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of the
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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: 31 July 2023

IGC-APPROVAL DOCUMENT FOR GNSS FLIGHT RECORDER
Maker - Recorder Names: **LX Navigation - Eos, Era and LX 10000**
Level of Approval: **IGC Level 1 - 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. The initial IGC-approval for the original Eos was dated 26 November 2014. The Eos 80, Era 57 and Era 80 were added on 15 April 2018 and the LX 10000 on 10 Novermber 2018. The reference to the FAI/IGC web site and some of the Manufacturer details at the top of page 2 were updated on 1 February 2020. A version dated 24 May 2020 included a new para (i-iv) with directions to the current web sites for documents related to the FR IGC-approval process, and the GFAC Chairman's new email address on page 4. This document changes the Chairman's address and contact e-mail address and removes references to the Chairman's website and other inactive website links.

(i-ii) IGC-approval Level. This is IGC Level 1 - all flights including world records. The Levels of IGC-approval are listed in Para 1.1.4 of Annex B to the Sporting Code. Also see para 7 below about future changes.

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

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

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

(v) Sporting Code. The attention of National 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; Annex D (SC3D) with the Official IGC Pilot Ranking List. Copies of all of these documents may be obtained from the IGC web site listed above and those particularly relevant to IGC Flight Recorders are also on the GFAC web site. A separate IGC document "Technical Specification for IGC-Approved Flight Recorders" is available on the IGC and GFAC web sites listed above, together with links to up-to-date IGC-approval documents for all IGC-approved Flight Recorders.

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

MANUFACTURER

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IGC manufacturer codes & DLL file: Three letter LXN, single letter L ; IGC-LXN.dll

1. HARDWARE

1.1 **Recorder Type and Model**. This document covers the original Eos 2014 model, the Eos 80, Era 57, Era 80, and adds the LX 10000, a variant of the Era 80 (see 1.3.3. below). The type and model is shown in the header record of IGC-format files in the form: " HFFTYFRTYPE:LX Eos" ; " ... LX Navigation, Eos 80" ; " ... LX Navigation Era 57" ; " ... LX Navigation Era 80" ; " ... LX Navigation LX 10000" .

1.1.1 Serial Identification (S/ID). The IGC Serial Identity (SID) of an individual Recorder consists of three alphanumeric characters that are shown on the outside of the case and on the start-up screen. The s/n is also in the first line of an IGC file prefixed by the letter A and the Manufacturer's three-letter IGC code, in the form: A LXN Q8G FLIGHT:3, standing for LX Navigation FR s/n Q8G, IGC file 3 of the day (the UTC date of flight is on the next line in the IGC file, prefixed "H"for a line in the Header record).

1.2 **Hardware Version**. Hardware Version 1 and higher is the IGC-approved standard, but see para 7.2 on updates. The Version number is shown in the header record of IGC files in the form " HFRHWHARDWAREVERSION:1.00 ".

1.3 **Dimensions, Weight, Power Source**. Power is from a 12V external supply and the internal battery lasts for about 3 hours when fully charged.

1.3.1 Eos Series.

1.3.1.1. Original Eos. The front of the case is 55 x 55 in size, and the main part of the case is 79 mm deep. At the back are three tubes 18mm long for pressure connections, and the button on the front stands out by 14mm. Weight is about 260 grammes.

1.3.1.2 Eos 80. The front of the case is 82 x 82mm in size, and the main part of the case is 50 mm deep. At the back are three tubes 18mm long for pressure connections, and two buttons on the front stand out by 18 mm . Weight is about 290 grammes.

1.3.2 Era Series.

1.3.2.1 Era 57. The front of the case is 63 x 63 mm in size, and the main part of the case is 63 mm deep. At the back are three tubes 18mm long for pressure connections, and two buttons on the front stand out by 18 mm. Weight is about 240 grammes.

1.3.2.2 Era 80. Dimensions are similar to the Eos 80, see para 1.3.1.2 above. For differences from the Eos 80, see 1.6.4 below.

1.3.3 LX 10000. This is an Era 80 with the controls under the screen rather than at the side, and no variometer function in its display.

1.4 **GNSS receiver**. This is either the LEA-6S GPS or NEO-M8 receiver, both by Ublox AG of Switzerland. This is shown in the header record of IGC files in the form " HFGPS:uBLOX-LEA-6S,50ch,50000 " or "HFGPS:uBLOX-NEO-M8,72ch,max50000m". The last figure is the maximum altitude that is processed by the FR. The figure before is the maximum number of channels that the receiver is capable of processing. As well as the US GPS system, these receivers are capable of processing signals from the European Galileo and the Russian GLONASS GNSS systems, which is why the total number of channels that can be processed is shown in the IGC file as 50 or 72, although only signals from the US GPS system are processed in these FRs.

1.5 **Pressure altitude sensor.** This is the MS5607 Pressure Altitude sensor by Measurement Specialities (ex-Intersema) of Switzerland. The pressure sensor is shown in the header record of IGC files in the form: "HFPRSPRESSALTSENSOR:INTERSEMA,MS5607,max15000m" (12000m for the original Eos of 2014). The last figure is the maximum pressure altitude in metres that can be recorded in the IGC file, subject to a pressure altitude calibration to IGC standards, see B6.4.1. The pressure sensor is fed by a tube from the static pressure connector at the back of the case, see 1.6.7 below.

1.6 Display, Antenna and Connectors

1.6.1 Display. A circular display is on the front face, 52mm diameter for the original Eos, 68mm for the Eos 80 and Era 80, 54mm for the Era 57. This has a variometer display on the outside and a screen in the middle with various options selected by rotating the control knob. In the Eos series the variometer has a red-coloured moving needle, in the Era series the variometer indicator is part of the overall digital display. The LX 10000 has no variometer display,

1.6.2 Power Connections. Red and blue wires lead to the back of the case and are for an external 12V DC supply.

1.6.3 GPS Receiver Antenna. A 6mm diameter SMA screw connecter for connecting to the GPS receiver antenna is on the back of the case.

1.6.4 PEV button. A 6-pin RJ11 connector on the back of the case connects by cable to a button for the Pilot Event (PEV) and fast-fix function.

1.6.5 CAN Bus. A 8-pin RJ45 connector on the back of the case is for systems that use the CAN bus, such as the external MOP sensor, see 4.2 below.
1.6.6 micro-SD Card.

1.6.4.1 Eos series. A 6-pin RJ11 connector on the back of the case connects by cable to a separate unit with a socket for a micro-SD card.
1.6.4.2 Era and LX 10000. A micro SD card socket is on the front of the case. In the Era series it is to the right of the screen; in the LX 10000 it is under the screen.

1.6.7 Pressure Connectors. Three 5 mm wide metal tubes project 16mm from the top of the back of the case and are for connecting to Pitot, Static and Total Energy.

1.6.8 Blind Flying Instrument (BFI) Function. One of the display options is an Artificial Horizon (AH) screen, selected by turning the lower button. To enable the AH function, a separate LX Navigation Attitude and Heading Reference System (AHRS) unit must be connected, otherwise the AH screen includes a large red cross. If the AHRS unit is not connected, a E-record line in the IGC file appears when GPS first locks on: " E Time BFIOFF AH LXN AHRS Not connected ". If the AHRS unit is connected, its state is recorded in E record lines under the BFI codes " BFION AH LXN AHRS Connected" when it is on, and if it is off " BFIOFF AH LXN AHRS Not connected". See also para A4.1.

1.6.9 Eos 80, Era 80 and LX 10000. These have a further two 6-pin RJ11 connectors for Flarm and other functions

2. FIRMWARE.

This refers to systems inside the FR. The IGC-approved standard is firmware Version 1.00 and higher, Version 1.40 and higher if the external MOP sensor (see para 4.2) can be fitted. See para 7.2 on updates. The version is listed in the header record of IGC files in the form: FRFWFIRMWAREVERSION:1.00 without the external MOP sensor and HFRFWFIRMWAREVERSION:1.40 if the sensor can be fitted.

3. SOFTWARE.

This refers to systems outside the FR.

3.1 Downloading Flight Data.

3.1.1 Eos series. Downloading in the Eos series is to a micro-SD card unit connected by cable to the RJ11 socket marked "SD"at the back of the Eos case. When the FR is installed in an instrument panel, the cable with the SD card socket should be routed so that the card is accessible after flight so that it can easily be removed and the IGC files transferred to a PC.

3.1.2 Era series and LX 10000. Downloading is to a micro-SD card socket. In the Era series this is on the right of the screen; in the LX 10000 it is under the screen.

3.2 Validation of Flight Data. The IGC standard for electronic flight data is that the IGC file must pass the IGC Validate check that is part of the IGC Shell program. See below for how to obtain the Shell program and B3.4 for how to carry out the IGC Validation check. The Validate procedure checks that the IGC file has originated correctly from a serviceable recorder and that the flight data is identical to when it was first written into the FR memory and then, if correct procedures are followed, as initially downloaded.

3.2.1 IGC Shell Files and FR Manufacturer's DLL file. These files are available from either the IGC or the GFAC web pages, see the web references at the top of page 1. The file igcdll.zip should be downloaded into the directory in the PC to be used for IGC file validation (the name IGCshell is recommended). For the shell program to work, the Dynamic Link Library (DLL) file from the recorder manufacturer must first be copied to the IGC Shell directory. For the DLL file name, see the Manufacturer's data at the top of page 2.

3.2.2 Latest versions. The latest versions of the files in igcdll.zip and the manufacturer's DLL files must be used, obtained as in 3.2.1 above.

4. Engine Recording - ENL and MOP systems.

A microphone and frequency filter system inside the FR automatically produces an ENL (Environmental Noise Level) value of acoustic noise which is added to each fix. This is intended to highlight any engine and propeller noise but to produce low ENL values in gliding flight. For engine and FR installations that produce low ENL numbers with engine running that could be mistaken for some aspects of soaring flight such as thermalling with cockpit panels open, the external MOP (Means of Propulsion) sensor box must be fitted close to the engine and/or propeller, see 4.2. The MOP sensor connects by cable to the RJ-45 CAN Bus socket on the back of the FR and records three MOP numbers on each fix in the IGC file in addition to the three ENL numbers from the microphone inside the FR case.

4.1 ENL System inside the FR. The Environmental Noise Level (ENL) system is made by LX Navigation and is most sensitive to noise at about 150 Hz.

4.1.2 ENL figures. ENL figures in each fix in the IGC file are between 000 and 999 in steps of 001.

4.1.3 ENL IGC-approval - Engine Types. This document gives IGC-approval for the use of the ENL system for the validation of glide performances to IGC standards of evidence with Motor Gliders that have engine and recorder installations that give high ENL values in IGC files when the engine is producing any forward thrust. Such ENL values must clearly differentiate between forward thrust from the engine and soaring flight, otherwise see 4.2. below.

4.1.3.1 Low-ENL Engine/Recorder combinations This approval does not include use of the ENL system with engines that produce small ENL values at the Recorder at low power when just producing positive forward thrust. Unless the FR is mounted very close to the engine and/or propeller, this includes rear- mounted electrical and jet engines, in the case of the jet because the noise is at higher frequencies than those for which the ENL system is designed. It may also apply to some 4-stroke engine/propeller combinations that are particularly quiet. If a low-ENL engine/recorder layout is to be used for flights to IGC standards of evidence, in addition to ENL, an external sensor is required that records three numbers in the IGC file under the MOP code, see 4.2 below.

4.1.4 ENL System and Cockpit Positioning. The recorder must be positioned in the glider so that it can receive a high level of engine and/or propeller noise when any forward thrust is being generated.

4.1.5 ENL and MOP testing. For details of typical ENL and MOP values, see para B.4.

4.2 External Means of Propulsion (MOP) Recording System. An LX Navigation MOP box can be connected by cable to the RJ-45 CAN bus socket on the back of the FR. The cable allows the MOP box to be positioned close to the engine and/or propeller so that it can receive high acoustic noise whenever the engine is run. The MOP box has a microphone-based sensor and is approved for use in low-ENL installations in accordance with this paragraph and the rules for external MOP sensors in Annex B to the Sporting Code for Gliding (SC3B). When MOP firmware is fitted, three MOP numbers are added to each fix in the IGC file in addition to the three numbers from the internal ENL sensor. The MOP numbers can be displayed by an analysis program with facilities for MOP as well as ENL. The type of MOP system is also shown in an extra Header record line at the beginning of the IGC file in the form: H F MOP SENSOR: Maker, ON/OFF, Acoustic, Sensor Model

4.2.1 Security. The MOP box is protected by both physical and electronic security in a similar way to the FR itself, and signals between the box and FR are encrypted, and some of the screws securing the case are covered by tamper-proof manufacturer's seals. If the box or its connecting cable is interfered with, its security is trashed and a signal sent to the FR that it is no longer secure. The ENL system inside the FR provides a check on MOP operation, although its readings will be much lower.

4.2.2 Installation. The installation of the MOP box must be inspected and sealed by an OO in a position where high MOP values are recorded whenever any forward thrust is produced. Claims must include evidence that the MOP installation after flight was as previously inspected, and that MOP figures in the IGC file are similar to those given in Annex B to this document.

4.2.3 LX Navigation MOP acoustic sensor box . This weighs about 45 grammes and is 47 x 33 x 25 mm in size . An RJ-45 socket is for connecting a cable to the CAN Bus socket on the back of the FR. There are two sensors with different frequency ranges.

4.2.3.1 Type 1 Low Frequency Sensor Box. This is similar to the ENL sensor inside the FR and has a peak response at about 150 Hz. It must be sealed into position by an OO as close as possible to the engine and/or propeller disc. It may be used with all engine types, subject to it being demonstrated that high MOP numbers in the IGC file are produced under any condition of forward thrust.

4.2.3.2 Type 2 High Frequency Sensor Box for Jet Engines. This has a peak response at about 6000 Hz (6 KHz) and must be sealed in position by an OO near the jet pipe (because most noise is propagated behind the engine and not in front). It is not advised for use with other than jet engines because there may not be enough signal at this frequency to produce high enough MOP numbers, but if the particular installation can be shown to produce high enough numbers on the IGC file whenever forward thrust is produced, this is valid under IGC rules.

5 Installation in the glider

These types of Flight Recorder are designed to be fitted in an instrument panel so that the pilot can see the screen. From the point of view of data recording, the unit may be fitted anywhere in the glider, subject to para 4 on engine recording, para 6 on security, the Pilot Event (PEV) button should be in easy reach of the pilot. The position of displays and operating buttons and controls used in flight in single-seat gliders should not be remote from sight-lines used for pilot lookout and scan for other gliders and powered aircraft.

5.1. **Check of Installation**. There must be incontrovertible evidence that the recorder was in the glider for the flight concerned, and was installed and operated in accordance with IGC procedures. Unless the recorder is part of a permanent installation in the Instrument Panel, this can be achieved either by independent Observation at takeoff or landing, or by sealing the Recorder to the glider at any time or date before takeoff and checking the seal after landing, see para B1 later.

6. Security - Physical and Electronic

GFAC is presently satisfied with the physical and electronic security of this equipment in terms of the integrity of the recorded flight data and the level of this approval for the types of flights concerned. See below on security seals. GFAC reserves the right to inspect production-standard equipment for security, compliance with the current IGC Specification , this Approval, and the accuracy of outputs from sensors such as for GPS Position, ENL and pressure altitude.

6.1 Physical Security. Tamper-evident seals with the manufacturer's logo are fitted over screws that hold the case together. In addition, an internal security mechanism using microswitches activates if the case has been opened.

6.2 Electronic Security. If the internal security mechanism has been activated, subsequent IGC files will fail the IGC Validation test for electronic security. This test will also fail if the IGC file being analysed is different from that originally downloaded from the Recorder, even by one character in the flight data. If corrupted firmware is detected, depending on the nature of the problem, either IGC files will not be generated or if they are, they will fail the IGC Validate test.

6.3 Recorder found to be unsealed. If either physical or electronic security is found to have failed, before it can be used again for flights to the IGC standard, the Recorder must be returned to the manufacturer or his appointed agent for investigation and resealing. A statement should be included on how the unit became unsealed.

6.3.1 Checks before re-sealing. Whenever any unit is resealed, the manufacturer or his agent must carry out positive checks on the internal programs and wiring, and ensure that they work normally. If any evidence is found of tampering or unauthorised modification, a report must be made by the manufacturer or agent to the Chairman of GFAC and to the NAC of the owner. The IGC approval of that individual unit will be withdrawn until the unit is re-set and certified to be to the IGC-approved standard.

7 Updates and Changes

7.1 Updates to IGC-approval Documents. The latest IGC-approval documents are posted on the GFAC and IGC FR web sites given at the top of page 1, and for flights to IGC standards the latest document is the only one that is valid. These sites also have a table of all IGC-approvals together with approval levels and links to the latest IGC-approval documents for each type of FR. Pilots are advised to check the latest IGC-approval document(s) for the FR(s) to be used before making a flight that is to be claimed, so that they are aware of any changes.

7.2 Manufacturer's Changes including later versions of Hardware, Firmware and Software. Notification of any intended change that might affect the recording function, the structure and security of IGC files, or the physical and electronic security of the FR, must be made by the manufacturer to the Chairman of GFAC so that a decision can be made on any further testing which may be required to retain IGC-approval. It includes changes to hardware and firmware including modules inside the recorder such as the GPS receiver unit, pressure altitude sensor, external MOP system, and so forth. If in doubt, GFAC should be notified.

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Annexes: A. Notes for owners and pilots.
B. Notes for Official Observers and NACs

NOTES FOR OWNERS AND PILOTS - PART OF IGC APPROVAL

A(i) *Status. To be read together with the main terms of approval on pages 1-4.*
A(ii) *IGC-Approval level. See page 1 heading "Level of Approval".*
A(iii) *Copy of this document. It is recommended that a copy of this approval document is kept with the FR, for the use of pilots and OOs.*

Pilot's Responsibility. It is the responsibility of the pilot to ensure or to note the following:

A1 **GPS Antenna and other connectors**. This approval does not presently require sealing of any connectors, ports or plugs, or stowage out of reach of the pilot(s), and no attempt must be made to pass unauthorised data into the Recorder including through the GPS antenna.

A2 **Geodetic Datum (Earth Model)**. This type of recorder is fixed on the WGS84 Geodetic Datum (earth model). It should be ensured that other lat/long data such as for start, turn and finish points, is also entered to the WGS84 Geodetic Datum (IGC rule).

A3 **Setting the Fix Interval**. The basic fix interval is part of the set-up menu that is shown on the screen and the Instruction Manual gives the switching required. A series of fast-fixes occur after the Event button is pressed, recording the letters PEV (Pilot EVent) on the first of the fast-fixes in the IGC file. Fast fix is at one second interval but the number of fixes can be set through the set-up menu and at least 30 fast fixes are required. The fix interval for *cruise flight* between PEV events (such as between Waypoints) is also set before flight through the set-up menu. There is no need to set a very short fix interval for cruise flight because points of interest can be marked by PEV events and fast fixing. Setting a short fix interval for *cruise flight* leads to IGC files of large size, particularly for long flights. This uses up more of the recorder's memory, causes downloading after flight to take a long time, increases the chance of data corruption, and may also cause problems with some analysis programs because of the large number of fixes that have to be processed.

A3.1 IGC rules. IGC rules on fix intervals are a maximum setting of 60 seconds, and a 10 second maximum for competitions under the rules of Annex A to SC3 (SC3A para 5.4C).

A4 **Checking the Recorder before a Claim Flight**. Pilots should check and analyse a selection of IGC files before flights that will require Validation. It is the pilot's responsibility to ensure that the recorder is performing correctly and in accordance with this approval, for instance ensuring that GPS fixes, pressure altitude, ENL, date/time and other values are recorded as expected. In particular, for motor gliders, ENL values (and MOP where fitted) should be in accordance with the figures given in para B5. See also A9 on ENL and A13 on pressure altitude calibration.

A4.1 Artificial Horizon (AH) Function. One of the display options is an AH screen and its state is recorded by Blind Flying Instrument (BFI) codes that are placed on the IGC file, see para 1.6.8 on page 2. The AH function becomes operative when the separate LX Navigation Attitude and Heading Reference System (AHRS) unit is connected. When the AH function is not operative, the AH display is overlaid by a red cross. In some gliding championships, cloud flying is not allowed and pilots must demonstrate to the organisers that blind flying instruments have not been used on championship flights. In addition to the use of BFI codes, with this recorder it is possible to switch off the AH facility for a selected number of days, and this can be demonstrated where required to the Championship organisers. For details see the Operating Manual.

A5 **Pre-flight Declaration in the IGC file**. Electronic pre-flight declarations of Waypoints are made by putting Start, Finish and Turn Points into the recorder in accordance with the FR manufacturer's instructions. Before making a flight that is to be claimed and requires a pre-flight declaration, pilots are advised to check that they can successfully carry this out, and that an IGC file is produced that satisfies the Sporting Code on pre-flight declarations.

A6 **Observing the installation in the glider**. The pilot must ensure that an OO has checked the place of the recorder in the glider and how it is fixed to the glider. In addition, where an external MOP engine sensor is fitted, the method of fixing and sealing must also be checked (see para 4.2 on page 3). On the position of the display, see para 5 on page 3 which refers to sight-lines and the need for pilot lookout and scan.

A7 **Connection to Ports**. Although this approval does not presently require sealing of any ports or plugs, no attempt must be made to pass unauthorised data into the Recorder.

A8 **Takeoff**.

A8.1 **Switch On**. The recorder is switched on by a press of the button on the front of the recorder. Pilots are advised to switch on at least 5 minutes before takeoff and check that GPS lock-on has occurred in time to establish a baseline of fixes before the start of the takeoff roll.

A8.2 **Takeoff - Independent evidence**. The pilot must ensure that the time and point of takeoff has been independently witnessed and recorded for comparison with takeoff data in the IGC file from the recorder, see B1.2.

A9 **Gliders with Engines**. This applies to gliders with any sort of power plant that could give forward thrust. A microphone inside the recorder automatically records the level of low-frequency acoustic noise, shown in the IGC file with each fix as three numbers under the ENL code. If ENL numbers with a particular engine installation are not high enough, these types of FR can be fitted with an external MOP sensor that can be positioned close to the engine and/or propeller; see para 4 on pages 3 and 4 on engine recording, and para A9.2 below on the external MOP sensor system.

A9.1 Cockpit Noise. Pilots should note that cockpit noises other than the engine will produce ENL figures on the IGC file, and should avoid those that could be mistaken for use of engine. ***Flight with the cockpit Direct Vision (DV) and/or ventilation panel(s) open can produce a low-frequency sound (organ-pipe note) which can register as high ENL. This is magnified if sideslip is present and in particular at high airspeeds. Flight with cockpit panels open when climbing and also at high airspeed should be avoided in case the ENL recorded is mistaken for use of engine***. High ENL may also be produced by stall buffet and spins, particularly in Motor Gliders if the engine bay doors flutter (vibrate or move in and out). Flight near powered aircraft should also be avoided, except for aero-tow launches. See B4.2 for levels that have been recorded on GFAC tests by the internal FR ENL system and by the external MOP system.

A9.1.2 Pilot check of ENL figures. Pilots should check that the ENL figures produced by their recorder show a clear difference between engine-on and engine-off flight (but see A9.2 below for low-ENL installations). ENL figures for piston engines should be in accordance with those found in GFAC tests and listed in para B5. This may be vital on a later flight when a claim is made.

A9.2 Low-ENL Installations - External MOP sensor. For engine and FR installations that produce low ENL figures in the IGC file a separate MOP system is required, see para 4.2 on page 3. This applies to electric, jet and some rear-mounted 4-stroke installations, unless the FR itself can be positioned close to the engine such as with an electric Front Engine System (FES) where the recorder is close behind in the instrument panel and can be shown to produce high ENL when any forward thrust is generated. The MOP sensor must be positioned so that high MOP numbers are produced in the IGC file whenever the engine system is producing forward thrust. Pilots should also check that low MOP numbers are produced in gliding flight, and should be aware that some MOP sensor installations have shown high MOP numbers, probably due to aerodynamic noise or vibration near the MOP mounting. In such cases the MOP mounting should be changed, or the MOP sensor installed in a different place that is free of vibration in gliding flight.

A10 **After Landing**. Until an OO has witnessed the Recorder installation to the glider, the pilot must not alter the installation or remove the Recorder from the glider. The pilot must ensure that there is evidence of the landing independent of the flight recorder data, see A11 below. Pilots are advised not to switch of the recorder for several minutes after landing, so that an adequate landing baseline can be established on the IGC file.

A10.1 After-flight calculation of security. If the pilot ends the IGC flight file by pressing the main button, or when the recorder is switched on again after having been switched off (for instance after landing), a digital signature is calculated for the IGC file for the flight. This process places security codes at the end of the IGC file for the last flight, which is then completed and stored in the memory ready for downloading. These codes are used to verify the integrity of the whole file at any later time by using the Validate function of the IGC Shell program.

A11 **Independent Check of Landing**. The pilot must ensure that the time and point of landing has been witnessed and recorded for comparison with IGC file data from the recorder (see para B2.1).

A12 **Switching Off**. The recorder is switched off by pressing the button on the front.

A13 **Downloading the Flight Data**. Downloading is to a micro-SD card in a socket whose location varies with the FR type and is described in para 3.1 on page 3. The flight to be downloaded is selected by rotating the button on the front of the Recorder.

A13.1 OO's actions. For a flight to IGC standards of evidence, an OO should carry out the actions given in para B3.3, and the OO's copy of the transferred flight data will be sent to the Organisation that will validate the flight, such as the National Airsport Control authority (NAC). The OO does not personally have to transfer the data from the Recorder, but witnesses the transfer, and immediately afterwards takes, or is given, a copy on a storage device such as a memory stick or SD card.

A13.2 Competitions. Different rules may apply for competition flights, for which pilots may be allowed to bring their own flight data on portable storage data to competition control, or a central data transfer facility may be used. However, for a flight to IGC rules such as for records and badges, OO monitoring as in A13.1 continues to apply.

A14 **Calibration of Barograph Function**. Pilots are advised to have a pressure altitude calibration carried out by an NAC-approved calibrator before any GNSS Recorder is used for a claimed flight performance. For the procedure, see para B6. A valid IGC file showing the pressure steps used in the calibration must be recorded and kept (Sporting Code rule). Altitude and height claims require a calibration for the flight performance concerned. Speed and distance claims need a calibration for calculating the altitude difference of the glider at the start and finish points. Also, the NAC or FAI may wish to compare pressure altitudes recorded on the Recorder for takeoff and at landing, with QNH pressures for the appropriate times recorded by a local meteorological office.

Annex B - **NOTES FOR OFFICIAL OBSERVERS AND NACs - PART OF IGC APPROVAL**

B(i) Status. To be read together with the main terms of approval on pages 1-4.
B(ii) IGC-Approval level. See page 1 heading "Level of Approval".
B(iii) Copy of this document. It is recommended that a copy of this approval document is kept with the FR, for the use of pilots and OOs.

B1 **Installation in the Glider**. An OO shall witness and record the position of the Recorder in the glider, the type and Serial Identification (S/ID) of the Recorder, the glider type and registration, date and time. This type of recorder is designed to be fitted in an instrument panel, and if this is done, no special sealing is required. The MOP box external to the FR (if fitted) must be sealed in position so that it receives maximum signal whenever forward thrust is being generated, see para 4.2 on page 3. A separate LX Navigation Attitude and Heading Reference System (AHRS) unit may also be fitted to enable the Artificial Horizon (AH) function, see paras 1.6.8 and A 4.1.

B2 **Takeoff - Independent Evidence**. The time and point of takeoff must be recorded, either by an OO, other reliable witnesses, or by other means such as an Air Traffic Control or official Club log of takeoffs and landings. After flight, this will be compared to the Recorder's takeoff data.

B3 **Landing**

B3.1 Independent Evidence. The time and point of landing must also be recorded, either by an OO, other reliable witnesses, or by other means such as an Air Traffic Control or official Club log of takeoffs and landings. After flight, this will be compared to the Recorder's landing data.

B3.2 Checking the Installation of the Recorder. As soon as practicable after landing, an OO shall inspect the installation of the Recorder in the glider (and its external MOP system, if fitted), so that this can be compared to the check described in para B1.

B3.3 Downloading the Flight Data. Downloading is to a micro-SD card in a socket whose location varies with the FR type and is described in para 3.1 on page 3. The button on the front of the case is used to select the screen headed "Logbook" and on pressing the button a list of flights in the memory is displayed. The flight required should be selected and the button pressed again ; this brings up a screen with the word "Copy" which should be selected and the button pressed again for the file transfer to take place (Note, if the screen shows "Transfer Error", check that the micro-SD card is seated correctly in its socket). After this, the IGC file for the flight is transferred from the micro-SD card to a PC under the control of the OO. Security of downloaded IGC files is maintained by electronic coding embedded in the Recorder which is then independently checked later at the NAC (and at FAI if the claim goes to them). See para B4 below for how this is done.

B3.3.1 Files Produced. This process will produce an IGC-format ASCII flight data file with the file name YMDFXXXN.IGC, where Y = year, M = month, D = day, F = firmware manufacturer, XXX = Recorder Serial Identification (S/ID)/letters and N = flight number of the day (full key, Appendix 1 to the IGC GNSS Recorder Specification, copied in Annex C to the Sporting Code, SC3C).

B3.3.2 OO's Copy. A copy of the IGC file must be retained securely by the OO such as by immediately copying it to storage media such as a memory stick, data card, or the hard disk of the OO's own PC. This IGC file must be retained by the OO for later checking and analysis under NAC procedures. The OO must be able to positively identify the flight data file as being from the flight concerned. Takeoff and landing data independent of the IGC file must also be available, see above in B2 and B3.1.

B3.3.3 Competitions. Different rules may apply for competitions, but for validation of performances for IGC badges and records, the rules in the IGC Sporting Code and this Approval document continue to apply. For competition purposes only, pilots may be allowed to download their own flight data and take it to Competition Control on portable storage media such as a USB stick or memory card, or a central competition data transfer facility may be used. For ease of identification within the competition, file names may be changed, for instance to the glider competition number or the pilot's name. Integrity of data within the file is preserved by the electronic security system and may be checked at any time by using the Validation process described in B3.3.1 above. For competitions in which cloud flying is not allowed, see 1.6.8 on page 2 and A4.1 on page 5.

B4 **Validation of and Analysis of Flight Data Files**. Before a Flight Performance is officially validated, the authority responsible for validation must check that the data in the IGC file has originated from the Recorder concerned, and is identical to the file that was downloaded from the Recorder to the PC. This is done by checking the IGC data file with an authorised copy of the IGC Shell program and using the Validate function in the IGC Shell menu (see below). The Recorder manufacturer's DLL file will also be needed in the IGC Shell directory. The Shell program and DLL file must be the same as those on the current FAI/IGC of GFAC web sites given at the beginning of this document. A Data Analyst approved by the NAC shall carry out this IGC Validation check on the IGC file and then evaluate the flight data using an analysis program approved by the NAC concerned.

B4.1 IGC Shell Program. Download the file igcshell.zip from the IGC or GFAC web pages, un-zip and place all the files in one directory (the name IGC Shell is recommended). For the shell program to work, the appropriate Dynamic Link Library (DLL) file from the recorder manufacturer must be copied to the IGC Shell directory. After copying it to the directory that contains the IGC Shell files, execute IGCshell.EXE. Set the path to the IGCshell directory using the "Set Directories" button on the screen. The IGCshell menu will now appear in a grey rectangular box with 9 software buttons for selecting the recorder type, recorder settings and flight logs. The recorder software box at the top has a list of FR manufacturers, and the appropriate one should be selected.

B4.1.1 Validation of IGC files. Select the FR manufacturer's logo from the top menu box (as above), press the "Validate" button and select the IGC file to be checked. If successful, the message "File has been successfully validated" appears. If there is a security problem, the message "Integrity Bad" appears, together with a likely reason.

B5 Means of Propulsion Record - Gliders with Engines. For recording engine noise at the recorder, the Environmental Noise Level (ENL) system inside the FR is used. A microphone-based system produces three ENL numbers between 000 and 999 that are added to each lat/long fix in the IGC file and are based on low frequency noise centred on 150Hz. For engine and FR installations where ENL figures are low, making it difficult to distinguish between engine running and other noises (such as with rear-mounted electric engines, jet engines, and some rear-mouted four-strokes), an external sensor operating under the MOP code may be connected by cable to the FR so that it can be positioned to receive a high signal whenever the engine produces forward thrust, and three MOP numbers are recorded in each fix in addition to those for ENL. See para 4 on pages 2 and 3, para A9 on page 6, and the rest of this para below.

B5.1 ENL - General. With piston engines it is normally easy to see when the engine has been running and when it has not. Other data such as rates of climb and groundspeed, will indicate whether or not energy is being added other than during soaring. Short term peaks in ENL (10 seconds or less) may be due to other factors such as undercarriage and/or airbrake movement, sideslip, open DV panels (particularly with sideslip), the nearby transit of powered aircraft, etc.

B5.1.1 Quiet period before flight. A low but positive ENL is used when no noise is present, to indicate that the ENL system is working. For this Recorder the base ENL in quiet conditions is between 010 and 025. Consistent ENL values of 000 indicate a fault in the ENL system.

B5.1.2 ENL during launching. During winch and aerotow launches, higher ENL values are to be expected than when soaring (B4.3), typically base on low frequency noise up to 350 for winch and 100 for aerotow, particularly if cockpit vents and direct vision panels are open. During the ground roll, short-term higher values may be recorded due to wheel rumble or tyre squeak.

B5.1.3 ENL during engine running. An ENL value of 999 has been produced by this type of recorder with two-stroke and forward-mounted four-stoke engines running at full power. At power for level flight, ENL values of 700 have been recorded in a two-stroke, lower in a 4-stroke. During engine running, these ENLs are produced for a significant time, and when altitude and speed are analysed it can be seen that substantial energy is being added, which can therefore be attributed to energy not associated with soaring. Previous tests with Wankel (Rotary) engines indicate that they produce similar ENL values to 4-strokes.

B5.1.3.1 Engines producing low ENL signatures. This approval does not include FR/engine installations with low ENL values when the engine is producing forward thrust and could be mistaken for soaring flight (such as with cockpit panels open). Engines such as electric, jet, and some 4-strokes produce low ENL values unless the FR is positioned close to the engine and/or propeller. In this case, an additional MOP system must be fitted, see para 4.2 on pages 3 & 4 and B5.2 below.

B5.1.4 ENL during gliding flight. ENL readings up to 050 indicate low-speed gliding flight in a well-sealed cockpit. However, flight with the canopy panel(s) open produces extra noise inside the cockpit and ENL values of up to 200 have been produced when thermalling with cockpit panels open. With sideslip or at higher speeds, a loud low frequency noise can be produced ("organ-pipe" effect) and ENL readings of up to 470 have been recorded. High ENL may also be recorded during stalling and spinning, particularly if the engine doors flutter or vibrate (move slightly in and out due to stall buffet, producing a clattering noise). Finally, where the engine is mounted on a retractable pylon, a high ENL reading will be shown if flying with the pylon up and engine not running, due to the high aerodynamic noise.

B5.1.5 ENL during the approach to land. ENL values are normally higher on a landing approach due to aerodynamic noises such as due to airbrakes, undercarriage, sideslip, turbulence, etc. Short-term peaks due to specific actions such as opening airbrakes, lowering undercarriage, etc., will be noted as well as a generally higher level of ENL because the glider is no longer aerodynamically clean.

B5.1.6 ENL during landing. During ground contact during landing, short-duration ENL readings of between 500 and 900 have been recorded, probably due to wheel rumble or tyre squeak. Unlike engine running these last only for a short time, showing a short "spike" on the noise/time trace.

B5.1.7 ENL analysis. It is normally easy to see when an engine has been running and when it has not. Other FR data such as rates of climb and groundspeed, will indicate whether or not non-atmospheric energy is being added. Short term peaks in ENL (less then 10 seconds) may be due to the other factors mentioned above such as undercarriage and/or airbrake movement, sideslip, open DV panel/sideslip, the nearby passage of a powered aircraft, etc.

B5.2 External MOP system, when fitted. Where there is an MOP sensor external to the FR (see para 4.2 on pages 3 & 4), during post-flight analysis the MOP numbers in the IGC file during engine running must be compared with the readings from the ENL sensor inside the FR. This is to check that they correspond in time and that both ENL and MOP numbers are as expected, particularly under high engine power, although the ENL readings will be lower. This is easy to carry out and is a "double check" on the working of the ENL and MOP systems.

B5.2.1 Engine-on. MOP numbers recorded with each lat/long fix should be at least 500 when any forward thrust is generated, and over 900 at high power settings.

B5.2.1.1 Acoustic Sensor LX Navigation MOP Type 1. This is described in para 4.2.3.1 on page 3, and is similar to the ENL sensor inside the FR but because it is on a cable it can be positioned close to the engine and/or propeller. In GFAC tests, MOP values between 900 and 999 have been recorded at high power, and over 600 at lower power settings. The Type 1 sensor can be used with all types of engines if the installation can be shown to produce high MOP values when any forward thrust is generated.

B5.2.1.2 Acoustic Sensor LX Navigation MOP Type 2. This is a high frequency acoustic sensor desgned to be used with jet engines, and is described in para 4.2.3.2 on page 3. MOPs over 950 have been recorded at high power in a Ventus. Jet when mounted near the jet pipe. The Type 2 sensor is not recommended for use with other types of engine, but if there is no alternative it may be used if the installation can be shown to produce high MOP values when any forward thrust is generated.

B5.2.2 Engine-off. In GFAC tests with engine off , MOP numbers in the IGC file were generally less than 050. This number will vary with the particular installation depending on what other noises are present at the sensor when the engine is not running. It should also be noted that some installations of MOP sensors in individual gliders have been found to be in places where unwanted high MOP numbers have been recorded in gliding flight, probably due to aerodynamic noise or vibration on or near the MOP mounting - see para A9.2 on page 6. Before a flight can be Validated, there must be a clear distinction in ENL and/or MOP figures in the IGC file between any engine running with forward thrust, and ENL and/or MOP figures in gliding flight. If this cannot be satisfied, the flight cannot be Validated to IGC standards.

B6 **Altitude analysis and calibration**. IGC files will be analysed in accordance with Sporting Code procedures. Part of this is to compare the general shapes of the GNSS and pressure altitude fix records with time and to ensure that no major differences are seen that could indicate malpractice or manufactured (false) data. So that accurate pressure altitude is available, the FR is calibrated in an altitude chamber with respect to the International Standard (the ICAO ISA), in the same way as a barograph or aircraft altimeter. Before the calibration, the Recorder fix rate should be set to a 1 or 2 second interval.

B6.1 Calibration method, making a calibration table. Recording starts after a pressure change of 1 metre per second for 5 seconds. No GPS fixes are required for a pressure altitude trace to be produced. The calibrator should be advised to make a short pressure change to trigger recording before starting the calibration itself. The calibrator will record the pressure steps used, for later comparison with the IGC file. The stabilised pressure immediately before the altitude is changed to the next level, will be taken as the appropriate value unless the calibrator certifies otherwise.

B6.1.1 After Calibration. After the calibration, the IGC file containing the pressure steps is transferred to a PC as if it was flight data (see B3.3). This may be done by an NAC-approved person if the calibrator does not have this knowledge. The IGC-format calibration data file will then be analysed, compared to the calibration pressure steps, and a correction table produced and authenticated by an NAC-approved person (for instance an OO or GNSS Recorder Data Analyst). The correction table will list true against indicated altitudes. This table can then be used to adjust pressure altitudes which are recorded during flight performances and which require correction before validation to IGC criteria. These include takeoff, start and landing altitudes for altitude difference and for comparison with independently-recorded QNH readings, and low and high points for gain-of-height and altitude claims. Only pressure altitude is valid for IGC altitude purposes except for (1) proof of flight continuity (no intermediate landing) or (2) above 15,000 metres used with a special High Altitude Flight Recorder (HAFR), where GNSS altitude may be used in accordance with Sporting Code procedures. The IGC file should be kept with the calibration paperwork so that it is not confused with other calibration files. The original IGC file may have a nominal date/time (because GPS lock may not be present during the calibration run), and the file can be copied and the file name changed to one that can be identified as the calibration. A text editor can be used to add a realistic date and time in the file itself, although this will mean that the Validation check will fail and the original IGC file must also be kept unaltered so that it can be Validated when required.

B6.2 GPS altitude figures recorded in the IGC file. Occasional short-duration differences in the shape of the GPS Altitude/time graph have been noted compared to the pressure altitude figures. Altitude accuracy is not as good as accuracy in lat/long, because satellite geometry is not as favourable for obtaining accurate altitude compared to horizontal position. This effect may be increased by less-than ideal antenna positioning in some gliders. Data analysts and NAC officials should allow for the above when comparing the GPS altitude and pressure altitude records. Lat/long fix accuracy is not affected and tests on this recorder show it to be typical of that for a multi-channel GPS system. From GFAC tests, the lat/long error taken from a moving vehicle at a surveyed point in average reception conditions, shows an average error of between 11 and 12m for all recorders tested since the year 2000, and between 5 and 10m for more recent recorder designs.

B6.3 GPS altitude figures recorded in the IGC file. Occasional short-duration differences in the shape of the GPS Altitude/time graph have been noted compared to the pressure altitude figures. GPS altitude accuracy is not as good as accuracy in lat/long, because satellite geometry is not as favourable for recording accurate altitude compared to accurate horizontal position, and processing inside GPS recording systems tends to place more priority on lat/long accuracy rather than altitude. This effect may be increased by less-than ideal antenna positioning in some gliders. OOs, data analysts and NAC officials should allow for the above when comparing GPS altitude and pressure altitude figures in IGC files. Lat/long fix accuracy is not affected and tests on this recorder show it to be typical of that for a multi-channel GPS system. From GFAC tests, the lat/long error taken from a moving vehicle at a surveyed point in average reception conditions, shows an average error between 5 and 10m for recent IGC recorder designs.

B6.4 Maximum Altitudes Recorded in the IGC file. The GPS system is capable of recording to almost unlimited altitudes, certainly up to 30km/100,000ft. Pressure altitude sensors have good altitude resolution at low altitudes, but as air density reduces at height, a small pressure step becomes a large altitude difference. The capability for fine resolution (small steps) in altitudes in IGC files also depends on how altitude figures are processed within the FR, and for pressure altitude the resolution capability of the altitude sensor. Altitude resolution requirements are given in the IGC FR Specification, and for this type of FR the maximum altitudes in accordance with these requirements are given below. It should be noted that for validation of IGC altitude performances above 15km (49,213ft), evidence is required from an IGC-approved High Altitude Flight Recorder (HAFR), for which special requirements for both GNSS and pressure altitude are given in the IGC Sporting Code and the FR Specification , and this type of FR is not an IGC HAFR.

B6.4.1 Pressure Altitude. As part of the IGC-approval process, the manufacturer provided pressure altitude calibrations up to 8000 metres for these types of FR. For certification of performances to IGC standards, the individual FR to be used must have a current pressure altitude calibration from an NAC-approved calibration laboratory up to at least the altitude needed for the claim. This could be higher than 8000 metres as long as the calibration is in accordance with IGC rules for pressure altitude calibrations.

B6.4.2 GNSS altitude. Up to 50 km (nominal), but see B6.4 above on IGC High Altitude Flight Recorders (HAFR).

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