

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

INTERNATIONAL GLIDING COMMISSION



**TECHNICAL SPECIFICATION
FOR
GNSS FLIGHT RECORDERS**

**Second Edition
with Amendment 4 - 10 September 2015**

AMENDMENT LIST (AL) RECORD

The latest version of this document is on the FAI/IGC or the GFAC web pages, as follows:

FAI/IGC web: via: www.fai.org/igc-documents

GFAC web: direct at: www.ukiws.demon.co.uk/GFAC/documents/tech_spec_gnss.pdf

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 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 may also be used by other FAI Airsports. It is published on the FAI/IGC and GFAC web pages at the web references given at the top of page (i). This document covers the normal design situation, but other designs will be assessed and tested by GFAC and given IGC-approval if security of data and other important provisions of this document can be demonstrated.

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. FAI, IGC and their 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 with 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, you can contact the FAI Office who will forward your message:

c/o FAI Secretariat, Fédération Aéronautique Internationale,
Avenue de Rhodanie 54, CH-1007 Lausanne, Switzerland

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 intended to happen. Where the context is appropriate, words of the male gender should be taken as generic and include 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. IGC committees such as ANDS and GFAC and their members and advisors are agents of IGC and therefore also of FAI, the legal entity.

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 members of ANDS and GFAC and their 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 position recording using GNS Systems. 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) for use in the IGC data file. A Glossary of more general FAI terms is in the General Section of the Sporting Code via: www.fai.org/fai-documents

Numerical

2D Position - A navigational position giving horizontal data (ie lat/long) but not vertical (altitude). In GNS Systems, at least three position lines (ie correct data from three satellites) are needed for a 2D fix.

3D Position - A navigational position giving both horizontal and vertical data (lat/long and altitude). In GNS Systems, a position from at least four position lines (ie correct data from four satellites) is 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, depending on the exact geometry of the position lines used in a particular fix. In addition, further short-term inaccuracies in GPS altitudes have been recorded in IGC files, including GPS altitude unlocks and short-term variations compared to pressure altitude. This is probably because of the low-cost GPS receivers used which are designed primarily for output in lat/long rather than altitude.

4D Position - A navigational position including Time as well as 3D position. Since highly accurate time is an integral part of the principle of operation of a GNS System, it is available with every 3D 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 to transmit the lat/long and altitude of aircraft that are equipped with it to other aircraft and to Air Traffic Management (ATM) systems. It has the accuracy of GPS, much better than older radar-based systems. It is Automatic, in that it is always live and requires no operator action. It is Dependent, in that it depends on a GNS 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 GPS-based ADS-B system is the basis for the U.S. NextGen Air Traffic Management (ATM) system and other future ATM systems.

Analysis - With reference to IGC Flight Recording, study of flight data with a view to 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 = The Air traffic, Navigation and Display Systems committee of IGC.

API = Application Programming Interface. A set of functions that an application can call, to tell the Operating System (OS) to perform a task.

ARINC = Aeronautical Radio Incorporated, a company that, amongst other things, develops standards for avionic equipment. When such a standard is accepted by bodies such as the US FAA or ICAO they are issued as numbered documents, such as ARINC 510 for avionic interfaces with simulators.

Augmentation systems, for GNSS - The term for systems that apply corrections to data from GPS receivers over a specified area. The generic term is Satellite-Based Augmentation Systems (SBAS), and examples include the European EGNOS and US WAAS. More detail is under SBAS below.

Authentication - see under Validation.

CEP = Circular Error Probable, or Circular Error of Probability. A distance within which a proportion of fixes will lie with respect to the accurate position. Normally to a 50% level of probability unless stated otherwise.

Constellation - When referring to GNSS, the set of orbiting satellites from which transmissions of those in range are used in a 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 used to denote the end of a line 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 - Where relevant to GNSS, the Geodetic Datum (qv). The WGS 84 Geodetic Datum (qv) must be used for all lat/long co-ordinates in IGC files that originate from an IGC-approved FR after flight. WGS84 assumes that the shape of the Earth is a three-dimensional ellipse ("ellipsoid"), the dimensions of which are defined (see later under WGS84). The WGS84 ellipsoid is the preferred FAI earth model for measuring flight distances, see the General Section of the FAI Sporting Code (the FAI GS), via www.fai.org/fai-documents

Digital Signature (DS) - see under Security

DLL = Dynamic-Link Library. A DLL is a small program containing functions that other programs or resources can call or use. DLLs are used in Microsoft Windows, in Distributed Interactive Simulation (DIS) links, and other processing. In IGC FRs a DLL produced by the recorder manufacturer is used to Validate the integrity of IGC file data files, see later in this document under DLL. (AL3)

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 satellite 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) to measurement error. 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.

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

Download - The transfer of data from a GNSS Flight Recorder either by cable to a PC or 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 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, reducing download times from FR to PC, and some computation can be done "on the fly" while the recorder is operating. However, DSA takes more computation than RSA to verify a signature, the IGC VALI process taking longer than RSA. However, the VALI process is not time-critical, whereas download from FR to PC is, particularly in competitions with many entrants. 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 192 bit private key is accepted by GFAC as equivalent to RSA with a 1536 bit private key, 160 ECC with 1024 RSA.

FR manufacturers using ECC should note that it is a patented system subject to license agreements. FAI and IGC are not responsible for such agreements which are the responsibility of the FR manufacturer concerned. See also in this Glossary under DSA, PKC, RSA and also: http://en.wikipedia.org/wiki/Elliptic_curve_cryptography (AL1)

EGNOS = European Geostationary Navigation Overlay Service. The Satellite-Based Augmentation System (SBAS) for the European area, similar to WAAS in North America. 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 exact 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 - An ellipse has two diameters, a "major axis" and a "minor axis", and an Ellipsoid is a three-dimensional version, its surface being formed by the rotation of the ellipse about its minor axis (see <https://en.wikipedia.org/wiki/Ellipsoid>). An ellipsoid is sometimes described as an Oblate (flattened) Spheroid, but the term Ellipsoid is preferred compared to other terms such as Spheroid 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 (qv), is ellipsoid based, as are other earth models used in 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. In Flight Recorders it may be due to Radio Frequency (RF) radiation from radios or other emitters in the aircraft or glider, or from RF sources outside the aircraft such as from radar and other equipment transmitting in the RF bands.

Enhancement systems, for GNSS - See above under Augmentation

ENL = Environmental Noise Level. A three-letter code used in an IGC file where three numbers between 000 and 999 placed in the fix record of the file indicate the acoustic noise level at a Recorder. This is 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 - www.eurocae.net. 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 the SAE (US Society of Automotive Engineers) 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 includes horizontal and vertical position (lat/long, GNSS altitude), time (UTC), also Pressure Altitude from a pressure sensor. This is recorded on a B-record line in an IGC file. In addition, other variables are recorded with each fix record, including fix accuracy (EPE/FXA), satellite constellation, acoustic noise (ENL) and other variables specified by IGC. See above for 2D, 3D, 4D, EPE, Constellation, and below for spurious and valid fixes.

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, this is a fix that successfully records the minimum parameters required by IGC for the analysis concerned, and is not assessed as Spurious (see above). It is marked in the B- (fix) record of the IGC file by a letter A in the appropriate place, see A4.2.

For the purpose of assessing presence in an Observation Zone, the geographical position shall be taken as the centre of the co-ordinates of a valid 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 include other facilities such as those for detecting engine use in self-launching or self-sustaining motor gliders, 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 and unique to that manufacturer, identifying an individual FR and IGC files from it. The S/N appears in the file name and also in the first line of the IGC file. If precise 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 such as gravitational constants, for an example see under WGS84.

Geoid - Sometimes used loosely to mean an Earth Model. 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). The WGS84 geoid is therefore a smooth but irregular surface over the whole earth, close to sea level. The maximum difference between the WGS84 Geoid and the WGS84 Ellipsoid is +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. See also Ellipsoid and Spheroid.

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

GLONASS = GLObal NAVigation Satellite System, the Russian GNS System. Over the years it has achieved compatibility with the US GPS system.

GNSS = Global Navigation Satellite System. A system for the determination of position, velocity and time, that includes one or more satellite constellations, receivers, system integrity monitoring, and other aspects supporting navigation performance. It includes the European Galileo system, Russian GLONASS, US GPS and the future Chinese BeiDou 2 GNS 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, Geodetic Datum and WGS84) is able to calculate position on the earth's surface in four dimensions (4-D, see above).

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 such as due to altitude drop-out leading to 2D fixes, it shall be recorded in the IGC file as zero so that the drop-out can be clearly identified during post-flight analysis. Note that in commercial GNS Systems, GNSS altitude may be set to show approximate altitudes above local sea level rather than distance above the ellipsoid.

GPS = Global Positioning System, the U.S. GNS System administered jointly by the Department of Defense (DoD) and the Department of Transportation (DoT). Signals are normally available from 24 out of about 30 satellites in six orbital planes at 55 degrees to the equator at an altitude of 20,200km and a period of 12 hours. This was the world's first commonly-available GNS System and first became operational in January 1980.

See http://en.wikipedia.org/wiki/Global_Positioning_System

GPS system time - is the continuous and highly accurate time used by the GPS satellites, kept by the GPS Master Clock in Colorado and continuously monitored by the US Naval Observatory (USNO) in Washington DC. It began as UTC for 6 Jan 1980 when the system first became operational, and maintains that time frame. This is so that it does not have to 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 2015, UTC was 17 seconds later than GPS System Time. However, the GPS system is programmed with leap second corrections, and most GPS receivers automatically output UTC rather than GPS system time.

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/fai-documents

HAFR - High Altitude Flight Recorder, a special type of IGC-approved Flight Recorder for the recording of altitudes above 15,000 metres. At and above this, the rate of change of pressure with altitude has fallen to a low level and special measures are required to record accurate altitude. See para 2.2.4.1. (AL4)

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 lost when the unit is switched off or its battery fails.

Horizontal fix accuracy - Where this is included in the IGC data file in the B (fix) record through the FXA three-letter code, this is the best prediction for the horizontal 2-sigma (95.45% probability) error of the overall position error.

ICAO = International Civil Aviation Organisation. See: www.icao.int

IGC-approval - Where this applies to IGC Flight Recorders, it refers to one of the Approval levels that are listed in Annex B to the IGC Sporting Code and para 1.1.4 of this Specification. The IGC GNSS Flight Recorder Approval (GFA) Committee (GFAC) test and evaluate GNSS FRs and issue Approval Documents on behalf of IGC.

International Standard Atmosphere (ISA) - The ISA to be used for FAI flight performances is the ICAO ISA. Details are in ICAO Document 7488 tables 3 and 4 and https://en.wikipedia.org/wiki/International_Standard_Atmosphere

At sea level, the ICAO ISA has a temperature of 15C and a pressure of 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 (the top of the "Atmosphere"), above which constant temperature (-56.5C) is assumed until 20km, thereafter increasing by about 1 degree per kilometre.

Pressure figures from the ICAO 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 scale, whether or not such figures correspond to actual heights on a given day. A similar principle is used in calibrating aircraft pressure altimeters, so that aviation worldwide has a common standard of pressure height indication in the cockpit.

ISA = International Standard Atmosphere, see above

ISO = International Standards Organisation, see http://en.wikipedia.org/wiki/International_Organization_for_Standardization

kph = Kilometres per Hour

Latitude - In the 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. For more precision, the LAT code (Para A7) may be used.

Leap Second - see under GPS System Time and UTC. Also http://en.wikipedia.org/wiki/Leap_second

Longitude - In an IGC file, this is an eight character numeric group expressed as three figures for degrees, two figures for minutes and three figures for tenths, hundredths and thousandths of minutes followed by the E or W character. For more precision, the LON code (Para A7) may be used.

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

MoP = Means of Propulsion, an IGC term meaning a system capable of giving forward thrust, such as a piston, jet or electric engine. A MoP recording system is part of a Flight Recorder and produces an after-flight record of engine operation against a timebase for the flight. There are two types of IGC engine recording systems, an ENL acoustic sensor system inside the FR case and an MOP system external to the FR and connected by cable, see under ENL and MOP.

MOP = A three-letter code used in the fix record of an IGC file together with three numbers between 000 and 999, to indicate engine running where the engine and Flight Recorder installation does not produce high enough readings on the ENL system inside the FR. The MOP sensor is external to the FR and connected to it by cable, enabling it to be placed so as to receive a high signal whenever the engine is developing forward thrust. See Chapter 5 for more details, particularly 5.4. (AL4)

Multilateration - literally, having many sides, the shape of such a geometric figure. In navigation systems, 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"), the centre of which is the "Most Probable Position" or MPP.

NAC = National Airsport Control. The authority in a nation recognised by FAI for the supervision of Sporting aspects of Air Sports in the nation concerned. Normally this will be the National Aero Club and matters specific to an individual Air Sport may be delegated to the National organisation for that Sport. This includes compliance with rules and procedures given in Sporting Codes and other documents published by FAI and its Sporting Commissions.

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. GNSS was developed for the marine as well as the aviation market, and 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 (http://en.wikipedia.org/wiki/NMEA_0183).

For instance, the sentence GGA gives GPS fix data, the sentence GNS gives fix data for all GNS Systems (US GPS, Russian GLONASS, European Galileo and other systems), the sentence GSA gives the satellites in view at any one time.

Some GNSS receiver boards output NMEA data directly and others use other output formats. In the latter case, the FR manufacturer must show that data that is acceptable to GFAC is recorded on the IGC data file.

Non-IGC FR. A recording device that records GNSS fixes in the form of the basic IGC file structure but is not designed for IGC-approval. However, it is recommended that 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 IGC files will work with the non-IGC Recorder. Such devices could be, for example, a flight instrument with a recording function, a stand-alone GNSS unit, or a portable device that receives and stores GNSS data. Where FAI Airports other than gliding are concerned, the type of device, the method of data storage and security considerations must 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 Waypoints themselves.

Pilot Event (PEV Code) - This is where a pilot presses an event button or switch that initiates a GNSS fix, marks the fix with the PEV code, followed by a series of fixes at one second intervals (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. 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 by Rivest, Shamir and Adelman (qv under RSA).

Pressure Altitude - In an IGC FR, this is a five numeric group indicating the pressure altitude in metres with respect to the ICAO International Standard Atmosphere (ISA) used in worldwide aviation, with a sea level datum of 1013.25 HPa. The FR may use either "cockpit static" (vented within the FR box), or use a tube connection to glider instrument system static tubing ("instrument static"). 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 distance based on the time recorded in a receiver when a signal from a GNSS satellite is received. The recorded time is made up of two parts, the time of travel from the satellite and an additional time due to the different clock times in the satellite and the receiver. When translated into distance this is true distance plus a spurious so-called "clock offset distance". For the receiver to calculate the clock offset, four Pseudorange values are required, and position accuracy is improved with data from additional satellites over the basic four. An individual value is called "Pseudo" Range because the time difference needs to be found before True Range can be calculated with any accuracy.

qv = quod vide, Latin for "which see", followed by a reference, which the reader is invited to look up.

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.

RJ = Registered Jack. For instance RJ-45, more correctly described as an 8P8C connector. The P and C terminology is where the number before P is the number of pins available, and the number before C is the number of pins in use. (AL1)

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 the Massachusetts Institute of Technology (MIT). 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 at: www.cs.auckland.ac.nz/~pgut001/cryptlib. GFAC will give advice as required.

RTCA Inc - a U.S. 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 US government body. The RTCA letter pages have the words: "Requirements, Technology and Concepts for Aviation ", which also abbreviates to RTCA.

SBAS = Satellite-Based Augmentation System. A system that increases GNSS accuracy by monitoring position errors at ground stations in the area concerned, and making corrections available to compatible receivers. The exact positions of the SBAS ground stations are known, therefore the position error of data from a GNSS receiver at each ground station is also known. This data is co-ordinated and corrections are transmitted to GNSS receivers in the area of SBAS cover, normally via a Geostationary satellite orbiting over the equator. SBAS that enhance the accuracy of the US GPS system include BeiDou 1 (China), EGNOS (Europe), GAGAN (India), MSAS & QZSS,(Japan), and WAAS (North America). A Ground-Based Augmentation System (GBAS) called SmartPath is used in Australia. More detail is under EGNOS & WAAS.

SC3 = Section 3 of the FAI Sporting Code. This is for FAI Class D (gliders) including Class DM (motor gliders). This document is administered by IGC, including its annexes A-D. Its annexes are SC3A (championships), SC3B (recording equipment, including GNSS and FRs), 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/fai-documents

Security - Digital Signature (DS) - A Digital Signature (DS) is a set of encrypted data generated by an FR and downloaded from 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 IGC file name 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" or "characters". Non-IGC recorders may have different S/N systems, for which IGC has no responsibility.

SHA = Secure Hash Algorithm. A set of cryptographic hash functions such as SHA-224, -256, -384 and -512. The SHA system was designed by the US National Security Agency (NSA) and published in 2001 as a U.S. Federal Information Processing Standard. See: http://csrc.nist.gov/groups/ST/toolkit/secure_hashing.html (AL1)

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 involves crossing a start line or exiting the Observation Zone (OZ) for the start point.

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.

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 Point or Waypoint Confirmation- The indication that the glider has reached the Point to the criteria in the IGC Sporting Code. For instance by demonstrating presence in the Observation Zone for a Turn Point or crossing a Start or Finish Line. For Turn Points, this is "reaching" the 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 based on the Greenwich meridian for zero longitude, a north/south line at the historic Observatory at Greenwich (pronounced Gren-Itch) in East London, UK. UTC is very similar to the older term Greenwich Mean Time (GMT). 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 the end of June or December and changes 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.

Validation, VALI check. 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.

Vertical fix accuracy - 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.

WAAS = Wide-Area Augmentation System. The Satellite-Based Augmentation System (SBAS) for North America, based on the actual position of ground-based monitoring stations. WAAS consists of an integrity and reference monitoring network, processing and control facilities, and dedicated WAAS geostationary satellites above the equator. Reference stations receive data from the GPS satellites and measure GPS position with respect to the known position of the station. These measurements are sent to Data Processing sites for calculation of corrections for the area of WAAS cover. 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, RAIM and SBAS.

Waypoint, way point (WP). 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 precise 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 (see the IGC Sporting Code, definitions, para 1.1.2). A waypoint may also be used as a reference point for defining an area that is to be reached as part of a task.

WGS 84 = World Geodetic System 1984. A Geodetic Datum and co-ordinate system based on a mathematical model of the earth and including variables such as gravity constants and coefficients, formulas for angular velocity, various constants, conversion factors, co-ordinate systems, a WGS84 ellipsoid (a three-dimensional ellipse approximating to the true shape of the earth) and a WGS84 Geoid (an irregular equipotential surface approximating to local sea levels, see below) . The WGS84 System Definition Document is Technical Report 8350 from the US National Geospatial-Intelligence Agency (NGA), see http://earth-info.nga.mil/GandG/publications/tr8350.2/tr8350_2.html.

An ellipsoid is the currently accepted best overall simple mathematical model for the earth's shape and in the US Global Positioning System (GPS), all Lat/Long and other fixes are referenced to the WGS84 ellipsoid.

Some years ago over 200 other ellipsoids (local Geodetic Datums) were in use, but these have fallen out of use in favour of the WGS84 ellipsoid which has become the *de facto* world standard Earth Model.

The General Section of the FAI Sporting Code (FAI GS), para 7.3.1.1, states that for accurate measurements on the earth's surface, the preferred earth model for FAI purposes is the WGS84 ellipsoid. See www.fai.org/fai-documents

The dimensions of the WGS 84 Ellipsoid are as follows:

The Major axis is the diameter at the Equator and the semi-major axis is the Equatorial radius = 6,378,137.00 metres

The Minor axis is the distance between the Poles and the semi-minor axis is the Polar radius = 6,356,752.3142 metres

Orientation: the semi minor axis is between the Earth's centre of mass and the Terrestrial Pole as defined by the International Earth Rotation and Reference Systems Service (IERS - www.iers.org).

This approximates to the Earth's spin axis.

For other ellipsoids with radii within 1 metre of WGS84, see para A8

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 +65metres at 60N 030W (S of Iceland, geoid above the ellipsoid) and -102metres 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 the GFAC Chairman. See also under Geoid in this Glossary.

Words, meaning. In this document the words "must", "shall", and "may not" indicate mandatory requirements; "should" indicates a recommendation; "may" indicates what is permitted; "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 members 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 (FR) system is submitted for IGC-approval, GFAC examines it for compliance with IGC rules and procedures. This includes hardware, firmware inside the FR, software external to the FR where relevant to flight recording, output in the IGC data file format, and physical and electronic security of the Flight Recorder and its output data.

Other aspects are matters between customers and FR manufacturers, including cockpit displays, navigational features, proximity warning devices, and post-flight analysis systems.

This document covers the normal FR design situation, but other designs will be assessed and tested by GFAC and given IGC-approval if security of data and other important provisions of this document can be demonstrated to the satisfaction of GFAC.

The "all flights" level of IGC-approval indicates that the type of Flight Recorder meets the standards of data integrity, accuracy, and security that are required for IGC World Record flights. See 1.1.4 for the levels of approval that apply to different types of flights.

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 IGC standards. Such other purposes include, but are not limited to, navigation, airspace avoidance, traffic alert, proximity-warning and/or anti-collision functions, terrain avoidance, any other matters concerning flight safety; and uses of FRs outside IGC such as by other FAI Air Sports and General Aviation.

1.1.2 IGC Flight Recorder Operating Procedures. Operating procedures and limitations for each type of Flight Recorder are 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.

1.1.2.1 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. Unless the FR is part of a permanent and secure fit in the Instrument Panel, 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 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, and it should be marked with the glider registration, the date, time and OO's name, signature, and identification number.

1.1.2.2 Other procedures specific to the type of Flight Recorder 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, and will depend on the Flight Recorder design and the results of GFAC test and evaluation.

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 is circulated in successive drafts to GFAC members and their technical advisors, other relevant experts, and the manufacturer concerned. When finally issued, the document includes detailed procedures for checking the recorder, installation in the glider, and operation for flights that are to be validated 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 and GFAC web pages.

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 subjects such as flight safety and intellectual property); manufacturer details; details of hardware (including the type of GPS receiver and pressure transducer); internal firmware and external software; connections; installation; security; engine recording; and other advice that might be useful to pilots, OOs and NACs. This is followed by two annexes. Annex A contains notes and recommendations for owners and pilots, including procedures and checks before, during and after flight, and other advice that might be useful to pilots. Annex B contains notes, recommendations and advice for Official Observers and bodies validating flight performances such as National Airsport Control authorities (NACs). Annex B includes pre-flight procedures including checking installation and serial number; after-flight procedures including ensuring that the installation has not been

changed; how to download IGC files; checking validity of data in IGC files; and pressure altitude calibrations. Annex B also contains details of Environmental Noise Level (ENL) figures recorded during GFAC testing and to be expected in various phases of flight; also figures from an external Means-of-Propulsion (MOP) sensor if such a system is fitted.

1.1.3.1.1 Checks on individual recorders. It is the responsibility of owners and pilots to check that the characteristics of the recorder correspond to those in the IGC-approval document. If the characteristics do not correspond, the FR should be re-set by the manufacturer or his authorised agent to the characteristics given in the IGC-approval. This particularly applies to the IGC Shell program for checking the electronic validity of downloaded IGC files (see 1.1.10.1 on the IGC Shell program), to the ENL and MOP figures recorded in IGC files which must be similar to those given in Annex B in the IGC-approval document, and to pressure altitude calibrations which must be with respect to the ICAO International Standard Atmosphere (ICAO 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. Where the FR uses static pressure from the glider's instrument system (rather than pressure at the recorder case, "cockpit static"), the tubing and the pressure connection to the FR shall also be checked to ensure that they are out-of-reach of pilots so that no unauthorised changes to static pressure can be made in flight.

1.1.3.2 IGC-approval document kept with the Flight Recorder. 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 printed or electronic form should be included with each recorder sold or updated.

1.1.3.2.1 Valid versions of the IGC-approval and manufacturer's DLL files. The latest versions of IGC-approvals and the FR Manufacturer's DLL files for use with the IGC Shell program are posted on the IGC and GFAC web sites. Only these versions are valid for use with claims under IGC procedures, earlier versions of the approval document and DLL files must not be used.

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, as 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 three levels of IGC-approval are listed below:

1.1.4.1 Level 1 - IGC-approval for all flights. This applies to Flight Recorders that may be used for evidence for all flights up to and including 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" (1.1.5.2 below) apply unless there are major differences compared to the current Specification, as assessed by GFAC.

1.1.4.2 Level 2 - IGC-approval for IGC/FAI badge and Diploma flights. This applies to Flight Recorders that may be used for evidence for all IGC/FAI badge and distance Diploma flights, but is not valid for evidence for IGC/FAI world records. For competition flights, see 1.1.4.6. This level may be used for new types of recorders that do not meet the current Specification in relatively small areas. For types of FR that are already IGC-approved, this level may be used for those which are now below the current Specification standard, particularly on security or accuracy of data, as assessed by GFAC.

1.1.4.3 Level 3 - IGC-approval for badge flights up to Diamonds. This applies to Flight Recorders that may be used for evidence for FAI/IGC Silver, Gold and Diamond badge flights but not for higher badges and diplomas, and records. 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.

1.1.5 Other approval-related aspects

1.1.5.1 Recorders that are not IGC-approved. This applies to types of Flight Recorders that have either not been tested by GFAC and approved 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 Air Sports that use the basic IGC file format but do not have an IGC-approval document.

1.1.5.2 Grandfather rights and approval levels. The term "Grandfather Rights" is used 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, generally being increased. 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 FR 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 EASA for designs that are already-certificated. However, GFAC reserves the right to change 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, particularly on matters of data security.

1.1.5.3 Competitions. The above sub paras apply to record, badge and distance diploma flights to be validated to IGC rules and procedures. For IGC competition flights, the types of recorders that may be accepted are at the discretion of the competition organisers, subject to any higher level rules and procedures under which the competition operates. For instance, Regional or National competition rules or Sporting Code Annex A procedures for World and other Championships that use Annex A rules.

1.1.5.4 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 then be made to the IGC Bureau. Further procedures, Appendix E.

1.1.6 **World Records.** Evidence must be from a Flight Recorder that is IGC-approved for World Record flights (SC3 para 3.0.b). See 1.1.4 on approval levels and 2.2.4.1 on High Altitude Flight Recorders (HAFRs) for use above 15,000 metres.

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. Although IGC cannot control the layout of instrument panels, it can draw attention to the potential dangers. Particularly in single-seaters, the position of displays from the FR and other sources should not be remote from sight lines used for pilot lookout and scan, and 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 GNS 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 registers on the internal electronic security system if the recorder case is opened in an unauthorised way or otherwise becomes insecure. Flights made after any such event should continue to produce IGC files, but such files must be clearly marked as insecure and must fail the IGC Validate check (see 1.1.10.1 below). Re-set of a recorder to a secure state must only be made by 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 three-letter code allocated by GFAC). Having executed IGC-Shell.exe, scroll down to 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 on the FAI/IGC and GFAC web sites

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 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 when 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 then 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 Flight Recorder that provides the evidence for the flight 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, the IGC file contains virtually all the evidence for the flight. There is little problem for FRs that are part of a permanent and secure fit in an Instrument Panel, but proof of presence is particularly important with small, lightweight types of FR that can easily be transferred to another aircraft. 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, for comparison with data in the IGC file for the flight. This is 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 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 clearly marked with the time, date and with the OO's identification, so that the OO can identify it later after a flight to be claimed.

1.1.11.2 **Check of takeoff, landing, and other data, independent of the Flight Recorder.** The times and points of takeoff and landing shall be recorded either by an OO, other reliable witnesses independent of the pilot, 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 (SC3C para 8.1). This is intended as a simple independent check of these parts 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 (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) can be compared to drift in thermals in the IGC file data. (2) conditions found by other aircraft and gliders in the same area at a similar time, including those from other IGC files for comparison, and (3) direct observation of the aircraft by other pilots or witnesses.

1.1.12 **Anomalies in evidence.** Any anomalies in evidence for a claim under IGC rules from a 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 FR 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). This is a committee of at least five persons, appointed by IGC to test, evaluate, and approve individual types of GNSS Flight Recorders in accordance with IGC procedures. In addition to the GFAC members, technical advisors may be used to give specialist advice and receive relevant correspondence. GFAC may also delegate specialist work to other experts but is responsible for co-ordinating the work and for producing IGC-approval documents and other recommendations. The detail of the work and any opinions expressed in GFAC discussion are confidential to GFAC, their advisors and other 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 wish to apply for IGC-approval for their equipment should contact the GFAC Chairman as early as possible during the design process. In the manufacturer's own interest, this should be before any design-fix, 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 notify the applicant of the current procedures for the approval process, including the application form, fee to FAI/IGC, 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 between a manufacturer and a specialist GFAC advisor (such as on the detail of GNS Systems, electronic security, or recording technology), but the GFAC Chairman must be copied with all correspondence so that he is aware of progress and of the issues involved and can inform GFAC members as appropriate.

1.3.2 Submission of a new model of 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 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 technical advisors, and co-ordinate comments to be sent to the manufacturer. For communication, use email with attached files in standard formats such as MS Word for text and JPG for diagrams and pictures. Details from the manufacturer will be treated as confidential to GFAC and its advisors.

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

1.3.2.2. When recorder hardware is available. Recorders should not be sent until GFAC comments have been made on the specification for the type of FR, and IGC files have been produced and sent. When a complete or Beta Test version is available, and *before the fix-of-design stage is reached*, notify the GFAC Chairman. When the Chairman requests, send an example of the equipment for initial evaluation. GFAC will test the hardware and the Chairman will correspond with the FR manufacturer.

1.3.2.3 Fee to FAI. When hardware is sent for testing, the FR manufacturer should fill in the application forms provided by the GFAC Chairman and pay the appropriate fee to FAI for the IGC/GFAC sub-account. IGC-approval will not be issued until the appropriate fee is paid. See also para 1.3.5.

1.3.3 Re-approval after changes. For re-approval or continued approval of a type of Flight Recorder after changes have been made, 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 type of Flight Recorder meets the IGC Specification.

1.3.4.1 Security Protection. 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 Pressure Altitude Calibration. The pressure altitude recording system in the Flight Recorder must be calibrated to the ICAO ISA using IGC procedures. A calibration table and the IGC file for the calibration from which the figures in the table were obtained, must be forwarded to GFAC when a FR 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, annotated GFAC and the name of the Manufacturer and type of FR) before IGC-approval can be given.

This should normally be done 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, on 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 2015) the fee is 1000 Euros for an application for testing a new type of 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 part of the application data that is 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 is intended to be of a non-destructive nature, but GFAC, IGC or FAI are not liable for any damage to, or loss of, any equipment. See Appendix B on GFAC Test and Evaluation. If other GFAC members wish to test equipment themselves, the equipment sent to the Chairman will be sent on from person to person unless the manufacturer can send separate equipment to each. Any excess expenses incurred by individuals (such as postal, excise and tax), shall be paid by the Flight Recorder manufacturer into the FAI account (for the IGC/GFAC sub-account) 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 attachments) is needed from an 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 Engine Recording Systems - General. The IGC Environmental Noise Level (ENL) system inside the FR is designed to differentiate between any engine running that generates forward thrust, and flight conditions in soaring flight without the use of engine. Where the ENL system in the recorder does not produce high enough readings with particular types of engine and FR installations, an additional external sensor under the MOP code must be used, that can be positioned to receive a high engine signal. Critical cases are covered in 1.4.2.2-4 below and more detail is in Chapter 5.

1.4.2.1 High Engine Power. A combination of engine and propeller noise at high power are expected to give ENL figures over 800 out of 999. Most two-stroke engine systems produce ENL values over 900 at high power and many give the maximum of 999. Four-stroke and Wankel (rotary) engines give lower figures which may be enough to differentiate between power-on and power-off flight, depending on where the FR is mounted. Some rear-mounted electric and jet engines at high power have also been shown to give moderate ENL values, depending on where the FR is mounted; however, high power is not the critical case, see below.

1.4.2.2 Critical ENL Cases

1.4.2.2.1 Power-on. 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. 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 unless the FR is mounted close to the engine), a system with a sensor remote from the FR recording engine running under the MOP code must be fitted (see 1.4.2.4 and chapter 5).

1.4.2.2.2 Power-off. 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, because this can be mistaken for running the engine. 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 confusing as thermalling with panels open because when thermalling the glider will be climbing and the ENL could be more easily be mistaken for use of engine. For the ENL baseline for zero noise, see para 5.3.1.

1.4.2.3 ENL numbers. The three ENL numbers as recorded in IGC files must differentiate between the "quiet engine" and the "noisy cockpit" cases. This is done by 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 100 and 300Hz with a typical "bell curve" (the statistical "normal distribution") for sensitivity either side of the peak frequency, gives a good ENL response to piston engine and propeller noise, and less response to cockpit noises in soaring flight.

1.4.2.4 Low-ENL installations - additional MOP sensor. Where an engine and FR installation produces ENL values that make it difficult to differentiate between power-on and power-off flight (as assessed by GFAC using the criteria in 1.4.2.2), an additional engine recording system shall be provided that produces three extra numbers in the IGC file under the three-letter code "MOP". This must be capable of clearly indicating any forward thrust from the engine system. This applies to relatively 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, unless the FR itself is placed close to the engine and/or propeller. For more detail, see 5.4

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 its technical advisors, and to the Flight Recorder manufacturer. The final version of the IGC-approval document is the responsibility of GFAC, which is 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 be where approval cannot be given until one of the FR's systems is improved, or could involve an approval with limitations, such as an approval level other than "all flights".

If the manufacturer notifies GFAC within one calendar 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 the engine sensor system (ENL, and/or MOP) either was not included, or was assessed by GFAC as not being adequate. In this case an IGC-approval might be issued without the engine sensor, pending a development which satisfies the IGC Specification, after which the sensor would then be added to the Approval document 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, internal firmware or external 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 to note the changes, or that a formal evaluation of such changed features is required. If the changes are extensive, GFAC may decide that another full approval process is needed.

1.6.3 **Changes in IGC-approvals.** An existing IGC-approval document may be modified or removed 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 both the previous and future Organisations, followed by amendment of the approval document.

1.6.4.2 **Significant changes in the Organisation.** If significant changes have been made in the Organisation listed in the IGC-approval document under "Manufacturer", GFAC reserves the right to require a new IGC-approval process for the types of flight recorder concerned. In this case, a signature or re-signature will be required on an approval application, and GFAC may require 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 must state whether support for the type will continue such as updates and/or repairs to existing recorders by the manufacturer or another organisation approved by the manufacturer.

1.6.4.3.1 **Pilot aspects - Validation of Flights.** Pilots should be aware that if they are using a recorder for which there is no manufacturer support, in the event of anomalies in IGC files, without manufacturer support 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. A GNSS Flight Recorder operated in accordance with its IGC-approval document shall be used for all flights that require validation to IGC criteria. This includes flights in championships under the rules and procedures of Annex A to the IGC Sporting Code (SC3A). An IGC-approved Flight Recorder must be used for evidence for IGC Badge, Diploma, Record and Competition flights except where a less sophisticated and secure IGC Position Recorder (PR) is used for silver and gold badge flights under IGC SC3 procedures. For the different levels of IGC-approval from world records to badges, see para 1.1.4. IGC-approved FRs must be used by NACs for flights under their jurisdiction where they specify IGC standards, such as for national and regional records, and competitions. Where validation is not required to IGC standards, evidence is at the discretion of the organisation responsible for validating the flight.

1.7.1 **IGC File Format.** For the format of the IGC Flight Data file, see Chapter 3 and the detail in Appendix A. For a performance to be validated to IGC standards, in all cases the file must pass the IGC electronic Validation check (see para 1.1.10.1).

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

1.8 NOTIFICATION AND ISSUE OF IGC-APPROVAL DOCUMENTS. 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 sent to the IGC-discuss email list. The complete IGC-approval document will be posted on the FAI/IGC and GFAC web sites, together with the FR Manufacturer's DLL file for validating the integrity of IGC files.

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 IGC-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 an FR for 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 document may be altered or the approval removed.

1.10 COMMENTS OR QUESTIONS IN USE. If any comments, problems or questions arise during use of an IGC-approved Flight Recorder, 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 manufacturers 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 this document, which is based on Chapter 1 of Annex B to the Sporting Code for Gliding (SC3B).

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 but also include the downloaded IGC flight data file and operating procedures both recommended and mandatory. These include pre-and after-flight checks by OOs or others, sealing, stowage, etc., where these relate to the integrity and security of downloaded IGC files.

2.2.2 **Downloaded Data**. This should be in the IGC text format. Some early FRs download in an intermediate format such as binary which is then converted to the IGC format.

2.2.3 **References for GNSS Data in the IGC file**. For IGC-approval, the Earth Model to which recorded latitudes, longitudes and GNSS altitudes 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 **4D Position data**. Within the FR it must not be possible to change position, altitude, time, and other data that will be used in the IGC file that is downloaded after flight other than by movement itself in flight. See 1.1.8 on the injection of false data through the antenna. However, manipulation of data for presenting on cockpit displays is allowed (but data for the downloaded IGC file must not be changed), such as to show altitude above sea level or above ground rather than above 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 **Loss of GPS fixing - Continuity of Time Data**. During any periods where GNSS data is not available, fixes must continue with the other data including pressure altitude and an accurate timebase. This may be achieved through a Real Time Clock (RTC) function to maintain accurate time if GNSS time is temporarily lost.

2.2.4 **Altitude Recording**. In addition to recording GNSS altitude, an IGC FR shall include a sensor producing an output of pressure altitude that can later be calibrated to the ICAO ISA under Sporting Code procedures. The pressure altitude system must be compensated for temperature changes at the FR and the sensor must be of a type acceptable to GFAC. Such an FR also has the status of an IGC-approved electronic barograph. Fixes including pressure altitude 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.

2.2.4.1 **High Altitude FRs (HAFRs)**. For flights over an altitude of 15km (49,213ft), SC3 para 4.5.3 and para 2.1.1.2 of SC3B refer. An IGC High Altitude Flight Recorder (HAFR) is a Flight Recorder that is IGC-approved at the "all flights" level and where its pressure and GNSS altitude systems have been calibrated to altitudes over 15km, at least up to the altitude that is claimed.

a. **Altitude Data**. Processing of the GNSS and pressure altitude data within the HAFR for use in the IGC file must be to a resolution of better than 10m for GNSS and 1/3HectoPascal for pressure altitude (for the latter, see 4.4.1.1). In testing for IGC-approval, the GPS altitude data in the IGC file will be closely analysed to check that the graph of GPS altitude with time is smooth and without short-term "spikes" that in the case of an IGC record flight would cause difficulty in establishing the exact altitude or gain of height of a claim.

b. **GNSS Receiver**. The GNSS receiver in the IGC-approved HAFR must be a high quality system with at least 16 channels, designed for aircraft use, tested and approved by GFAC as part of the IGC-approval process. Some GPS receivers are barred from producing fixes at very high altitudes and speeds (such as above 60,000ft) and are not suitable for use in a HAFR. The GPS Receiver in a HAFR must be capable of producing 3D fixes at the altitudes and speeds appropriate to the flights that are intended. (AL4)

c. **Calibration of Altitude Data**. See Annex B to the Sporting Code, para 2.1.1, which requires that the type of altitude in the IGC file that is used for the claim is calibrated before flight by an approved Instrument Laboratory to a range that includes the highest altitude of the claim.

2.2.5 Motor glider Engine Recording. For gliders with an engine of any sort capable of producing forward thrust, an IGC-approved system that records its operation must be available. Inside the FR itself, the IGC Environmental Noise Level (ENL) system operates within the recorder case, and is mandatory for any glider with a self-launching or self-sustaining engine system. For 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 1.4.2.2 and 5.6), an additional sensor operating under the three-letter MOP code must be used, for which details are given in Chapter 5. Tests on engine-on and gliding conditions will be carried out by GFAC and details of the use of ENL and MOP systems will be given in the IGC-approval document, which will include typical numbers between 000 and 999 that were found in GFAC tests for both ENL and MOP.

2.2.5.1 **Production standards.** 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 engine detection system(s) produce results similar to those described in Annex B of the IGC approval document.

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. In all cases security must be demonstrated, particularly resistance to the injection of spurious or false data. For further details on security, see chapter 6.

2.2.6.1 **Identification Markings.** 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 the individual recorder. Where a display is available, the recorder manufacturer, FR type, s/n, hardware and firmware versions, must be shown on that display on power-up for at least 10 seconds before it changes to another presentation, so that this data can easily be written down by an OO before flight, and after flight can be checked against this data in the downloaded IGC file. Other details on the display are optional. 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. (AL3)

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, altered, corrupted, or combined in a way that could compromise security of flight and other data (such as in a storage device with software partitions). 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 **Preservation of memory data.** 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 be re-charged on application of external power.

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, the download of data, and the structure and integrity of the IGC file used for flight validation.

2.2.9 Units and Conversion Factors. Where conversions are made, the following shall be used, and are in accordance with international agreements. Other conversions must also follow international standards, if in doubt refer to GFAC:

| | |
|---------------------------|---|
| 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 |
| ICAO ISA Sea Level: | Pressure equivalent to 760mm of Mercury = 29.9213 inches based on 2.54 cm to the inch, as above = 1013.2500 HectoPascals (or Millibars) |

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 applies:

2.2.10.1 **FRs not yet submitted to GFAC or under evaluation for IGC approval.** The change must be incorporated before IGC-approval is given.

2.2.10.2 **FRs already having IGC approval.** Changes involving internal alterations to FR units will not normally be required, except for units returned to the manufacturers or agents for other reasons (such as firmware or hardware updates), when important changes must be incorporated at the same time (in the case of hardware changes, where this is physically possible), in case of doubt, refer to GFAC. A software change outside the FR unit 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 above the WGS84 ellipsoid and pressure altitude to the ICAO ISA, must be recorded.
- 3.3 **GNSS Receiver and Satellite capability.** For IGC-approval, the type of GPS receiver must be of a type that is acceptable to GFAC, and must be able to process 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 or pressure altitude change 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, choice before flight must include a range of fix intervals for normal flight. A Fast Fix/Pilot Event (PEV) facility must also be provided. The choice of fix intervals for normal flight must include a 20 second interval to allow for very long flights (some record flights have been over 14 hours) and smaller intervals such as 5 and 10 seconds. In addition, after a Pilot Event (PEV) has been selected in flight, 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 second. 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, flashing light, 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, also to establish pre-takeoff and after-landing baselines.
- 3.6.1 **Other data.** 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.
- 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) to allow for being static in ridge or wave lift; (2) after the recorder is switched off by deliberate action, (3) if power is lost in flight for more than 5 minutes (to allow for battery change in flight or other short-term power loss). Also, for FRs with displays, if power is re-established within 5 minutes, the previous display mode shall continue, or; (4) if the recorder is still powered after the flight, when the user establishes a connection for downloading from the recorder. (AL3)
- 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 IGC-approval of a Recorder at the "all flights" and "all badges and distance diplomas" levels, an electronic declaration facility is required and is desirable at the "silver and gold badge" approval level.
- 3.9.2 **Electronic declarations in IGC files.** 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 (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) may be used, see A4.5.2.

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 that works with the IGC Shell system (see Appendix C) in order to electronically validate the structure of IGC files. For some recorders, IGC Shell is also used for download, and in others for conversion from binary to the IGC format where the initial download is in binary. See C1 and C2 later in this document. (AL3)

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. For DOS-based files, see Appendix D.

The above software is made available by IGC as freeware on the FAI/IGC and GFAC web sites:

through: www.fai.org/gnss-recording-devices/free-software
and directly at: www.ukiws.demon.co.uk/GFAC/downloads.htm

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 posted.

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 Validation part of IGC Shell program (or the earlier VALI short program file) by the NAC or other validation body before an 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 algorithms that 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 inaccurate fixes. The principle is that all 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 GNS Systems have a forward-prediction system (sometimes called "DEDuced" or "dead - reckoning", or predicted fixes), where fixes are not derived from GNSS lines-of-position but, if GNSS lock is temporarily lost, fixes are predicted based on past velocity. If this system is enabled, a glider approaching a Turn Point and losing GNSS lock can "throw forward" a series of predicted fixes so that fixes are recorded in an Observation Zone when the glider has not reached the Zone. For IGC-approval, any such predicted fix systems must be disabled, and the test described later in B4.1.1 should be carried out by the FR manufacturer before submitting a new model to GFAC for evaluation.

CHAPTER 4 PRESSURE ALTITUDE RECORDING

This chapter amplifies the basic requirement of 2.2.4

4. **PRESSURE-ALTITUDE RECORDING – BASIC PRINCIPLES.** An IGC FR shall include a sensor producing an output of pressure altitude. This must be calibrated to the ICAO ISA in a pressure chamber and a correction table produced. Fixes must continue to be recorded including pressure altitude data if the GNSS is inoperative for all or part of the flight. References: para 2.2.4, conversions between Mercury pressures and HectoPascals/Millibars, para 2.2.9

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.

4.2 **Baselines for Takeoff and Landing.** In accordance with 3.5.1, a baseline of fixes 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 mounted in the cockpit, the pressure recorded in the IGC file is "cockpit static" because the pressure sensor is in the FR box itself. 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 pressure sensors have settings that can be adjusted by the FR manufacturer or his authorised agents. These are generally (1) an adjustment for sea level pressure and (2) a gain setting for the rest of the altitude range. The output from the sensor 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. At S.L., 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 table of pressure against altitude.

4.4.2 **Start of recording and calibrations.** For calibrations in an altitude chamber it must be possible to produce an IGC 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 mean that pressure-altitude fixes are produced in flight if GNSS data fails. A suitable pressure change 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 in-flight fix intervals over 2 seconds, this may be set through a special calibration mode. Any such 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 or his authorised agent so that the output in the IGC file corresponds closely to the ICAO International Standard Atmosphere (ICAO 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 is 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;
(1 mb 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 all IGC FRs used in any glider with a motor of any sort. 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 (See also 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 a power source capable of producing forward thrust. 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 that the 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 gliders with any sort of motor, 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, particularly two-strokes. However, in design, careful processing of the raw noise signal is required (frequency filtering and weighting) so that a high ENL value is always recorded when any forward thrust is generated. ENL values associated with gliding flight must be significantly lower, see 5.3.1. Where an ENL sensor is fitted it must not be possible to disable it.

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. Periods of time showing 000 are not acceptable because this could mean that the ENL system is not working. When the ENL system is serviceable, a base figure of 010 must be shown under no-noise conditions. Figures between 011 and 030 should be achieved in a well-sealed cockpit during quiet slow speed flight. 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 5.6 on critical ENL conditions and Appendix B para B8.5 on flight testing.

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 in the ENL circuit.

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 typically produce a "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 engine installations where GFAC assesses the ENL values from a cockpit-mounted FR as being too low to differentiate between engine-on and engine-off flight, an additional system using the MOP code shall be required. The MOP sensor is external to the FR and connected to it by cable, enabling it to be placed to receive a high signal whenever forward thrust is developed. It applies to electric and jet engines and some relatively quiet 4-stroke engine installations, except where the FR itself is mounted very close to the engine - an example is a nose-mounted electric engine with the FR in the instrument panel just behind the engine. The MOP system is in addition to the FR's internal ENL system, the signal from which can be used as a check on the functioning of the MOP system.

If an acoustic (noise) MOP sensor is used, it must be placed close to the engine and/or propeller. It is permissible to use a similar system to the FR's internal ENL system, increased engine signal being obtained by positioning the MOP sensor very close to the engine and/or propeller.

With a jet engine the sensor must be close to the jet pipe at the rear of the engine where noise is greatest. Acoustic sensors specifically designed for jet engines may have a higher frequency response than those designed for piston engines or propellers but must not be used with piston/propeller systems because the frequency response will not match.

Sensors of electrical current should be able to be clamped round the main power cable to the electric engine unless the engine system provides a cable with this data. Sensors of other engine functions will be assessed by GFAC.

In all cases the design must make it easy to apply an OO seal so that the sensor position cannot be changed without breaking the seal. In addition, a system must be in place so that any break, or interference with, the cable from the FR to the MOP sensor will be detected and shown in the IGC file (see 5.4.3 below).

At maximum engine power, a MOP value over 900 is required, and at power for level flight, a value of over 600. See also under MOP in Appendix A (the IGC file structure), particularly A3.2.4 (Header Record). A5 (Definitions) and A7 (Three-Letter Codes). (AL4)

5.4.1 Positioning of Acoustic Sensors. The sensor is connected by cable to the FR (see below for security aspects) and must be positioned close to the engine, propeller or jet pipe, so that it receives a strong signal whenever the engine is running. The sensitivity of the sensor should be matched to the frequency of sound produced by the engine or propeller. 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 the acoustic 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. In the IGC file, a description of the type of sensor shall be given in the H (Header) record in the form HF MOP Text String, see A3.2.4.

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 testing before IGC-approval.

5.5. Early Engine Sensors. One early IGC FR design had an engine sensor based on Vibration, and another used an engine Microswitch. These still have Grandfather Rights, within the terms in the IGC-approval document for the FRs concerned. (AL4)

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 unless the FR can be fitted close to the engine, such as in the instrument panel close to a nose-mounted electric engine), the extra MOP system must be fitted.

5.6.2 Power-off. The critical power-off case for ENL and MOP 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 with the cockpit panel(s) open, but this is not as critical as thermalling with panels open because when thermalling 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.

CHAPTER 6

SECURITY OF RECORDERS AND DATA

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

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 by the IGC electronic validation program. More detail is in this chapter and in Appendix G. 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 in an IGC file 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 using heat or solvents, so that it could be re-fitted without this being detected.

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 a flight starting with 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. Push-pull antenna connectors are discouraged because they can become disconnected in a glider installation if the wire is inadvertently put under tension.

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. Cable for other functions may be approved by GFAC, provided that no alteration to GNSS fixes or the geodetic datum/earth model used for IGC files is possible through such cables. Such functions external to the FR include a Pilot Event (PEV) button and an Motor Glider sensor under the MOP code.

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

6.3.6 Connectors and fittings for data download from FR to PC. The types of IGC-approved connectors or fittings on the FR case for download of flight data are specified in Appendix F. 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 F. Where a PC is used for downloading, either the RJ45 or USB 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 the IGC Plenary 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. Other FAI sports and activities are also encouraged to use the format.

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) are recorded continuously in flight and also to establish fix baselines both before and after flight. 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 of at least 20 fixes must be provided (see para 3.5.1 earlier). 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 for the flight.

A1.1.1.2 **Ending recording.** Under flight conditions of little horizontal or vertical movement such as when ridge or wave soaring, the IGC file must continue to record data and must not be ended while flight continues. For more detail, see para 3.7 earlier.

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 later (but not earlier) 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 coordinates of each Waypoint. The order of Record types within an IGC file is given in 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").

A2.1.1 **Characters.** 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 such as in a manufacturer's proprietary file format, such characters shall be changed to a valid character when converting to the IGC format. This is so that analysis programs designed for the IGC format are not confused by non-standard characters.

A2.1.2, **Examples.** Descriptions and examples in this document may have white space between various elements and the CRLF characters at the end of each line may be omitted, so that the elements may be more clearly seen on the page. (AL4)

A2.2 **Record Types.** Each record types is identified 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 FR serial no. | 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 Satellite Constellation (F) used for the fixes (B) that follow. Time-specific Records are 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 (additional 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.

Date (of the first line in the B record) - DDMMYY (day, month, year, with respect to Universal Time (UTC).

Time - UTC, for source, see para 3.4 in the main body in this document. Note that UTC is not quite the same as the internal system time in the U.S. GPS system, see under "GPS system time" in the Glossary.

Latitude and Longitude - Degrees, minutes and decimal minutes to three decimal places, with N,S,E,W designators

Altitude - Metres, separate records for GNSS and ICAO ISA pressure altitudes.

Pressure Settings (where used) - HectoPascals (the same as millibars) to two decimal places, see on the next page under Pressure Settings and Ppppp

and, where calculations (optional) are made based on 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:

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

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".

Lat/Long - D D M M m m N D D D M M m m E

DD - Latitude degrees with leading 0 where necessary

DDD - Longitude degrees with leading 0 or 00 where necessary

MMmmmNSEW - Lat/Long minutes with leading 0 where necessary, 3 decimal places of minutes (mandatory, not optional), followed by North, South, East or West letter as appropriate

Altitude - AAAAAaaa

(In Metres, both GNSS altitude above the WGS84 ellipsoid and Pressure Altitude to the ICAO ISA)

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)

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

Pressure Settings (where recorded) - PPPPpp - Pressure in hPa (mb) with two decimal places, PPPPpp fixed at 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 980.75 mb has a code of 098075. 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, the pressure altitude recorded in the IGC file is always shown in metres with respect to the ICAO ISA with its fixed sea level datum of 1013.25 mb.

and, where calculations (optional) are made based on successive fixes:

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

Speed (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)

A2.5 FILE NAMING New types of FRs must use the IGC long file name format given in A2.5.2.

A2.5.1 Short file name style: YMDCXXXF.IGC

Y = Year; value 0 to 9, cycling every 10 years

M = Month; value 1 to 9 then A for 10, B=11, C=12.

D = Day; value 1 to 9 then A=10, B=11, C=12, D=13, E=14, F=15, G=16, H=17, I=18, J=19,

K=20, L=21, M=22, N=23, O=24, P=25, Q=26, R=27, S=28, T=29, U=30, V=31.

C = manufacturer's single-letter IGC identifier (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, B=11, etc

A2.5.2 Long file name style. 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: 56HCXXX2.IGC

Long file name: 2015-06-17-MMM-XXX-02.IGC

MMM = manufacturer's three-letter IGC identifier (see table on next page)

XXX = unique FR Serial Number (S/N); 3 alphanumeric characters

02 = second flight of the day

In the long file name, the XXX 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 FR Serial Number (S/N). For an IGC FR, the three-character individual 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. Date of flight - the date used in the file name and in the H-record (DTE code) is the UTC date of the first valid fix in the B-record of the IGC file downloaded after flight. In time zones where a flight starts close to midnight UTC, this is not necessarily the local date.

A2.5.5. Security of file name. 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.

A2.5.6 Manufacturer codes. 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 XYX codes, see note 2 at the end of the table.

A2.5.6.1 Name of Intermediate Format file. 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 the IGC Shell program (see Appendix C) when used with the manufacturer's IGC-XXX.DLL file or, for earlier systems, through the CONV-XXX.EXE program file (see Appendix D).

| IGC-approved Flight Recorders - Manufacturer Codes | | | | |
|--|---|----------------------|-----------------------|--|
| s/n | Manufacturer Name | Three Character Code | Single Character Code | Remarks |
| 1 | Aircotec | ACT | I | |
| 2 | Cambridge Aero Instruments | CAM | C | |
| 3 | ClearNav Instruments | CNI | n/a | Full file name used, no need for single character code |
| 4 | Data Swan/DSX | DSX | D | |
| 5 | EW Avionics | EWA | E | |
| 6 | Filser | FIL | F | Transferred to LX Navigation 2006 |
| 7 | Flarm (Flight Alarm) | FLA | G | |
| 8 | Flytech | FLY | n/a | Full file name used, no need for single character code |
| 9 | Garrecht | GCS | A | |
| 10 | IMI Gliding Equipment | IMI | M | |
| 11 | Logstream | LGS | n/a | Full file name used, no need for single character code |
| 12 | LX Navigation | LXN | L | |
| 13 | LXNAV d.o.o. | LXV | V | |
| 14 | Naviter | NAV | n/a | Full file name used, no need for single character code |
| 15 | New Technologies s.r.l. | NTE | N | |
| 16 | Nielsen Kellerman | NKL | K | now Clearnav Instruments (one FR under NKL name) |
| 17 | Peschges | PES | P | |
| 18 | PressFinish Electronics | PFE | n/a | Full file name used, no need for single character code |
| 19 | Print Technik | PRT | R | No longer making IGC FRs |
| 20 | Scheffel | SCH | H | |
| 21 | Streamline Data Instruments | SDI | S | |
| 22 | Triadis Engineering GmbH | TRI | T | |
| 23 | Zander | ZAN | Z | |
| | Other manufacturers using the IGC file format | XYY | X | For non-IGC-approved devices, see notes below table |

Note 1. New types of FR must use the long file name format that uses the manufacturer's three-letter code. Manufacturers making only such FRs have no need for a single-character code and this is listed as "n/a" (not applicable) above. (AL4)

Note 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 for an H Record line (with extra spaces for clarity):

HF FTY FR TYPE : Manufacturers Name, FR Model Name CRLF.

Some other FAI air sports have their own systems for non-IGC recorders:

For instance, for Hang Gliding (FAI Commission CIVL), see <http://vali.fai-civil.org/supported.html>

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

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

| Mandatory Record type in file order | Appendix A reference | Remarks |
|--|-----------------------------|--|
| A | 3.1 | Manufacturer code and unique ID for the individual FR |
| H | 3.2 | Header record |
| I | 3.3 | Additions to B-record FXA (fix accuracy), ENL (Environmental Noise Level) for motor gliders, MOP for motors with low ENL figures |
| B | 4.1 | Fix records (lat/long/alt etc.) |
| F | 4.2 | Satellites used in B record fixes |
| G | 3.6 | Security record |

A3 SINGLE INSTANCE DATA RECORDS.

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

A3.1 A RECORD - FR ID NUMBER. The A Record must be the first record in an FR Data File, and includes the FR manufacturer's code, the three-character GNSS FR Serial Number (S/N) unique to the manufacturer, and an optional text string . The data stored in the A-record is part of the data to be signed (see A3.6 on signing and the G record). The format of the A Record is as follows, with extra spaces for clarity:

A MMM NNN: TEXT STRING CR LF

| A record - Description | Size | Element | Remarks |
|-------------------------------|-------------|----------------|---|
| Manufacturer ID | 3 bytes | MMM | Alphanumeric, see para A2.5.6. For Non-IGC FRs this will be <code>XYZ</code> (see 2.5.6 table). The full manufacturer name will be seen later in the Header record in the form: <code>HFITYFRTYPE:MANUFACTURERSNAME,FRMODEL</code> |
| Unique FR ID | 3 bytes | NNN | The FR Serial Number, valid characters alphanumeric. For IGC FRs this must be three alphanumeric characters. Non-IGC FRs may use different systems. |
| Additional data | Optional | Text String | Valid characters alphanumeric. If used, start with a colon separator to distinguish it from the earlier characters for Unique ID (because some non-IGC recorders may have S/Ns of more than 3 characters). Short data may be added such as more complete identification of the recorder maker, type & number, unless this is already covered in the Header record under <code>FRTYPE</code> . |

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) listed in section 7 that have the H flag 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. The data stored in the H-record with data source F is part of the data to be signed (see A3.6 on signing and the G record) (AL1). See the line "Data Source" in the table below. The H-Record data with source code F must be 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 (F=FR), three letter code for the subject of the line, long name for the subject of the line, colon, descriptive text string. The long name and text string are intended to make it easier for people reading the file to see what data is recorded. (AL4)

A3.2.3 Earth Model. The GPS system uses the WGS84 ellipsoid and for IGC-approval the FR must record lat/longs with respect to the WGS84 Ellipsoid. (AL4)

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

```
H F DTE DATE: DD MM YY, NN 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 GPS DATUM: WGS84 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 NAME CRLF
H F GPS RECEIVER: MANUFACTURERS NAME, MODEL NAME, CHANNELS, MAX ALT CRLF
H F PRS PRESS ALT SENSOR: MANUFACTURERS NAME, MODEL NAME, MAXALT CR LF
```

Notes:

DATE line: NN is the flight number on the day, prefixed by a comma to separate it from the date group.

Before Amendment 4 the second line was for three numbers for Fix Accuracy (FXA) in metres.

This has now been removed because it is not relevant to a Header record and is used in individual B- (Fix) records under the FXA code.

GPS DATUM line - In FRs before Amendment4 the IGC number 100 refers to the WGS84 datum.

See also para A8 on Earth Models that have radii that are very close to WGS84.

GPS RECEIVER LINE - If a GNSS other than the US GPS system is used, the three letter code for the GNS System is added after MAX ALT, preceded by a comma. Codes are listed in A7 and include GLO for Russian GLONASS, GAL for European Galileo, BEI for Chinese BeiDou 2. For receivers processing data from more than one system, use all of the appropriate codes after at the end of the line, such as ... MAX ALT, GPS, GAL CRLF for a receiver using the US GPS and European Galileo systems. (AL4)

Where FR firmware includes provision for an external MOP sensor, an additional line is required as follows:

```
H F MOP SENSOR: Maker, ON/OFF, Acoustic / ECurrent / Other, Sensor Model CRLF
```

A3.2.5 A table follows with more detail on Header records:

| 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 |
| 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 | 5 bytes or as required | GGGG | GGGG = Geodetic Datum/Earth Model used. WGS84 is the default, see A3.2.3 and 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. Where a GNS System other than the US GPS is used, see the note headed "GPS Receiver Line" in 3.2.4 on the previous page. (AL4) |
| HFPRS line | As required | Text String | Gives the pressure altitude sensor Manufacturer and type, and the maximum pressure altitude in metres that could be recorded in the IGC file. Use comma separators between each element. |
| HF FRS line | If security is suspect | Text String | Format: HF FRS SEC SUSPECT USE VALI PROG: TEXTSTRING CRLF Must be used where security is suspect, for instance if the recorder's physical security checking system (for instance, the internal security microswitch) has operated. The VALI program is carries out a security check on the IGC file. The text string should be a description of the likely fault, such as: "Security Micro Operated FR re-set needed" |
| HFMOP line | Required when MOP facility is included in the FR firmware | Text String | H F MOP SENSOR: ON/OFF, Maker, Acoustic / ECurrent / Other, Sensor Model CRLF The sensor model name and its characteristics will be described in the IGC-approval document for the FR, see para 5.4. The ON/OFF field allows for an FR with the MOP facility in its internal firmware, but its external MOP sensor is not connected, for instance if the FR is used to record a piston engine for which the FR's internal ENL system gives high enough readings. When the external MOP sensor is off or inoperative, the MOP number in fix records shall be recorded as 000 (AL 4) |

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 use 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 (as 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:

| <p style="text-align: center;">ISO 3166 TWO-LETTER NATIONAL CODES - EXTRACT for the full table, see: www.iso.org</p> | | |
|---|-----------------|---------------------|
| AR = Argentina | FR = France | NL = Netherlands |
| AT = Austria | GR = Greece | NO = Norway |
| AU = Australia | HR = Croatia | NZ = New Zealand |
| BE = Belgium | (HR = Hrvatska) | PL = Poland |
| BR = Brazil | HU = Hungary | PT = Portugal |
| CA = Canada | ID = Indonesia | RU = Russia |
| CH = Switzerland | IE = Ireland | SE = Sweden |
| CL = Chile | IL = Israel | SI = Slovenia |
| CN = China (PRC) | IN = India | SK = Slovakia |
| CO = Colombia | IS = Iceland | TR = Turkey |
| CZ = Czech Republic | IT = Italy | TW = Taiwan |
| DE = Germany | JP = Japan | UK = United Kingdom |
| DK = Denmark | KR = Korea (S) | US = United States |
| EC = Ecuador | LT = Lithuania | UY = Uruguay |
| EE = Estonia | LV = Latvia | VE = Venezuela |
| EG = Egypt | MX = Mexico | ZA = South Africa |
| ES = Spain | MY = Malaysia | |
| FI = Finland | | |

A3.2.7.5 Non-IGC FRs. For Non-IGC FRs, the following H-records apply. If others would be useful to non-IGC Airports, 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 | T L C i n R e m a r k s c o l u m n | 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 | T L C i n R e m a r k s c o l u m n | 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. The data stored in the I-record is part of the data to be signed (see A3.6 on signing and the G record) (AL1). The data stored in the I-record is part of the data to be signed (see A3.6 on signing and the G record) (AL1). 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), and ENL is mandatory for all Gliders with a motor of any sort. FXA must 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 38 FXA CR LF
```

The above line shows that the three numbers for Fix Accuracy (FXA) are recorded between bytes 36 and 38 on each B-record line. For a device that also records Satellites In Use (SIU), Environmental Noise Level (ENL) inside the FR, and the external MOP sensor:

```
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 data stored in the J-record is part of the data to be signed (see A3.6 on signing and the G record). 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, and a declaration continues to be valid until it is replaced by a new one. It is placed in the IGC file before the first fix (B-) record and after the Header, I and J records. The C Record group has at least 5 lines, 6 or more if there are Turn Points. The first is a header line with the declaration date and time, followed by lines with coordinates for the waypoints: Takeoff, Start, Turn Points (if any), Finish and Landing. The lines for Takeoff and Landing are for information and are not part of the official IGC Declaration which runs from the declared Start via Turn Points to the declared Finish. (AL4)

A3.5.1 Lines in the C Record. The first line contains the UTC-date and time that the declaration was made, the number of Turn Points in the task (excluding the Start and Finish points) and a text string which can be used to describe the task ("500k triangle", etc). The other lines contain the WGS84 lat/long coordinates and a text string describing the place or point concerned. These include take-off, Start Point, Turn Points, Finish Point and landing. The text describing the type of point (see below) is so that the nature of the points can be clearly seen by viewing the IGC file.

A3.5.2 IGC terminology - Waypoint/Turn Point. In IGC terminology, "Waypoint" refers to either a start point, turn point or finish point. The term "Turn Point" refers to a point 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 polygon tasks such as in competitions.

A3.5.3 Takeoff and Landing. Two lines in the C-record of the IGC file are for the takeoff and landing. They are for general information rather than being part of an IGC Flight Declaration and can be the airfield's position or the points of takeoff and landing. They can be entered approximately or, if co-ordinates are difficult to obtain, 00000000N000000000E can be entered.

| 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 only in one place.

A4.1 **B RECORD - FIXES.** The data stored in the B-record is part of the data to be signed (see A3.6 on signing and the G record). Not counting the last CRLF, a B record line 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, required for all motor gliders), MOP (required for motor gliders with engine installations giving low ENL). The required basic data is: UTC, WGS84latitude, WGS84 longitude, fix validity, pressure altitude and GNSS-altitude. All of the information within each B-record must have a data issue time within 0.1 seconds of the time given in the B-record. Where NMEA data is used within the FR, fix data should be taken either from the GGA or GNS sentences. GGA is specific to the US GPS system. GNS is intended for all GNS Systems (GPS, GLONASS, Galileo, BeiDou2 and future GNS Systems), and should be used if it is available from the GNSS receiver. In the B Record FXA shall 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.

A4.1.1 The format of the basic data, with extra spaces for clarity, is:

B HHMMSS DDMMmmN/DDMMmmE V P P P P G G G G G CR LF

A4.1.2 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 | DDMMmmN/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 | DDDMMmmE/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 |

A4.1.3 Other data in Fix lines. To append the Fix Accuracy (FXA, mandatory), Satellites in Use (SIU, mandatory), internal Environmental Noise Level (ENL, mandatory), signal from the external MOP sensor (see para 5.4), or any other variable to each fix, these have to be defined earlier in the IGC file in the I Record (so that the data will be recognised by analysis programs). For instance, with extra spaces for clarity:

I 04 3638FXA 3940SIU 4143ENL 4446MOP CRLF

This shows that on each B-record line, Fix Accuracy (FXA) is recorded between bytes 36 and 38, Satellites In Use (SIU) between bytes 39 and 40, ENL between bytes 41 and 43, and MOP between bytes 44 and 46. The resulting B Record becomes (with extra spaces for clarity):

B HHMMSS DDMMmmmN DDDMMmmmE V PPPP GGGGG AAA SS EEE MMM CRLF

| 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 inside FR | ENL | 3 bytes | EEE | Valid characters 0-9 |
| Propulsion Sensor external to FR | MOP | 3 bytes | MMM | Valid characters 0-9. For FRs with MOP sensor system in FR firmware. |

A4.2 **E RECORD - EVENTS.** The data stored in the E-record is part of the data to be signed (see A3.6 on signing and the G record) (AL1). 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), switching a Blind Flying instrument on or off (BFION or BFIOFF), or, for recorders fitted with proximity sensing devices with respect to other aircraft (for traffic avoidance purposes), 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 such as PEV) 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. Over-use of E-record lines 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 identifier, 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.** The data stored in the F-record is part of the data to be signed (see A3.6 on signing and the G record) (AL1). 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 unnecessary F-record lines. For the US GPS system, the satellite ID for each satellite is the PRN of the satellite in question, for other GNS Systems such as the Russian GLONASS, European Galileo or Chinese BeiDou 2 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 n satellites in use 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 data stored in the K-record is part of the data to be signed (see A3.6 on signing and the G record) (AL1). 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. Logbook 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 Validation check. L-records with the Manufacturer's ID (MMM) must be included in the Validation check, L-records from other sources must not be. The data stored in the L-record which has the manufacturers TLC as the first 3 characters after the letter L is part of the data to be signed (see A3.6 on signing and the G record) (AL1).

A4.5.2 Free Flights - Post Flight Declarations. In the case of Free Flights where waypoints are claimed after 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). This data may 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 Post Flight Claim (PFC) waypoints.

A4.5.3 Length. 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.

A4.5.4 FRs with Flarm. For FRs that use the FR manufacturer's own firmware and systems but where there is also a Flarm module inside the FR, the Flarm state must be recorded in the L-record in the same way as FRs that use Flarm firmware as primary firmware. In particular:

For Stealth mode, the following format must be used: LFLAnnnnn STEALTH OFF/ON

For the Flarm ID, the following format must be used: LFLAnnnnnID 2 XXXXXX

Where nnnnn is the time and XXXXXX is the six Hex-decimal Flarm ID, replacing 'FLA' with the manufacturer's three-letter code as required.(AL4)

The general 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. The data stored in the D-record is part of

the data to be signed (see A3.6 on signing and the G record) (AL1). 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 use 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 alphabetical and/or numeric character from the list of valid characters (para A6).

Competition Class - The IGC/FAI competition class of the aircraft, such as Open, 15metre, Standard etc.

Constellation - The precise satellite IDs from which data was used to determine the GNSS fix.

Course - The direction between two lat/long points expressed as degrees magnetic or true.

Datum, Geodetic - The GNSS datum (earth model) used when Lat/long figures are produced.

Engine Down - The engine and/or propeller is stowed and cannot generate forward thrust.

Environmental Noise Level (ENL) - Acoustic noise at the FR in three numbers, maximum 999.

Engine Off - The engine is in a condition where thrust cannot be generated.

Engine On - The engine 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.

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 - A point marking 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 a fix expressed as EPE in metres, normally to a 2-sigma (95.45%) probability. See the Glossary for EPE.

FR Serial Number - A three-character alphanumeric which is unique to all FRs of all types from that manufacturer, and identifies 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 WGS84 ellipsoid.

GNSS Connect/disconnect - Where a separate GNSS unit is used, indicates GNSS connection to the FR module. This applied to one type designed in the 1990s, now withdrawn as an IGC FR. Today, for IGC-approval, the GNSS receiver unit must be within the secure FR case (subject to exceptions covered in para 1 of the Preliminary Remarks on page (iv)).

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 ellipsoid.

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 ellipsoid.

MOP - Means of Propulsion. When the Three-Letter Code MOP is used in an IGC file, this refers to an engine function (in addition to ENL) supplied to the recorder by a remote sensor that can be positioned close to the engine and/or propeller. See para 2.2.5 and 5.4. (AL4)

On Task - The pilot is attempting a Task.

OO ID - A series of alphanumerics that may be 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 and 4D position. This may record a number of occurrences or events such as crossing a start line or arriving at a point. After a PEV event, a sequence of fast fixes follows (see para 3.6 earlier).

Pressure Altitude - A five numeric group indicating the pressure altitude in metres above the 1013.25 hPa sea level datum of the ICAO ISA.

RAIM - Receiver Autonomous Integrity Monitoring (when used) - indicates the quality of GNSS navigation data, see the Glossary.

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

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

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

Task - The main points of a flight intended or declared by the pilot. Includes start, turn points and finish.

Total Energy Altitude - The combination of an aircraft's 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 7D, except those tabulated below as reserved. The IGC file must not use characters outside this range, except the CRLF line ending. 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 has the same information in hex order:

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

The same information in hex order:

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

A7. THREE-LETTER CODES (TLC) These may be 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 (that is, the first letter of a line in the IGC file, such as B for a fix line, E for an event line, etc). If a manufacturer wants to add a new type, a new TLC should be requested from GFAC. The manufacturer should provide an exact definition of the type and a proposed coding.

| TLC | IGC File Records used with the TLC | Three Letter Code - meaning and 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) as a 6 digit number PPPPp including 2 decimal places, see A2.4 under Pressure Settings. For instance, ICAO ISA Sea Level (1013.25 mb) has an PPPPp code of 101325, and 980.75 mb has a code of 098075. 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. |
| BEI | H | BeiDou 2 GNS System from the People's Republic of China (AL4) |
| BFI | E | Blind Flying Instrument. Recorded as ON or OFF in the format BFION or BFIOFF, followed by a space and then AH (Artificial Horizon) for an instrument displaying the horizon, or TI (Turn Indicator) for one giving rate of turn, change of heading, or similar. If the ON/OFF status is uncertain, use the format BFIUN (for Status Unknown). A Text String (optional) may follow to give more detail of the instrument and its status. The initial state shall be reported in an E record at the time of the first B record in the IGC file with the Fix Validity byte set to A (3D Fix, see A4.1.2). |
| CCL | H | Competition class |
| CCN | E | Camera Connect |
| CDC | E | Camera Disconnect |
| CGD | E | Change of geodetic datum |
| CID | H | Competition ID |
| CLB | H | Club or organisation, and country, from which flown or operated (eg Elmira US, Lasham UK). For Nation, use the ISO 3166 two-letter codes, some of which are given in 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, DB4 etc. |
| 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. The ENL system is inside the FR and is intended to record when an engine is running in three numbers between 000 and 999 in the fix records of the IGC file. See para 2.2.5 and 5.3, also references to ENL in Appendix A. |
| EOF | E | Engine off. See note on line for EON |
| EON | E | Engine on. Note: In some legacy recorders where ENL (now mandatory) and MOP (where required) are not used, the EON/EOF or EUP/EDN codes were used instead. EON/EOF was based on functions such as ignition ON/OFF, generator output, etc. EUP/EDN was used for a microswitch sensor for engine bay doors open/closed or pylon up/down. Continuation of these functions is at the discretion of GFAC. (AL1) |
| 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 (MMM) for the individual fix concerned, to a 2-Sigma (95.45%) probability |
| GAL | H | Galileo (European GNS 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 GNS System), followed by receiver maker, type & version letter/number. See 3.3.1 above |
| GPS | H | GPS (US GNS System), followed by receiver maker, type & version letter/number. See 3.3.1 above, also 3.3.4 for other GNS Systems such as the European Galileo, Russian GLONASS, and Chinese BeiDou 2 |
| 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 from a sensor connected by cable to the FR and placed close to the engine and/or propeller, giving three numbers between 000 and 999 in the fix records of the IGC file. See Para 2.2.5 and 5.4, also references to MOP in Appendix A |
| 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 (in the H record line this is followed by the maximum altitude processed by the FR) |
| 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) |
| 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. |
| 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 code where N is the manufacturer's single-character IGC name (para A3.5.6) and * is any character. The manufacturer must specify its meaning and use 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 DATUM AND EARTH MODEL. The Sporting Code for Gliding (SC3) states that the WGS 84 Geodetic Datum shall be used for all lat/long co-ordinates in the IGC file. This appears in the Header record of IGC files as shown in A3.2.4. The WGS84 Earth Model is a three-dimensional ellipse (ellipsoid) with an equatorial radius of 6378.1370 km and a polar radius of 6356.7523 km, for more details see the glossary under WGS84.

For IGC-approved FRs, earth models with radii within 1 metre of WGS84 will also be accepted. These include the European Terrain Reference Frame (ETRF) which is used by the European Galileo GNS System and has the same equatorial radius as WGS84 and a polar radius within 1 centimetre of WGS84. Where the term WGS84 appears in this document it includes other ellipsoids that are very close to it and are covered by this paragraph. (AL4)

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 at the start of the line when it is viewed in text format. For full details of record order and the formats of individual records, see the relevant paragraphs earlier in this Appendix.

A9.2 In the following short example, for simplicity the CR LF line-ending characters are not shown, but they must be used at the end of every line. In the example, some spaces are used to show the different elements on a line, but in the IGC file itself there should be no spaces except within a text string to separate different words. Notes are in brackets and italics and are not part of the file format.

```
A CAM XYZ (Cambridge FR serial XYZ)
HF DTE DATE: 16 08 15 , 02 (Flight on 16 August 2015, second flight of the day)
HF PLT PILOT IN CHARGE:Bloggs Bill D
HF CM2 CREW2:Nil
HF GTY GLIDER TYPE:Arcus M
HF GID GLIDER ID:G-GLID
HF DTM GPS DATUM:WGS84
HF RFW FIRMWAREVERSION:6.4
HF RHW HARDWAREVERSION:3.0
HF FTY FR TYPE:Cambridge CAI 302
HF GPS RECEIVER:Marconi Superstar,12,10000
HF PRS PRESS ALT SENSOR:Sensyn,XYZ1111,11000
HF CID COMPETITION ID:111
HF CCL COMPETITION CLASS:20m Motor Glider
I 03 3638FXA 3940SIU 4143ENL (The I record shows the extra data that will be added to each B records, in this case
FXA, SIU and ENL, the numbers showing where the data is along a B record line, for instance for ENL, characters 41-43)
J010810HDT (The J record shows what will be recorded in K record lines that follow, in this case True Heading HDT)
C 210815 093841 02 500K Triangle
C 5111419N 00101915W TAKEOFF Lasham Clubhouse
C 5110185N 00102647W START Lasham LA4
C 5209092N 00255227W TURN Sarnesfield
C 5230147N 00017612W TURN Norman Cross
C 5110185N 00102647W START Lasham LA4
C 5111419N 00101915W LANDING Lasham Clubhouse
F 160240 04 06 09 12 36 24 22 18 21 (The initial F record shows the time and then 9 two number satellite Idents)
B 160240 5407121N 0 0249342W A 00280 00421 055 09 950 (in this B record, after the time and Lat/Long, it shows a pressure
altitude of 280m, GPS altitude of 421m. FXA (error radius) 55m, SIU 9 satellites and noise (ENL) 950)
B 160245 5107126N 00149300W A 00288 00429 050 09 970
B 160250 5107134N 00149283W A 00290 00432 045 09 980
B 160255 5107140N 00149221W A 00290 00430 032 09 965
F 160300 06 09 12 36 24 22 18 21 (Satellites in use reduces from 9 to 8 because Ident 04 is no longer received)
B 160300 5107150N 00149202W A 00291 00432 026 08 022 (the last three numbers show that the engine is now stopped)
E 160305 PEV (Pilot Event followed by a period of fast fixing at 1 second intervals (not shown here))
B 160305 5107180N 00149185W A 00291 00435 024 08 015
K 160310 090 (The K record contains the values listed in the J record, in this case a true heading of 090)
B 160310 5107212N 00149174W A 00293 00435 020 08 024
B 160315 5107220N 00149150W A 00494 00436 015 08 018
B 160320 5107330N 00149127W A 00496 00439 013 08 015
(followed by many more B and other time-ordered records)
L PLT Ruritanian Standard Nationals Day 1 (L=logbook data, entered as required, in this case by PLT (the pilot))
L PLT My first 500k triangle (This is a post flight comment by the pilot)
G JNJK2489IERGNV3089IVJE9GO398535J3894N358954983O0934
G SKTO5427FGTNUT5621WKTC6714FT8957FGMKJ134527FGTR6751 (the G record contains security coding that
allows the whole IGC file to be checked for integrity by IGC Shell and the manufacturer's VALI program)
```

APPENDIX B

GFAC TEST AND EVALUATION

The following tests may be carried out by GFAC members and their Technical Advisors. GFAC may also delegate detailed testing and assessment to other experts who are bound by the same confidentiality as GFAC. Results, assessments and opinions are confidential to GFAC members, their advisors and experts, and to any IGC or FAI officials who may be involved. The tests in this Appendix are not necessarily all. GFAC reserve the right to carry out other non-destructive testing where it is considered to be relevant to assessing the recorder and the validity and security of flight data.

B1 GENERAL REQUIREMENTS. Ease of operation in an air sport environment of competitions, record and badge flights, will be evaluated. This will include integrity of flight data, fix accuracy, security against unauthorised input and changes to data, failure recovery, standard IGC file structure including flight declarations, recording of errors and anomalies.

B2 EVALUATION AND ANALYSIS. An analysis program independent of the FR manufacturer will be used. IGC files will be analysed from presentations of the flight path in plan (horizontal) views of fixes with respect to a lat/long grid, 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 the separate MOP system for engine installations with low ENL signatures.

B3 PHYSICAL INSPECTION OF THE EQUIPMENT

B3.1 Construction. Quality and robustness of construction and components. Preservation of flight data after impact such as accidental dropping on the ground.

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.

B4 SYSTEM ACCURACY AND RECORDING CAPABILITY

B4.1 Ground Tests. Tests will start with the equipment mounted in a ground vehicle driven over a test course (the "Proof Drive" mentioned in the Definitions section). Accuracy will be recorded over pre-surveyed ground positions. Fix records must closely compare with those from any control equipment. Runs of up to several hours may be made to check memory and battery capacity for long flights.

B4.1.1 Tests will be made for any "throw forward" of fixes not based on actual satellite lines-of-position. A vehicle containing a working FR will be driven over a 90 degree feature such as a road junction, to mark the feature on the IGC file, using a fast fix interval such as one per second. The vehicle will then be turned round and the feature approached at a high but safe speed. When nearly at the feature, the GPS antenna will be disconnected ,or, for units with internal antennas, the case covered so that GPS signals are blocked (for instance by metal foil used in cooking). The IGC file must show that on the second run, no fixes were projected beyond the feature. The drive with the antenna connected will be repeated several times and the lat/long of the feature at the right angle in the IGC file compared with the lat/long of the feature from a system showing WGS84 lat/longs such as Google Earth or Google Maps. (AL4)

B4.1.2 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 ICAO 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/IGC 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).

B4.1.3 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 considered to be necessary to preserve security in worldwide operation of the FR type.

B6 POWER SOURCE. Measurements of power consumption will be made, and, where relevant, of battery characteristics under different conditions of charge. 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 EASA 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 between the radio and FR antennas. No adverse effects should be shown on the FR 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, also 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; GNSS 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 GNSS data.

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, 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 (if available to the tester) 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 it could be mistaken for a climb under power.

APPENDIX C

WINDOWS-BASED IGC SHELL PROGRAM

*for Validation of IGC file data, and, where required, download from FRs,
also conversion to IGC format from binary where this applies*

C1. INTRODUCTION

C1.1 DLLs - General. This appendix describes an IGC standard for FR Manufacturer-supplied Dynamic Link Library (DLL) files for the Validation function that is described in para 3.11 of the main part of this Specification, and, for some types of FR, for file Download and Conversion to IGC format. The DLLs must work with 32- and 64-bit MS Windows Operating Systems in types of PCs used for downloading flight data shortly after flight. This includes, but is not exclusive to, Windows XP, Vista, 7 and 8, home and professional editions. See C2.1.1 below on Static Linking. (AL3)

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.

C2.1.1 Static Linking of DLLs. The DLL supplied by the manufacturer must be statically linked to the Microsoft C runtime library to avoid possible runtime errors when loaded into the control program. Follow these steps when building the release version of the DLL: (a) Within Visual Studio, right click on the project, go to Properties. (b) From the list on the left, go to "Configuration Properties", then "C/C++", then "Code Generation". (c) Make sure the "Runtime Library" option is set to "Multithreaded" (not "Multithreaded DLL"). The resulting DLL should not have a dependency on any version of MSVCR*.DLL. This may be verified using the free tool: www.dependencywalker.com. (AL3)

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. The API subroutines must use the CDECL calling convention (note: not the Win32 API stdcall convention which could produce DLLs that could cause the IGC Shell program to crash). In their 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 nonzero integer value. (AL4)

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(LPCTSTR 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(LPCTSTR 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, LPCTSTR 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 exist, 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 is 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.

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 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 a summary of the now-obsolete program files because some old 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 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.

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 taken 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

Based on Appendix A to the IGC Sporting Code Annex B (SC3B)

E1 Changes of approval level. If GFAC proposes to lower the approval level of a type of IGC-approved recorder, this will be discussed with the manufacturer and then with the IGC ANDS Committee. As much notice as possible will be given to the manufacturer so that there is the opportunity of offering an upgrade that will retain the existing approval level. The IGC Bureau may also be informed if considered appropriate at this stage.

E1.1 After these discussions, if GFAC still recommends a lowering of the approval level it will then make a detailed recommendation to the IGC Bureau. The Bureau will then assess the evidence and make a decision. If the Bureau decides to seek opinions from other than IGC Officials and Committees, confidential or proprietary information will be avoided in such correspondence.

E1.2 If the decision is to lower the approval level, this will be announced on the IGC web page, to the FAI IGC discussion group (igc-discuss@fai.org) and on the international soaring newsgroup (rec.aviation.soaring) avoiding confidential or proprietary information. The next IGC Plenary meeting will be informed as part of the normal procedure for confirmation of Bureau decisions that were made between Plenaries.

E2 Factors in Lowering Approval Levels. These include the following.

E2.1 False Data. Evidence that flight data from an IGC-approved recorder has been, or can relatively easily be, manipulated or altered. For instance, if it can be shown that the secure areas in an IGC file (Such as data in a B- fix-record line(s)) can be changed and the file continues to pass the IGC electronic Validation check.

E2.2 FR Security. Evidence that the security of the FR itself has been compromised, or could relatively easily be compromised. This includes where security devices in the FR could be by-passed.

E2.3 Dates of Change. In the above cases, the lowering of IGC-approval level will take effect at a date agreed between GFAC and the Bureau. Where there is a risk that compromised data could be submitted for flight claims from other recorders of the same type, this could be a date soon after the public announcement.

E2.4 Other factors. If the approval level is to be lowered for reasons other than those above, the date of implementation will be decided by the Bureau. This will normally be between 6 and 12 months after the date of the public announcement.

E3 Appeal against a lowering of approval level. The manufacturer of the recorder or any entity with a direct interest (which must be shown in the appeal papers) in that type of recorder (the "appellant") may appeal to the IGC Bureau to have the decision reviewed. Pending the result of the appeal, the decision and its implementation timescale will stand.

E3.1 Making an Appeal. Within one calendar month of the public announcement, the appellant must notify the IGC President, and pay an appeal fee of 500 Euros to the IGC account at FAI. The fee is refundable if the appeal is upheld. The full case for the appeal must be received by the IGC President or his nominee within a further calendar month. Communication should be by email and include attachments, pictures and diagrams as appropriate.

E3.2 Appellant's Agreement. In submitting the appeal, the appellant agrees to accept the result, which is at the sole discretion of FAI as the legal entity, its agent IGC, its agents the IGC Bureau, Committee members and advisors. The appellant also agrees not to institute proceedings against the FAI or its agents including any person who was involved on behalf of FAI or IGC.

E3.3 Appeal Evidence. The appeal must include evidence in support so that the Bureau can assess it and consider whether their decision should be changed. Where technical evidence is submitted, this will be assessed by technical experts nominated by the Bureau which will include the ANDS and GFA Committees and their technical advisors, and, where necessary, independent experts.

E3.4 Decision on the Appeal. The decision on the appeal is the responsibility of the IGC Bureau, but it may nominate specific members and/or experts to deal with the detail of the appeal and make recommendations to the full Bureau. A decision will normally be made within one calendar month of receiving the evidence from the appellant, but if technical detail has to be assessed the timescale may be longer. The decision will be sent to the appellant before any public announcement is made.

APPENDIX F

STANDARD IGC CONNECTORS

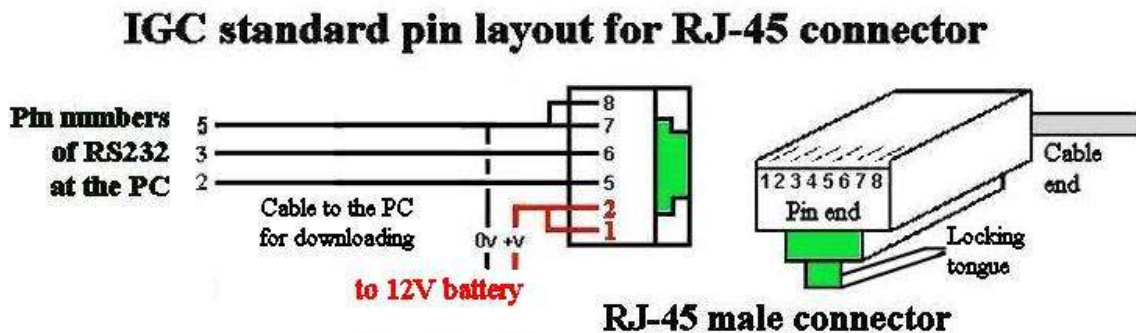
F1 Connectors and Fittings for downloading Flight Data. IGC-approved types of connectors or fittings on the recorder case for downloading flight data are listed below. Many FRs have connectors for storage devices such as an SD card (including micro-SD), USB memory sticks, etc., and do not need a PC connection, particularly for downloading after flight.

F1.1 Connectors to PCs. Where a PC is used for downloading flight data or for uploading declarations before flight, the RJ45 or the USB are recommended because standard wiring to these types includes both power and download. 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, micro 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.

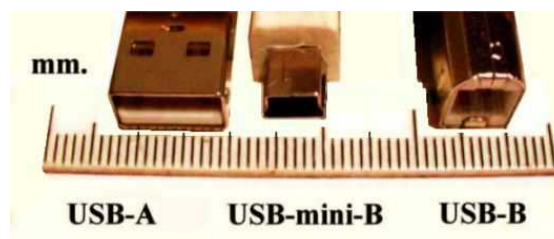
F2 Stand-alone Memory Devices. Downloading of IGC files may be to industry-standard devices such as SD cards, USB memory sticks or others. SD cards include full-size, mini- and micro- variants. It is recommended that where such a memory device is in place during and after flight, downloading of the last 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. Outside the FR, the IGC Shell program (Appendix G) is 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.

| <u>RJ-45 Pins</u> | <u>Function</u> |
|-------------------|--|
| 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 below:



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:

| <u>RJ-11 Pins</u> | <u>Function</u> |
|-------------------|--|
| 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. 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 check for any alteration of flight data in an IGC file from that initially download from the FR. This check must be possible to carry out at any time after initial download. 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, and may affect the IGC-approval level given to a type of FR. There are three IGC-approval levels which are 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 is used to generate the G- (security) record at the end of each IGC file. The IGC electronic Validation system in the IGC Shell program 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 from the SHA-256 or SHA-512 groups or another system agreed by GFAC (AL1). 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 private keys. The details of the encryption algorithm must be given to GFAC by the FR manufacturer, and only publicly known algorithms are permissible. A reference must be provided to a the public document which was used as the basis (AL1). 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 data content of the IGC file was digitally signed with the unique private key that is held in each recorder. The batch of public keys that a manufacturer intends to use for the foreseeable future (at least the next year) and all public keys used in the past, must be embedded in the DLL file supplied by the manufacturer to GFAC. This DLL file is posted on the IGC GNSS web pages for use with the IGC Shell program (for older recorders not using the IGC Shell program, the VALI-XXX program file is used instead). More than one private key may be stored in the FR and this is encouraged to increase security. Private keys may be of different length and may be used to generate several signatures. The private key used by the FR may depend on the date of the flight. (AL1)

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.** Use of a digital signature system is required, using a Public Key Cryptography (PKC) algorithm agreed by GFAC. RSA or DSA algorithms are currently accepted by GFAC. For "all flights" IGC-approval of types of FR using RSA, a modulus of at least 1536 bits is required, and the equivalent for other systems (see the Glossary under DSA, ECC, PKC and RSA). The DSA system (see Glossary) may give shorter times for data download from the FR to a PC. With the DSA system it may be possible to make security calculations while the FR is recording data, which may save time during data download to a PC after the flight.

G2.1.2.1 **Message Digest Algorithms.** The digital signature system must use a message digest algorithm of at least 256 bits. SHA2 algorithms are currently accepted by GFAC (see the Glossary under SHA) and alternative signature algorithms may be considered. In all cases, GFAC must be informed of the private key length and the type of algorithm used. (AL1)

G2.1.2.2 **Alternatives to RSA & DSA.** Alternative systems may only be used after review and acceptance by GFAC. If required, the manufacturer must provide at least two peer-reviewed papers that confirm the quality and strength of the method. For advice, consult the GFAC Chairman who will refer questions to appropriate experts in security of FRs and IGC flight data files.

G2.1.2.3 **Future Electronic Security.** As a result of continual advances in computing technology, public key algorithms become less secure over time. It should therefore be expected that the minimum modulus and SHA length required for continued "all flights" approval will increase in the future, and that existing designs that are not capable of increased lengths may be reduced in IGC-approval level. Design should be such that security enhancements are straightforward to make.

G2.1.2.4 **Download Times.** An IGC file covering 10 hours of flight data with fixes at 5 second intervals must download from the FR with full security encoding 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 but should not take substantially longer.

G3. Checking the Integrity of the IGC File. The NAC or other authority responsible for validating the flight performance will use the VALI program in IGC Shell (para G2) to check the integrity of the IGC file. If the VALI check is successful, this shows that the flight data is an exact copy of that which 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 and 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 (which must not only protect the Digital Signature, but also protect the internal circuits and modules inside the FR case from unauthorised interference). 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.

G6.1 Re-programming - General. Where firmware can be re-programmed without component replacement by using tools external to the FR (such as where EEPROMs, flash PROMs, or equivalents are used), 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.

G6.2 Component Replacement. Where components have to be physically replaced, the Private Key (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 be ensured that a valid PK and other security items after such reprogramming are only entered as a result of a valid FR Manufacturer's program and that there is protection from false programs being entered and allowing later IGC file Validation to take place. See also G6.3 below.

G6.3 External Re-programming. 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 for external programming. It may be possible for unauthorised persons to attempt to reprogram the EEPROM or Flash Memory, but this must not result in a working recorder that will pass future VALI checks on downloaded IGC files.

APPENDIX H

SPECIMEN FIRST PAGE OF AN IGC-APPROVAL DOCUMENT

H1 General. What follows is an example of a first page of a typical IGC-approval document. It gives the scope and limitations of the IGC-approval process, before the detailed wording of the particular Approval. FR manufacturers should note the wording, particularly the various limitations, disclaimers and caveats.

H2 Scope. Amongst other things, it points out that FAI is the legal entity and Swiss law applies. IGC and its committees (including ANDS and GFAC) are agents of FAI, including experts and others that provide advice and services to them.

H2.1 Paras (ii) and (iii) cover the responsibilities of FR manufacturers for hardware, firmware and software both generally and also where the origin is from sources other than the FR manufacturer.

H2.2 Para (iii) covers Intellectual Property (IP) and relations of FR Manufacturers with other entities such as sub-contractors and suppliers of hardware, firmware, software and other systems associated with the FR.

H3 Updates. The wording is kept under review by the IGC ANDS and GFA Committees, IGC itself and FAI.

H4 IGC-approval documents. In actual IGC-approvals, the wording may vary slightly from what is given in this annex, which is intended as an example rather than to be re-used word-for-word.

Next page: Example IGC-approval first page



SPECIMEN - EXAMPLE ONLY
GNSS FLIGHT RECORDER APPROVAL COMMITTEE (GFAC)
FAI INTERNATIONAL GLIDING COMMISSION (IGC)
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FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE
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References:

IGC web site: www.fai.org/gliding
GFAC web site: www.ukiws.demon.co.uk/GFAC
IGC FR web site: www.fai.org/igc-our-sport/gnss-recording-devices

To: IGC GNSS and GFAC web sites
Notification to: IGC email mailing list <igc-discuss@fai.org>
Internet newsgroup rec.aviation.soaring
Copy: FR Manufacturer

Date: XX YYY ZZZZ

IGC-APPROVAL FOR GNSS FLIGHT RECORDER

Level of Approval: All flights / All IGC Badges and Diplomas / Badge Flights up to Diamonds (see para i-ii)
Manufacturer & Recorder Name: MMM NNN

(i) General. This document gives formal approval from the above date for the Recorder equipment described below to be used for validation of flights under the FAI Sporting Code Section 3 (Gliders and Motor Gliders), subject to the conditions and notes given later. FAI and IGC reserve the right to alter this approval in the future.

(i-i) Document Versions. This is the initial / other IGC-approval for this type of Flight Recorder.

(i-ii) IGC-approval Level. At the date of this document, this type of Recorder is approved for / all IGC flights including world records (or other Approval level). The Levels of IGC-approval are listed in Para 1.1.4 of Annex B to the Sporting Code. Also see para 7 below about future changes to this document.

(i-iii) GNS System. The Global Navigation Satellite System (GNSS) used in this Recorder is the US NAVSTAR Global Positioning System (GPS).

(ii) Data Recording. This document is concerned with the functions of the equipment that record data. More specifically, with the accuracy and reliability of recorded data for the exclusive sole purpose of validation and certification of flight performances to the criteria of IGC and FAI. FAI is the legal entity and Swiss law applies. FAI Commissions such as IGC are agents of FAI; GFAC members and its advisors are agents of IGC. Tests made by GFAC on behalf of IGC and FAI concern accuracy and security of data, transfer and conversion to and conformity of the output data with the standard IGC file format in relation to the validation and certification purposes mentioned above. Other functions of the equipment are not part of this IGC-approval and the relevance of this document does not extend beyond the specific validation and certification purposes mentioned above. In particular this applies to any function linked with aspects that could be critical to flight safety such as navigation, airspace avoidance, terrain avoidance and any aircraft traffic alert, proximity-warning and/or anti-collision functions. This document does not constitute any approval, guarantee and/or any statement by GFAC, IGC and/or FAI as to the reliability or accuracy of the equipment for operation in flight and any liability in connection therewith is hereby expressly excluded.

(iii) Intellectual Property. This approval is not concerned with, and FAI has no responsibility for, matters related to: (a) Intellectual Property (IP), Intellectual Property Rights (IPR) and/or, (b) the relations of the Manufacturer listed below with any other entities except with FAI and its agents or as they affect FAI, its agents and this approval.

(iv) National and other Regulations. These Regulations may apply to electrical and electronic equipment and compliance with such regulations is not the responsibility of FAI or IGC.

(v) Sporting Code. The attention of National Airport Control (NAC) authorities, officials and pilots is drawn to the latest edition of the FAI Sporting Code Section 3 (Gliding) including its annexes and amendments. Annex A to this code (SC3A) deals with competition matters; Annex B to the Code (SC3B) with equipment used in flight validation; Annex C to the Code (SC3C) with guidelines and procedures for Official Observers, pilots, and other officials involved in the flight validation process; Annex D (SC3D) with the Official IGC Pilot Ranking List. Copies of all of these documents may be obtained from the IGC web site listed above and those particularly relevant to IGC Flight Recorders are also on the GFAC web site. A separate IGC document "Technical Specification for IGC-Approved Flight Recorders" is available on the IGC and GFAC web sites listed above, together with the full up-to-date IGC-approval documents for all IGC-approved Flight Recorders.

(vi) Copy of this Document. It is recommended that a copy of this approval including its two annexes is kept with each unit of the equipment so that it is available for pilots and Official Observers.