



**GNSS FLIGHT RECORDER APPROVAL COMMITTEE (GFAC)
FAI INTERNATIONAL GLIDING COMMISSION (IGC)**

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

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References:

FAI web site: www.fai.org

IG C web site: www.fai.org/gliding

GFAC Chairman's web site: www.ukiws.demon.co.uk/GFAC

FAI/IGC GNSS FR web site: www.fai.org/igc-our-sport/gnss-recording-devices

FAI/IGC GNSS FR software web site: www.fai.org/gnss-recording-devices/free-software

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

25 April 2016

IGC-APPROVAL FOR GNSS FLIGHT RECORDER

Level of Approval: All flights (see para i-ii)

Recorder Name: LXNAV S-10 and S-100

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

(i-i) Document Versions and Scope. This is the initial approval for this type of recorder.

(i-ii) IGC-approval Level. This approval is for all flights including world records. 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).

*(ii) 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 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 Airport Control (NAC) authorities, officials and pilots is drawn to the latest edition of the FAI Sporting Code Section 3 (Gliding) including its annexes and amendments. Annex A to this code (SC3A) deals with competition matters, annex B to the Code (SC3B) with equipment used in flight validation, Annex C to the Code (SC3C) with guidelines and procedures for Official Observers, pilots, and other officials involved in the flight validation process. 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.

3 SOFTWARE

3.1 **Downloading of Flight Data.** Downloading is to the Micro SD card holder to the right of the screen, and is automatic if a card is in the holder when an IGC file is saved after flight. Downloading can also be made through a menu that displays a list of IGC files in the recorder memory.

3.2 **Validation of Flight Data.** The Validation function of the IGC Shell system checks the integrity of data in IGC files.

3.2.1 **IGC Standard for the Validity of Flight Data.** The IGC standard for electronic flight data is that the IGC file must pass the IGC Validate check. The Validate function of the IGC Shell program is used to interrogate the IGC file that is to be Validated. The IGC Validate procedure checks that the IGC file has correctly originated from a specific recorder and that it is identical to when it was initially downloaded.

3.2.2 **IGC Shell Files.** The IGC Shell files should be downloaded into a specific directory in the PC that is named in advance (the name IGCshell 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. For this recorder, the file IGC-LXV.DLL is available on the IGC GNSS web site.

3.2.2.1 **Latest versions.** The latest versions of the files should be used. These can be obtained from the IGC GNSS site for software given at the beginning of this document. The file igcdll.zip contains the IGC shell program and the manufacturer's DLL files are also available through the IGC GNSS web site.

3.2.2.2 **Free availability.** The IGC Shell program is free and the manufacturer's DLL file is freeware but is copyright of the recorder manufacturer.

4 **Engine Recording - ENL systems.** A microphone and frequency filter and weighting system inside the FR automatically produces an ENL value (Environmental Noise Level) with each fix. The system is designed to highlight engine noise but to produce low ENL values in soaring flight. For flights in gliders with any sort of engine, the ENL figures in the IGC file must be analysed to show that the engine was not used to produce forward thrust during the part of the flight that contains the claimed soaring performance. ENL data has also been shown to be useful for non-motor gliders in the case of accidents and incidents. For engine installations that only produce low ENL, an FR with an external MOP (Means of Propulsion) sensor box must be fitted, and the manufacturer has stated that the LXNAV MOP system will be made available for this type of recorder in due course.

4.1 **ENL System Manufacturer.** The ENL systems in this recorder are by LXNAV.

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

4.3 **ENL IGC-approval - Engine Types.** This document gives IGC-approval for the use of the ENL system for the validation of soaring performances to IGC standards of evidence when flown with Motor Gliders that have piston engines that give substantial acoustic noise levels at the FR and produce high ENL values when the engine is producing any forward thrust.

4.3.1 **Low-ENL Engine/Recorder installations.** This approval does not include use of the ENL system with engines that produce small ENL values at the Recorder, particularly at low power when just producing positive forward thrust. Unless the FR is mounted very close to the engine and/or propeller, such engines include those that are electrically or jet powered, 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, as well as ENL, an external sensor recording in the IGC file under the MOP code is required, in accordance with Annex B to the Sporting Code.

4.4 **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 whenever forward thrust is being generated. For low-ENL situations, see 4.3.1.

4.5 **ENL testing.** For details of typical ENL values found on GFAC tests, see para B.4.

5 **Installation in the glider.** From the point of view of data recording, the FR may be fitted anywhere in the glider, subject to para 4 on ENL, para 6 on security, and that the control buttons 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 IGC file for the Claim originated from the recorder in the glider for the flight concerned, and that the FR was installed and operated in accordance with IGC procedures. 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. For how this is to be done, see para B1.

6 Security - Physical and Electronic.

6.1 **Physical Security.** Tamper-evident seals with the recorder manufacturer's name are fitted over screws that hold the case of the recorder unit together. In addition, an internal security mechanism operates if the case is opened.

6.2 **Electronic Security.** If the internal security mechanism has been activated, the security record (G-record) will be removed from subsequent IGC files and a line placed in the IGC file header record that includes the words "SECURITY CHECK FAILED". Also, such 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. The system used is RSA with a private key of 2048 bits. Firmware updates for the recorder are encrypted and the encryption key is known only to the manufacturer. The firmware state of the recorder is checked during power-up, and if corrupted or tampered firmware is detected, IGC files will still be generated but will fail the IGC Validate test (see 3.2 above and B3.3.1.1).

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 IGC standards, the Recorder must be returned to the manufacturer or his appointed agent for investigation and resealing. A statement should be included on how it 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 National Airsport Control authority (NAC) of the owner (the National body that validates flights to the criteria of IGC). 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 valid version. 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 recent updates.

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 and its sensors, 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 of any sort to hardware and firmware including modules inside the recorder such as the GPS receiver, pressure altitude sensor, external MOP system, and so forth. If in doubt, GFAC should be notified.

Ian W Strachan
Chairman, IGC GFAC

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

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NOTES FOR OWNERS AND PILOTS - PART OF IGC APPROVAL

- A(i) Status. To be read together with the main terms of approval to which this is an Annex.
A(ii) IGC-Approval level. All flights including world records, see para (i-ii).
A(iii) Copy of this document. It is recommended that a copy of this approval document is kept with the equipment concerned, for the use of pilots and Official Observers.

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 require 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.

A1.1 Flarm Antenna. The GPS receiver antenna should be positioned at least 15 cm from any Flarm transmit/receive antenna, to avoid interference between the two systems

A2 Geodetic Datum (Earth Model). . For IGC purposes, all latitudes and longitudes must be referenced to the WGS84 ellipsoid. This type of recorder is fixed on the WGS84 datum and no selection or switching is required except to ensure that other lat/longs such as for start, turn and finish points, are also referenced to the WGS84 ellipsoid (IGC rule).

A3 Setting the Fix Interval. The fix interval for cruise flight between waypoints is set through the menu, and fast fixing at one second interval is automatic near waypoints for the task entered. A pilot-selected fast-fix facility is indicated by "Event Marked" on the screen and gives 30 fixes at one second intervals after a Pilot Event (PEV) is recorded on the IGC file by pressing the Event button that is connected by cable to the D-connector at the back of the FR. There is therefore no need to set a very short fix interval for cruise flight because points of interest can be marked by PEV followed by fast fixing. Setting a short fix interval for *cruise flight* leads to IGC files of large byte size, particularly for long flights. This uses up more 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 on Fix Interval Settings. IGC rules include maximum fix interval setting of 60 seconds, 10 seconds for competitions that use the rules of Annex A to SC3. Annex C to SC3 (the OO guide) says: "10 to 20 seconds has been found to be suitable, and does not use up as much memory as a more frequent setting for the whole flight. A more frequent fix interval is recommended near a Waypoint to ensure that a fix is recorded within its observation zone".

A4 Checking the Recorder before a Claim Flight. Pilots are recommended to check and analyse a selection of IGC files from their recorder before attempting 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, and other values are recorded as expected. For motor gliders, ENL values should be similar to the figures given in para B5. See also A8 on ENL and A13 on pressure altitude calibration.

A5 Pre-flight Declaration in the IGC file. Electronic pre-flight declarations of Waypoints are made by selecting Start, Finish and Turn Points from Waypoint data that has been uploaded into the recorder. 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 electronic pre-flight declarations.

A6 Observing the Recorder 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. See para 5 on page 4 which refers to the position of the display, sight-lines and the need for pilot lookout and scan.

A7 Switch on. The recorder is switched on by pressing the top button on the right of the screen, then making appropriate selections to obtain the map display. 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 takeoff starts.

A8 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 an Engine (including self-sustainers). The internal microphone system automatically records the level of acoustic noise at the recorder, shown in the IGC file as three ENL numbers attached to each lat/long fix. The recorder must be placed so that engine noise is clearly received when the engine is producing forward thrust and the recorder must not be covered or insulated (even so, automatic gain should continue to ensure high ENL readings under engine power).

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 will register as high ENL. This is magnified if sideslip is present and in particular at high airspeeds. Opening cockpit panels at high airspeeds and climbing with cockpit panels open 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 normal aero-tow launches. See B4.2 for levels that have been recorded on GFAC tests by the internal ENL 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. ENL figures 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. If ENL figures are found to be significantly different to those in para B5 when using internal combustion engines, the recorder should be returned to the manufacturer for the ENL system to be re-set.

A9.2 Low-ENL Installations. For engine and FR installations that produce low ENL figures in the IGC file a separate MOP system is required, see para 4 on page 3. This applies to electric, jet and some 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.

A10 Blind Flying Instrument (BFI). The screen can be switched to Artificial Horizon (AH) mode and this is recorded in the IGC file under the BFI code. Pilots should be aware that cloud flying may be prohibited in a number of circumstances including competitions under the rules of Annex A to the Sporting Code (SC3A para 5.1) and the IGC file BFI code together with altitude may be used as a check.

A11 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 off the recorder for 5 minutes after landing because data needed to certify the flight may be lost if the recorder is switched off too early.**

A11.1 After-flight calculation of security. When the pilot ends the IGC flight file by pressing the appropriate buttons, or when the recorder is switched on again after having been switched off 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.

A12 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 B3.1).

A13 Switching Off. This is by holding in the top left control knob until the screen count-down completes.

A14 Downloading the Flight Data. Downloading is through a micro SD card inserted into the socket to the right of the display. For more details, see B3.3.

A14.1 OO's actions. For a flight to IGC standards, an OO will then carry out the actions given in para B3.3.1, 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) for gliding. The OO does not personally have to transfer the data from the Recorder, but witnesses the transfer, and immediately takes or is given a copy from the USB memory stick or SD card.

A14.2 Competitions. Different rules may apply for competition flights, for which pilots may be allowed to bring their own flight data on portable storage media 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.

A15 Pressure Altitude Calibration. 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, and 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.

A16 Caution on Electrical Power Connection. DC power is supplied through the 15 pin D-connector in the rear of the recorder. On the back there are also RJ11 or RJ45 connectors and these should not have wiring that includes DC power or damage may occur.

----- end of Annex A -----

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 to which this is an Annex.

B(ii) IGC-Approval level. All flights including world records, see para (i-ii).

B(iii) Copy of this document. It is recommended that a copy of this document is kept with the equipment concerned, for the use of pilots and Official Observers.

B1 Installation in the Glider. The FR can be fitted to an instrument panel or mounted on a bracket in the cockpit as long as the screen is easy to view by the pilot without making it difficult for external lookout and scan. An OO shall witness and record the position of the Recorder in the glider, the type and serial number of the Recorder, the glider type and registration, date and time. Before flight, if requested, the OO shall then seal the Recorder to the glider in a way acceptable to the NAC and to IGC, and such sealing may be at any time or date before flight. If sealing is not used, either a pre-flight check of the installation must be made after which the glider must be under continuous observation by an OO until it takes off on the claimed flight, or an OO must witness the landing and have the glider under continuous observation until the Recorder installation is checked. This is to ensure that the installation is as previously inspected, and that the data transfer (B3.3) is from the correct Recorder. On the position of the display, see para 5 on page 4 on sight-lines, pilot lookout and scan.

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 takeoff data from the Recorder.

B3 Landing

B3.1 Independent Evidence of Landing. The time and point of landing 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 landing data from the Recorder.

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 including any sealing to the glider of the Recorder, so that this can be compared to the check described in para B1 above.

B3.3 Downloading the Flight Data. Downloading is to the Micro SD card holder to the right of the screen. This is automatic if a card is in the holder after flight and the pilot selects the IGC flight file to end. Otherwise, downloading can be made at any time after flight by switching on and using the buttons to select a list of flight files in the memory and then the download function displayed on the screen. Security of downloaded IGC files is maintained by electronic coding placed by the FR on the file which can then be checked at any time later. See para B4 below.

B3.3.1 Files Produced. This process will produce an IGC-format ASCII flight data file with the file name YMFXXXXN.IGC, where Y = year, M = month, D = day, F = firmware manufacturer, XXX = Recorder Serial Number/letters and N = flight number of the day. The full key is in Appendix A to the IGC GNSS Recorder Specification with a summary 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, and takeoff and landing data independent of the IGC file must also be available see B2 for takeoff and B3.2 for landing.

B3.3.3 Competitions. Different rules may apply for competitions, for which 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. However, for flights that are to be Validated to IGC rules, normal IGC procedures must continue to apply including OO supervision of download after flight and secure storage of flight data independent of the pilot until the flight is Validated by the appropriate organisation.

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 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 web site for software 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 detailed flight data using an analysis program approved by the NAC concerned. The file name is not included in the IGC file validity check. The IGC Shell system only checks the data in the file, and the file name itself (B3.3.1) is not part of Validation of the flight data to IGC standards.

B4.1 IGC Shell Program. Download the IGC Shell program from the IGC GNSS web pages under "software" and place all the files in one directory. These files are on the IGC GNSS web pages through the file igcdll.zip. For the shell program to work with a particular Recorder, 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 should include the line "LXNAV V1.0" (or a later version), and this should be selected.

B4.1.1 Validation of IGC files. Select the LXV 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" or "Validation check failed" 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. For engine and FR installations where ENL figures are too low to distinguish between engine running and other noises (such as rear-mounted electric and jet engines) an FR with an external sensor operating under the MOP code is needed, see para 4 on page 3. Other detail on ENL is given 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 may be due to other factors such as undercarriage and/or airbrake movement, sideslip, open DV panels (particularly with sideslip), the nearby transit of a powered aircraft, etc. If in doubt, email the IGC file to the GFAC Chairman for further analysis and advice.

B5.1.1 ENL during Launching. During winch and aerotow, higher ENL values are expected than when soaring, 50-300 for winch and 100 for aerotow have been recorded. During the ground roll, short-term higher values may be recorded due to wheel rumble or tyre squeak.

B5.1.2 ENL during Engine Running. An ENL value of 999 has been produced by this type of recorder with a two-stroke engine running at full power and 700-950 with a 4-stroke engine at high power. At power for level flight, ENL values of 700 have been recorded. During engine running, these figures are produced for a significant time, and when altitude and speed are analysed it can be seen that substantial energy is being added not associated with soaring. Tests with Wankel (Rotary) engines indicate that they produce similar ENL values to 4-strokes.

B5.1.3 Engine and FR Installations producing Low ENL Values. Where only low ENL values are produced during engine running (such as with rear-mounted electric and jet engines), an additional MOP system must be fitted, see para 4 on page 3.

B5.1.4 ENL during Gliding Flight. ENL readings between 005 and 020 indicate slow-speed gliding flight in a well-sealed cockpit. However, flight with the canopy panel(s) open produces extra noise inside the cockpit. ENL values 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 300 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 always higher on a landing approach due to aerodynamic noises 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. With this type of recorder, ENL values of up to 340 have been recorded on the approach.

B5.1.6 ENL during landing. During ground contact during landing, short-duration ENL readings of up to 720 have been recorded, probably due to wheel rumble, or tyre squeak when landing on a hard surface.

B6 Altitude analysis and calibration. Flight data files will be analysed in accordance with Sporting Code procedures. Part of this procedure is to compare the general shapes of the GNSS and pressure altitude fix records with time, so as to ensure that no major differences are seen that could indicate a malfunction or manufactured (false) data. To ensure the accuracy of Pressure Altitude figures, the Recorder must be calibrated in an altitude chamber in accordance with Annex C to the Sporting Code.

B6.1 Calibration Method and Producing a Calibration Table. The FR should first be set to a fast fix rate. No GPS fixes are required for a pressure altitude trace to be produced, and recording starts after a pressure change of 1 metre per second for 5 seconds. The calibrator should 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 flight file. The stabilised pressure immediately before the altitude is changed to the next level, will be used for the calibration table 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; this may be done by a NAC-approved person other than the calibrator if the calibrator does not have this knowledge. The calibration file will then be analysed and a correction table produced and authenticated by an NAC-approved person (for instance an OO or FR Data Analyst). The correction table will list true ICAO altitudes against those recorded. This table can then be used to adjust pressure altitudes recorded during flights that 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. Up to an altitude of 15,000 metres, only pressure altitude is valid for IGC altitude purposes except for proof of flight continuity (no intermediate landing) where GNSS altitude may also be used. The IGC file for the calibration should be kept with the calibration paperwork. If the IGC file has a nominal date/time (because of the absence of GPS lock), the file name can be changed to one that can be identified as the calibration. Also, 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 later if 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. This is not unusual with GPS receivers operating without regional Enhancement Systems or a local Differential Beacon. Altitude accuracy will not be as good as accuracy in lat/long, because satellite geometry is not as favourable for recording altitude compared to horizontal position. This effect may be increased by poor antenna positioning or interference from other glider systems. Data analysts should allow for the above when comparing the GPS altitude and pressure altitude records. Lat/long fix accuracy is not affected. From GFAC tests over many years the average lat/long error from a moving vehicle at a number of accurately-surveyed ground points in average reception conditions is between 11 and 12m, better in good reception conditions.

B6.3 Maximum Altitudes Recorded in the IGC file. The GPS system is capable of recording to almost unlimited altitudes, certainly up to 30km/100,000ft. The pressure altitude sensor is also capable of recording to high altitudes, although as air density reduces at height, a small pressure step becomes a large altitude difference. However, the type of processor in the recorder and the need for good resolution (small steps) across the altitude range, results in limitations in altitudes that can be recorded in the IGC file. The maximum altitudes for figures in IGC files that apply to this recorder are given below.

B6.3.1 Pressure Altitude. Pressure altitude is recorded up to 30 km. However, for IGC Altitude performances over 15km (49,213ft), a High Altitude Flight Recorder (HAFR) is required in accordance with Sporting Code rules for HAFRs. This type of FR is not a HAFR.

B6.3.2. GNSS altitude. GPS altitude is recorded up to 50 km, but see above about IGC HAFRs.

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