 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:
XXX|Acme Instruments|XL 100, 200|2.0|XL1,XL2|XL1,XL2,IGC

C3.2 **LoadIconDLL**

HICON LoadIconDLL()

The control program calls LoadIconDLL to load a unique 32x32x4 (16 color) icon that may be used to identify the DLL.
Return Values
Returns the handle for the loaded icon. If there is an error, returns a null handle.

InitializeDLL

void InitializeDLL(HWND windowHandle, BOOL quietMode)

C3.3 **InitializeDLL** This is an initialization function that must be called before any of the other functions, with the exception of IdentifyDLL and LoadIconDLL.

Parameters
windowHandle
[in] Handle for the control programs main window, or NULL if there is none.
quietMode
[in] if TRUE, application is operating in quiet (non-interactive) mode.
Remarks
The window handle shall be stored in the DLL, and is normally used as the parent handle for any dialog boxes displayed by DLL functions, unless overridden by a call to SetWindowDLL. These dialogs shall be centered within the parent window. If quiet mode is requested, the DLL functions shall only display dialogs resulting from non-recoverable error conditions, progress and informational dialogs shall not be displayed.

C3.4 **SetWindowDLL**

VOID SetWindowDLL(HWND windowHandle)

The control program shall call this function to set a new top-level window handle. This handle shall be used as the parent window for any dialog boxes displayed by DLL functions, unless overridden by another call to SetWindowDLL.

Parameters
windowHandle
[in] Handle for the control programs new top level window.

C3.5 **KeepAwakeIntervalDLL**

DWORD KeepAwakeIntervalDLL()

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

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

C3.6 **UseSerialOptionsDLL**

BOOL UseSerialOptionsDLL()

The UseSerialOptionsDLL function is called by the control program to determine if there are any user settable connection options which may be set using the dialog provided by SerialOptionsDLL. If there are none, the control program shall not call SerialOptionsDLL.

Return Values
Returns TRUE if there are user settable serial options (and SerialOptionsDLL shall be called), FALSE if not

C3.7 **SerialOptionsDLL**

DWORD SerialOptionsDLL(LPTSTR options, DWORD size)

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.
Parameters
options
[out] pointer to buffer which shall receive the connection options.
size
[in] size of the buffer pointed to by *options* in bytes.
Return Values
If successful, function returns number of bytes in the returned option string. if actual length of string exceeds size, the string shall be truncated to size -1 bytes. If cancelled, returns 0 and options string is left unmodified. If error, a modal dialog is displayed, and -1 is returned.

Remarks
This dialog shall 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.

C3.8 **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.

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.
    Return Values
Returns TRUE if connection established, FALSE otherwise.
    Remarks
If a connection cannot be established, the function shall display a modal dialog box detailing the problem.

C3.9 **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.
Return Values
Returns TRUE if the FR still connected or FALSE if connection has been broken.

Note: The KeepAwakeFR function may be called asynchronously by the program that has loaded the DLL. There is no guarantee that KeepAwakeFR will not be called while another request is in progress, such as DownloadLogFR. It is up to the DLL implementer to ignore any KeepAwakeFR requests that will interfere with other operations in the DLL.

C3.10 **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.
Parameters
value
[out] pointer to a buffer which shall receive the string result.
size
[in] size of the buffer pointed to by value in bytes.
Returned Values
Function returns number of bytes in returned string, if actual length of string exceeds size, the string shall be truncated to size -1 bytes.

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 ("SEALED" if sealed, "UNSEALED" if not). Maximum permitted length of the string (excluding the terminating NUL character) is 63 characters. Example:

AXL01F|XL 100|SEALED

For types of recorders with original IGC-approvals dated before 2003, if the FR Serial Number cannot be returned (for instance due to firmware limitations), a Serial Number of 000 shall be used.

C3.11 **IdentifyLogFR**

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

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

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

Return Values
IdentifyLogFR returns number of bytes in the returned string, if actual length of string exceeds size, the string shall 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 shall return 0.

Remarks
The returned string consists of seven fields, separated by the "pipe" character ("|", 0x7C), the default log file name (including addition), 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 shall start by calling IdentifyLogFR with index 0, incrementing index by 1 until IdentifyLogFR returns 0.

C3.12 **DownloadLogFR**

BOOL DownloadLogFR(DWORD index, LPCTSTR fileName)
The DownloadLogFR function is used to download a log file from the currently connected FR.
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 shall be downloaded. If NULL, the default file name shall be used in the current working directory.
Return Values
DownloadLogFR returns TRUE if successful, FALSE if there was an error.

Remarks
If a file with the specified name and path already existed, it shall be overwritten. If there is an error, DownloadLogFR shall display a modal dialog box giving the details. If the quietMode flag was set to TRUE in the call to InitializeDLL, the download shall occur silently, without any dialog boxes displayed, unless there is an error. If quietMode was set to FALSE, DownloadLogFR shall display a modal dialog box with a progress indicator and a cancel download button.

C3.13 **DisconnectFR**

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

C3.14 **UseConvertLog**

BOOL UseConvertLog()
The UseConvertLog function is called by the control program to determine if the DLL ConvertLog function is needed to convert from a proprietary log file format to IGC. If it does not, the control program shall not offer the user the option of converting log files.
Return Values
Returns TRUE if conversion from proprietary format to IGC is required, FALSE if not

C3.15 **ConvertLog**

BOOL ConvertLog(LPCTSTR fileName, LPCTSTR igcFileName)
ConvertLog converts the log file specified by fileName to an IGC format file specified by igcFileName.
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.
Return Values
Returns TRUE if successful, FALSE if there is an error.

Remarks
If a file with the specified igcFileName already exists, it shall be overwritten. If there is an error, the function shall display a modal dialog with the details.

C3.16 **ValidateLog**

BOOL ValidateLog(LPCTSTR fileName)
ValidateLog is called to authenticate the digital signature on a specified log file.
Parameters
fileName
[in] a null terminated string containing the name of an existing log file (which may include a path) to be validated.
Return Values
Returns TRUE if file can be validated, FALSE otherwise.

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 shall display a modal dialog detailing the problem, then return FALSE.
If quietMode was set to FALSE in the call to InitializeDLL and the validation takes more than a few seconds, ValidateLog shall display a modal dialog box with a progress indicator and a cancel validation button.

C4. **PROGRAMMING FRAMEWORK FOR CONTROL PROGRAMS**
In order to utilise the freeware DLLs described earlier in this appendix, a Control program is required. Authors of Analysis Software, Scoring Software etc. may wish to incorporate the facilities of such a program into their products. In order to assist Flight Recorder manufacturers and other Software writers, the following files are provided on the IGC website at http://www.fai.org/gliding/gnss/freeware.asp.

Working Sample Shell Program.
Source of Shell Program.
Dummy DLL file (to assist in Shell Program testing).
Source of Dummy DLL. (can be used as a Template for Manufacturer's DLL code)
These files are provided free of charge and with no warranties of any kind. If portions of the source files are used in any product, then the copyright conditions in the source files must be observed.

[Note: paragraph C4 is also used on the IGC web site as an introduction to the files for free downloading.]

---------------- Appendix C ends ----------------

APPENDIX D

DATA, CONV and VALI short program files

These DOS-based program files have been replaced by the IGC Shell system described in Appendix 3.
This Appendix gives more detail on the now-obsolete program files because some older types of recorder
do not have the manufacturer's DLL file needed for the IGC Shell program.

D1. Short Program Files for Download and Conversion to the IGC File Format.

The full names of the short program files are DATA-XXX.exe, CONV-XXX.exe and VALI-XXX.exe, where XXX is the code for the recorder manufacturer given in the table in para A2.5.6. The DATA file is for downloading flight data from a recorder, CONV is for converting binary or other flight data to the ASCII IGC format (where the recorder downloads in another format rather than direct into the IGC format), and VALI is for checking the downloaded IGC file for integrity under the IGC Validation system described in para D3. These short program files were used before the availability of MS Windows, and are DOS-based. They should work without other requiring other files or programs except the operating system of the PC. For MS Windows-based systems, the DOS files should execute correctly either through a self-booting memory stick or other device, or from the main Hard Disk with Windows running, if necessary through the DOS window (where one exists in the OS concerned).

D2. Data download from FR to PC - DATA program.

The program file DATA-XXX.EXE and its Windows equivalent (appendix 3) shall download the flight data from the FR memory to a PC and shall also convert downloaded data to the IGC file format at the same time. The DATA DOS file shall 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 where evidence is submitted to NACs and FAI on portable disks, the disk must be formatted for use on PCs, although email is now normally used and the IGC file can be sent as an attachment. Appendix A para A1.1.1 gives the conditions for which the DATA program and the FR must produce a separate IGC flight data file. The DATA program file shall be the shortest software program that can download data from 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. For those FRs that have a more comprehensive manufacturer's software program in addition to the short program files, the DATA program provides a free and rapid option for data download in the absence of other programs.

D2.1 Last flight. On executing the DATA program, the data from the last flight must automatically be downloaded to the PC to the same directory as the DATA program, without needing special switching or keyboard actions on the recorder. Download of the data on the last flight shall be as quick as possible (at competitions up to 100 FRs may be involved and long time downloads cannot be tolerated for obtaining individual IGC files).

D2.2 Options through menu. After the automatic download of the last flight, options must be offered through a menu for downloading data from other flights in the FR memory. The menu shall list all flights in the FR memory in reverse chronological order, giving the date/times of start and finish of recording and the duration of the recording. After the automatic download of the last flight, it must be possible to scroll to and highlight other flights for downloading either individually or collectively. If a selected flight is already in the PC memory, it shall be possible to bypass the further downloading of that particular flight. All erase and overwrite actions must have a second check keystroke to avoid inadvertent erasure or overwriting of data already in memory in the FR or the computer.

D2.3 Execution of program. No special switching or keyboard actions on the recorder shall be required for the DATA program to work, although a timeout function of at least 60 seconds is acceptable after the FR is switched on during which contact with a PC may be made. It must be possible to download to an IGC data file containing 3600 fixes (B-record lines) in 1 minute or less, using a Pentium 500MHz PC running the Windows XP operating system and the standard IGC-shell program for downloading with the DLL supplied by the manufacturer. 3600 fixes are equivalent to recording a 5 hour flight at a 5 second fix interval or a 10 hour flight using a 10 second fix interval. Full security encoding must be included in this downloaded IGC file so that the IGC VALI check can be made on it later. The 60 second time is from when the download process is initiated to when the complete IGC file becomes available for analysis on the PC concerned, and includes any time required for security calculations before flight data is downloaded from the recorder to the PC. The time to execute the VALI program (para D2.9) later is considered to be less critical because the VALI check can be made after initial downloading of the IGC file to the PC.

D2.4 Ports. The DATA program must be capable of downloading via serial COM ports 1 and 2, and manufacturers shall include compatibility with other COM ports, LTP ports, USB ports, and shall allow (wherever possible) for 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 the FAI internet reference: http://www.fai.org/gliding/gnss/freeware.asp (also through a link from http://www.fai.org/gliding/gnss), and manufacturers shall 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.

D2.5 Integrity of data. If a problem is detected in the integrity of the recorder or the data (such as if the recorder has been opened in an unauthorised manner) and the recorder has a screen display, the words describing the problem must stay on screen until positive action is taken to proceed to the next stage in the data download process. This is so that the person viewing the screen can take notice of the message, even if distracted when the message first comes up.

D2.6 Conversion to the IGC Format - the CONV file. Unless data is always downloaded from the FR in the IGC file format, a separate program CONV-XXX.EXE or its Windows equivalent (Appendix C) shall be provided. 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, para A1.1.1). For conversion of a flight data file, a short menu may be provided, otherwise for the DOS program, type "CONV-XXX" followed by a space and the name of the file to be converted, then "enter". The DOS file is not expected to exceed 100kb in size.

D2.7 PC Speeds. The DATA and CONV programs shall not need high PC speeds and large amounts of RAM. When used for data download after flight, the programs must be capable of being used on portable storage media (memory stick, etc) 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.

D2.8 Data download. It must be possible to download 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) and to create the IGC file for the flight on the PC hard disk or portable storage media by use of the DATA program.

D2.9 Other methods. These include the use of separate software programs which include data download (such as part of a manufacturer's integrated program for setup, download and analysis), also the use of PalmPCs and PC cards for data download 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 program on a low-range PC.

D3. **The VALI program file - Digital Signature (DS) check**. The program file VALI-XXX.EXE is for validating the DS of the IGC-format file. If there is an intermediate format (such as binary) which is downloaded from the FR before conversion to the IGC format, it must be ensured that DS data is downloaded 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 downloaded from the FR. The VALI program may be copyright but shall be freeware, and may be copied by NACs. The DOS VALI program is not expected to exceed 100kb in size.

D3.1 Operation of VALI program file. The VALI program 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 for the DOS version type "VALI-XXX" followed by a space and the name of the file to be authenticated, then "enter". The result shall be presented clearly on screen, either pass or fail. If "pass", the words "Validation check passed, data indicated as correct" shall appear. If "fail", after "Validation check failed", a likely reason shall be given if possible, for instance "File data may have been altered", or "security microswitch may have operated, recorder case may have been opened". The result must remain on screen until a positive action is take to change it. NACs may copy the VALI file for use by their agents such as OOs, Data Analysts, and competition organisers. However, 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. Validation software must also work correctly if the CRLF at the end of a line is replaced by CR or LF. This will make it possible that a file downloaded in ASCII mode from a MS operating system to a UNIX system and in binary mode from a UNIX system to a MS operating system, will continue to pass the VALI check.

D4. **Parameters (switches)**. These apply to the appropriate DOS program files and 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:

-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. Downloads all flights not on disk unless-o is also used, in which case all available flights are downloaded. 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 downloaded, 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

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

An example, for instance for use in a competition: DATA-XXX -q -nEE25JUL
In this case, the download program of the manufacturer XXX will download 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 which is designed for records and badges under OO supervision.

D5. **Multiple Program Files - File Naming**. If a manufacturer has several different types of FRs, more than one set of short program files may be needed. For naming further program files, first the hyphen shall be deleted and a number added (DATA-XXX is followed by DATAXXX2). After XXX9 only the first two letters of the manufacturer's code shall be used, plus a number eg DATAXX10, XX11, etc.

APPENDIX E
CHANGES OF IGC-APPROVAL LEVEL

E1 Changes of approval level. If GFAC proposes to lower the approval level of a type of IGC-approved recorder, this will be discussed in confidence, first with the IGC ANDS committee and then with the manufacturer (for approval levels, see para 1.1.4 in the main body of this document). The IGC Bureau may also be informed if appropriate at this early stage. Such lowering of level may apply to a particular type of recorder or to a specific modification state or a hardware and/or firmware version of the type. As much notice as possible will be given so that the manufacturer can be given the opportunity of offering an upgrade that will retain the existing approval level. After these discussions, if GFAC still decides to recommend a lowering of the approval level it will then make a detailed recommendation to the IGC Bureau. The Bureau may decide to make a public domain announcement asking for comments. The Bureau will then assess all of the evidence and make a decision. If they accept the GFAC recommendation to lower the approval level, the details will be announced immediately but the next IGC Plenary meeting will be asked for confirmation as part of the normal procedure for confirmation of Bureau decisions that were made between Plenaries. Announcements will be made on the FAI IGC discussion group (igc-discuss@fai.org) and on the international soaring newsgroup (rec.aviation.soaring) but will not include confidential or proprietary information.

E2 Data integrity factors. Factors that may lead to a lowering of approval level, particularly from "all flights" to a lower level, include the following. Evidence that flight data generated from an IGC-approved recorder has been or can be manipulated, altered or falsified. For instance, if it can be shown that the secure parts of an IGC flight data file can be changed and it still passes the electronic VALIDATION check. Also, evidence that the security function or functions have been compromised, or if IGC experts in data security assess or demonstrate that security could relatively easily be compromised by commonly-available equipment and methods. This includes a situation where it can be shown that the security microswitch can easily be by-passed. In these cases, the lowering of approval level will take effect at a date agreed between GFAC and the Bureau. In serious cases such as where there is a risk that compromised data could be submitted for flight claims from other recorders of the same type, this could be the date of the public announcement of the Bureau decision.

E3 Other factors. If the approval level is to be lowered for reasons other than those given above, the date of implementation will be decided by the Bureau and will not normally be before 12 months after the date of the public announcement of the Bureau decision.

E4 Appeal against a lowering of approval level. If it is decided to lower the approval level of a type or version of a recorder, the manufacturer of the recorder or any entity with an interest may appeal to the IGC Bureau to have the decision reviewed. The organisation or individual making the appeal must notify the IGC President of an intention to appeal within one calendar month of the public announcement of the lowering of the approval level. Notification by email or fax is acceptable and will be acknowledged using the same medium. Pending the appeal, the decision and its implementation timescale will stand. In submitting the appeal, the organisation or individual making the appeal agrees to accept the result, which is at the sole discretion of FAI as the legal entity and its agent IGC, and also agrees not to institute proceedings against the FAI or its agent IGC or against any person who was involved on behalf of FAI or IGC.

E4.1 Procedure and evidence. The Bureau will then appoint a tribunal of either three or five persons, one of whom will be nominated as Tribunal President. These persons must have an understanding of the technical area concerned but must have no direct commercial or strong personal interest in the result. Evidence shall be given in the English language and be sent by email to the Tribunal President. Tribunal members will correspond with each other by email. Evidence may include proprietary or confidential information that must not be divulged to the Public Domain. Such evidence must be kept confidential to the Tribunal members and parties authorised by the Tribunal to see it such as the manufacturer, the appellant (if different), the IGC GFA and ANDS committees and authorised technical experts used by IGC. Evidence should be submitted by email in commonly-used formats such as MS Word for text and JPEG for pictures and diagrams. GFAC, and if appropriate the ANDS committee, will present evidence to the tribunal in favour of the change of approval level; evidence from the organisation or individual making the appeal is covered in 1.4.2 below. Within 3 calendar months of receipt of appeal documentation from the appellant, unless exceptional circumstances prevail, the tribunal shall reach a decision and notify the IGC President of their findings and recommendations. These may include proprietary and confidential information. The President will pass these on to the Bureau and to the GFA and ANDS committees. An edited summary without any proprietary or confidential information and suitable for the Public Domain will be prepared and announced as soon as it is agreed by the Bureau and the manufacturer, the organisation or individual making the appeal (if not the manufacturer), and the GFA and ANDS committees have been given time to comment.

E4.2 Appeal documentation and financial deposit. Appeal documentation from the organisation or individual making the appeal must be received by the Tribunal President within three calendar months of the date that the change in approval level was announced in the public domain. The appeal financial deposit must be received by FAI within the same three calendar month period. The amount of deposit will normally be that specified for appeals under the FAI Sporting Code General Section (GS Chapter 9) unless decided otherwise by the IGC Bureau. The deposit is payable in Swiss Francs (ChF) and the amount can be obtained on request to the IGC President or the Chairmen of the GFA or ANDS committees. The deposit must be lodged with the FAI account in Zurich and banker's drafts must be marked "IGC account for IGC GNSS Recorder appeal" so that FAI and the IGC Treasurer will know what it is for. Bank and other transfer charges must be paid by the applicant so that the full deposit is received in the FAI account without any deductions for transfer or other bank charges by either the sending or receiving bank. The deposit is not returnable unless the case of the organisation or individual making the appeal is accepted without reservation, although a partial refund may be made if recommended by the Tribunal.

APPENDIX F
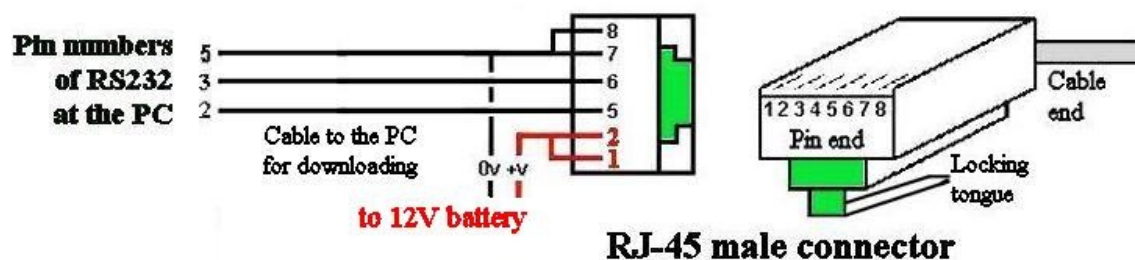**STANDARD IGC CONNECTORS**

F1 Connectors and Fittings for downloading Flight Data. IGC-approved types of connectors or fittings on the recorder case for downloading flight data are listed below. Where a PC is used for downloading, either the RJ45 or the USB type is recommended because standard wiring to these types includes both power and data download facilities. The IGC standard connections for the RJ45 are given below and the USB connections are to the international standard. For panel-mounted recorders, it is recommended that an industry-standard memory fitting is on the front face (such as an SD card or USB connector); if the connector for downloading is elsewhere, an extension cable must be supplied so that there is no need to gain access to the back of the instrument for routine downloading.

F2 Stand-alone Memory Devices. Downloading of IGC files may be to industry-standard devices such as SD cards, USB memory sticks or others. SD cards include full-size, mini- and micro- variants. It is recommended that where such a memory device is in place during and after flight, downloading of the last flight should be automatic rather than requiring pilots to make selections. Such memory devices may also be used for uploading data into the recorder such as settings and Waypoints, but the design must prevent false data or unauthorised programs affecting the security of the recorder. A manufacturer's DLL file for the IGC Shell program (see Appendix 3) is still required for electronic Validation of downloaded IGC files.

F3. 8-pin RJ-45 connector. This is a female 12 x 6 mm RJ-45 socket with 8 connections. It is also used for ISDN and Ethernet connections (but with different pin allocations). In the IGC layout, with the male plug end held towards the observer and the pins uppermost, the locking tongue underneath and the cable running away from the observer, pins are numbered 1-8 from left to right. IGC functions are listed below and also in the diagram that follows.

RJ-45 Pins	Function
1&2	Volts +
3&4	Spare, for future application with GFAC approval
5	Data out
6	Data in
7&8	Earth (Volts -ve)

F4. USB connectors. The connector on the recorder case may be a female Universal Serial Bus (USB) B-type receptacle, for connecting the recorder to a PC through a standard USB-B to USB-A cable. Wiring to the connector on the recorder case shall be to the USB standard (see www.usb.org). The recorder port shall be compatible with USB 1.1 and USB 2.0 devices. On the recorder, the receptacle shall be either a full-size USB series B receptacle (for which the male is about 8 x 6mm) or the 5-pin USB series mini-B receptacle for which the male is about 6 x 3mm with angled ends. See the photo provided
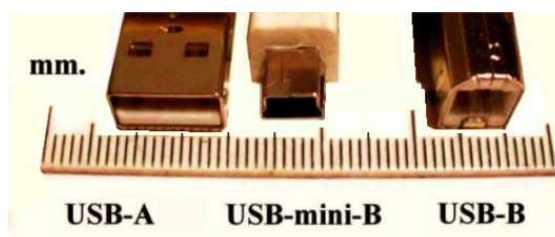
F5. 9-pin RS232 connector. This is a 9-way D-type Subminiature female connector with RS232 standard pin assignments, as used in existing systems such as Cambridge, Print Technik and Zander. Pin 2 is for RXD (data from FR to PC), pin 3 for TXD (data from PC to FR), and pin 5 for GND (signal ground). Other 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.

F6. Connectors for other functions. Connectors that include functions other than the download of data can be of any type as long as the cable connector can be securely attached to the FR case (that is, it can be secured by screws or clips and cannot be detached by a straight pull force). Power and backup download facilities may be included. Such functions include connections to other units such as those with variometer, speed-to-fly or final glide facilities. .

F7. "Grandfather Rights" for RJ-11 telephone connector with 6 pins. The RJ-11 was an IGC-approved connector but was withdrawn for new types of recorder by Amendment 6. This was because it had been found that after repeated use the locking tongue can break off, leading to the use of sticky tape or other methods to secure the connector to the recorder. The larger and stronger RJ-45 is a significant improvement over the RJ-11 because it is stronger, has more pins and its cable is (normally) shielded. The details of the RJ-11 pin layout continue to be included below so that users of equipment with RJ-11 connectors that has "Grandfather Rights" know what pin layout to use when making up connectors for download of data. The IGC RJ-11 system used a female 9 x 6 mm RJ-11 socket on the recorder with pin assignments as follows:

RJ-11 Pins	Function
1	Volts +
2	Spare (For future application (FFA) with GFAC approval. (Some recorders use this for an external LCD)
3	Spare (remarks as for pin 2)
4	Data out
5	Data in
6	Ground

F8. Other Plugs and Sockets. The IGC standard of wiring is published above. The wiring of any other plugs used on the recorder must be such that, if the other plug is put in the IGC socket by mistake, damage will not occur to the recorder. The pinning for any voltage wiring is particularly important if damage is to be avoided if a plug is put in the wrong place.

APPENDIX G

PRINCIPLES AND PROCEDURES FOR IGC SECURITY

G1. **GENERAL**. For IGC-approval, security procedures and hardware, firmware and software must be used so that no alteration of data may occur without such alteration being detectable. For the IGC file, this is achieved by the generation of a digital signature (DS) by the FR, which becomes part of all downloaded IGC files from the FR, see 2.8.3 below. Regardless of the level of physical control used in handling and transmitting data between the FR and the authority validating the flight, the DS must enable detection of any alteration of data from that initially download 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.

G1.1 **Levels of IGC-approval**. Security aspects are important factors in the types of flights for which a recorder is given IGC-approval, the highest approval level being for "all flights". The list of different approval levels is in para 1.1.4 in the main body of this document and is also in Annex B to the Code (SC3B).

G2 **DIGITAL SIGNATURE AND IGC ELECTRONIC VALIDATION SYSTEM**. The Digital Signature (DS) in the FR must be used to generate the G- (security) record at the end of each IGC file. The IGC electronic Validation system checks the DS/G-record of an IGC file and can be used at any time for checking a file. See para 1.1.10.1 in the main body of this document.

G2.1 **Message Digest and Public/Private Keys**. 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 downloaded 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. 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 (see 2.8.1) must have an asymmetric algorithm such as RSA, or have a system providing equivalent security as decided by GFAC. FRs for other IGC-approval levels must have algorithms which are complex enough to discourage malpractice. 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.

G2.1.1 Public and Private Keys. It must be ensured that the minimum number of persons have knowledge of any security keys and details of any encryption used in IGC-approved recorders. The FR manufacturer must keep a register of people with this knowledge. Such knowledge must be confined to persons at the manufacturer's facility and not, for instance, passed on to agents or others in such a way that they could build a list of such keys. Flights made by any persons using an individual FR for which they have this knowledge will not be validated for IGC purposes.

G2.1.1.1 Public Keys. The purpose of the public key is to check that the IGC file was digitally signed with the unique private key that is held in each recorder. As used in IGC-approved recorders, the public key is not intended to be available "in clear" to everyone, but should be regarded as a confidential part of the IGC security system in the same way as the private key. The batch of public keys that a manufacturer intends to use with a production run of IGC-approved recorders must be encrypted and embedded in the DLL file supplied by the manufacturer and that is posted on the IGC GNSS web pages for use with the IGC Shell program (or for older recorders, in the VALI-XXX program file). A DLL is expected to contain at least 500, and preferably 1000 encrypted public keys, to allow for a production run of this number of recorders, each with their own unique key pair. It is not acceptable to have public keys embedded in the recorder and/or the IGC output file, even if encrypted.

G2.1.1.2 Private Keys. Before initial sale, a private key of the appropriate length must be placed in the flight recorder by the manufacturer in such a way that it will be erased if the recorder is opened or otherwise tampered with. After sale, if a security re-set becomes necessary, it may be replaced only by the manufacturer or by an agent authorised by the manufacturer to re-set the security of the recorder having obtained replacement key data from the manufacturer in a secure way.

G2.1.2 Public/Private Key Cryptography (PKC) systems and data download times. For "all flights" IGC-approval, a digital signature system using a Public Key Cryptography (PKC) algorithm will be required, or a system of similar strength as decided by GFAC. RSA or DSA algorithms are currently accepted by GFAC, using a modulus of at least 512 bits, 1024 bits being preferred (see the Glossary under DSA, PKC and RSA). Alternative methods may only be used after review and acceptance by GFAC; the manufacturer should provide at least two peer-reviewed papers that confirm the quality and strength of the method. 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 download from the GNSS FR to a PC. The ECC system (see Glossary) is also a permissible alternative and enables a shorter private key length to be used compared to RSA and DSA for a similar level of electronic security. With the DSA system it may be possible to make security calculations while the FR is recording data, which may save time during data download to a PC after the flight. A 100kB IGC file must download with full security encoding from the FR to a typical laptop PC in 1 minute or less. The time to execute the IGC validation program (para G2) is considered to be less critical. For more information on RSA and DSA, see the Glossary, and for advice on these matters, consult the GFAC Chairman who will refer questions to appropriate experts in software security for flight data files.

G3. **CHECKING THE INTEGRITY OF THE IGC FILE**. The NAC or other authority responsible for validating the flight performance will use the VALI program (para G2) to check the integrity of the IGC file. If the VALI check is successful, this shows that the file content is an exact copy of the file that was initially downloaded from the FR, and that the FR has not been opened or otherwise altered since it was sealed by the manufacturer or his agent authorised to seal such recorders. The system is similar to that used for encrypting and checking files & mail on the Internet. The DS from the G record is decrypted in order to get the original MD using the public key which is stored independently of the FR. This public key is contained within the appropriate VALI program.

G4. **OPERATION OF THE SECURITY MECHANISM**. If a FR is opened or otherwise interfered with either physically or electronically, a mechanism must exist so that any subsequent data from that FR will be detected as not having the correct DS. This shall be achieved by a system that operates if the FR case is opened and deletes the encryption key(s) required to compute a valid DS, such as a microswitch or equivalent system. The principle being that if the security mechanism of the FR is activated, any data originated after such activation must not have a valid security signature from the FR, until the recorder is re-set by a secure and authorised method. It is permissible to retain data for flights that were in the memory when the security system operated. If such flight data has the previous valid security signature and will pass the VALIDATE check, it must be stored in such a way that it cannot be altered even though the recorder itself is insecure. 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 para G2 on Validation programs.

G4.1 Protection of the Security Mechanism. The security mechanism inside the FR must be protected from any interference from outside, such as an attempt to prevent the mechanism from operating while the FR case is opened. There is the possibility that a probe or tool could be inserted through ventilation holes (if any), through a partially-removed connector on the case, or through a gap in a slightly-opened case. This can generally be prevented by fitting a guard or shield over the microswitch or other mechanism. This will be closely looked at during GFAC testing.

G4.2 If the security mechanism has operated. If the internal security mechanism (for instance a microswitch) has operated, the recorder shall continue to produce flight data in the IGC file format, although such data must fail the various security tests and cannot be used for flights that require validation to IGC/FAI criteria. Authorised agents of FR Manufacturers or anyone else shall not be given (or acquire over time) lists of codes or keys for re-initialisation purposes, that could be used again without reference to the FR Manufacturer. The system must be protected in the case where an agent might transfer to another manufacturer or even be involved in hacking at a future date. The normal procedure shall be that a security code or key is transmitted by the FR manufacturer to an authorised agent for the re-sealing of an individual recorder on a specific date, the code or key being itself coded or using a "one-use pad" system. This is so that an agent or anyone else cannot, over time, collect a database that would allow recorders to be initialised without reference to the FR manufacturer and that could be used later in some illicit way. The use of publicly known algorithms is preferred, so that the level of security can be assessed by GFAC. Also, to prevent loading of invalid programs, if application code with an invalid signature is loaded, the battery backed RAM must be cleared.

G5 **USE OF COMPUTERS.** There must be security devices (such as 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. 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 or PDAs for display and other purposes. However, it is difficult to prevent this, particularly in a two-seat glider. The worst-case in terms of security, which must be taken into account, is that a powerful laptop PC 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.

G6 **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 should be 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 checks.