FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

INTERNATIONAL GLIDING COMMISSION

FAI

GLIDING

TECHNICAL SPECIFICATION
FOR
IGC-APPROVED
GNSS FLIGHT RECORDERS

Second Edition
with Amendment 9
3 December 2024

LATEST VERSION

For the latest version of this document, see the FAI/IGC web page, as follows:
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AMENDMENT LIST (AL) RECORD

Amendments may be proposed to the Chairman of the IGC ANDS or GFA Committees
ANDS = The IGC Air traffic, Navigation and Display Systems Committee
GFAC = The IGC GNSS Flight Recorder Approval Committee
for current contact data and more information, see page (iv)

Proposals should include reasons, and a form of words for direct incorporation in this document.

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Amendment List	**Action Date**	**Status**
AL1	31 May 2011	
AL2	31 December 2013	
AL3	30 June 2014	
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AL5	30 October 2019	
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AL7	31 January 2022	
AL8	1 February 2023	
AL9	3 December 2024	Incorporated in this edition
AL10		
AL11		
AL12		

Contents

PRELIMINARY REMARKS

1. **Title and Status**. This document contains the rules, procedures and specifications applying to Flight Recorders (FRs) that are to be IGC-approved for validation of flight performances to IGC criteria. Such FRs may also be used by other FAI Airsports under their own rules and procedures. This document is published on the FAI/IGC web page at the web references given at the top of page (i).

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 technical experts concerned with GNSS recording 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 flight data format.

   2.1 Other Documents. Other IGC documents concerned with validation of flights include the FAI Sporting Code Section 3 for Gliders and Motor Gliders and its four annexes, available at www.fai.org/gilding. These are:
   FAI Sporting Code Section 3 (Gliders and Motor Gliders) - SC3
   Annex A (SC3A) on gliding championships;
   Annex B (SC3B) on equipment used for flight validation, including GNSS Flight Recorders;
   Annex C (SC3C) guide for Official Observers and Pilots, amplifying the main volume of SC3;
   Annex D (SC3D) rules for the IGC Ranking List.

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

3. **Amendments**. Proposals for amendments should be sent to the Chairman of the IGC GFA and ANDS Committees, preferably in the form of exact 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 GFA and ANDS Committees, and the IGC Sporting Code (SC) Committee will be copied for information and to give them the opportunity to propose inputs to this document.

   3.1 GFAC = The IGC GNSS Flight Recorder Approval Committee,
   Chairman at the time of publication of this document: Peter Purdie gfac@fai.org
   ANDS = The IGC Air traffic, Navigation and Display Systems Committee,
   Chairman at the time of publication of this document: Rick Sheppe rws@sover.net

   3.2 FAI Office. FAI Secretariat, Fédération Aéronautique Internationale,
   Avenue de Rhodanie 54, CH-1007 Lausanne, Switzerland
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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 GFAC and ANDS 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 by members of GFAC and ANDS and any technical experts and advisors who may be consulted on specialised subject areas.

GLOSSARY OF TERMS AND ABBREVIATIONS

This expands the glossaries in the main volume of the Sporting Code for Gliding (SC3) including its Annexes, in particular Annex B (SC3B) on equipment used for flight Validation. This Glossary includes 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 for the Three-Letter Codes (TLC) used in IGC files Detailed explanations of technical terms are also available on the web from sources such as Wikipedia.

Numerical

2D Position - A navigational position giving horizontal data (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 GNSS 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 GNSS altitudes have been recorded in IGC files, including GNSS altitude unlocks and short-term variations compared to pressure altitude. This is probably because of the use of low-cost GNSS receivers 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

Accuracy - this term refers to how close different measurements are to the correct value, compared to the term "precision" which is the closeness of measurements to each other. It is therefore possible to have a set of close measurements (high precision) that have a systematic error and so have low accuracy. The preferred situation is to have both high accuracy and high precision of data points. See: https://en.wikipedia.org/wiki/Accuracy_and_precision (AL6)

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 GNSS accuracy, much better than 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. For further details, see:

https://en.wikipedia.org/wiki/Automatic_Dependent_Surveillance%E2%80%93Broadcast and
https://www.skybrary.aero/index.php/Automatic_Dependent_Surveillance_Broadcast_(ADS-B)

ANDS - The Air traffic, Navigation and Display Systems committee of IGC.

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 ICAO or the US FAA, they are issued s numbered documents, such as ARINC 510 for avionic interfaces with simulators. For further details, see:

https://en.wikipedia.org/wiki/ARINC

Augmentation systems, for GNSS - The term for systems that apply corrections to data from GNSS receivers over a specified area, using ground receivers at accurately known positions. 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.

Calibration The formal definition of calibration by the International Bureau of Weights and Measures (BIPM) is the following: "Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties (of the calibrated instrument or secondary standard) and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication." This definition states that the calibration process is purely a comparison. In the context of this Specification, the second step is the creation of a Calibration Chart which can be applied to the Pressure Altitude figures in the IGC File to give a more accurate measurement. See https://en.wikipedia.org/wiki/Calibration (AL9)

CAS - these initials can mean Calibrated Air Speed, Controlled Air Space, or Chief of the Air Staff, depending on the context in which the initials are used. Calibrated Air Speed is the Indicated Airspeed (IAS) on a cockpit airspeed indicator, corrected for instrument and position error. (AL6)

CEP - Circular Error Probable. 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 - In GNSS systems, the constellation is the set of orbiting satellites from which transmissions of those in range are used in a GNSS fix of ground position. Where details of the received constellation are recorded in an IGC file, this can be used to verify the validity of flight data. These details appear in the IGC file F Record (see Appendix A under F-record).

CRLF - Carriage Return followed by a Line Feed. These characters, represented by the hex symbols 0D and 0A, are used to denote the end of a field in the IGC file.

Data Analyst - A person familiar with electronic flight data and authorised by an NAC to carry out analysis of such data.

Datum - Where relevant to GNSS, the Geodetic Datum (see page vii).

Declaration - The pre-flight recording of pilot name(s), glider type and identification, and any waypoint coordinates required to certify a soaring performance in accordance with SC3 procedures for that type of performance. The date and time when the latest declaration was received by the FR after action by the pilot or a system used by the pilot, is recorded in the first line of the C-Record at the beginning of of the IGC file. (AL6)

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 from the FR manufacturer is used to Validate the integrity of IGC flight data files, see later under DLL.

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 - In an IGC FR, this is the transfer of data from the FR to a PC or to a memory device attached to the recorder. This terminology follows normal avionics terminology 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 a flight recorder from a PC or other system.

DSA - Digital Signature Algorithm, 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, so the IGC VALI process takes longer than RSA but the VALI process is not time-critical, whereas download from FR to PC may be, for instance in competitions with many entrants.

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, and is therefore preferred compared to systems with longer key lengths. For IGC FR purposes, ECC with a 256 bit private key (ECC256) is accepted by GFAC as equivalent to RSA with a 3072 bit private key, 224 ECC

with 2048 RSA, 192 ECC with 1536 RSA, 160 ECC with 1024 RSA, 106 ECC with 512 RSA. For more detail on Private keys, see G2.1.1.2. 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:
https://en.wikipedia.org/wiki/Elliptic-curve_cryptography

EGM - Earth Gravitational Model - a complex worldwide surface calculated to have equal gravity ("equipotential") rather than a simple geometric Earth Model such as an Ellipsoid (see below). Examples include EGM84, EGM96 and EGM 2008, as defined by the US National Geospatial Agency (NGA). See below under "Geoid".
More detail is at https://en.wikipedia.org/wiki/Earth_Gravitational_Model

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-augmented 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 corrections can be applied to initial GPS positions. EGNOS became operational in July 2005.

Ellipse and Ellipsoid - An ellipse is a simple two-dimensional smoothly curved figure with two diameters, a "major axis" and a "minor axis". 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). When an ellipsoid is used to model the shape of the earth, the semi-major axis is the radius at the equator and the semi-minor axis is the radius at the poles. The WGS84 Ellipsoid is used by ICAO, FAI and IGC for location and measurement purposes, see later under "WGS84".
EMI - Electro-Magnetic Interference. Interference with the working of equipment (hardware, software or firmware) due to ElectroMagnetic radiation external to the equipment. In Flight Recorders EMI may be due to Radio Frequency (RF) radiation from radios or other sources in the aircraft or glider, or from RF sources outside the aircraft such as 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, referring to three numbers between 000 and 999 in the fix record that indicate the acoustic noise level at the Recorder at peak frequencies between 100 and 200 Hz. This is intended to differentiate between engine-on and engine-off flight, particularly with 2-stroke engines. See Chapter 5 for 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 (see above) with the addition of other 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 normally calculated to a 2-sigma (95.45%) level, implying that there is about a 95% (19 out of 20) probability that the accurate 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 including manufacturers of aircraft, airborne equipment, Air Traffic Management (ATM) systems, service providers, national and international aviation authorities and users (EASA, NACs, 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 account of ICAO standards and ARINC specifications.

FES - Front Electric System - an electric engine mounted in the nose of a glider, driving propeller blades that fold back flush with the fuselage when not in use. Originally the letter "S" stood for Sustainer but with improvements in battery technology many FES systems are capable of self-launching.

Fix - For IGC flight analysis of FR data, a fix is a sample of near-simultaneous data from GNSS satellites that includes horizontal and vertical position (lat/long, GNSS altitude), time (UTC). This is recorded in each B-record line in IGC files. Other variables are recorded with each fix record, including fix accuracy (EPE/FXA), satellites in view, low-frequency acoustic noise (ENL), Pressure Altitude, and other variables recorded by the FR in a format 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 indicating presence in an Observation Zone, spurious fixes must be rejected. Early GNSS recorders showed a number of spurious fixes in their IGC files but this is less common with more modern FR systems.

Fix, Valid - For IGC flight analysis, 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 capable of producing a flight data file in the IGC format, and for which there is a current IGC-approval document. It includes a GNSS receiver, pressure altitude sensor, data storage, input of Waypoints and pre-flight declarations, detection of motor glider engine running, plus physical and electronic security to protect the validity of flight data in its IGC files. See also non-IGC FR.

FR Serial Identification (S/ID) - For an IGC FR, a set of three or more alphanumeric characters allocated by the manufacturer and unique to that manufacturer, identifying an individual FR and IGC files from it. The S/ID 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/ID should be prefixed by the manufacturer's name followed by the FR model and type.

GD - Geodetic Datum, see the next item

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 can be constructed. WGS84 includes a three-dimensional ellipse model of the earth ("the WGS84 ellipsoid"), see later under WGS84. The WGS84 ellipsoid is the earth model used by the US GPS system, by worldwide civil aviation (ICAO), and by FAI, for defining exact Lat/Longs, and measuring flight distances. In an IGC-approved FR the WGS 84 ellipsoid (see page xii) must be used as the reference for all lat/long co-ordinates and GNSS altitudes.

Geoid - Sometimes used loosely to mean an Earth Model, in the WGS84 Specification document it has a more precise meaning. The WGS84 Geoid is the shape of a theoretical equipotential (equal gravity) surface, shaped by the earth's mass, mountains, seas, and the earth’s rotation; short-term effects such as winds and tides are not included, see:
https://en.wikipedia.org/wiki/Geoid. The WGS84 Geoid is therefore an irregular surface close to local sea levels. The maximum difference between the WGS84 Geoid and the WGS84 Ellipsoid is +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). The variation depends on the gravity effects of mountains, ocean trenches, crustal thickness and density. The surface of an equipotential Geoid is irregular and therefore, unlike an Ellipsoid (qv), can not be defined by a simple formula. Such Geoids include various Earth Gravitational Models, see above under "EGM". Several Geoid definitions exist with differences in the exact shape and resolution of the Geoid surface, unlike the WGS84 ellipsoid which is a smooth surface based solely on an equatorial and a polar diameter. For these reasons, IGC FR files use the WGS84 Ellipsoid as the GNSS altitude zero datum rather than one of several different Geoids of differing complexity.

GFAC - The GNSS FR Approval Committee, of IGC. See IGC Approval on the next page, and Chapter 1.

GLONASS - GLObal NAvigation Satellite System, the Russian GNS System, now compatible with the US GPS system.

GNSS - Global Navigation Satellite System. A general term for a system based on a constellation of satellites and ground receivers in which signals from the satellites are processed to calculate position on the earth’s surface. GNSS systems include the US GPS, Russian GLONASS, European Galileo, and Chinese BeiDou 2. Ground receivers calculate time delays between signals from different satellites and, by knowing the exact position of the satellites and accurate time, together with an assumed mathematical model of the earth's shape, position on the earth's surface can be calculated. See above under 4-D, Ellipsoid, Geodetic Datum and WGS84.

GNSS Altitude - altitude calculated from GNSS position lines. In IGC files, GNSS altitude must be referenced to the surface of the WGS84 ellipsoid. In a fix, sometimes GNSS altitude is not available leading to 2D fixes, and in this case the figures for GNSS altitude in the IGC file B-record shall be recorded as 000 so that altitude drop-out can be identified during postflight analysis. Note that in commercial GPS Systems, GNSS altitude may be set to show approximate altitudes above local sea level rather than above the ellipsoid.

GPS - Global Positioning System. The term "GPS" is sometimes used as a general term for satellite-based navigation systems, where the more precise general term should be "GNSS" (see above). In its more exact meaning, the term "GPS" applies to the US GNS System administered jointly by the Department of Defense (DoD) and the Department of Transportation (DoT). In the US system, signals are normally available from 27 out of over 30 satellites in six orbital planes at 55 degrees to the equator at an altitude of 20,200km and a rotational period of 12 hours. This was the world’s first commonly-available GNS System and became operational in January 1980.
See http://en.wikipedia.org/wiki/Global_Positioning_System

GPS system time and Leap Seconds - the highly accurate time used by the US GPS system is from the GPS Master Clock at Schriever AFB in Colorado and is continuously monitored by the US Naval Observatory (USNO) in Washington DC. It began as UTC for midnight on 6 Jan 1980 when the GPS system first became operational, and maintains that time frame. This is so that it does not have to change with each "leap second" that is added to UTC to allow for the slowing down of the Earth's rotation (see under UTC). In 2020, UTC was 18 seconds later than 1980 GPS System Time. Modern GPS receivers incorporate leap second corrections so that they 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). The term is used in Commercial Aircraft certification, and its application to IGC-approved GNSS Flight Recorders is in para 1.1.4.

GS - The General Section of the FAI Sporting code, containing the principles to which other Sporting Codes must conform. See: www.fai.org/sites/default/files/documents/fai_sporting_code_gs_2020_v1.1.pdf

HAFR - High Altitude Flight Recorder, a special type of IGC-approved Flight Recorder for the recording of GNSS altitudes above 15,000 metres with respect to the WGS84 Ellipsoid, which is the IGC file datum for zero GNSS altitude. At and above 15,000 metres, the rate of change of pressure with altitude has fallen but the resolution of GNSS altitude with altitude change is relatively constant. See para 2.2.4.1.

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 and/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, with its headquarters in Montreal, Canada. 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 para 1.1.4 of this Specification and Annex B to the IGC Sporting Code (SC3B). The IGC GNSS Flight Recorder Approval Committee (GFAC) tests and evaluates GNSS FRs and issues IGC-approval Documents.

igc-info The mailing list to distribute IGC information, including updates to the Specification, Sporting Code and its Annexes and new Flight Recorder Approvals. To subscribe see https://www.fai.org/page/igc-mailing-list

International Standard Atmosphere (ISA) - For FAI flight performances, the ICAO ISA must be used for pressure altitudes. See ICAO Document 7488 tables 3 and 4 and https://en.wikipedia.org/wiki/International_Standard_Atmosphere
At sea level, the ICAO ISA defines a temperature of 15 degrees Centigrade and a pressure equivalent of 1013.25 hPa (mbar). Above Sea Level (ASL), 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 is the Stratosphere in which constant temperature (-56.5C) is assumed until 20km, thereafter increasing by about 1 degree per kilometre rise in altitude. Pressures from the ICAO ISA are used in calibrating aircraft pressure altimeters so that aviation worldwide has a common standard of pressure height in the cockpit. This allows aircraft flying at different Flight Levels to maintain the same separation. Although the real atmosphere varies from day to day, internationally agreed figures are needed so that all use the same scale. A similar principle is used in of pressure altitude sensors in Flight Recorders because the ICAO ISA is the FAI standard.

ISA - International Standard Atmosphere, see above

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

JPEG - Joint Photographic Experts Group. This Group developed a system for compressing digital data for pictures and diagrams so that the byte size is smaller than the un-compressed version. It is abbreviated JPG which is also used as a file suffix such as image.jpg. (AL6)

Key - see later under Public/Private Key.

Latitude - In an IGC file, 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 and accuracy, 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 and accuracy, the LON code (Para A7) may be used.

mbar. mb - Millibar. A unit of pressure, one thousandth of a Bar (one million dynes per square centimetre), the same as a hectoPascal (hPa). The ICAO International Standard Atmosphere (ISA) defines sea level pressure as exactly 1013.25mb / hPa. The reason for this irregular number (compared to exactly 1010 or 1000mb), is that it is equivalent to the previous international standard which was 760 mm of a mercury column at 15°C, corrected for local gravity. (AL6)

MoP - Means of Propulsion, an FAI term for an engine capable of producing forward thrust, such as a piston, jet or electric motor. A engine recording system is part of a IGC Flight Recorder and produces three numbers in each fix line in an IGC file under the ENL code, and in some FRs also under the MOP code. See under ENL and MOP.

MOP - A three-letter code referring to three numbers between 000 and 999 in each fix line of an IGC file, designed to indicate engine running where the ENL system inside the Flight Recorder does not produce high enough readings during use of engine. The type of MOP sensor is described in an extra MOP line in the IGC file header record, and may sense acoustic sound at high or low frequencies, current flow to electric engines, fuel flow to piston or jet engines, or any other variable tested and approved by GFAC for the engine type. The MOP sensor is designed to be placed so as to receive a high signal whenever the engine is developing forward thrust, and may be external to the FR close to the engine, or inside the FR but using a different frequency to the ENL sensor. See Chapter 5 for more details.

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 https://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, or has, IGC-approval. However, it is recommended that the output 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, part of a stand-alone GNSS unit, or a portable device that receives and stores GNSS data. Where other FAI Airsports 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 GNSS fix is required to validate an IGC event such as a 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 middle of which is opposite the middle angle of the two legs making up the 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. Straight lines for official Start and Finish are also permitted as well as the 90 degree angle. In gliding competitions, Circular OZ may also be used, but for IGC distance calculations the radius of each circular OZ must be subtracted from the distance via the Waypoints themselves.

Pascal - The International Standard (SI) unit of pressure, defined as a pressure of one Newton of force per square metre (one Newton is the force needed to accelerate 1 Kg mass at 1 metre/sec/sec, equivalent to 0.225 lb force or 4.45 Newtons per pound force). One hundred Pascals are a hectoPascal, abbreviated hPa (the same as a millibar (mb), see above), named after the French mathematician Blaise Pascal, and was adopted as the SI pressure unit in 1971. (AL6)

Pilot Event (PEV Code) - A mandatory facility initiated by an easily accessible event button or switch that initiates a GNSS fix marked in the IGC file 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 public application of PKC was the RSA system by Rivest, Shamir and Adelman (see under RSA), first published in 1983 (https://en.wikipedia.org/wiki/RSA_(cryptosystem)). It was later revealed that the principle of "non-secret encryption" was the subject of a 1970 paper by James Ellis of the UK GCHQ organisation (https://en.wikipedia.org/wiki/James_H._Ellis) although this paper was Classified and only revealed in the Public Domain after the RSA system had been announced. For more detail on Private keys, see G2.1.1.2.

Precision - see above under "Accuracy"

Pressure Altitude - In an IGC FR file, this is a group of five numerals giving the pressure altitude in metres with respect to the ICAO International Standard Atmosphere (ISA). The FR may derive pressure altitude either from "cockpit static" (pressure within the FR box), or be connected to static-pressure tubing used in the instrument panel ("instrument static"). More detail is under International Standard Atmosphere (ISA) above. See also para 1.1.4 and Chapter 4.

Pressure Reference An instrument with traceable accuracy to a standard with better uncertainty than 0.1 hPa, used for comparison with an Approved Flight Recorder for calibration purposes. (AL9)

Proof Drive or Flight - These are methods of checking that a Flight Recorder produces a correct IGC flight data file. In a proof drive under the control of an OO or other official, the FR is driven in a vehicle over a course on the ground that includes Waypoints with accurately known co-ordinates. A proof drive in hilly terrain can be used to check FR altitude. A proof drive including a sharp turn at a surveyed point is used to check GNSS fix accuracy. A proof flight can check altitude data and other figures such as the use of engine in a motor glider.

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.

Public/Private Key. See above under PKC, Public/private Key Cryptography. (AL6)

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 GNSS 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. RAIM calculations need 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.

Reach, Reaching - when this refers to a Turn Point (TP), it refers to complying with IGC criteria for "reaching the point". Unlike activities such as air racing at low level where the aircraft must fly round a ground feature such as a pylon, IGC require that there must be proof that a glider has entered the Observation Zone (OZ) relevant to the TP. (AL6)

RJ - Registered Jack. For instance RJ-45, also described as an 8P8C connector. The number before P is the number of pins available, and the number before C is the number of pins in use.

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).
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

RTCA Inc - a U.S. not-for-profit corporation concerned with aviation and aviation electronic systems, see ww.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 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 which applies to FAI Class D (gliders) including FAI Class DM (motor gliders). The SC3 series is administered by IGC, including its annexes A-D. These are SC3A (championships), SC3B (recording equipment, including GNSS and FRs), SC3C (OO Guide), and SC3D (pilot ranking list). For the full list of FAI Sporting Codes, see Chapter 1 of the General Section of the FAI Sporting Code, also www.fai.org/igc-documents

Security - Digital Signature (DS) - A Digital Signature (DS) is a set of encrypted data generated by an FR and downloaded with the flight data. 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 data match and so the alteration can be detected. See para 6.1 and Appendix G.

Serial ID (S/ID) – The Alphanumeric identifier for an individual IGC Flight Recorder, see A2.5 on file naming. This appears as a group in the IGC file name and also in the first line of the IGC file. Non-IGC recorders may have different S/ID systems, for which IGC has no responsibility.

SHA - Secure Hash Algorithm. A set of cryptographic hash functions such as SHA-224, -256, -384, -512, SHA-512/224, and SHA-512/256. 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: https://csrc.nist.gov/projects/hash-functions and https://en.wikipedia.org/wiki/Secure_Hash_Algorithms

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 with a smooth surface based on the two radii.

Spurious Fix - see under Fix

Start - in IGC terminology, 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. This refers to 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.

Traceability –Measurement The term *measurement traceability* is used to refer to an unbroken chain of comparisons relating an instrument's measurements to a known standard. Calibration to a traceable standard can be used to determine an instrument's bias, precision, and accuracy. In many countries, national standards for weights and measures are maintained by a National Metrological Institute (NMI) which provides the highest level of standards for the calibration / measurement traceability infrastructure in that country. Examples of government agencies include the National Physical Laboratory, UK, the National Institute of Standards and Technology in the USA, the Physikalisch-Technische Bundesanstalt in Germany, and the Instituto Nazionale di Ricerca Metrologica in Italy. As defined by NIST, "Traceability of measurement requires the establishment of an unbroken chain of comparisons to stated references each with a stated uncertainty." See also Calibration and https://en.wikipedia.org/wiki/Traceability . (AL9)

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 - This is the indication that the glider has "reached" the Point to the criteria of the IGC Sporting Code. For instance by demonstrating presence in the Observation Zone for a Turn Point; 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) on the East side of London, UK. UTC is very similar to the older term Greenwich Mean Time (GMT) and is also known as "Z time" or "Zulu Time" because UTC times carry the suffix "Z" whereas other time zones have other suffix letters. The UTC system is maintained by the Bureau International des Poids et Mesures (BIPM - www.bipm.org), headquartered in Sevres, France. 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 is agreed internationally and may be one year, or several years. The IGC flight data file requirement (Appendix A) requires times to be in UTC. See above under GLONASS, GNSS, GPS, Leap second.

Validation, VALI check. The IGC electronic Validation system is used to check an IGC file at any time and ensures that the flight data in the file has the integrity to be used for 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 different types of IGC-approved recorders are available on the IGC/GNSS web pages.

Vertical fix accuracy - The geometry of the lines-of-position between GNSS satellites and the surface of the earth is such that errors in recorded GNSS altitude are generally between 1.8 and 2.2 times those for lat/long, depending on the exact geometry of the position lines used in a fix. When Vertical Fix Accuracy is included in an IGC data file, it is through the VXA three-letter code, and uses the 2-sigma (95.45%) probability for vertical position error.

WAAS - Wide-Area Augmentation System - the Satellite-Based Augmentation System (SBAS) for the US GPS system in North America, based on the actual position of ground-based monitoring stations in the region. It consists of a monitoring network, processing, and dedicated geostationary satellites orbiting above the equator. Reference stations receive data from GPS satellites and measure GPS position with respect to the known position of each monitoring station. These measurements are sent to Data Processing sites for calculation of corrections for that area of WAAS cover. This data 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. An IGC Waypoint may be a Start point, a Turn point, or a Finish point and has a defined Observation Zone (OZ). A waypoint may also be used as a reference point for defining an area that is to be reached as part of an area task.

WGS 84 - World Geodetic System 1984, see https://en.wikipedia.org/wiki/World_Geodetic_System . This is a Geodetic Datum and co-ordinate system based on an Ellipsoid earth model and including variables such as gravity constants and coefficients, formulas for angular velocity, other constants, conversion factors, co-ordinate systems, a WGS84 ellipsoid and a WGS84 Geoid (an irregular equi-potential surface approximating to local sea levels, see below). The original WGS84 System definition document was Technical Report 8350 by the National Imagery and Mapping Agency (NIMA) of the US National Geospatial Agency (NGA). In 1989, ICAO adopted WGS-84 as the standard geodetic reference for world aviation. The complexity of defining an equi-potential surface is why IGC uses the relatively simple WGS84 Ellipsoid as a datum for Lat/long and GPS altitude figures in IGC files, rather than more complex Earth Models such as one of several Geoids that approximate to local sea levels. See under WGS84 in Annexes B and C to SC3 (SC3B and SC3C), and in the General Section of the FAI Sporting Code. Ellipsoid. An ellipsoid is a simple mathematical model and can be used to model the earth's shape. For instance, in the US Global Positioning System (GPS), all Lat/Long fix data is referenced to the WGS84 ellipsoid whose dimensions are given below. In the past there were over 200 other ellipsoids (local Geodetic Datums) in use, but the WGS84 ellipsoid has become the ***de facto*** standard Earth Model. The General Section of the FAI Sporting Code (FAI GS) states that for accurate measurements on the earth's surface, the earth model for FAI purposes is the WGS84 ellipsoid. See www.fai.org/documents

WGS 84 Ellipsoid. The dimensions of the WGS84 Ellipsoid are as follows:

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

The Minor axis is the distance between the Poles.
The semi-minor axis is the Polar radius = 6,356,752.314245 metres

Orientation: the semi minor axis is between the Earth's centre of mass and the Terrestrial Pole s 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. The WGS84 Geoid is 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). Several Geoid definitions exist with differences in the exact shape and resolution of the Geoid surface, unlike the WGS84 ellipsoid which is a smooth surface based solely on an equatorial and a polar diameter. (see above under WGS84 Ellipsoid) For these reasons, IGC FR files use the WGS84 Ellipsoid as the GNSS altitude zero datum rather than one of several different Geoids of differing complexity. See also under Geoid in this Glossary and https://en.wikipedia.org/wiki/Geoid .

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 IGC-APPROVAL AND RELATED PROCEDURES

Based on Chapter 1 of Annex B to the FAI Sporting Code Section 3 Gliders and Motor Gliders (SC3B)

1.1 **IGC FLIGHT RECORDERS - POLICY AND GENERAL**.

IGC-approval of a particular type of GNSS Flight Recorder follows Test and Evaluation (T&E) by the IGC GNSS Flight Recorder Approval Committee (GFAC), whose terms of reference are given below. GFAC members and advisors are agents of IGC; FAI Commissions such as IGC are agents of FAI; the legal entity is FAI, headquartered in Lausanne, Switzerland; 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 from the FR in the IGC data file format, and physical and electronic security of the Flight Recorder and its output data. Other capabilities of FRs are matters between customers and FR manufacturers, including cockpit displays, navigational features, proximity warning devices, and other characteristics not subject to IGC FR rules and procedures. See para 1.1.4 for IGC-approval levels that apply to different types of flights such as world records, IGC diplomas & badges, and competitions.

1.1.1 **FAI and IGC Liability**. FAI and IGC have no liability for the consequences of the use of Flight Recorders covered by this document for purposes other than validation 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 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 its IGC-approval document. One objective is to make procedures on the day of flight as simple as possible, and his 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 in the IGC 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, 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 to the glider by an OO at any time or date beforehand, to avoid the need for extra OF 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, 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 part of the IGC-approval document, and will depend on the Flight Recorder design and GFAC test and evaluation.

1.1.3 **IGC-Approval Documents for Flight Recorders**. The definitive version of the IGC-approval document for a particular type of flight recorder is the document that is currently available on the IGC web page, and is produced by GFAC on behalf of IGC. Before an 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 IGC-approved procedures for checking the recorder before flight, installation in the glider, and operation for flights that are to be validated to IGC criteria.

1.1.3.1 Format of IGC-approval documents. These 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 GNSS 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 should be followed by 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 the recorder ID; 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 altitudes. Annex B also contains details of Environmental Noise Level (ENL) figures recorded during GFAC testing, those to be expected in flight; also figures from an additional 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 para 1.1.10.1), the ENL and MOP figures recorded in IGC files must be similar to those given in Annex B in the IGC-approval document, and to pressure altitude s 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 5.5. OOs inspect recorder installations in accordance with Annex B to the IGC-approval document for the particular 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 should 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 annexes is made available to users of the FR, so that it can be consulted by pilots and OOs as required. A copy of the current IGC-approval document in printed or electronic format should also be included with each recorder sold or updated.

1.1.3.3 Validation of data in IGC files - IGC Shell Program. The latest versions of 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. This is to ensure that when an IGC file is used to Validate a flight performance, the FR from which the file originated has not been altered in an unauthorised way or has incurred damage that could cause errors in flight data, and data in the IGC file used for Validation of a flight is the same as the data initially downloaded from a serviceable and secure FR. In the event of damage or alteration, causing a breach of security, the FR should continue to produce an IGC file if possible but this and future files must fail the IGC Validation process, and the HFFRS record in the IGC file must be changed to read 'SECURITY SUSPECT' (or other relevant words such as SECURITY MICROSWITCH OPERATED, etc). See A 3.2.4 and A 3.2.5 for required data in IGC files and Appendix C for the IGC Shell program. (AL7)

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 Level 1 (all flights) 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 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 at 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 1.1.5.3. 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, 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 1.1.5.3. This level may be used for recorders 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 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 security or other problem has been found that 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 unless major differences exist in the type of FR compared to the current Specification or Sporting Code. A similar "Grandfather Rights" 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 level 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 security. For more detail on changes of IGC-approval levels, see Annex E, particularly para E2.2.

1.1.5.3 Competitions. 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 with the manufacturer and then with the IGC ANDS committee and, if necessary, with the IGC Bureau. (approval levels, para 1.1.4). Further procedures, Appendix E.

1.1.5.5 Compliance with IGC-approval standards. If after IGC-approval of a type of FR, it is found that provisions of the Approval are not being fulfilled by production-standard FRs, the Approval may be withdrawn pending compliance with the standards agreed by GFAC for IGC-approval to be issued.

1.1.6 **World Records**. Evidence must be from a type of FR that is IGC-approved for World Record flights (Level 1). See 1.1.4 on approval levels and 2.2.4.1 on High Altitude Flight Recorders (HAFRs) for altitude records above 15,000 metres.

1.1.7 **Cockpit displays**. Some IGC-approved FRs with cockpit displays have options for display of Blind Flying Instruments (BFI) such as Artificial Horizon or Turn Indicators. The operation of such instruments is recorded in the IGC file under the BFI code and more detail is given in the Technical Specification document for IGC FRs. For some gliding competitions, cloud flying is prohibited and BFI systems must either be disabled or proved not to be used.

1.1.7.1 Proximity Warning Systems. In some gliding competitions the fitting of proximity warning systems such as Flarm may be required. These can be in the form of a separate Flarm module within the overall FR or in the form of Flarm primary firmware in a case by Flarm or in a case by another manufacturer.

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. Unless the FR is an integral part of the instrument panel and can not be removed without showing evidence of such removal, 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 and it must not be possible to peel off the seal intact so that it could be re-installed without evidence that it had been removed. In any case, a system must also be fitted that operates if the recorder case is opened, for instance based on a security microswitch or microswitches inside the case. Other systems may be considered if they can be shown to give the same level of security, to the satisfaction of GFAC, and for more detail see Appendix G on Security. For microswitches, the switch or switches must be shielded so that they cannot be prevented from operating as the case is opened, such as by inserting a specially-shaped tool to hold down the operating arm of the switch. Flights after security is breached may 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. See para G2.1.1.2 for more detail on Private keys, and para G4 on requirements for security systems with and without microswitches.

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, and more detail is in Appendix C.

1.1.10.1.1 Validation - Pass. 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 in the FR when the flight file was ended and downloaded immediately after flight.

1.1.10.1.2 Validation - Fail. This indicates that the IGC file cannot be used for validation of flights to IGC standards of security, and the FR should be returned to the manufacturer of his designated agent for investigation and a security re-set. The IGC Shell validation program is designed to 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 file should once again pass the IGC Validation program.

1.1.11 **Proof of presence of the Flight Recorder in the aircraft**. There must be incontrovertible proof 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 types of FR that can easily be transferred from one aircraft to another. There are two methods: (1) OO inspection of the FR installation, and (2) independent evidence of take-off, 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 take-off or landing (or immediately before and after these times), the FR used for flight validation must either be a permanent fit in the instrument panel, or, if a separate unit, be sealed to the glider structure by an OO. Sealing may be carried out at any time or date before flight as long as the seal is clearly marked with the time, date and with the OO's identification, so that the OO can identify it later.

1.1.11.2 Check of take-off, landing, and other data, independent of the Flight Recorder. The times and points of take-off 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 take-offs and landings. This shall be compared to the Flight Recorder data for starting the take-off roll and finishing the landing run. 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, if necessary, 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 by the OO concerned or by the body that will validate the flight (such as the NAC) as soon as an anomaly is discovered, so that other supporting evidence is not lost due to the passage of time. It is vital that the FR is kept in its original state and is not reset 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, created by IGC to test, evaluate, and approve individual types of GNSS Flight Recorders (see para 1.4.1). 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. The GFAC Chairman and members are confirmed at the annual IGC Plenary meeting.

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 ***must*** be made before IGC-approval can be considered. The GFAC Chairman will notify the applicant of current procedures for the approval process, including data that must be provided, the 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 information is 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, the latest documents including drafts should be sent as soon as they are available. The GFAC 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 latest IGC standard.

1.3.2.2. FR hardware for IGC testing. Recorders should not be sent until GFAC comments have been made on the specification for the type of FR, and IGC files have been 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 keep the manufacturer informed of comments and any required changes before IGC-approval can be considered.

1.3.2.3 Fee to FAI. When hardware is sent for testing, the FR manufacturer must fill in the IGC FR application forms and should 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 apply that are relevant to the changes.

1.3.4 **Documentation**. The recorder manufacturer or applicant for IGC-approval must 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 Altitudes and Checks. The pressure altitude figures in the IGC file must be calibrated with respect to the ICAO ISA using the procedures in Annex C to the Sporting Code. A table listing ISA and IGC file figures and the IGC file from which the figures were obtained, must be forwarded to GFAC when an FR is sent for testing. After an FR has been in service, later Pressure Altitudes by the FR manufacturer (or an agent authorised by the manufacturer to make such checks, retaining FR security), should include re-setting FR Pressure Altitudes to figures to those that are as close as possible to minimum-error values. The original error figures before the re-set must also be preserved and made available in the form of a Correction Table for use with flights made before the re-set. The updated Correction Table must be used for flights after the re-set. (AL8).

1.3.4.2.1 HAFRs. An IGC-approved High Altitude Flight Recorder (HAFR) must be used for altitude claims above 15,000 metres. For IGC-approval of a HAFR, an independent check of GPS altitude figures above the WGS84 Ellipsoid in its IGC files is required using a high-quality GPS signal generator at an NAC-approved facility that also uses figures above the WGS84 Ellipsoid that is the GPS altitude zero-altitude datum. The signal generator injects signals that include precise GPS altitudes into the FR's antenna. Differences between the signal generator figures and GPS altitudes in IGC files are then used to make a table that is sent to GFAC together with the IGC file on which it is based, similar to a pressure altitude table. A pressure altitude to at least the same altitude as the GPS altitude check must also be provided. For more detail, see para 2.2.4.1 which includes a specimen table and GPS altitude graph, also Appendix 6 to Annex C to the Sporting Code (SC3C).

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, marked for 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.

1.3.5.1 At the date of this document (31 November 2024) the fee is 1200 Swiss Francs (CHf) for an application for testing a new type of Flight Recorder for IGC-approval. Where an FR is closely related to one that is already approved, a reduced fee will be charged, at the discretion of the GFAC Chairman, depending on the amount of testing and other work involved. If FAI does not receive the appropriate fee, an IGC-approval may not be issued or an existing IGC-approval may be withdrawn pending receipt of the fee by FAI.

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 non-destructive, 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 post, 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 reimbursed and do not have to pay these expenses themselves.

1.4.1 **GFAC Testing and the IGC FR Technical Specification**. Tests by GFAC will include drives in vehicles over known routes and exact points, and flights in gliders, motor gliders and/or powered aircraft. These are sometimes known as Proof Drives and Proof Flights (see the Glossary under "Proof ...") . Comparisons will be made with FRs that are already IGC approved, and the IGC file structure of the FR under test will be checked for compliance with the current IGC FR Technical Specification. Checks will include functions such as Pre-Flight Declarations (see the Glossary under Declaration), accuracy of fixes, recording of correct pressure and GNSS altitudes, and the required number of pre-flight and after-flight fixes to establish where the take-off roll started and the landing run finished, and other Specification requirements. (AL6)

1.4.2 **Engine Recording - ENL & MOP Systems**. Engine recording is by systems that are designed to differentiate between conditions of forward engine thrust, and gliding flight without the use of engine. The low-frequency Environmental Noise Level (ENL) system inside the FR is most sensitive to acoustic noise between 100 and 200 Hz. It was originally designed to record the operation of two-stroke engines, but, subject to testing, may also record high ENL numbers with Forward Electric Systems (FES) if the FR is installed just behind the engine and its retractable propeller. Where the ENL system in the recorder does not produce high enough readings with particular types of engine and FR installations, an additional sensor under the MOP code must be fitted so that a high engine signal can be recorded as three MOP numbers in each fix line in the IGC file, in addition to the three ENL numbers. Critical cases are in 1.4.2.2-4 below, more detail is in Chapter 5 and SC3 Annex C (SC3C) Chapter 11.

1.4.2.1 High Engine Power. A combination of engine and propellor noise at high power should give ENL figures over 800 out of 999. Most two-stroke engine systems produce ENL values over 900 at high power and may 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 separate sensor 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 the FR manufacturer 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 gliders, gliders with engines, and powered aircraft. Experience has shown that peak sensitivity between about 100 and 200Hz with a typical "bell curve" (in statistics, the "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 engine sensor using the MOP code. Where an engine and FR installation produces ENL values that make it difficult to differentiate between power-on and power-off flight (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", standing for "Means of Propulsion". The type of sensor is described in an extra line in the IGC file header starting with HF MOP, and may sense acoustic sound at high or low frequencies, current flow to electric engines, fuel flow to piston or jet engines, or any other variable tested and approved by GFAC for the engine type. The MOP sensor can be either inside the FR (in addition to ENL) or connected to it by cable, and must be capable of indicating any forward thrust from the engine. 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 where FR ENL figures can be shown to comply with the critical cases in 1.4.2.2. See 1.4.2.5 & Chapter 5.

1.4.2.4.1 Approval of individual type installations. An approval for use of an acousic ENL system on electric of jet equipped giders may be issued if flight tests demonstrate that the flight recorder clearly differentiates the use of the engine at low power levels. Such an approval shall be for a specific Flight Recorder and Glider Type. The approval shall by added as an Appendix to the Flight Recorder approval giving details of the Glider Type and full installation details. Testing for compliance with para. 1.4.2.5.2 must be carried out before issuing such an approval.

1.4.2.5 Engine Recording. IGC files produced by individual recorder installations, particularly for ENL (and MOP where fitted), must indicate a clear difference between engine-off flight and any flight with the engine developing positive thrust. See also Chapter 11 of Annex C to the Sporting Code (SC3C) for more information and diagrams on engine recording.

1.4.2.5.1 ENL and MOP figures. The three ENL figures (and the three extra MOP figures where available) in each IGC file fix line, should be similar to those found in GFAC tests and listed in the IGC-approval document for the type of FR and engine sensor concerned. The figure with engine-off must not exceed 300 (generally, much less) and the figure when the engine produces forward thrust should not be less than 700. If either ENL or MOP figures are outside these margins, there is a risk that glide performances may not be able to be validated, see 1.4.2.5.3. below.

1.4.2.5.2 Checking Individual Glider Installations. Flight Validations have been lost in the past where installations of FR engine recording systems in individual gliders fail to differentiate clearly between engine-on and engine-off conditions. This may be either (1) because use of engine does not produce high enough ENL/MOP figures in the IGC file, or (2) because the particular installation allows unwanted high figures to be recorded in gliding flight which could be confused with use of engine. Some specific conditions follow.

1.4.2.5.2.1 Cockpit-mounted ENL systems. With cockpit-mounted ENL systems, flight conditions that produce high ENL figures in gliding flight should be avoided. Such conditions may include flight with DV panels open, particularly with sideslip when thermalling, and at high speed. In some gliders, flight with DV panels open at some speeds can produce a so-called "organ pipe" noise that records as high ENL, and opening DV panels at such speeds should be avoided. High ENL can also occur with operation of airbrakes and undercarriage, but as this is normally when descending before landing this can normally be distinguished from engine running.

1.4.2.5.2.2 MOP sensor placement. In some MOP systems that record high-frequency sound, high MOP has been found in gliding flight because the sensor has inadvertently been placed where high frequency sound is present, probably due to vibration at certain airspeeds of the structure on which the sensor has been mounted. In such cases the sensor must be moved to another position so that low MOP values are always recorded in gliding flight but the sensor continues to record high values with forward engine thrust.

1.4.2.5.3 Actions if IGC files do not clearly show use of engine. If ENL, MOP and other figures in IGC files make it difficult to distinguish between engine-off flight and flight with forward engine thrust, action must be taken before Validations of important flights are compromised. Possible actions include moving the engine sensor to a more favourable position to record use of engine (if the sensor is separate from the main FR), moving the whole FR to a more favourable position (where this is possible with a small FR), returning the recorder and/or the engine sensor to the manufacturer or his authorised agent for the ENL and/or MOP systems to be re-set, or using a type of FR that has an external sensor that can be placed close to the engine.

1.4.3 **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 will 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.

1.5 **IGC-APPROVAL**.

GFAC shall either 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 FR manufacturer. The final version of the IGC-approval document is the responsibility of GFAC, in its capacity as 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), the manufacturer will be informed 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 Level 1 (all flights), or an approval with limitations pending improvement of systems such as ENL and/or MOP.

1.5.1.1 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.

1.6.1.2 **Action on Changes**. GFAC may decide to note the changes, or that a formal evaluation of such changed features is required and an updated FR sent to GFAC for testing. If the changes are extensive, GFAC may decide that another approval process is required.

1.6.2 **Changes in IGC-approvals**. An existing IGC-approval document may be modified or removed at any time after a decision by GFAC.

1.6.3 **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.

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

1.6.3.2 Significant changes in Manufacturer details. If significant changes have been made in the Organisation named 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 may be required on an approval application, certifying that the new Organisation will comply with current IGC procedures, and GFAC may require to test Recorders produced by the changed Organisation. What changes are considered significant will be assessed by GFAC and include: transfer of manufacturing to a different Organisation, acquisition of a name by another Organisation, or a change of structure or key personnel within the current Organisation.

1.6.3.3 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. In this situation, GFAC may consider lowering the IGC-approval level of such FRs.

1.6.3.3.1 Pilot aspects - Validation of Flights. Pilots should be aware that if they are using a recorder for which there is no manufacturer support, if there are anomalies in IGC files it may not be possible to validate such flights.

1.6.3.4 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 Manufacturer with any other organisations 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 IGC-approved GNSS Flight Recorder operated in accordance with its IGCapproval document shall be used for all flights that require validation to IGC criteria (except Silver and Gold badge flights which may also use a less secure IGC Position Recorder (PR)). Flights in gliding championships that use IGC rules must also comply with Annex A to the IGC Sporting Code (SC3A). 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 IGC standards are specified, such as for IGC badges and diplomas, national and regional records. 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, the file must pass the IGC electronic Validation check (see para 1.1.10.1). See the Glossary under ENL, Fix, Missed Fixes, and MOP.

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 IGC-info mailing list. The complete IGC-approval document will be posted on the FAI/IGC web site, together with the FR Manufacturer's DLL file for validating the integrity of IGC files.

1.8.1 Valid Approval Document. Only the latest published IGC-approval document for a given type of FR is valid for IGC purposes. (AL6)

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 may be carried out by GFAC at any time and without prior notice to the FR manufacturer. 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**.

If any comments, questions, or problems arise during use of an IGC-approved Flight Recorder, the GFAC Chairman gfac@fai.org should be notified in the first instance. See also para 1.1.12 on Anomalies in Evidence.

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 deliberate 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 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 international use of the recorder.

2.1.2 **Rôle 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 errors, malpractice or cheating; compliance with the IGC data file format; and other IGC requirements.

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 before and after flight checks by OOs or others, sealing, stowage in the glider, etc., where these relate to the integrity and security of downloaded IGC files.

2.2.2 **Downloaded Data**. This must be in the IGC text format, see Annex A for the detail. It should be noted that some early IGC-approved FRs download in an intermediate format such as binary which is then converted to the IGC format for flight analysis, see also para 3.11.

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. As long as the data in the IGC file is not changed, other data may be presented on cockpit displays, such as to show altitude above ground level (AGL) rather than above the 1013.25 hPa sea level pressure altitude datum of the ICAO International Standard Atmosphere (ISA), or above the WGS 84 Ellipsoid for GNSS altitude. 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).

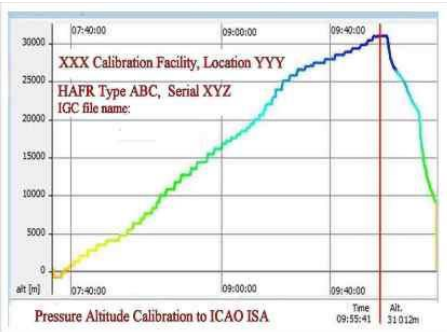
2.2.3.2 Loss of GNSS fixing - Continuity of Time Data. During any periods where GNSS data is not available, fixes must continue with other data including pressure altitude and an accurate timebase. This may be achieved through a Real Time Clock (RTC) function to maintain accurate time if GNSS time is temporarily lost.

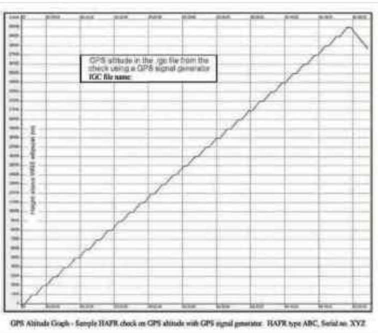
2.2.4 **Altitude Recording**. In addition to recording GNSS altitude, an IGC FR shall include a sensor producing an output of pressure altitude that can be calibrated to the ICAO ISA under IGC Sporting Code procedures. The pressure altitude system must be compensated for temperature changes at the FR and the sensor must be of a type acceptable to GFAC. If the GNSS is inoperative for all or part of the flight, fixes including pressure altitude must continue to be recorded and GNSS altitude must be recorded in the IGC file as zero so that it can be clearly seen that an unlock has occurred. 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.

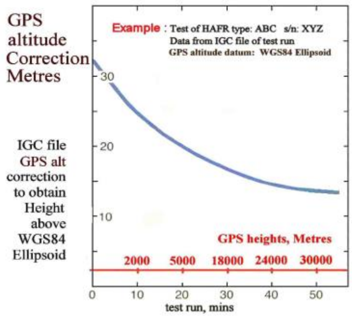
2.2.4.1 High Altitude FRs (HAFRs). An IGC High Altitude Flight Recorder (HAFR) is a Flight Recorder that is IGC-approved at "all flights" level and also for the validation of altitude performances above an altitude of 15km (49,213ft) with respect to the WGS84 Ellipsoid. The IGC-approval of a HAFR will be up to the altitude for which satisfactory checks on pressure and WGS84 GPS altitude figures in its IGC files have been provided to GFAC by an NAC- and IGC-approved instrument laboratory. For other references, see SC3 para 4.5.3, SC3B para 2.2.2, and SC3C Appendix 6.

2.2.4.1.1. GNSS Receiver. The GNSS receiver in an IGC-approved HAFR must be a high-quality system with at least 16 channels, designed for aircraft use, and IGC-approved for use in a HAFR. It should be noted that some types of GNSS receivers are prohibited from producing fixes at very high altitudes (such as above 50,000ft) and at slow glider speeds, and cannot be used in a HAFR unless such altitude/speed limits can be shown to be removed by testing with a GNSS Signal Generator.

2.2.4.1.2. GNSS Altitude Data. GNSS altitude data must be with respect to the WGS84 Ellipsoid which is the IGC GNSS altitude zero datum. Processing of 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 1/3 hectoPascal for pressure altitude (for the latter, see 4.4.1.1). In testing for IGC-approval, the GNSS altitude data in the IGC file will be analysed to check that the graph of GNSS altitude with time is smooth and without short-term "spikes" that in the case of a record flight would cause difficulty in establishing the exact altitude or gain of height of a claim. GNSS altitudes above the WGS84 Ellipsoid in the IGC file from the HAFR used for an altitude claim above 15,000 metres must have been independently checked and documented before the claim for accuracy and freedom from anomalies. They must also be checked ***after*** an altitude claim above 15,000m to ensure that processing of GNSS altitude by the FR has not changed, for instance due to other updates, changes, or faults in the FR that have occurred since the initial check, which could be up to 5 years before the claim flight. These checks must be carried out at an NAC-approved instrument laboratory, at which a high-quality GPS signal generator is used







2.2.4.1.3 Pre-flight check - this is required up to the maximum altitude for which the HAFR is to be approved for record claims. Differences between the IGC file figures and those from the signal generator are then listed in a table that is used to correct figures for the altitude claim in a simular way to correcting IGC file pressure altitudes to the ICAO ISA. The diagrams show an example of a GNSS altitude check made as part of IGC-approval of a HAFR and are from Appendix 6 of SC3C. (AL6)

2.2.4.1.4 Time periods for these checks - these are the same as SC3 requirements for pressure altitudes. That is, within 5 years before and two months after the flight, except that if the claim flight is made from a site remote from GNSS altitude checking facilities, the after-flight period starts when the FR is returned to a location at which GNSS checks can be carried out at a facility approved by the NAC dealing with the claim. (AL6)

2.2.4.1.5 Minimum requirement - for the post-flight GNSS altitude check this is for check points to be recorded above and below (and close to) the claimed altitudes. A check over the complete altitude range is not essential, but could provide the official pre-flight check for a later claim. (AL6)

Example - Table of GPS altitudes - HAFR test with GPS Signal Generator
HAFR: Type: ABC Serial Number (from IGC file name): XYZ
Test organisation:
Date of test:
Name of Tester or Head of Test Team:
GPS Signal Generator used, type:
SigGenSpecification, Ref:
SigGen Certificate of Performance, Ref:
GPS Altitude zero datum used: WGS84 Ellipsoid (ref: IGC FR Specification)

Signal Generator figure above WGS84 Ellipsoid metres	IGC File GPS Altitude metres	Correction in metres to be applied to figure in IGC file to obtain altitude above WGS84 Ellipsoid
0	-32	32
1000	972	28
2000	1975	25
3000	2977	23
4000	3978	22
5000	4979	21
6000	5979	21
7000	6980	20
8000	7980	20
9000	8980	20
10000	9981	19
11000	10981	19
12000	11981	19
13000	12982	18
14000	13982	18
15000	14982	18
16000	15983	17
17000	16983	17
18000	17983	17
19000	18984	16
20000	19984	16
21000	20984	16
22000	21984	16
23000	22985	15
24000	23985	15
25000	24985	15
26000	25985	15
27000	26986	14
28000	27986	14
29000	28986	14
30000	29986	14

2.2.4.1.6 Pressure altitude - this is also required within 5 years before the claim up to at least the altitude to be claimed, but there is no requirement for a post-flight pressure altitude for altitude claims above 15,000 metres because GNSS altitude will be used for the claim. (AL6)

2.2.5 **Motor Glider Engine Recording**. For gliders with an engine capable of producing forward thrust, an IGC-approved system that records its operation is required. See Chapter 5 for more detail. The IGC Environmental Noise Level (ENL) system operates within the recorder case and is mandatory for use in 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 5.5), an additional sensor operating under the three letter MOP code must be used, see para 5.4 later. Tests with engine-on and glide conditions will be carried out by GFAC and details on 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.

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) produces results similar to those in Annex B of the IGC approval document for the FR concerned.

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. Security of data 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 alphanumeric Serial ID (S/ID) of the individual recorder. See para. A2.5.3 for the format of the S/ID. Where a display is available, on power-up it must show for at least 10 seconds the FR type and manufacturer, S/ID, hardware and firmware versions, before the display changes to another presentation, so that this data can easily be written down by an OO before flight, and after flight this data can be confirmed 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.

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 first 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 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 IGC files 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, by International definition
Miles:	International Statute Mile = 5280 feet	exactly, by International definition
	International Nautical Mile = 1852 metres exactly, by International definition	
Speed:	Knots are Nautical Miles per hour "mph" refers to Statute Miles per hour	
ICAO ISA Sea Level:	1013.2500 HectoPascals (the same as Millibars) exactly, by International definition (Based on a Pressure equivalent to 760 mm of Mercury at 15 degrees C and standard gravitational acceleration of 9.80665 m/s^2) = 29.9213 inches based on exactly 2.54 cm to the inch, as above	

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 can be 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 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.

2.2.11 **Approval level changes**. If GFAC proposes to change the approval level of a type of IGC FR, generally to lower the level, or to remove the approval, this will first be discussed with the FR manufacturer. The manufacturer will be given the opportunity of offering an upgrade that will retain the existing approval level for modified recorders. The IGC ANDS Committee will be informed, and the IGC Bureau may also be informed if considered appropriate at this stage.

Further detail on changes of IGC-approval Level is in Appendix A to SC3B (the IGC Sporting Code Annex B on equipment requirements for Validation of flights). (AL6)

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 and GNSS altitude 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 GNSS 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 GNSS is not locked on, from the Real-Time Clock (RTC) in the recorder that gives continuity of time data. For GNSS systems where leap-second corrections need to be applied to obtain current UTC, the correction must be applied in the FR so that accurate UTC is always shown in times in IGC files. For leap seconds in the US GPS system, see page viii under GPS System Time.

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 important where pressure altitudes are made in a sealed chamber in which GNSS lock-on is not possible. Recording should always begin when the FR is switched on and horizontal or vertical movement is detected, and no special switching should be required.

3.5.1 Pre-take-off Baseline. To establish an accurate take-off position and pressure altitude, a baseline of at least 30 valid fixes must be provided at not less than 1 second intervals in the minute before take-off movement is detected. See Appendix A para A1.1.1 for more detail.

3.6 **IGC file - Fix Data**.

3.6.1 Fix Intervals. The choice of fix intervals for normal flight must include 1 second (required for world championships). A 5 second or longer interval should also be provided to allow for very long flights (some record flights have been over 14 hours). 1 second fix intervals should be automatic when near to declared Start, Turn and Finish points. After a Pilot Event (PEV) has been selected, a fix must be made immediately to which the PEV code is attached in the IGC file, followed by at least 30 seconds at a 1 second fix interval. The Pilot Event must be easy to select 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.

3.6.2 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 conditions apply:

(1) if no horizontal or vertical movement has been detected for at least 5 minutes with no change of exact position (thresholds as in 3.5 above) to allow for being static for a short time 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 one minute (the minute is to allow for battery change-over in flight or other short-term power loss). Also, for FRs with displays, when power is re-established, 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.

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, an electronic declaration facility is mandatory.

3.9.2 Electronic declarations in IGC files. The FR manufacturer must include setup software that allows the user to create the declaration data required by the Sporting Code (SC3). The most recent declared start, finish and turn points appear in the C-record of the IGC file together with the date and time that the FR received the declaration. 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 (instead of being nominated separately), a 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 or six digit alphanumeric Serial ID (S/ID) 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 GNSS receiver and Pressure Altitude sensors (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) to electronically validate the structure of IGC files. For some recorders, IGC Shell is also used for download, and in some early FRs for conversion from binary to the IGC format. See C1 and C2 later in this document.

Software is made available by IGC as freeware on the FAI/IGC web site through: www.fai.org/igc-documents , look for IGC Shell program

FR manufacturers must check that their DLL and other files included on these web references are up to date, and if not up-to-date, advise the GFAC Chairman so that action can be taken. Manufacturer's manuals should remind customers to check the web site above for the latest versions.

Before the IGC Shell system was produced, self-executing DOS-based program files DATA, CONV and VALI were used but these now only apply to some old types of recorders. For DOS-based files, see Appendix D.

3.11.1 Format of downloaded data from the FR. In accordance with para 2.2.2, the data downloaded from the FR must be in the IGC file format described in this Chapter and in more detail in Appendix A. For some old FR designs, initial download was in a manufacturer's format such as binary. In the IGC file format, whether obtained on initial download or on later conversion from binary, the source of the G- (security) record must be from the FR itself and not originate from the program external from the FR that is 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 for some old FR designs) by the NAC before a flight performance may be validated to the standards of IGC.

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

3.12 **Fix Accuracy - Averaging Algorithms**.

All fixes recorded on the IGC data file must be based on the processing of real position-lines from GNSS satellites. Some GNSS 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 than a "zig-zag" track that might be produced without a small amount of averaging. FR manufacturers must ensure that any averaging programs still allow all real manoeuvres to be shown when the IGC file is analysed.

3.12.1 Throw-forward of fixes. Some GNSS receiver modules designed for use in ground vehicles have a forward-prediction system (sometimes called "DEDuced" or "dead - reckoning", in other words, Predicted fixes). This is where "fixes" are not based on GNSS lines-of-position but, if GNSS lock is temporarily lost, fixes are predicted based on past speed and heading. If this system is enabled, a glider approaching a Turn Point and losing GNSS lock could "throw forward" a series of predicted fixes so that fixes are recorded in an Observation Zone when the glider has not reached the Zone - this was seen in early GPS recorder systems tested by GFAC. 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. The FR must be calibrated by the manufacturer in accordance with para 4.5.1 to the ICAO ISA. Subsequent Pressure Correction Charts may be produced by one of the methods in para. 4.5. If GNSS recording is inoperative for all or part of the flight, fixes must continue to be recorded including pressure altitude. References: para 2.2.4, also 2.2.9 on conversions between columns of Mercury and HectoPascals/Millibars. The duration of validity of a calibration is 5 years, whether carried out by a manufacturer or another facility approved by an NAC. A calibration carried out within a 2 month period following a soaring performance may also be used as supporting evidence

If pressure errors are adjusted during calibration by a manufacturer or other organisation approved by the manufacturer, two calibration charts should be provided, the first before making changes marked "Valid only for flights before calibration date" and the second after corrections marked "Valid only for flights after the calibration date". (AL8)

Manufacturers calibrations must include a point at zero altitude ISA (1013.25hPa) and should comply with the IGC Format (see appendix J). They may also be supplied as a hard copy compliant with para. 4.5.1.4.

4.1 Other uses of pressure altitude data.

FR pressure altitude 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. The ICAO ISA 1013.25 hPa. zero datum must always be used for pressure altitudes recorded in the IGC file.

4.2 Baselines for Take-off 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, and similarly for landing under para. 3.7.

4.3 Cockpit or Instrument static sources.

FRs designed to be mounted in an instrument panel should have an external tube connected to the static pressure sensor inside the FR, the tube to be connected to the instrument panel static pressure system. FRs without this tube-static connection will record the pressure inside the FR case, so-called "cockpit static".

4.4 Pressure Altitude

4.4.1 Sensor adjustments. Electronic pressure sensors have settings that can be adjusted by the FR manufacturer or his authorised agents. This is normally a pressure offset. The output from the sensor is a digitised pressure measurement which is converted into ISA Pressure Altitude by software in the recorder. The resolution of the A-to-D converter (10-bit, 16-bit, etc.) will govern the size of any steps (altitude resolution) in the pressure altitude output to the IGC file, for which a limiting value is in 4.4.1.1 below.

4.4.1.1 Resolution. The maximum permissible step in digital recording of pressure altitude in the IGC file is 0.1 hPa (mb) throughout the height range of the FR. On the ICAO ISA at Sea Level, one hPa is 27.0 ft (8.23m) in altitude and 1/3 hPa is about 2.74m (9 feet), 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 switching. For FR pressure altitudes in an pressure 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 . For FRs that do not record continuously after switching on, this must be achieved by ensuring that a rate of change of pressure altitude of about 1 metre per second for 5 seconds starts the FR recording fixes. Pressure-altitude fixes must continue to be produced in flight if GNSS data fails, see para 2.2.3.2.

4.4.3 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 as closely as possible to the ICAO International Standard Atmosphere (ICAO Document 7488 tables 3 and 4). If large corrections are found due to drift over time, they should be corrected by returning the FR either to the manufacturer or an authorised agent. Such agent must also be qualified to re-set security on re-sealing the FR. The tolerances in 4.4.3.1.below are copied from Chapter 2 to Annex B to the Sporting Code for Gliding (SC3B), and apply to set-up and before or immediately after initial sale:

4.4.3.1 For all FRs before or immediately after initial sale, on set-up and calibration of their pressure altitude system, the sea level setting should correspond to 1013.25 hPa ±0.5 hPa/mb, and the error in pressure no more than 1.5 hPa/mb up to the maximum altitude specified in the FR IGC Approval document

4.4.3.2 For all FRs, the correction error at any altitude may not exceed 99 metres. If such an error is found then the FR shall be returned to the Manufacturer or authorised agent for adjustment or repair. Any such agent must also be autthorised to re-set security on resealing the FR. Until the maximum error is brought within limits, such FRs may be accepted as Position Recorders subject to NAC approval.

4.5 Calibration

The purpose of calibration is to produce a pressure altitude correction file to determine the altitudes used for flight performance. It should be the format defined in Appendix J, and may also be output as a hard copy or PDF chart.

4.5.1 Pressure Chamber Calibration This is the only method that may be used for Manufacturer's calibrations. It may also be used for calibration by other facilities approved by an NAC.

4.5.1.1 Pressure reference The pressure reference instrument used for measuring chamber pressure during calibration must itself have been calibrated to International Standards within the previous 2 years unless another validity interval is specified in the instrument test certificate, in which case the test laboratory date will apply. The pressure reference instument calibration must cover the full range of the FR calibration.

4.5.1.2 Fix interval during calibration. The fix interval during calibration must be set to a maximum of 2 seconds (1 second fix interval is recommended) so that the duration of a stable chamber pressure is reasonably short, but at least 10 altitudes are recorded. The operator may note the interval set before calibration and reset the recorder after calibration.

4.5.1.3 Pressure Altitude Intervals Pressure steps may be in feet or metres. A point must be recorded at 1013.25 hPa (Zero ISA Pressure Altitude). If in metres, altitude steps of 500 metres up to 2,000 metres and then 1,000 metre steps to the maximum altitude of the recorder approval should be recorded. If in feet, altitude steps of 1000 ft up to 6,000 ft and then 2,000 ft steps to the maximum altitude of the recorder approval should be recorded. For HAFRs the presssure steps above 15,000 metres should be not more than 2,500 metres or 5,000 ft.

4.5.1.4 Recording of calibration data After the calibration, the IGC file containing the pressure steps is downloaded to a computer in the same way as flight data. The stabilised pressure immediately before the altitude is changed at each pressure step shall be taken as the value of the step unless the calibrator certifies otherwise. The IGC file will then be analysed, compared to the calibration pressure steps, and a correction table produced and certified by the calibrator or another NAC-approved person. Only the pressure recorded in the IGC file may be used, and not any other indication that may be displayed on the recorder. A copy of the IGC file must be retained by the calibration facility.

4.5.1.4.1. The correction table must list the Recorder type and serial identity (S/ID), date of calibration, pressure reference details, laboratory ambient conditions, name and address of calibration facility and accurate ISA against indicated altitudes. An example of such a table is shown.

IGC Flight Recorder calibration certificate

Device under test:
Type: GARRECHT INGENIEURGESELLSCHAFT,VOLKSLOGGER 1.0
Serial number: GCS0002LK
IGC file name: 491A2LK1.IGC

has been calibrated on 29 Jun 2024 by:

GBR-007 A.N.Other
1600 Pennsylvania Avenue, Washington DC

Correction Table:

ISA altitude (ft)	Device reads (ft)	Correction (ft)
0	-76	76
1000	927	73
2000	1912	88
3000	2931	69
4000	3917	83
5000	4912	88
6000	5905	95
8000	7909	91
10000	9885	115
12000	11865	135
14000	13855	145
16000	15816	184
18000	17823	177
20000	19815	185
22000	21767	233
24000	23721	279
26000	25743	257
28000	27715	285
30000	29698	302

This calibration is valid from **29 Jun 2024** for the period specified in FAI Sporting Code.
As this is a FAI/IGC approved flight recorder, the .IGC calibration file is held on record at this facility.

Reference manometer:
Type: acme
Serial number: 1234
Manometer calibration date: 28 Feb 2018 Manometer certificate number: abc
Test conditions: QFE: 1013.87 hPa, temperature: 17°C

Calibrator's stamp/signature

Data prepared with FR-cal v0.7.0. Certificate printed with FR-cal v0.7.0.

4.5.2 Single point pressure correction. The major contribution to sensor drift is a pressure offset which is constant throughout the measurement range. Accurate measurement of pressure offset at one point may be applied to calculate the equivalent pressure altitude offset at other altitudes. For this method to be used, it is necessary for the pressure reference used to determine the offset to also be accurate to within ±0.1 hPa.

4.5.2.1 Single point correction using a pressure reference instrument. An instrument measuring pressure to a precision equal to or better than ±0.1 hPa with a valid calibration certified to International Standards must be used. The pressure indicated by the instrument (after any correction in its calibration is applied) which is positioned at the altitude of a Recorder recording an IGC file is noted together with the UTC time. The IGC file Pressure Altitude averaged over 10 records is converted to a pressure and the pressure error compared to the reference is used to calculate the equivalent altitude correction over the range of the Recorder Approval. The program FRCAL located on the FAI website at https://igcfrcal.fai.org/ and must be used for the calculation. The helpfile is recomeded and can be found at https://www.fai.org/sites/default/files/correction_chart_frcal_helpfile.pdf An example correction table is given below:

IGC Flight Recorder single point correction

Device under test:

Type: LXNAVIGATION,LX7007F
Serial number: LXN000GGC
IGC file name: 46TLGGC1.igc

has been checked on 29 Jun 2024 by:

GBR-007 A.N.Other
1600 Pennsylvania Avenue, Washington DC

>>> Single point correction <<<

FR pressure correction: -0.64 hPa

Correction Table:

ISA altitude (m)	Device reads (m)	Correction (m)
0	5	-5
500	506	-6
1000	1006	-6
1500	1506	-6
2000	2006	-6
3000	3007	-7
4000	4008	-8
5000	5009	-9
6000	6010	-10
7000	7011	-11
8000	8012	-12
9000	9014	-14
10000	10016	-16

Note: values in table above are not valid outside altitude range of tested device. These values are valid from **29 Jun 2024** for the period specified in FAI Sporting Code.

Reference manometer:

Type: acme
Serial number: 1234
Manometer calibration date: 28 Feb 2023
Manometer certificate number: abc
Test conditions: QFE: 1013.85 hPa, temperature: 17°C

....
Calibrator's stamp/signature

Data prepared with FR-cal v0.7.0. Certificate printed with FR-cal v0.7.0.

CHAPTER 5 ENGINE RECORDING

This chapter amplifies the general provisions of 2.2.5

5.1 **GENERAL**.
The Environmental Noise Level (ENL) system operates completely within the recorder case, and is mandatory for all IGC FRs. It is fundamental for gliders with engines and is sometimes vital in gliders without engines in accident and incident situations. For types of engine installations in 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 5.5), an additional sensor under the MOP code must be used (See also 2.2.5). The baseline figure with a serviceable ENL and MOP system and no signal is 010; a figure of 000 indicates that the system is unserviceable.

5.2 **Fix recording**.
When any forward thrust is generated, a fix must be recorded immediately irrespective of the FR setting for fix sample rate. 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 all IGC-approved FRs, a working ENL system is mandatory (see paras 2.5 and 5.1). This is where acoustic noise is recorded using a microphone and been shown to record the running of piston engines, particularly two-strokes. However, careful processing of the raw noise signal is required (using frequency filtering and multiplication at critical frequencies) so that a high ENL value is always recorded in the IGC file when any forward thrust is generated by such engines. 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 be disabled and must always give significant positive readings when noise is detected.

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 glider cockpit. Less noisy engines such as 4-stroke and Wankel (rotary) engines, may not produce such high figures, but should still result in ENL values over 700 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 should 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 5.5 on critical ENL conditions and Appendix B para B8.5 on flight testing.

5.3.2 Covering the FR. The FR should be mounted in the cockpit without any objects placed closely around it. However, if FR is 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 adjustment 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 have been made during testing. Experience has shown that a peak frequency sensitivity between 100 and 200 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 may include using an acoustic generator to produce ENL numbers as they vary with frequency; these tests typically produce a "bell curve" (the "normal distribution"). For more detail on ENL tests, see Appendix B para B8.5.

5.4 **Sensors in addition to ENL - the MOP three-letter code**.
For types of engine installations where GFAC assesses the FR ENL values as being too low to differentiate between engine-on and engine-off flight, an additional system using the MOP (Means Of Propulsion) code shall be required. The MOP sensor may be external to the FR and connected to it in a secure way approved by GFAC, or be inside the FR in addition to the ENL system. In either case, this should enable the MOP sensor to be placed to receive a high signal from the engine type for which it is designed, whenever forward thrust is developed. Guidelines for the positioning of the sensor for different types of engines will be given in the IGC-approval document for the type of FR. It applies to rear-mounted electric and jet engines and some relatively quiet 4-stroke engine installations, except where the FR itself can be mounted very close to the engine such as in a nose-mounted Forward Electric System (FES) with the FR in the instrument panel just behind the engine. As 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.

5.4.1 Acoustic MOP sensor. This must be placed close to the engine and/or propeller, or in the case of a jet engine, close to the jet pipe, unless it can be shown that other positions give high enough MOP values when the engine generates positive thrust. 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 ENL systems are designed, and high sound values are produced near and to the rear of the jet pipe. The sensor position must also be free from other noise or vibration that could occur in gliding flight and could be mistaken for use of engine.

5.4.2 MOP sensor separate from the FR . Its characteristics may be similar to the FR internal ENL sensor, but being separate can be positioned close to the engine/propeller/jet pipe (as appropriate), if it can be shown that the required MOP numbers are obtained when the engine is run. If appropriate MOP numbers cannot be demonstrated, a different type of sensor must be used.

5.4.3 Jet engines. FR acoustic sensors designed for jet engines have a higher frequency response than those designed for piston engines or propellers and should not be used to detect running of propeller systems because the frequency response will not match.

5.4.4 Sensors of electrical current. These 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.

5.4.5 Sensors of other engine functions. Before an FR is sent with such a sensor for IGC-approval these must be assessed by GFAC.

5.4.6 OO Seal of MOP sensors external to the FR. 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 able to show that any break, or interference with, the cable from the FR to the MOP sensor will be detected and shown in the IGC file.

5.4.7 Engine power. 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).

5.4.8 Type of Sensor and IGC file Header Record. The nature of the sensor and how its signal is processed shall be approved by GFAC and will be tested before IGC-approval. In the IGC file, a short description of the type of MOP sensor shall be given in the H (Header) record in the form HF MOP Text String, see A3.2.4. If more than one type of MOP system is fitted, the letters MOP in the IGC file are followed by a number so that each system can be described separately in the header record. In each fix (B) record line, the first MOP system is to use the three letters MOP, other systems use MP2, MP3 etc.

5.4.9 Integrity of the system. When the system is not sensing any signal an MOP value of 010 shall be used to indicate:

(1) continuity of any wire leading to the sensor or supplying the signal, and

(2) serviceability of the sensor or signal itself where 000 would otherwise be recorded). One solution is for the Recorder to generate a coded pulse that is sent at regular intervals down the wire, the return of which indicates the two conditions 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 **Critical ENL and MOP Recording Cases**.

Amplifies para 1.4.2.

5.5.1 Power-on. The critical power-on case that is used for testing ENL and MOP systems is power for positive engine thrust, 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 in 5.5.2 below. If ENL is not high enough under such engine power, the extra MOP system must be fitted; this may apply to electric and small jet engines; unless the FR is fitted close to the engine, such as in the instrument panel close to a nose mounted electric engine if the ENL signal can be shown to be high enough in the particular installation.

5.5.2 Power-off. The critical power-off case for ENL and MOP is not a quiet, well-sealed cockpit in which ENL figures should be low in gliding flight. 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 in some IGC files. Another high-noise case is high speed with cockpit panels 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. In some installations, unexpected high noise levels have been found, probably due to aerodynamic vibration on or near the component on which the sensor is mounted. In these cases, the sensor must be moved to a place that is free of unwanted recorded noise or vibration in gliding flight.

5.5.3 ENL and MOP numbers. The three ENL and MOP numbers recorded in IGC files must differentiate between the "quiet engineon" and "noisy cockpit" cases. This is done by using 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 motor gliders, gliders and powered aircraft.

5.5.4 Approval of individual type installations. An approval for use of an acousic ENL system on electric of jet equipped giders may be issued if flight tests demonstrate that the flight recorder clearly differentiates the use of the engine at low power levels. Such an approval shall be for a specific Flight Recorder and Glider Type. (see para. 1.4.2.4.1.)

5.6 **Production standards**.

FR manufacturers must ensure that, on initial operational use, the engine detection system of an individual recorder produces figures results similar to those described in Annex B of the IGC-approval document for the type of recorder. The design must be able to allow for updates required by amendments to IGC FR documents.

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 must be used to protect hardware, firmware and software so that no alteration of flight data in IGC files may occur without such alteration being detectable. This is achieved by a digital signature (DS) system in 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. The DS system must enable detection of any alteration of data in an IGC file from the version initially downloaded from the FR and from the same IGC file at any time afterwards.

6.1.1 Security Keys. Individual FRs must not have the same security keys as 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. For the number of different Private keys required, see G2.1.1.2. (AL6)

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, also in Annex B to the Sporting Code for Gliding (SC3B).

6.2 **Physical Seal**.

Unless the construction of the recorder 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 (so-called "no-peel Labels" or "non-removable Stickers") 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 with normal recording for at least 10 hours, it must be designed for use with an external 12V DC battery system. 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 GNSS 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 a type that is commonly available worldwide, be separate from other connectors on the recorder case, and be designed and specified for low energy antenna signals, including GPS frequencies around 1.5 GHz. An exception is where FR designs have antennas inside the recorder case where an external connector does not apply.

6.3.2.1 Antenna connectors. The IGC preferred external antenna connectors on the FR case include 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, 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, may include controls for switching the display to different modes. 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. Such functions external to the FR include a Pilot Event (PEV) button for FRs that are not mounted in the instrument panel, and an external Motor Glider engine sensor operating under the MOP code.

6.3.5 Connectors and fittings for data transfer. The types of IGC-approved connectors or fittings on the FR case for download of flight data are specified in Appendix F.

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, it is recommended that either the RJ45 or USB connector is recommended because standard wiring to these types includes both power and data download facilities. It is recommended that USB connections are to international and IGC standards for the RJ45, see Appendix E. For panel-mounted recorders, it is recommended that an industry-standard memory fitting (such as an SD card socket or USB connector) is on the front face. 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.

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 who were mainly concerned with analysis programs for flight data . It was approved by the IGC Plenary in March 1995 for use with the new concept of IGC-approved Flight Recorders, and has been refined and developed through regular amendments. It provides a common world data format for the verification of flights to IGC criteria, and several other FAI sports and aviation bodies also 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). Position fixes in the IGC file are in B-record lines in the form of lat/longs and altitude before, during and after flight. Unless the type of FR employs continuous fix recording after switching on, the thresholds for starting fix recording after initial switch-on are a speed of 15 kph or a pressure altitude change of 1 metre per second for 5 seconds.

A1.1.1.1 Pre-take-off Baseline. For types of FRs that start recording fixes in the IGC file after movement is detected (compared to types of FRs that record fixes in the IGC file after switch-on), a pre-take-off baseline must be provided consisting of a continuous series of at least 30 valid fixes at a steady fix rate throughout the minute before take-off movement is detected (Chapter 3 para 3.5.1 also refers). For this, when movement is detected, the pre-take-off baseline fixes are placed in the first B-record lines in the IGC file (in current IGC-approved FRs this is achieved through a memory loop that continuously stores the correct number of fixes ready for insertion into the B record at the appropriate time).

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 on how IGC files are ended.

A1.1.1.3 Data for Different Flights. Where 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 after the first file in the memory are those relevant to each later flight. If any record types are changed between flights (such as declaration, pilot name, etc.) the changes must be included in the later flight data files, but not in earlier 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 amendments on page (i).

A2. GENERAL

A2.1 **File Structure**. An IGC-format file consists of fields of characters, in some cases all on one line, each giving a set of data such as for a GNSS fix and other information. Each field 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). Generally, the B, I, J, L and K records have a maximum of 99 characters, excluding CRLF which is hidden and does not appear in text form. Some Record types are on only one line, others can be on several lines. The Header (H-) Record includes separate lines for GNSS FR type, type of GNSS receiver and Pressure altitude sensor, pilot name, glider identification, etc, and the Flight Declaration (C) Record includes lines for the co-ordinates of each Waypoint. The order of Record types within an IGC file is given in 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 spaces 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.

A2.2 **Record Types**. Each record type is identified by an upper-case letter that appears in the IGC file as the first character of the field concerned:

IGC DATA FILE FORMAT - RECORD TYPE IDENTIFICATION LETTERS	
A - FR manufacturer and FR serial no. B - Fix C - Task/declaration D - Differential GNSS E - Event F - Satellite constellation G – Security H - File header	I - List of additional information after the basic B-record data J - List of information in K-record data (Security signed) K – Multiple instance data, security signed. L - Logbook/comments M - List of information in N-record data (Non-security signed) N – Multiple instance data, (Non-security signed.) O, P, etc. – Spare

A2.3 **Record Order**. The A-Record is always the first in the file, and the last that is relevant to the data recorded in flight is the Security (G) Record that allows the validity of fix data to be checked at any time through the IGC VALI system. 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 Record lines are placed in the file in time order using either GNSS fix-time if the GNSS is locked on, otherwise time is taken 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 there may be several L-record lines in the file.

A2.3.1 After-flight Data. In some FRs, extra data is calculated ***after flight*** such as statistics for the flight. This must be placed at the end of the IGC file after the G record in the form of another L record, but ***it is essential that*** the integrity of fix data before the G record and the VALI system for checking the flight data, are not affected by such additions. In particular, no B-record fix lines must appear after the G-record because this could be false data added after the flight. If any B-record data is detected after the G-record, this must cause Validation of the IGC file to fail. (AL8)

A2.3.2 Sequence of Record Types. The following sequence of Record types is typical, although in a real IGC 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) H - File header (always after the A-record) I - List of other data added at end of each B record J - List of other data added at end of each K record M - List of other data in each N record C - Task/declaration (if used) L - Logbook/comments (if used) D - Differential GNSS (if used) F - Initial Satellite Constellation B - Fix plus any additional data listed in I Record B - Fix plus any additional data listed in I Record E - Pilot Event (PEV) B - Fix plus any additional data listed in I Record K - Additional data as listed in J Record N – Additional unsigned data 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 F - Constellation change B - Fix plus any additional data listed in I Record K - Additional data as defined in J Record N – Additional unsigned data B - Fix plus any additional data listed in I Record E - Pilot Event (PEV) 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 K - Additional data as defined in J Record N – Additional unsigned data L - Logbook/comments (if used) G - Security record L - Data added after the flight is completed

A2.4 **Units**. Data in the IGC file uses 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 H record) – DDMMYY (day, month, year, with respect to UTC).

Time - HHMMSS (hours, minutes, seconds) UTC, for source, see para 3.4 in the main body in this document. Note that UTC is not the same as the internal system time in the U.S. GPS system because so-called "Leap seconds" must be applied to GPS system time to obtain UTC, 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 (1) ICAO ISA pressure altitudes, and (2) GNSS altitude above the WGS84 ellipsoid.

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

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

A2.4.1 **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 mandatory codes such as FXA, SIU, ENL), this is indicated in the I record as: "4949TDS".

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

DD - Latitude degrees with leading 0 where necessary
DDD - Longitude degrees with leading 0 or 00 where necessary
MMmmmNSEW - Lat/Long minutes with leading 0 where necessary, 3 decimal places of minutes are mandatory, followed by N, S, E or W as appropriate. If additional digits are used, for the fractional minutes define the positions through codes LAD and LOF in the I record.

Altitude - AAAAAaaa there are 2 altitude figures in metres: (1) GNSS altitude above the WGS84 ellipsoid, and
(2) Pressure Altitude to the ICAO ISA

AAAAA - fixed to 5 digits of metres with leading zero and if necessary with leading minus sign
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 must 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 (mbar / 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 must always be in metres with respect to the ICAO ISA with its sea level datum of 1013.25 mb.

and, where calculations (optional) are 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 will therefore be 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)

Temperature - TTTttt. TTT with leading zeros (and leading minutes if required). TTT fixed to 3 characters. ttt - number of temperature decimals. The number of fields recorded are those available for temperature in the Record concerned, less 3 already used for TTT. (AL7)

A2.5 **FR FILE NAME (FILE ID)** New types of FRs must use the IGC long File Name/ID format as defined in A2.5.3.

A2.5.1 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 which was the original IGC FR name format. For instance:

Long file name example: 2021-05-15-MMM-XXXXXX-01.IGC
2021-05-15 = date
MMM = manufacturer's three-letter IGC identifier (see table on next page)
XXXXXX = unique FR Serial ID (S/ID); 6 alphanumeric characters (see the note below)
01 = second flight of the day, 02 for second flight, etc.

Note: The XXXXXX field has 6-characters, with hyphens at the start and end, with leading zeros if necessary to make up the 6 characters. It can also be used by a manufacturer to differentiate between different FR types, such as using the first characters to indicate each FR type. (AL7)

A2.5.2 Short file name style: YMDCXXXF.IGC
This was the first IGC system and for recent and new types of FR it may be replaced by the long name style above
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 ID (S/ID); 3 alphanumeric characters
F = Flight number of the day; 1 to 9 then, if needed, A=10, B=11, etc

A2.5.3 FR Serial ID (S/ID). This is the identifier for an individual IGC Flight Recorder. For an individual IGC FR, its S/ID 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/ID. For older recorders it is a 3-character Alphanumeric text string. For all new types of recorder it must be a 6-character string of which the first character is Upper Case Alphanumeric (omitting I and O to avoid confusion with numbers Zero and One) and the remainder characters numeric. The use of the first character to designate an individual model of recorder in the manufacturer’s range is recommended.

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 outside the contents of the file is not protected by the electronic security system. The IGC electronic security system applies to flight data within the file itself. File names may therefore be changed for purposes such as competitions, where it may be more convenient to use glider competition number or pilot name. There is no loss of data or security, since all data in the original file name is in the file A and H records.

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

A2.5.6.1 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 IGC Shell program (see Appendix C) when used with the manufacturer's IGC-XXX.DLL file (see Appendix D).

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

Note 1. New types of IGC FR must use the long file name that includes the manufacturer's three-letter code (also see A2.5.1 and A3.1). Manufacturers making only such FRs have no need for a single-character code and this is listed as "n/a" (not applicable) above.

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 Three letter Code, FR Model Name CRLF.

Some other FAI air sports have their own systems for non-IGC recorders; for example, for Hang Gliding (FAI Commission CIVL), see http://vali.fai-civl.org/supported.html

Note 3. The codes PFC, PLT and OOI must not be used because 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 **THE "A" RECORD - FR IDENTIFICATION (ID).** The A Record must be the first record in an IGC FR Data File, and includes the FR manufacturer's code, the GNSS FR Serial ID (S/ID) for the particular FR, and an optional text string The format of the A Record is as follows, with extra spaces for clarity:

A MMM XXX TEXT STRING CR LF or A MMM XXXXXX 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 XYY (see 2.5.6 table). The full manufacturer name will be seen later in the Header record in the form: HFFTYFRTYPE:MANUFACTURERSNAME,FRMODEL
Unique FR ID (S/ID)	3 or 6 bytes	XXX or XXXXXX	The FR Serial ID, valid characters alphanumeric. New types of FR must use the IGC long File Name/ID format and 6-character S/IDs, see A2.5 for IGC file names. If data follows the FR ID, a hyphen must be used to separate the file name from data that follows, see under Additional Data below. Note that non-IGC FRs may not conform and use different ID systems
Additional data	Optional	Text String	Valid characters alphanumeric. If used, start with a hyphen separator to distinguish it from the earlier characters for Unique ID (because later FRs have S/IDs of more than 3 characters). Short extra data may be added unless this is already covered in the Header record under FRTYPE.

A3.2 **<u>H RECORD - FILE HEADER</u>**

The H- (Header) Record includes 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 listed in section 7 that have the H flag are possible subtypes of the H-Record.

A3.2.1 <u>Source Codes</u>. The line entries in the H-record are created by the FR (source code F). In recent types of FR, they may also be created after flight under Source Code O by the OO or others. See the line "Data Source" in the table in 3.2.5.

A3.2.2 <u>General format</u>. The general format of H-Record lines is: H, data source (F=FR, O=other source), the three letter code for the subject of the line, the long name for the subject of the line, colon, then a 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.

A3.2.3 <u>Earth Model</u>. The U.S. GPS system uses the WGS84 ellipsoid, and for IGC-approval the FR must record lat/longs and GPS altitudes with respect to the WGS84 Ellipsoid.

A3.2.4 <u>Required records.</u> The following H records are required. In what follows, extra spaces between items are added so that it is easier to see the items; these spaces are not present in actual IGC files when viewed in text format:

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: HARDWARE MANUFACTURERS THREE LETTER CODE , 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
H F FRS SECURITY OK or SECURITY SUSPECT / SECURITY MS OPERATED (as relevant): TEXTSTRING CRLF

Notes:

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

FIRMWARE line: In the text string after the Firmware version number, where a type of FR has been updated so that GPS altitude is recorded as height above the WGS84 Ellipsoid (where this was not the situation before), to make this clear to pilots, OOs, and NACs using a text editor to read the header records, the following words shall be added: "with WGS84 Ellipsoid GPS altitude datum". This update shall also have a new Firmware edition number. In this situation, the updated H record line for new firmware edition XX will be:
"HFRFWFIRMWAREVERSION: XX with WGS84 Ellipsoid GPS altitude datum"

FRTYPE line: Both Manufacturer's name and FR model Name are required, separated by a comma (,) character

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 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 for a receiver using the US GPS and European Galileo systems.

FRS SECURITY line - see next page in the A3.2.5 table under HF FRS (AL6)

MOP line. Where FR firmware includes provision for an MOP sensor, an additional line is required that describes the type of sensor as follows:
H F MOP SENSOR: Maker, ON/OFF, type and model of sensor + what it records, CRLF
If more than one type of MOP system is fitted, these must be numbered MOP2, MOP3 etc in the header record, followed by the details of each system as given above. In the I-record line for additional data these are identified as MP2, MP3, etc. For more detail see the MOP entry in the table that follows.

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 a leading H letter: F=FR for data downloaded from the FR including pilot inputs before flight such as task, etc. Data entered before flight is protected by the security system and if it is changed after flight, the IGC file will fail the VALI check., O=other source entered after flight (such the OO) as allowed by this Specification. Data entered after flight is NOT protected by the security system.
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
GNSS 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 (e.g. RHW for FR Hardware version)
FR Type line	As required	F	Includes Hardware Manufacturers 3 letter code, and model data including sub-types. For instance, not only Model XXX 1 but 1a,1b, etc
HFGPS line	As required	Text String	Gives the GNSS 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.
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	As required	Text String	Format: HF FRS SECURITY OK , or HF FRS SECURITY SUSPECT: Text String with reason CRLF Line 2 above is used where security is suspect, for instance if FR firmware has changed in an unauthorised way or if the security microswitch has operated. The text string should be a description of the likely fault and recommended action, such as: "internal firmware changed FR re-set needed" or "Security Micro Operated FR re-set needed" (AL6)
HFMOP line	Required when MOP facility is included in the FR firmware	Text String	H F MOP SENSOR: Maker, ON/OFF, type and model of sensor/brief description of what it records, CRLF Under "what it records", some alternatives are: Acoustic + peak frequency sensitivity Hz/KHz; or Ecurrent (for electric engines); or Engine Management System data (describe what is recorded); or other system. The sensor model name and its characteristics is described in the FR IGC-approval document, see para 5.4 on the MOP Code. 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 000.

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 Three Letter Codes given in para A7. Additional data may follow 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 should 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. This is under code CM2, with 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 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 in the following table:

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

A3.2.7.5 Non-IGC FRs. For Non-IGC FRs, the following H-records apply :

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 (GNSS Altitude)	Three characters	TLC in Rema r k s column	ELL for WGS84 Ellipsoid (mandatory zero datum for IGC FRs) GEO for WGS84 Geoid (approx. Sea Level datum) NKN = GNSS altitude datum not known NIL = GNSS altitude not recorded, In which case B records must have V for the fix validity and 00000 for GNSS altitude
HF ALP (Pressure Altitude)	Three characters	TLC in Rema r k s column	ISA = ICAO ISA (mandatory setting for IGC FRs) MSL = Above Mean Sea Level NKN = Pressure altitude datum not known NIL = Pressure Alt not recorded, and 00000 must 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 in the form of a list of the appropriate Three-Letter Codes (CCC), data for which will appear in subsequent B Records. Only one I-Record line is included in each file, located after the H record and before the first B Record. For IGC FRs, Fix Accuracy (FXA) must be included, in the form of the Estimated Position Error figure (see Glossary under EPE). Also, Environmental Noise Level (ENL) is mandatory, and FXA must be followed by SIU, ENL and MOP (if MOP is recorded in the FR). 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 during the flight but is not required as often as the regular fix (B-) Records. The data stored in the J-record is 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

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: Take-off, Start, Turn Points (if any), Finish and Landing. The lines for Take-off 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.

A3.5.1 Lines in the C Record. The first line contains the UTC-date and time at which the declaration was made, the number of Turn Points in the task (excluding the Start and Finish points), and a text string to describe the task ("500k triangle", etc). The other lines contain the WGS84 lat/long coordinates and a text string describing the point. 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 a either a start point, turn point or finish point. The term "Turn Point" (TP) refers to a point-of-turn 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 TPs 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 competition polygon tasks.

A3.5.3 Take-off and Landing. Two lines in the IGC file C-record are for take-off 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 take-off and landing. They can be entered approximately or, if co-ordinates are difficult to obtain, 00000000N000000000E should be entered.

A3.5.4 C-record format. In the examples below, spaces have been added between data fields to aid clarity.

Line 1. DD MM YY is the UTC date on which the declaration was made; followed by the time of declaration in hours, minutes, seconds UTC in the format HH MM SS. This can be before the day of flight, unless a later declaration is received by the FR which replaces the earlier one. For the characters used in Flight Date, XXXX and TT, see the right-hand column below.

C DD MM YY HH MM SS DD MM YY XXXX TT TEXT STRING CR LF

Other lines. DD = degrees latitude, MM = minutes; mmm = decimal minutes: DDD = degrees longitude; The Text String is for the name and short description of the Point. The first and last lines are for the co-ordinates of the intended airfields of take-off and landing (or the intended take-off and landing points), but the official IGC declaration is from the Start Point to the Finish Point
via any Turn Points in the declared order, in the example below a triangle with 2 TPs with N latitude and E longitude.

C DD MM mmm N DDD MM mmm E TAKEOFF TEXT STRING CR LF

C DD MM mmm N DDD MM mmm E START TEXT STRING CR LF

C DD MM mmm N DDD MM mmm E TURN TEXT STRING CR LF

C DD MM mmm N DDD MM mmm E TURN TEXT STRING CR LF

C DD MM mmm N DDD MM mmm E FINISH TEXT STRING CR LF

C DD MM mmm N DDD MM mmm E LANDING TEXT STRING CR LF

C record – Description	Size (bytes)	Element	Remarks
Declaration date UTC	6	DDMMYY	
Declaration Time UTC	6	HHMMSS	
Flight date	6	DDMMYY	
Task number for the flight date	4	XXXX	
Number of Turn Points	2	TT	
T.O. or A/F LatLon Start LatLon T/P LatLon T/P LatLon Finish LatLon Land or A/F LatLon	as required	DDMMmmmN DDDMMmmmE to the WGS84 Geodetic Datum	The exact declared point is defined by the WGS84 latitude and longitude. The text string may include local waypoint code numbers, letters, name or description. The declared start point, turn points (if any), and the finish point are mandatory for a valid IGC pre-flight declaration. Take-off and landing data are not part of an IGC pre-flight declaration and including Lat/Long data in these lines is optional. It may be useful, for instance where remote starts or finishes are used. If exact data is not available, the take-off and landing data should be set to zero, such as 0000000N 00000000E

A3.5.4.1 The following is a example of a declaration for a 500 km triangle to be flown from Lasham Gliding Centre in the UK, with spaces between elements added to make it easier to read:

C 21 08 15 09 38 41 000000 0000 02 500K Triangle
C 51 11 359N 001 01 899W TAKEOFF Lasham Clubhouse
C 51 10 179N 001 02 644W START Lasham Start S
C 52 09 092N 002 55 227W TURN Sarnesfield
C 52 30 147N 000 17 612W TURN Norman Cross
C 51 10 179N 001 02 644W FINISH Lasham Start S
C 51 11 359N 001 01 899W LANDING Lasham Clubhouse

A3.5.5 Area Tasks. These are set in some gliding competitions but are not relevant to the flight declaration section of IGC files. Competition scoring is based on the fix record in IGC files and does not need a Declaration in the file.

A3.6 **G RECORD - SECURITY**. The G record is the digital security signature in the form of a coded sequence of characters. It is used to verify that flight data recorded inside the FR is identical to the flight data in the IGC file that is being checked. The signature is generated using a system described in Appendix G. The FR manufacturer must provide a method to check via this signature that the flight data in the IGC file is identical to that recorded in the FR. The G-record checks all of the Records required to be security-protected, as specified in the definition of each Record in this Appendix. G-records may consist of several lines, larger character counts generally implying higher security.

Format of G Record: G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR L F
G S S S S S S S S S S S S S S S S S S S S S S S S S S S S S S CR L F etc

G record - Description	Size	Element	Remarks
Security code	As required for the appropriate security level.	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.

A3.7 **M RECORD - ADDITIONS TO THE N RECORD**. The M record is a single line that defines what data will be in subsequent N-record lines, the N-record being used for data that is updated during the flight but may not require as often as the regular fix (B-) Records, and is not to be signed (see A3.6 on signing and the G record). The M-record (para. A4.7) fulfils the same function for the N Record as the J Record (3.3 above) does for the K record, and operates in the same way. It is placed in the file immediately after the J record line, or the I record if the J record is not present before the first B Record. The format of the M Record with extra spaces for clarity, is: M 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

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 basic fix data, plus mandatory characters that are defined in the I Record including Environmental Noise Level (ENL), Fix Accuracy (FXA) in the form of the figure for Estimated Position Error (see the Glossary under EPE), MOP (Means of Propulsion), and Satellites In Use (SIU) (AL8).

A4.1.1. The required basic data is: UTC, WGS84latitude, WGS84 longitude, fix validity, pressure altitude, GNSS altitude with respect to the WGS84 Ellipsoid. 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 other GNS Systems), and should be used if it is available from the GNSS receiver.

A4.1.2 In the B Record FXA shall be recorded as a three-figure group in metres and SIU as a two-group number. 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 SIU and ENL. In each B-record line, FXA would therefore normally occupy bytes 36, 37 and 38, SIU bytes 39 and 40, ENL 41-43.

A4.1.3 The format of the basic data, with extra spaces for clarity, is:

B HHMMSS DDMMmmmN DDDMMmmmE V PPPPP GGGGG CR LF

A4.1.4 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 GNSS system initially locks on, in the short period before the current leap-second data is available from the ephemeris data of the GNSS system, the leap-second correction that was used when that recorder was last locked on should be used
Latitude	8 bytes	DMMmmmN/S	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 GNSS system initially locks on, in the short period before the current leap-second data is available from the ephemeris data of the GNSS system, the leap-second correction that was used when that recorder was last locked on should be used
Longitude	9 bytes	DDDMMmmmE/W	Valid characters N, S, 0-9. Obtained directly from the same GNSS 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 GNSS fixing is regained
Fix validity	1 bytes	A or V	Use A for a 3D fix and V for a 2D fix (no GNSS altitude) or for no GNSS data. Note that pressure altitude data must continue to be recorded using UTC times from the RTC
Press Alt.	5 bytes	PPPPP	Altitude in metres relative to the ICAO ISA 1013.25 HPa datum, valid characters 0-9 and negative sign "-". Negative values to have negative sign instead of leading zero
GNSS Alt.	5 bytes	GGGGG	Altitude in metres above the WGS84 ellipsoid, valid characters 0-9 and negative sign "-". Negative values to have negative sign instead of leading zero

A4.1.4 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 in each fix line, these must be defined earlier in the IGC file 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 PPPPP GGGGG AAA SS EEE MMM CRLF

B record - Description	**Code**	**Size**	**Element**	**Remarks**
Fix Accuracy	FXA	3 bytes	AAA	Valid characters 0-9, metres
Satellites in Use	SIU	2 bytes	SS	Valid characters 0-9, metres
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). The E-record is used to record specific events in 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 the list in section 7. More than one event record may be used at the same time, but Events initiated within the FR (compared to those made 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 an Event record after every fix (B-record line), so that the IGC file does not become unnecessarily large.

A4.2.1 If a manufacturer 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.

A4.2.2 The form of the E-Record is record identifier, time, TLC, text string. Examples follow, with extra spaces to show the different elements in the line:

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 Three Letter Code for interpretation, for instance, with extra spaces for clarity: E 104544 ATS 102312 CR LF. This shows that the altimeter setting in a display device connected to the FR was changed to 1023.12 hPa at the time 10:45:44

A4.3 **F RECORD - SATELLITE CONSTELLATION.** For IGC FRs, this is a mandatory record. However, there is no requirement to update the F-record at intervals of less than 5 minutes, so that transient changes of satellites received due to changing angles of bank, flying in valleys, etc do not lead to unnecessary F-record lines.

In the US GPS system, SVN is the Space Vehicle Number of each satellite, and PRNs are "Pseudo-Random Noise" sequences, or Gold codes, that each satellite transmits to differentiate itself from other satellites (SV Numbers are not transmitted).

For other GNS Systems such as the Russian GLONASS , European Galileo or Chinese BeiDou 2 the ID is the nearest equivalent. Where NMEA data is used within the FR, the ID should be taken from the GSA sentence that lists the IDs of those satellites used in the fixes which are recorded in the B record. The F Record is not recorded continuously but at the start of fixing and then only when a change in satellites 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 is needed less frequently than fix (B) records. The K record should have a default interval of 20 seconds. As an example, if the B-record records every 2 seconds, the K-record could be set to record every 20 seconds. 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 are comments that can be placed anywhere in the file after H, I and J records and the term "comment record" may be a better description. In the IGC file they may either be before the G (security) record at the end of the in-flight data, or after the G-record. If before the G-record, ***it is essential*** that the security of the in-flight data and its after-flight Validation check is not affected. See A2.3 on Record Order within the file and A7 on how new TLCs are to be notified to GFAC. The L-Record allows free-format text lines to be added, although this record is not time-stamped. It can be initiated by a program in the FR, by pilots or official observers. If the data is not from the FR (source letter F), 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 but 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).

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 may be used as a Logbook Record line starting LPFC followed by Waypoints in the same format as the C Record (Pre-flight declaration). The PFC data may be inserted after initial download of the flight data either manually or by a software program, so that it can be recognised by analysis programs designed to read PFC data and show the flight on screen together with the Post Flight Claim (PFC) waypoints. Since it is added after download of the flight it is not part of the data to be signed (see A3.6 on signing and the G record).

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. They form part of the data to be signed (see A3.6 on signing and the G record).
In particular:
For Stealth mode, the following format must be used: LFLAnnnnnn STEALTH OFF/ON
For the Flarm ID, the following format must be used: LFLAnnnnnnID 2 XXXXXX
Where nnnnnn is the time and XXXXXX is the six Hex-decimal Flarm ID, replacing 'FLA' with the manufacturer's three-letter code as required.

A4.5.5 Format. 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**	**Included in data signed by the G-record?**
Manufacturer input	3 bytes	MMM	Manufacturer's code, see para A2.5	Yes
Pilot input	3 bytes	PLT	Text string after PLT	No
OO input	3 bytes	OOI	Text string after OOI	No
After flight pilot input	3 bytes	PFC	For free flight after-flight choice of course	No

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

A4.6 **D RECORD - DIFFERENTIAL GNSS**. This indicates that differential GNSS 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). 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. The facility to use DGPS is subject to GFAC approval, and it must be shown that it preserves the integrity of basic lat/long and other flight data.

A4.7 N **RECORD - DATA NOT SIGNED BY THE SECURITY SIGNATURE** The N record is for data that may be recorded less frequently than fix (B) records, and is not included in the data signed by the G-record. The N-record–will record at 20 second intervals or at a significant change in data to be recorded, whichever is the shorter period. The following M Record specifies the information in the N Record in the next line (with extra spaces for clarity):

M 02 08 10 HRT 11 13 OXY CR LF
N HHMMSS 112 098 CR LF (This N Record shows that the pilots Heart Rate was 112 bpm and Oxygen Saturation 98%)

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).
Calibration – the creation of a table of pressure altitude correction values
Competition Class - The IGC/FAI competition class of the aircraft, such as Open, 15metre, 20 m, Standard, Club etc.
Constellation - The precise satellite IDs from which data was used to determine the GNSS fix, see A4.3 for IDs
Course - The direction between two lat/long points expressed as degrees magnetic or true.
Datum, Geodetic - see below under Geodetic Datum
Engine Down - The engine and/or propeller is stowed and cannot generate forward thrust.
Environmental Noise Level (ENL) - low frequency 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 take-off), as opposed to events generated after flight by the analysis of the FR flight data (such as establishing presence in a Turn Point Observation Zone or crossing a start or finish line).
Finish - The formal end of a task, such as crossing a finish line, entering a finish observation zone, or (for some distance flights) landing. For definitions see the Sporting Code (SC3) main volume.
Fix Accuracy - The accuracy of a fix expressed as Estimated Position Error (EPE) in metres, normally to a 2-sigma (95.45%) probability.
FR Serial ID (S/ID) - a multi-character alphanumeric which identifies an individual FR. It is used in the first (A) record (para A3.1) and in the IGC file name (para A2.5).
Geodetic Datum - The GNSS datum (earth model) used for Lat/long and GPS altitude figures in IGC files, for IGC-approval this must be the WGS84 Ellipsoid
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.
Ground Speed - Speed over the ground in kph.
Heading - The direction in which the aircraft is pointed (the longitudinal axis) in degrees true or magnetic (which should be stated as T or M).
Latitude - A seven-character alphanumeric group referenced to the WGS84 ellipsoid and 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 used in a FR as part of a flight declaration, the N/S character must be capable of being entered in either upper or lower case.
Longitude - An eight-character alphanumeric group referenced to the WGS84 ellipsoid and 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 used in a FR as part of a flight declaration, the N/S character must be capable of being entered in either upper or lower case.
MOP - Means of Propulsion - when used in an IGC file, this refers to an engine function in addition to ENL, from a separate sensor either inside the FR or separate from the FR and positioned close to the engine and/or propeller. See para 2.2.5 and 5.4.
On Task - The pilot is attempting a Task.
OO ID - A series of alphanumeric that may be entered by an OO into the FR before flight, with a minimum of four characters.
Pilot Event (PEV code) – A fix in an IGC file where the pilot has pressed a button or switch to mark a particular time and place. PEV may record events such as crossing a start line or arriving at a particular point. After a PEV event, a sequence of fast fixes follows (see para 3.6).
Pressure Altitude - A five number group indicating the pressure altitude in metres above the 1013.25 HPa sea level datum of the ICAO ISA.
Pressure Reference An instrument with traceable accuracy to a standard with better uncertainty than 0.1 hPa, used for comparison with an Approved Flight Recorder for calibration purposes
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) - A security system to verify that the flight data has not be altered since the flight was originally recorded.
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.
Traceability – the establishment of an unbroken chain of comparisons to stated references each with a stated uncertainty
Track - The true track (flight path) over the ground that the aircraft has achieved.
Turn point Validation - Proof of presence (such as a valid GNSS fix) 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	A = Hex 41 B = 42 C = 43 D = 44	N = 4E O = 4F P = 50 Q = 51 R = 52	a = Hex 61 b = 62 c = 63 d = 64 e = 65	n = 6E o = 6F p = 70 q = 71 r = 72	Space= Hex 20 *Res = 21* " = 22 # = 23	. = 2E / = 2F : = 3A ; = 3B < = 3C	CR = 0D LF = 0A $ = 24 * = 2A ! = 21

<table>
<tr><td>5 = 35
6 = 36
7 = 37
8 = 38
9 = 39</td><td>E = 45
F = 46
G = 47
H = 48
I = 49
J = 4A
K = 4B
L = 4C
M = 4D</td><td>S = 53
T = 54
U = 55
V = 56
W = 57
X = 58
Y = 59
Z = 5A</td><td>f = 66
g = 67
h = 68
i = 69
j = 6A
k = 6B
l = 6C
m = 6D</td><td>s = 73
t = 74
u = 75
v = 76
w= 77
x = 78
y = 79
z= 7A</td><td>Res = 24
% = 25
& = 26
' = 27
(= 28
) = 29
@ = 40
` = 60
Res = 2A
+ = 2B
, = 2C
- = 2D</td><td>= = 3D
> = 3E
? = 3F
[= 5B
Res = 5C
] = 5D
Res = 5E
_ = 5F
{ = 7B
| = 7C
} = 7D
Res = 7E</td><td>\ = 5C
^ = 5E
~ = 7E

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

The same information in hex order:

<table>
<tr><th colspan="5">VALID CHARACTERS IN HEX ORDER
Res = reserved</th><th>RESERVED CHARACTERS</th></tr>
<tr><td>20 = space
21 = Res
22 = "
23 = #
24 = Res
25 = %
26 = &
27 = '
28 = (
29 =)
2A = Res
2B = +
2C = ,
2D = -
2E = .
2F = /
30 = 0
31 = 1
32 = 2</td><td>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</td><td>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</td><td>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</td><td>6C = l
6D = m
6E = n
6F = o
70 = p
71 = q
72 = r
73 = s
74 = t
75 = u
76 = v
77 = w
78 = x
79 = y
7A = z
7B = {
7C = |
7D = }
7E = Res</td><td>0D = CR
0A = LF
24 = $
2A = *
21 = !
5C = \
5E = ^
7E = ~

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

A7. THREE-LETTER CODES (TLC)

These are shown as CCC in the formats earlier in this appendix. Their meanings are listed below together with the first letter of the fields in the IGC file where they may be used, such as B for a fix, E for event, etc. If a manufacturer proposes to use a TLC not listed below, they should inform GFAC giving its proposed initials, its general purpose, a definition suitable for publication in this document, number of bytes, units to be used, etc. If agreed by GFAC, the new TLC will be added to the list below at the next Specification update. Meanwhile, this system of early notification will enable GFAC to inform manufacturers if another manufacturer has already submitted a TLC for the same function, or there is already a proposed TLC that uses the same code letters but for a different function.

TLC	**IGC File Records used with the TLC**	**Three Letter Code - meaning - notes on how it is to be used**
ACX ACY ACZ	I, B	Linear accelerations in X, Y and Z axes, for aerobatic aircraft equipped with appropriate sensors feeding to the recorder and IGC file. X = longitudinal, Y = lateral, Z = vertical (so-called "G")
ANX ANY ANZ	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 in degrees per second
AOA	I,B,J,K	Angle of attack is in tenths of degrees. Four signed digits in range from -999 to 9999, (eg.: AOA=13.4 is encoded as 0134, AOA=-7.5 is encoded as -075).
AOP AOR	I, B	Attitude Pitch Angle, Attitude Bank/Roll Angle in degrees (for nose down or left bank angle, start with "-") (AL8)
ATS	H, E	Altimeter pressure setting in hectoPascals (the same as Millibars) as a 6 digit number PPPPpp including 2 decimal places, see A2.4 under Pressure Settings. For instance, ICAO ISA Sea Level (1013.25 mbar) has an PPPPpp 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
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 table under Fix Validity).
CCL	H	Competition class
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.
COT	J, K	Controller temperature (for instance for FES) in degrees C. (AL5)
CUR	I, B,J,K	Electrical current, Amperes. (AL9 I, B allowed)
CU1	J, K	Electrical Current, Amperes, of the first propulsion battery where 2 batteries are installed (AL8)
CU2	J, K	Electrical Current, Amperes, of the second propulsion battery where 2 batteries are installed (AL8)
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 more than two crew, use DB3, DB4 etc
DTE	H	Date UTC, expressed as DDMMYY
DTM	H	Geodetic Datum in use for lat/long records (for IGC purposes this must be set to WGS84)
EGT	J, K	Exhaust gas temperature in degrees C (for jet engines) AL5
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
FIN	E	Finish
FLE	J, K	Fuel level, centilitres. AL5
FFL	J, K	Fuel flow, litres per minute (AL8)
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 para 3.3.1
GID	H	Glider Identification (ID)
GLO	H	GLONASS (Russian GNS System), followed by receiver maker, type & version letter/number. See para 3.3.1

GPS	H	GPS (US GNS System), followed by receiver maker, type & version letter/number. See para 3.3.1, also 3.3.4 for other GNS Systems such as European Galileo, Russian GLONASS, and Chinese BeiDou 2
GSP	B, E, I, J, K, L	Groundspeed - used in some FRs, figures derived from algorithms based on successive fixes. Note: GSP can also be calculated after flight, derived from a series of fixes
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
JPT	J, K	Jet Pipe Temperature, for jet engines. AL5
HRT	M, N	Heart Rate, 3 numbers, beats per minute. Usage only in M & N records to allow deletion of personal data without affecting the file security signature
HUM	J, K	Relative Humidity, percent (AL8)
LEB	J, K	Battery - state of charge, percent. AL5
LE1	J, K	Battery 1 - state of charge, percent, first propulsion battery where 2 batteries are installed (AL8)
LE2	J, K	Battery 2 - state of charge, percent, first propulsion battery where 2 batteries are installed (AL8)
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
LCU	L	Data from the SeeYou system after flight, not needed for Validation but used in some flight analysis systems
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. 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)
MCU	E	Data from SeeYou after flight, not needed for Validation but used in some flight analysis systems
MP2 MP3, etc	I, B	Means of Propulsion systems fitted in addition to the basic MOP system, see MOP below
MOT	J, K	Motor temperature, degrees C
MOP	H, I, B	Means of Propulsion. A signal from an engine-related function from a sensor separate from the ENL system in the FR, giving three numbers. See A.3.2 note.
NET	I, B,J,K	NETTO - NETT (=overall) Vertical Air Movement Vertical speed of air in metres per second (AL9 I,B allowed)
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 GNSS 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 a specific task
OOI	H	OO ID – Official Observer Identifier
OXY	M, N	Oxygen Saturation, 3 numbers for % saturation. Usage only in M & N records to allow deletion of personal data without affecting the file security signature
PEV	E	Pilot EVent - Pilot initiated action followed by a series of fast fixes (see para 3.6)
PFC	L	Post-Flight Claim. For Free Flights where the pilot decides after the flight which waypoints are to be claimed
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 under Receiver Autonomous Integrity Monitoring
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
RPM	J, K	Revolutions Per Minute (of engine) AL5
SIT	H	Site, Name, region, nation etc.
SIU	I, B	Satellites in use. A two-character field from the NMEA GGA or GNS sentences, or equivalent data agreed by GFAC.
STA	E	Start event such as starting a pre-declared task
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
TPC	E	Turn point confirmation - Equipment generated event (not to be used for IGC flight validation which requires independent checking of fixes and relevant Observation Zones)
TRT	J, K	True Track - used in some FRs based on algorithms that calculate track from a number of fixes
TZN	H	Time Zone Offset, hours from UTC to local time.
UND	E	Undercarriage (landing gear), recorded as UP or DOWN, 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
VOL	I, B, J, K	Voltage of propulsion battery if only one is installed (AL9 I,B allowed)
VO1	I, B, J, K	Voltage of first battery where two propulsion batteries are installed (AL9 I,B allowed)
VO2	I, B, J, K	Voltage of second battery where two propulsion batteries are installed (AL9 I,B allowed)
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	J, K	Wind Direction (the direction the wind is coming from). Three numbers based on degrees clockwise from 000 for north – recommended to be replaced (together with WSP) by WVE
WSP	J, K	Wind speed, three numbers in kilometres per hour– recommended to be replaced (together with WDI) by WVE
WVE	J, K	Wind Velocity - wind direction (degrees from True North) and strength (kph) to 2 d.p. such as "2702210" meaning due West (270 degrees) at 22.1 kph (AL9). **Recommended to replace WSP and WVE**
X**	As Appropriate	The X prefix is intended to allow a trial with a new code before deciding whether it should be added to the full list. The asterisk symbol (*) 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.

A7.1 Obsolete Three Letter Codes (TLCs) - these may be still in use in old types of Recorders:

CCN	E	Camera Connect
CDC	E	Camera Disconnect
DOB	H	Date of Birth of the pilot, now use DB1
PHO	E	Photo taken (shutter-press)
SCM	H	Second Crew Member Name, now use CM2
SEC	G	Security - Log security data

A7.1.1. Old Engine codes. In some old models of recorders where ENL (now mandatory) and MOP (where required) are not used, the EON/EOF or EUP/EDN codes were used. 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.

EDN	E	Engine down
EOF	E	Engine off
EON	E	Engine on
EUP	E	Engine up

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 and GNSS altitudes in the IGC file. This appears in the Header record of IGC files as shown in A3.2.4.

A8.1 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.

A8.2 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.

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. In this appendix, spaces are added between subject lines to make this easier to understand.

A9.2 In the following, 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 italics and are not part of the file format.

A CAM XYZ *(Cambridge FR serial XYZ)*
HF DTE DATE: 16 08 19 02 *(Flight on 16 August 2019, 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
HF FRS SECURITY OK or SECURITY SUSPECT / SECURITY MS OPERATED (as relevant) : TEXTSTRING CRLF

I 03 3638 FXA 3940 SIU 4143 ENL *(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)*

J 01 0810 HDT *(The J record shows what will be recorded in K record lines that follow, in this case True Heading HDT)*

C 210815 093841 000000 0000 02 500K Triangle *(for the reason for the two fields with zeros, see A3.5.4)*
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, GNSS 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 and/or laboratories 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 comprehensive or complete. GFAC reserve the right to carry out other testing where it is considered to be relevant to assessing the recorder and the validity and security of its flight data.

B1 GENERAL REQUIREMENTS.

These include ease of operation in an air sport environment of competitions, record and badge flights. This will include integrity of flight data, fix accuracy, the IGC file structure including fixes, pre-flight declarations, recording of errors and anomalies, security against unauthorised inputs and changes to flight data. They will also include ease of operation in an air sport environment of competitions, record and badge flights and completeness and clarity of documentation.

B2 EVALUATION AND ANALYSIS.

An analysis program independent of the FR manufacturer will be used. IGC files will be analysed including 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 data such as fix accuracy (FXA), Pilot Event (PEV) and fix rates, and engine recording (ENL and MOP systems).

B3 PHYSICAL INSPECTION OF THE EQUIPMENT

B3.1 Construction. This includes quality and robustness of construction and components, and preservation of flight data after impact such as accidental dropping on the ground.

B3.2 Layout and type of components. This includes susceptibility to production of invalid flight data. Factors to be assessed include 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, and compared to fix records from control equipment. Runs of up to several hours may be made to check memory and battery capacity for long flights.

B4.1.1 Dead Reckoning and Throw Forward of fixes not allowed. 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 short fix interval such as one second. The vehicle will then be turned round and the feature approached at a high but safe speed. When nearly at the feature, the GNSS antenna will be disconnected, or, for units with internal antennas, the case covered so that GNSS signals are blocked (for instance by metal foil). The IGC file must show that on the second run, no fixes were projected beyond the feature (so-called "Dead Reckoning"). The lat/long of the feature at the right angle in the IGC file will also be compared with the lat/long of the feature from a system showing WGS84 lat/longs such as Google Maps.

B4.1.2 Pressure Altitude. The pressure-altitude recording system will be calibrated using standard procedures for barograph, and a 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 GNSS Altitude. The GNSS altitude figures in the IGC file will also be checked for accuracy, lack of anomalies, and the use of the WGS84 Ellipsoid as the IGC file zero GNSS altitude datum. For IGC High Altitude Flight Recorders (HAFRs), see paras 1.3.4.2.1 and 2.2.4.1.

B4.1.4 Temperature - of the equipment may be varied during the test runs between +40C and -20C, depending on facilities available.

B4.1.5 ENL Operation. The frequency response and sensitivity of the ENL system will be checked against a range of test tones.

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

B5 ANTI-TAMPER PROTECTION

B5.1 General. Tests will be made to assess the susceptibility of the FR to corruption of recorded flight data by inadvertent or deliberate means.

B5.2 Minimum standard. The minimum standard is a positive 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 from malpractice or deliberate attempts to falsify data.

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 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 powerful ground-based transmitters. Tests will be made with hand-held and fixed glider radios using VHF transmissions up to 1 watt RMS. Transmission distances tested will be down to 1 foot between the radio and FR antennas, and no adverse effects should be shown on the FR and its output data.

B8 FLIGHT TESTS.

Flight tests will be made in types of glider or motor glider, or 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, such as at high angles of bank. 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. Pressure altitude recording must continue if GNSS signal is lost; and GNSS re-lock must occur quickly once signal is restored. These tests will involve disconnecting and re-connecting the antenna, or, for Recorders with internal antennas, covering the FR with RF shielding (such as metal foil), and checking that fixes continue to be recorded, less GNSS data.

B8.5 Engine recording systems. Such systems include those under Three-Letter Codes ENL and MOP. The critical cases are described in para 5.5 on Page 14. Tests will be made in different types of glider, motor glider, and powered aircraft. These may 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 inside the FR 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 and MOP systems, see Chapter 5 on pages 13 and 14.

B8.5.1 Engine-on Tests. 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. A critical test will be with a relatively quiet engine, typically a rear-mounted 4-stroke or electric engine at power for level flight.

B8.5.2 Engine-off Tests. For gliding flight, tests will be made with the cockpit ventilation and other panels open, both at high speed and during turns. In some gliders an "organ pipe" noise can be heard in the cockpit with panels open, and ENL will be recorded for this condition. A particular test is turning at 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

The IGC Shell Program was introduced in 2007 as a common system for Validation of IGC file data, and, where it applies to the type of FR, download and conversion to IGC format from binary

C1. INTRODUCTION

C1.1 DLLs - General. This appendix describes the 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 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. See C2.1.1 below on Static Linking.

C1.2 Availability on the IGC GNSS web site. The DLLs are freeware and available through links from the IGC/GNSS web site. A control program will load a DLL and call each of the Application Programming Interface (API) functions specified below.

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-XXX.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 GNSS FRs in the product range concerned. .

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 Windows operating systems. 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.

C.2.1.1 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 .

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.

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 **<u>UseSerialOptionsDLL</u>**

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 **<u>SerialOptionsDLL</u>**

DWORD SerialOptionsDLL(LPTSTR options, DWORD size)

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

Parameters
options
[out] pointer to buffer which shall receive the connection options.
size
[in] size of the buffer pointed to by *options* in bytes.
Return Values

If successful, function returns number of bytes in the returned option string. if actual length of string exceeds size, the string shall be truncated to size -1 bytes. If cancelled, returns 0 and options string is left unmodified. If error, a modal dialog is displayed, and -1 is returned.

<u>Remarks</u>. 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 **<u>SerialConnectFR</u>**

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.

<u>Remarks.</u> If a connection cannot be established, the function shall display a modal dialog box detailing the problem.

C3.9 **<u>KeepAwakeFR</u>**

BOOL KeepAwakeFR()

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

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

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

C3.10 **IdentifyFR**

DWORD IdentifyFR(LPTSTR value, DWORD size)

The IdentifyFR function is used to obtain the manufacturer id/Serial ID, 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, it shall be truncated to size - 1 bytes.

Remarks. The string consists of three fields, separated by the "pipe" character ("|", 0x7C), the manufacturer id/Serial ID (formatted MMMNNN, where MMM is the manufacturer id, and NNN is the Serial ID), 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 ID cannot be returned (for instance due to firmware limitations), a Serial ID of 000 shall be used.

C3.11 **IdentifyLogFR**

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

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

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: B8X01F1.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. To assist Flight Recorder manufacturers and other Software writers, the following files are provided on the IGC website.

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)

Remarks. 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.

APPENDIX D DATA, CONV and VALI short program files

These DOS-based program files were replaced in 2007 by the IGC Shell system described in Appendix C.

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 should 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 (DATAXXX 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 Lowering of approval level.

If GFAC proposes to lower the approval level of a type of IGC-approved recorder, or to remove the approval, this will be discussed with the FR manufacturer and the IGC ANDS Committee will be informed. The manufacturer will be given the opportunity of offering an upgrade that will retain the existing approval level for modified recorders. 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 discuss with the ANDS Committee and then inform the IGC Bureau.

E1.2 If the decision is to lower or remove the approval level together with the date on which it is to take effect, after the IGC Bureau has had time to comment on the proposal, the decision will be announced to the FAI IGC discussion group igcdiscuss@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, ANDS and GFAC activities between Plenaries.

E2 Factors in Lowering Approval Levels.

These include the following

E2.1 False or Incorrect Flight Data in IGC Files. Evidence that flight data in IGC files from a particular type of IGC-approved recorder has been, or can relatively easily be manipulated, altered, or is incorrect. For instance, if it can be shown that flight data 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 it has been found that security devices in the FR could be by-passed or where the length of security keys in old recorder designs is considered by ANDS and GFAC to make them vulnerable to interference or hacking, after which IGC files might continue to pass the Validation check.

This includes cases where security key lengths or other features are significantly below the current requirements for new types of recorders as given in para G2.1.2 on Digital Signature Systems such as RSA and equivalents, in the judgement of ANDS and GFAC.

For existing recorders with security keys or other features that are not considered a current or foreseeable future major threat to interference or hacking, the "Grandfather Rights" principle continues to apply in which approval levels are not changed even though the key length or other features for completely new recorder designs has been increased.

E2.3 Dates of Change. The lowering or removal of IGC-approval level will take effect at a date proposed by GFAC and ANDS to the IGC 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 FR manufacturer is notified.

E2.4 Other factors. If the approval level is to be lowered or removed for reasons other than those above, the date of implementation will be decided by GFAC and ANDS and the Bureau will be notified.

E3 Appeal against a lowering or removal of IGC-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 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 being notified of the change of Approval level, the appellant must notify the IGC President, copy to the Chairmen of ANDS and GFAC, and pay an appeal fee of 1000 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 with copies to the Chairmen of the IGC ANDS and GFA Committees. Communication by email should 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, ANDS and GFAC 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 ANDS, GFAC, and the IGC Bureau, can assess it and consider whether the decision should be changed. Where technical evidence is submitted, this will be assessed by the ANDS and GFA Committees, their advisors and other experts who may be nominated.

E3.4 Decision on the Appeal. The IGC Bureau will confirm or modify the decision that was recommended by the ANDS and GFAC Committees. This will normally be made within one calendar month of receiving evidence from the appellant, but if technical detail has to be assessed the timescale may be longer. The decision will be communicated 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 variants such as micro-SD), USB memory sticks, etc, and do not need a PC connection for downloading after flight.

F1.1 Connectors to PCs. Where a PC is used for downloading flight data or for uploading declarations before flight, RJ45 or the USB connectors 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 should be to the international standard. For panel-mounted recorders, it is recommended that an industry-standard memory fitting is on the front face (such as a socket for an SD card, micro-SD card, or a 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.

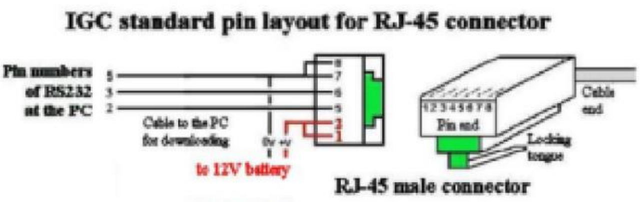
F2 Stand-alone Memory Devices.

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, selection of the last flight for downloading 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 C) is required for electronic Validation of downloaded IGC files.

F3 8-pin RJ-45 connector.

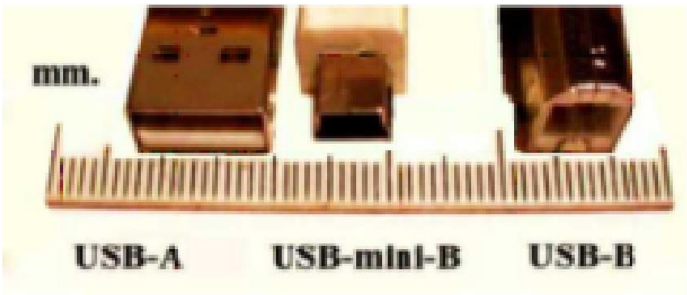
This is a female 12 x 6 mm RJ-45 socket with 8 connections. It is also used for ISDN and Ethernet connections (but with different pin allocations). In the IGC layout, with the male plug end held towards the observer and the pins uppermost, the locking tongue underneath and the cable running away from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

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



F4 USB connectors.

The connector on the recorder case may be a female Universal Serial Bus (USB) B-type receptacle, for connecting the recorder to a PC through a standard USB-B to USB-A cable. Wiring to the connector on the recorder case shall be to the USB standard (see www.usb.org). The recorder port shall be compatible with USB 1.1 and USB 2.0 devices. On the recorder, the receptacle shall be either a full-size USB series B receptacle (for which the male is about 8 x 6mm) or the 5-pin USB series mini-B receptacle for which the male is about 6 x 3mm with angled ends. See the photo 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, 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 functions such as variometer, speed-to-fly or final glide.

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

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

F8 Other Plugs and Sockets.

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

APPENDIX G PRINCIPLES AND PROCEDURES FOR IGC SECURITY

G1. General.

For IGC-approval, security procedures and hardware, firmware and software must ensure that no after-flight alteration of flight data may occur without such alteration being detectable. For the IGC file, this is achieved by a Digital Signature (DS) that is generated by the FR and enables downloaded files to be checked at any time. 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. This IGC security system checks for any alteration of data in an IGC file from that initially downloaded from the FR, and the check can be made at any time afterwards.

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 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 also in Annex B to the Sporting Code (SC3B).

G2 Digital Signature and IGC Electronic Validation System.

The Digital Signature (DS) system 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 after initial download of an IGC file. See para 1.1.10.1 on page 3.

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 (flight and other data), 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. The data in the file itself (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. It must not be possible to access the security algorithms by dis-assembly of the FR, for instance through an EPROM reader. 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 work under an agreement of confidentiality.

G2.1.1 Public and Private Keys. The FR manufacturer must ensure 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 the public document which was used as the basis and the FR manufacturer must keep a register of people with this knowledge. Such knowledge must be confined to the minimum number of 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 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, see Appendix D). More than one key may be stored in the FR and this is encouraged to increase security, and keys may be of different lengths and used to generate several signatures.

G2.1.1.2 Private Keys. The Private Key(s) stored in an individual FR are used in the validation of IGC-format files originating from that FR. Before initial sale, Key(s) of the appropriate length must be placed in the flight recorder by the manufacturer in such a way that they will be erased if the recorder is opened or otherwise tampered with. For Level 1 and 2 FRs, unique Private Key(s) shall be provided for each individual FR, and the private keys used in one FR shall not be stored in other FRs. For Level 3 FRs, Private Key(s) for each type of FR may be provided from a bank of at least 1000 keys that can be re-used when all have been used for the first time in FRs of that type. Only private keys to be used by the individual FR shall be stored in that FR. At the FR manufacturer, the detail of private keys must be kept strictly confidential to the fewest number of people. 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 secure replacement key data from the manufacturer.

G2.1.2 Public/Private Key Cryptography (PKC) systems and data download times. Use of a digital signature system is required, using an asssymetric Public Key Cryptography (PKC) algorithm agreed by GFAC. An ECC algorithm is currently the recommended method of signature encryption, althugh DSA and RSA are also currently accepted. For "all flights" IGC-approval of new designs of FR, a key length of at least 256 bits (ECC) or 3072 bits (RSA/DSA) is required and the equivalent for other systems (for equivalents, see the Glossary under DSA, ECC, PKC and RSA).

G2.1.2.1 Message Digest Algorithms. The digital signature system must use a message digest algorithm of a bit count agreed by GFAC. SHA2 algorithms are currently accepted (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.

G2.1.2.2 Alternatives to RSA, ECC & DSA. Other systems may only be used after review and acceptance by GFAC. The FR manufacturer may be asked to 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 continuing 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 FR designs that are not capable of increased lengths may be reduced in IGC-approval level. Therefore it is desirable that FR design should be capable of making security enhancements.

G2.1.2.4 Download Times. An IGC file covering 10 hours of flight data with fixes at 5 second intervals should download from the FR with full security 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. A successful VALI check indicates that the flight data in the IGC file is an exact copy of that which was initially downloaded from the FR, and that the FR itself has not been 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, and this public key is in 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 Digital Signature (DS). This shall be achieved by a system that operates if the FR case is interfered with and deletes the encryption key(s) required to compute a valid DS, such as through a microswitch, or equivalent system approved by GFAC. This must not only protect the Digital Signature, but also protect the internal circuits and modules inside the FR case from unauthorised interference. The principle is 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. The FR security system may only be re-set to normal after being returned to the manufacturer or his authorised agent. Knowledge of the method of re-setting must be restricted by the Manufacturer to the minimum number of persons and controlled so that unauthorised persons cannot gain such 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 such as by inserting a physical probe or tool through ventilation holes, through a partially-removed case cover, or through a gap in a slightly-opened case. This can generally be prevented by fitting a guard or shield round the microswitch or other security mechanism. This will be closely looked at during GFAC testing and the manufacturer may be asked to improve the security of such installations such as by fitting better physical guards round the microswitch.

G4.1.1 Non-microswitch Systems. If a new FR design does not include a security microswitch, to obtain IGC-approval its internal firmware must be specially designed so that it will detect any subsequent errors or deliberate attempts to change or interfere with it. After any such errors or deliberate interference ("hacking"), either no IGC files should be produced at all, or files downloaded must be clearly marked as invalid and must fail the IGC file Validation check. Applications for IGC-approval must submit analysis showing how equivalent security of the private key protection and detection of unauthorised interference with the hardware or internal firmware are achieved, and how firmware updates can be applied while maintaining security. The manufacturer must be able to demonstrate the above to the satisfaction of GFAC before approval can be considered at any IGC-approval level. GFAC will consult the IGC ANDS Committee and other experts if required. If the above cannot be achieved, microswitch-based security will be required for the new FR design before IGC-approval can be given. (AL6)

G4.1.2 Flight Recorders with repeater display systems. If a repeater display can download an IGC file, it must use an 'X' character as the first letter of the Manufacturer's TLC in the A-record, indicating that the file is downloaded from a non-approved recorder.

G4.1.3 If the security mechanism has operated. If the internal security mechanism has operated and the recorder continues to produce flight data in the IGC file format, such data must fail security tests so that it 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 reinitialization purposes, that could be used again without reference to the FR Manufacturer. The system must be protected 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 use a "one-use pad" system. This is so that an agent (or anyone else) cannot, over time, collect data that could allow recorders to be initialised without reference to the FR manufacturer and that could be used later in an illicit way. Publicly known algorithms should be used 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. 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 must be taken into account, such as 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 and will be tested by GFAC.

G6 Changes and Upgrades - Maintenance of Security.

Changes and upgrades can include replacement of components such as GNSS receivers, processors, boards, ROMs, and microchips. Such changes 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.

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 how such tools/firmware work to a minimum number of persons. Any security codes (including Private Keys (PK)) 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 potential "hackers". It is expected that the secret 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 FR components have to be physically replaced, the FR Private Key (PK) should be trashed (as above) when the case is opened to gain access to the component to be replaced. After repair, 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. Unauthorised persons may 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 the 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 subcontractors 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.

Next page: Example first page of an IGC-approval document. Items specific to the Approval are indicated in RED

GNSS FLIGHT RECORDER APPROVAL COMMITTEE (GFAC)
INTERNATIONAL GLIDING COMMISSION (IGC)
of the
FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE (FAI)
Maison du Sport International, Avenue de Rhodanie 54
CH-1007 - Lausanne, Switzerland
www.fai.org ; sec@fai.org

References: See para (i-iv) below

To: IGC GNSS web site under "IGC-approval Documents"

FR Manufacturer; info to igc-news@fai.org, newsgroup rec.aviation.soaring Date of issue: DD Mmm YYYY

IGC-APPROVAL DOCUMENT FOR GNSS FLIGHT RECORDER

Recorder Name: Manufacturer FR Type
Level of Approval: IGC Level N - see Para (i-ii) below

(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. Only the terms of the latest IGC-approval documents currently posted on the IGC web site are valid for use in IGC/FAI claims. IGC reserves the right to alter this approval in the future.

(i-i) Document Versions and Scope. The initial IGC-approval document was dated DD Mmm YYYY and Reason for change was added on DD Mmm YYYY. . This version dated DD.Mmm.YYYY updates.reason for change

(i-ii) IGC-approval Level. This is IGC level N - flights for see reference. This type of recorder can also be used in gliding competitions in which the organisers allow this level of IGC-approval. The Levels of IGC-approval are listed in Annex B to the Sporting Code for Gliding, para 1.1.4.

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

(i-iv) Current web sites. References for the latest versions of documents relating to IGC-approval of FRs (including the latest version of this document) are given in para 2 on page 1 of the main table that lists all IGC-approvals. The latest version of the table is available through www.fai.org/igc-documents.

The detailed references are placed in the main FR table rather than in each IGC-approval document, so that if the reference changes, only the main table has to be updated rather than all IGC-approval documents.

(ii) This IGC-approval 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 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) This approval is not concerned with, and FAI has no responsibility for, matters related to: (a) Intellectual Property (IP) and 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) The attention of National Airsport 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. Copies of all of these documents may be obtained from the FAI/IGC web sites listed above and links are provided from the IGC web site. A separate document published by FAI is entitled "Technical Specification for IGC-Approved Flight Recorders" and is also available through the IGC/GNSS web site shown above.

(v) 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.

APPENDIX J – IGC FORMAT FOR PRESSURE CORRECTION FILES

J1. Scope.

J1.1. Data presentation. The data may be presented either in hard copy, in electronic format, or both. This document defines a Standard Format for recording the results of Calibrations, for inclusion in on-line databases. For this, a JSON file as defined in this document is required.

J1.2. Electronic format. The system is designed to work with a basic level of PC and software as well as with high-specification devices. This is consistent with the IGC GNSS FR Technical Specification.

J1.3. Data produced using a Barometric Chamber is to be referred to as **Calibration Data**, whereas data produced by the Single Point Altitude Correction process is to be referred to as **Correction Data**.

J2. Source Data.

J2.1 The source data will be an IGC Flight Recorder format file.

J2.2 The source data may include PEV (Pilot Event) markers. These may be used to indicate significant events in a Single Point correction, they will also produce a string of 'fixes' at 1 second intervals. Calibrators may use these to mark events such as the point at which the Altitude/Pressure reading was taken. Provision should be made to take proper account of these.

J3. Accuracy.

J3.1 It is hard to overstress the importance of accuracy when compiling Calibration and Correction Tables.

J3.2 When entering data to create the Pressure Error value for a Single Point Correction Report, an accuracy in hPa values to at least 0.1hPa or One Metre for Altitude values, is the minimum precision that is acceptable. Higher precision is desirable.

J3.3 Calculations should be made to as high a precision as is appropriate, but entries in the .JSON file should be rounded to two decimal places, .005 being rounded up.

J3.4 For the above reasons, Altitude/Pressure reference devices must meet the requirements of para 2.1 of Sporting Code Section 3D (Gliding), Annex B AL15 et seq. in the IGC Documents pages. https://www.fai.org/igc-documents

J3.5 The Single Point Altitude Correction method is only to be used for correction of pressure altitudes below 10,000 metres because of other sensor response errors.

J3.6 The Period of Validity of the calibration/correction of any device shall be that given in the Sporting Code – Section 3D (Gliding), Annex B AL15 et seq. in the IGC Documents pages.

J3.7 If the correction required exceeds the limits set in the Sporting Code, Section 3D (Gliding), Annex B AL15 et seq., no output will be produced. The FR will require corrective action as detailed in SC3B.

J4. Calculations.

J4.1 The relationship between Pressure and Altitude is not linear. Some examples of links to formula follow:

https://edwilliams.org/avform.htm and follow the link "*Altimetry and the standard atmosphere formulae*"

http://www.4wx.com/wxcalc/formulas/pressureAltitude.php

J5. Data Fields.

J5.1. Characters in a Field. If the full number of characters in a field are not needed, all do not have to be used, except were defined elsewhere, such as in paragraph 7 below. To avoid fields becoming too long, most have a recommended maximum number of alphanumeric characters.

J6. Electronic Versions and Field Boundary Systems.

J6.1 The following system is currently approved, and others may be added later if they become commonly available industry standards.

J6.2 JSON. JSON (or JavaScript Object Notation) is used since it defines a set of rules and structure to make interchange of data universal and further produces documents that are both human and computer-readable. It is a standard text-based format for representing structured data based on JavaScript object syntax. It is commonly used for transmitting data in web applications (e.g., sending some data from the server to the client, so it can be displayed on a web page, or vice versa).

There are slight differences between the files produced under rules 4.5.1 and 4.5.2. See J11. JSON format examples.
Note that in either case, the calibration is valid for the period specified in the Sporting Code.

J6.3. Industry Standards. This document does not cover the complete definition of any industry-standard file format for which there is already a defined standard.

J6.4 Only JSON files will be considered for inclusion in a database, and must conform to the standards below. No further definition will be made of other standards

J7. Filenames and Units Needed for Calibration and Correction Database Entry.

J7.1 Data to be entered into the Central Calibration and Correction Database MUST be in the chosen Format.

J7.2 The filename will be a construction of four parameters, three of which are taken from the IGC file's A-record, and HFDTE-record. The filename extension will be **.JSON**

J7.2.1 **The IGC filename must not be used when making the construction, nor must any number marked on the case of the recorder.**

J7.2.2 The components of the filename will be as listed below, and in this order
- Firmware Manufacturer's Three-Letter-Code (TLC) taken from characters 2-4 of the A-record.
- FR Serial Identification (S/ID) taken from the A-record, character 5 onwards to end of record or (but not including) any separator character, such as comma, hyphen or colon, zero-filled to six characters as shown in the second example below. **(but see Note 1)**
- "-B-" if a barometric calibration, or "-S-" if a Single Point Altitude Correction.
- Numeric_date taken from the HFDTE record, expanded to 8 characters in the ISO 8601 format without delimiters (yyyymmdd).

J7.2.3 There are however, some instances of A-records with no separator, or separators in other places, e.g. ALXVXYZFLIGHT:1. In these cases, assume a three-character S/ID. The following rules will be applied:
i. Where FR Serial Identification (S/ID) is 6 digits, enter unchanged.
ii. Where the FR Serial Identification (S/ID) is three alpha-numeric characters, pad with leading zeros to six characters.
iii. In the rare cases where the FR Serial Identification (S/ID) is 5 numeric characters 1-46655, convert to three base-36 alpha-numeric characters (as detailed in the Flight Recorder Specification document), padded to six characters with leading zeros. Note: These will be older recorders which may be in the list of recorders in J12. Flight Recorders Unsuitable for Single Point Corrections as being unsuitable for Single Point Altitude Corrections.

Typical filenames:

e.g. NAV153142-S-20220521.JSON FLA00089K-B-20230125.JSON

Note 1: Some Conversion programs convert Cambridge Models 10, 20 & 25 from .CAI to .IGC but add an extra character "C" to the S/ID making it appear to be a 4-character SID. This extra character should be removed, making a 3-character S/ID. e.g. In ACAMCXYZ, S/ID of CXYZ become XYZ and filename becomes **CAM000XYZ-S-20240629.JSON**

J7.3 Units of altitude in the JSON file will always be Metres. Calibration will be in 500 metre (or less) steps up to 3000 metres, and may optionally be in 1000 metre steps above 3000 metres.

J7.4 Units of Pressure will always be hectopascals (hPa)

J7.5 **FR Pressure Error is the <u>signed</u> difference between ambient pressure (hPa) and the Pressure derived from the Recorded Altitude**. If the recorder records a lower Altitude (higher pressure), this will be a positive value, as will the Altitude Correction to be added to the Recorded Altitude to obtain the True Altitude. If the recorder reads a higher Altitude (lower pressure), FR Pressure Error and Altitude Correction will be negative values.

Pressure Error (in hPa) = FR under test altitude (converted to pressure in hPa) minus Ambient Pressure (in hPa) taken from Barometer or Reference FR (corrected by calibration table, and converted as required to pressure).

Worked Example:
Let Flight Recorder Altitude be 243 feet (or 74 metres if you prefer)
Let Corrected Ambient Pressure be 1004.73 hPa
First, Convert Flight Recorder Altitude to a Pressure: =1004.39 hPa
Pressure Error = 1004.39 - 1004.73 = **-** 0.34 hPa (note the minus value in this instance).

J8. <u>Labels and Data Format.</u>

J8.1 <u>JSON Format.</u>

J8.1.1 Each Calibration's top-level Label will be "IGC_Flight_Recorder_Calibration": { encapsulating the whole entry, followed by
"Software_Used": "*Software Name here, Software Version Here, Comment:Optional*",
"Calibration_type": " *Single_Point_Correction* or *Barometric_Calibration* "according to the type of Calibration/Correction. Hence both types may be included in the same database entry. Only the most recent Calibration of each type should be included.

Under "Software_Used" the field Comment above is optional and may contain any comments pertinent to the software version. If omitted, the preceding comma should be omitted also. The line is limited to 60 characters.

J8.1.2 This shall be followed by Header Information which is encapsulated by the label "Headers":

For Corrections under rule 4.5.2.: (Example data in Orange text)

"Calibration_Date": "20221209",
"Valid_From": "20221209",
"Calibrator": "A.N. Other. Approved Calibrator for Gliding Federation of Utopia.",
"Calibrator_Id": "GBR-007",
"Calibrator_Address": "1600 Pennsylvania Avenue, Washington D.C.",
"Calibration_IGC_Filename": "2CA_TK.IGC",
"Manometer_Type": "LXNAV_V1",
"Manometer_Serial_No": "0002",
"Manometer_Calibration_Date": "20221011",
"Manometer_Calibration_Certificate_No": "N31896",
"Ambient_Temperature": "15",
"FR_Serial_Identification": "LXN000GGC,LXN"
"Flight_Recorder_Type": "LXNAV"

J8.1.2.1 Words in Field Names shall be separated by an underscore character and not a space character.

J8.1.2.2 The Calibrator ID shall consist of 3-letter country code and a unique NAC assigned number, separated by a hyphen.

J8.1.2.3 For calibrations under Rule 4.5.2. The manometer type is subject to NAC approval and the requirements of para **2.1** of Sporting Code Section 3 (Gliding), Annex B AL15 *et seq*. in the IGC Documents pages.

J8.1.2.4 Flight_Recorder_Serial_Number is taken from IGC file, filled to six characters as per paragraph 7 above, followed by the Hardware Manufacturers TLC, separated by a Comma.

J8.1.2.5 FR_Pressure_Error is a calculated value as defined in paragraph 7.5 above.

J8.1.2.6 If a Mercury Manometer is used, Manometer Calibration Certificate Date and Manometer Calibration Certificate Number will be those of the latest Purity Check of the Mercury.

J8.1.3 For Single Point Altitude Corrections, this shall be followed by Pressure Error Information.

"FR_Pressure_Error": "-1.83"

J8.1.4 There then follows the Correction data Encapsulated by the Array Label (For Barometric Calibrations)

"Correction Table": [{
Correction data will be pairs of figures, Starting at Zero Altitude and in 500 metre (or less) steps, optionally in 1000 metre steps above 3000metres.

"ISA_Altitude ": "0",
"FR_Pressure_Altitude": "0.21"

J8.1.5 Correction Tables are only required for Pressure Chamber Calibrations. For *Single Point Altitude Corrections* these can be calculated from the *FR Pressure Error* value. Similarly, for Pressure Chamber Calibrations, the FR Pressure Error Value has no meaning and should be omitted.

J8.1.6 Negative Corrections are quite possible, see paragraph 7.5.

J8.1.7 Examples.
An example is given in J11. JSON format examples

J8.1.8 JSON format as showed here may be extended with new fields in the future. Any software parsing a JSON file should ignore such extra fields unknown at the time of software development

J8.1.9 JSON file size should be limited to 10KB.

J9. Optional Events.

J9.1 A warning may be given to the User when the Calibration Period of the Reference Device is within 30 days of expiry and thereafter until recalibrated..

J10. Privileges.

J10.1 Only NAC-approved Calibrators should create Calibration files.

J10.2 Only Calibrators notified to IGC as approved by their NAC, should have permissions to upload Calibration Files to any FAI Database of Calibrations.

J11. JSON format examples.

J11.1 JSON Single Point Correction Report prepared under rule 4.5.2.


```
{
   "IGC_Flight_Recorder_Calibration": {
      "Software_Used": "FR-cal v0.7.0",
      "Calibration_Type": "Single_Point_Correction",
      "Headers": {
         "Calibration_Date": "20240629",
         "Calibrator": "A.N.Other",
         "Calibrator_Id": "GBR-007",
         "Calibrator_Address": "1600 Pennsylvania Avenue, Washington DC",
         "FR_Serial_Identification": "LXN000GGC,LXN",
         "Flight_Recorder_Type": "LXNAVIGATION,LX7007F",
         "Calibration_IGC_Filename": "46TLGGC1.igc",
         "Valid_From": "20240629",
         "Manometer_Type": "acme",
         "Manometer_Serial_No": "1234",
         "Manometer_Calibration_Date": "20230228",
         "Manometer_Calibration_Certificate_No": "abc",
         "Ambient_QFE": "1013.85",
         "Ambient_Temperature": 17
      },
      "FR_Pressure_Error": "-0.64"
   }
}
```


J11.2 JSON Barometric Calibration Report:


```
{
   "IGC_Flight_Recorder_Calibration": {
      "Software_Used": "FR-cal v0.7.0",
      "Calibration_Type": "Barometric_Calibration",
      "Headers": {
         "Calibration_Date": "20240629",
         "Calibrator": "A.N.Other",
         "Calibrator_Id": "GBR-007",
         "Calibrator_Address": "1600 Pennsylvania Avenue, Washington DC",
         "FR_Serial_Identification": "GCS0002LK,GCS",
         "Flight_Recorder_Type": "GARRECHT INGENIEURGESELLSCHAFT,VOLKSLOGGER 1.0",
         "Calibration_IGC_Filename": "491A2LK1.IGC",
         "Valid_From": "20240629",
         "Manometer_Type": "acme",
         "Manometer_Serial_No": "1234",
         "Manometer_Calibration_Date": "20180228",
         "Manometer_Calibration_Certificate_No": "abc",
         "Ambient_QFE": "1013.87",
         "Ambient_Temperature": 17
      },
      "Correction_Table": [
```

{
  "ISA_Altitude": "0",
  "FR_Pressure_Altitude": "-23.20"
},
{
  "ISA_Altitude": "305",
  "FR_Pressure_Altitude": "282.70"
},
{
  "ISA_Altitude": "610",
  "FR_Pressure_Altitude": "583.30"
},
{
  "ISA_Altitude": "914",
  "FR_Pressure_Altitude": "893.00"
},
{
  "ISA_Altitude": "1219",
  "FR_Pressure_Altitude": "1193.81"
},
{
  "ISA_Altitude": "1524",
  "FR_Pressure_Altitude": "1497.21"
},
{
  "ISA_Altitude": "1829",
  "FR_Pressure_Altitude": "1800.00"
},
{
  "ISA_Altitude": "2438",
  "FR_Pressure_Altitude": "2410.39"
},
{
  "ISA_Altitude": "3048",
  "FR_Pressure_Altitude": "3013.01"
},
{
  "ISA_Altitude": "3658",
  "FR_Pressure_Altitude": "3617.00"
},
{
  "ISA_Altitude": "4267",
  "FR_Pressure_Altitude": "4222.79"
},
{
  "ISA_Altitude": "4877",
  "FR_Pressure_Altitude": "4820.99"
},
{
  "ISA_Altitude": "5486",
  "FR_Pressure_Altitude": "5431.99"
},
{

```
                "ISA_Altitude": "6096",
                "FR_Pressure_Altitude": "6039.61"
            },
            {
                "ISA_Altitude": "6706",
                "FR_Pressure_Altitude": "6635.01"
            },
            {
                "ISA_Altitude": "7315",
                "FR_Pressure_Altitude": "7230.01"
            },
            {
                "ISA_Altitude": "7925",
                "FR_Pressure_Altitude": "7846.80"
            },
            {
                "ISA_Altitude": "8534",
                "FR_Pressure_Altitude": "8447.01"
            },
            {
                "ISA_Altitude": "9144",
                "FR_Pressure_Altitude": "9052.01"
            }
        ]
    }
}
```

J12. Flight Recorders Unsuitable for Single Point Corrections.

The following Flight Recorders are unsuitable for using Single Point Corrections, and therefore must only be calibrated in a Barometric Chamber.

- Cambridge Models 10, 20 & 25
- Garrecht Volksloggers
- LX Navigation LX5000-IGC
- LX Navigation LX20/21 (excluding LX20/2000)
- Scheffel Themi.
- Position Recorders.
