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

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE
Maison du Sport International, Avenue de Rhodanie 54
CH-1007 - Lausanne, Switzerland
Tel +41 21 345 1070; Fax +41 21 345 1077; sec@fai.org

References:
FAI web site: www.fai.org
IGC 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

5 October 2015

IGC-APPROVAL FOR GNSS FLIGHT RECORDER

Level of Approval: **All flights (see para i-ii)**
Recorder Name: **LXNAV LX9000 series**

(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. The initial approval for this type of recorder was dated 14 June 2010. An update dated 10 January 2012 added an external Means of Propulsion (MOP) sensor, the version dated 5 May 2013 amplified the MOP paragraph, the LX9070 with a larger screen was added on 10 Oct 2013, the LX9050 with a different screen size was added on 30 June 2014, and this version adds an external MOP sensor that senses electric current for electric powered motor gliders.

(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 Airsport Control (NAC) authorities, officials and pilots is drawn to the latest edition of the FAI Sporting Code Section 3 (Gliding) including its annexes and amendments. Annex A to this code (SC3A) deals with competition matters, annex B to the Code (SC3B) with equipment used in flight validation, Annex C to the Code (SC3C) with guidelines and procedures for Official Observers, pilots, and other officials involved in the flight validation process. Copies of all of these documents may be obtained from the FAI/IGC web sites listed above and links are provided from the IGC web site. A separate document published by FAI is entitled "Technical Specification for IGC-Approved Flight Recorders" and is also available through the IGC/GNSS web site shown above.

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

MANUFACTURER

LXNAV d.o.o.	Kidriceva 24a, 3000 Celje, Slovenia
Email & Web:	info@lxnav.com www.lxnav.com
Contact:	Erazem Polutnik, Uroš Krašovic
Manufacturer Codes:	Single letter: V, three letters: LXV

EQUIPMENT

1. HARDWARE

1.1 **Recorder Name**. LXNAV LX9000, LX9050 and LX9070. Where an internal Flarm module is fitted, the letter F is added to the name. The name is shown in the header record of IGC-format files in the form: "HFFTYFRTYPE:LXNAV,LX9000F".

1.2 **Hardware Version**. Version 1.0 was the original IGC-approved hardware standard. The Version number is shown in the header record of IGC-format flight files in the form "HFRHWHARDWAREVERSION:1.0"

1.3 **Size, Weight, Power Source**. Power is from an external DC source between 11 and 16 Volts. Size and weights are as follows, less connectors on the back and knobs on the front:

LX9000	145 x 110 x 41mm ,	weight about 630 grammes.
LX9050	136 x 83 x 65 mm,	weight about 500 grammes.
LX9070	180 x 113 x 41mm,	weight about 650 grammes.

1.4 **GPS receiver**. A 16-channel LEA-4S GPS receiver by u-blox of Switzerland (www.u-blox.com) is fitted. The type of receiver and the number of channels are shown in the header record of IGC files in the form "HFGPS:uBLOX LEA-4S-2,16,max9000m". The last figure is the maximum altitude in metres processed by the recorder to the altitude resolution requirements of para 2.2 of the IGC Specification.

1.5 **Pressure altitude sensor.** A MS5561C Pressure Altitude sensor by Measurement Specialities (ex-Intersema) of Switzerland (www.meas-spec.com/pressure-sensors.aspx is fitted. This is shown in the header record of IGC files in the form "HFPRSPRESSALTSENSOR:INTERSEMA,MS5534A,max16000m". The last figure is the maximum altitude processed by the recorder to the altitude resolution requirements of para 2.2 of the IGC Specification. The pressure altitude system is compensated for temperature variation and calibrated to the ICAO ISA. The recorder case is not pressure-sealed and "cockpit static" pressure is recorded on the IGC file.

1.6 **Antenna , Connectors and Display**.

1.6.1 GPS Receiver Antenna. A SMC (Sub-Miniature type C) screw-type connector with 4mm female and 3.5mm male components is on the back of the recorder.

1.6.2 15-pin D-connector. A 25mm wide 15 pin D-connector is on the back of the recorder, and is for supplying DC power and other functions.

1.6.3 RJ-45 Connector. An 11mm 8-pin RJ-45 (8P8C) is on the back, and is for an ethernet connection. Other connections should not be used because of the risk of damage if voltage is applied to some of the pins.

1.6.4 SD Card. A receptacle for an SD card is on the front above the screen. This is for uploading files and programs to the recorder and for downloading data from the recorder.

1.6.5 Display. A colour screen is fitted to each model, slightly less in size than the largest side, and is surrounded by buttons and knobs for use for various functions in accordance with the manufacturer's instructional manual.

1.6.6 Flarm Traffic Alert function. In the F models, the Traffic Alert (TA) function is through a separate module inside the recorder case produced by Flarm Technology GmbH (www.flarm.com). The TA function is not part of this IGC-approval and IGC has no responsibility or liability for it or its use; the caveat at para (ii) on page 1, refers. References to it are solely to ensure that the description of the main features of this recorder is complete.

1.6.6.1 Flarm Transmit/Receive Antenna. A 5mm diameter SMA screw fitting on the back of the recorder is for a cable to an antenna (AE) for the Flarm Traffic Alert transmit and receive (TX/RX) function.

1.6.6 2 Flarm RJ-11 connector. A 6-pin RJ-11 socket on the back of the recorder is for connecting the Flarm display module with its indications of proximity of other Flarm-equipped aircraft.

1.6.7 D-Type Connector to the external MOP box. In FRs with firmware for an external engine sensor operating under the MOP code, the MOP sensor box (para 4.6) is connected to the 15-pin D-type connector on the back of the case via a branch to the main unit.

1.7 **National and other regulations**. These regulations may apply to electrical and electronic equipment and compliance with such regulations is not the responsibility of FAI. See the caveat on page 1, para (ii) .

2. **FIRMWARE.** Firmware Version 2.3 was the original IGC-approved firmware standard. Later versions may be used if they are IGC-approved, see para 7 below for IGC-approval of updates. The firmware version is listed in the header record of IGC files in the form: "HFRFWFIRMWAREVERSION:2.3".

3 SOFTWARE

3.1 Downloading of Flight Data. Downloading is to the SD card holder above the screen, and can be automatic if an SD card is in the holder during flight. Downloading can also be after flight through a menu that displays on the screen 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 with a recorder, 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 and MOP 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, the external MOP (Means of Propulsion) sensor box must be fitted, see 4.6 below. For the MOP sensor, the 15-pin D-connector on the back of the FR case branches into two, one branch connecting by cable to the sensor box that 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 Manufacturer. The ENL and MOP systems (where MOP is fitted) in this recorder are made by LXNAV.

4.2 ENL and MOP figures. ENL and MOP 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, see 4.6 below.

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 4.6 below.

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

4.6 External Means of Propulsion (MOP) Recording System. The MOP box has either an acoustic sensor (LXNAV MOP Type 1) or a sensor for electrical current (LXNAV MOP Type 2), and is attached to the FR by a cable. It is approved for use in low-ENL situations 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 seen by using an analys program capable of analysing 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 / ECurrent / Other, Sensor Model

4.6.1 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. If the box is interfered with, its security is trashed and a signal sent to the FR that it is no longer secure.

4.6.2 Installation. The installation of the MOP box must be inspected by an OO and, if necessary, sealed in position by the OO. It must be able to be shown that high MOP values are recorded when any positive 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 previously tested.

4.6.3 Acoustic Sensors. The LXNAV MOP Type 1 acoustic sensor box weights about 70 grammes and is 66 x 50 x 25 mm in size . A 9-pin male D-connector adds 5mm at one end. It must be installed so that it picks up maximum engine or propeller noise when any forward thrust is being produced. There are two sensors with different frequency ranges.

4.6.3.1 Type 1a Low Frequency Sensor Box. This has a similar to the ENL sensor inside the FR and has a peak response between 100 and 200 Hz, it should be placed as close as possible to the engine and/or propeller disc. It may be used with all engine types, subject to producing high MOP numbers in the IGC file when any forward thrust is being produced.

4.6.3.2 Type 1b High Frequency Sensor Box for Jet Engines. This has a peak response about 5 kHz and should be installed close to the rear of a jet engine because most noise is propagated behind the engine and not in front. It should not be used with other than jet engines because there may not be enough signal at 5 kHz to produce significant MOP numbers in the IGC file.

4.6.4 Electric Current Sensor Box. The LXNAV MOP 2 sensor box is for use with rear-mounted electric engines. It is the same size and weight as the acoustic sensor box (para 4.6.3) and in addition has a short cable connection to a unit with a ring fitting that senses electrical current when the main engine electrical supply cable is inserted through the ring. The ring can be opened and then closed round the main engine motor cable and must then be sealed by an OO so that if it becomes detached from the engine cable, the seal will be broken. The ring fitting is about 50 x 30 x 15mm in size with an 18mm aperture for the engine cable, and weighs about 30 grammes. If the cable between the box and ring is broken or interfered with, the MOP reading increases to 999 and this invalidates any IGC flight claim.

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 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 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 1024 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

Any questions to: Chairman IGC GFAC,
Bentworth Hall West Wing, Alton, Hampshire GU34 5LA, UK
Tel: +44 1420 564 195; Fax (on request): +44 1420 563 140
email: ian@ukiws.demon.co.uk

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 the Flarm transmit/receive antenna for the Traffic Alert (TA) function, 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 fast-fix facility gives 60 fixes at one second intervals and occurs after a Pilot Event (PEV) is recorded on the IGC file. A long press of the lower button on the left of the screen on the display unit records a PEV event and starts fast fixing. Also, fast fixing is automatic near waypoints for the task entered for the flight. The fix interval for *cruise flight* between PEV events (such as between Waypoints) is set by the pilot before flight through a menu on the screen. There is therefore no need to set a very short fix interval for cruise flight because points of interest can be marked by PEV events 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 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 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, ENL and other values are recorded as expected. For motor gliders, ENL (and MOP where fitted) 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. In addition, where fitted, the method of fixing of an external MOP engine sensor (para 4.6 on pages 3 & 4). 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 left of the screen and 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 FR ENL system and by external MOP systems.

A9.2 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 4.6 on pages 3 & 4. 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 installation 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 **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.**

A10.1 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.

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 B3.1).

A12 **Switching Off**. This is by pressing the appropriate buttons, or by disconnecting external power.

A13 **Downloading the Flight Data**. Downloading is through an SD card inserted into the socket over the top of the display. For more details, see B3.3.

A13.1 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.

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 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 A13.1continues to apply.

A14 **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.

A15 **Caution on Electrical Power Connection**. DC power is supplied through the 15 pin D-connector in the rear of the recorder. Damage may occur if RJ11 or RJ45 connectors are used with wiring that includes DC power.

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

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 approval 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. The same applies to the MOP box external to the FR (if fitted), which must be positioned to receive maximum signal whenever forward thrust is being generated, see para 4.6 on pages 3/4. 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 (and its external MOP system, if fitted), so that this can be compared to the check described in para B1 above.

B3.3 Downloading the Flight Data. Downloading is to the SD card holder above the screen. This is automatic if an SD card is in the holder during flight and the pilot manually selects the IGC flight file to end or on swithcing on again after switching off after flight. Otherwise, downloading can be made at any time after flight by switching on and using the top right knob 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 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 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. 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. 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 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 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.

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 available 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 with rear-mounted electric and jet engines), an external sensor operating under the MOP code must be connected by cable to the FR so that it can be positioned to receive a high signal whenever the engine produces forward thrust, see para 4.6 on pages 3/4. In this case, three MOP numbers are recorded in each fix in addition to those for ENL. Other detail on ENL and MOP 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 (10 seconds or so) 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 (see page 5 for email address).

B5.1.1 ENL during Launching. During winch and aerotow, higher ENL values are expected than when soaring, typically up to 250 for winch and 100 for aerotow. During the initial 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 850 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 that is 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 vales are produced during engine running (such as with rear-mounted electric and jet engines), an additional MOP system must be fitted, see para 4.6 on pages 3 & 4 and B5.2 below.

B5.1.4 ENL during Gliding Flight. ENL readings between 004 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 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 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 470 have been recorded on approach with cockpit panels open.

B5.1.6 ENL during landing. During ground contact during landing, short-duration ENL readings of up to 700 have been recorded, probably due to wheel rumble, or tyre squeak on landing on a hard surface.

B5.2 External MOP system, when fitted. Where there is an MOP sensor external to the FR (see para 4.6 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 numbers are as expected, particularly under high engine power, although the ENL readings will be much 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 LXN MOP Type 1a. This is described in para 4.6.3.1 on page 3, 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 over 950 have been recorded at high power in several types of gliders with engines.

B5.2.1.2 Acoustic Sensor LXN MOP Type 1b. This is the high frequency acoustic sensor for jet engines, described in para 4.6.3.2 on page 3. In GFAC tests, MOPs over 950 have been recorded at high power in a Ventus. Jet. The lower frequency sensor (B5.2.1.1) can also be used with a jet engine as long as the installation can be shown to produce high enough MOP values.

B5.2.1.3 Electric Current Sensor LXN MOP Type 2. This is described in para 4.6.4 on page 4. In GFAC tests, MOPs over 950 have been recorded at high power in an electric-powered Antares. The lower frequency sensor (B5.2.1.1) can also be used with an electric engine as long as the installation can be shown to produce high enough MOP values in the IGC file.

B5.2.2 Engine-off.

B5.2.2.1 Acoustic Semsors. In GFAC tests with acoustic sensors and 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.

B5.2.2.2 Electrical Current Sensors. In GFAC tests in an Antares 20E, with engine off the MOP averaged about 100 because the cable from which the current was measured also supplied the instruments. This may or may not be so in other installations, depending on whether the cable from which the current is sensed feeds just the engine or other functions as well.

B6 **Altitude analysis and calibration**. Flight data 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 a malfunction or manufactured (false) data. As part of this process, the Recorder is 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 an 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 or 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 16 km (52.493 ft).

B6.3.2. GNSS altitude. GPS altitude is recorded up to 18 km (59,055 ft).

-------------------- ends -------------------