Report to IGC from the Chairman of the GNSS Flight Recorder Approval Committee (GFAC)

for the agenda of the 2020 IGC Plenary

5 January 2020

1. **GNSS Flight Recorders**. A total of 62 types of GNSS Flight Recorders (FRs) from 19 different manufacturers are currently IGC-approved. If different models within types are included, the number increases to 71.
References: www.ukiws.demon.co.uk/GFAC/igc_approved_frs.pdf or through www.fai.org/igc-documents
These numbers are slightly lower than reported to the Plenary last year, so it might be thought that GFAC had little to do during 2019. However, the reverse was the truth, as shown below.

2. **Update of IGC-approval Levels**.

2.1 IGC-approval Levels. The three IGC-approval levels are: Level 1for all flights including world records; Level 2 for all badges and distance diplomas; Level 3 for badge flights up to and including the three Diamonds. The 2019 Plenary was briefed that we need to lower the Levels of FRs that are vulnerable to hacking because they were designed to Specifications that are now obsolete. For instance, Level 1 includes world records and is therefore no longer appropriate to FRs whose manufacturers no longer exist, or where the FR design standards are well below those in the current FR Specification, particularly on aspects of security.

2.2 Approval Level Update. During 2019, each manufacturer of IGC-approved Flight Recorders was asked to check that the FR data on the IGC and GFAC web pages was up-to-date, and whether it was possible to update old types of FR. After this, the approval levels of all IGC-approved FRs were re-assessed in the light of the higher standards needed today compared to when the IGC FR system started in 1995. It also took into account manufacturers no longer in the FR business, and therefore unable to update or check flight data from FRs that continue in service. In accordance with the GFAC presentation to the 2019 Plenary, a revised approval table was prepared by the ANDS and GFA Committees for the IGC Bureau, and after time was allowed for Bureau comments, the process of making changes was started, as described below. This was the second largest such exercise carried out by GFAC since it was created. The following changes were made:

2.2.1 Level 1 FRs reduced to Level 2. These were the Aircotec XC Profi, Cambridge 302, ClearNav 1, DSX T-Advisor & Tracer, EW microRecorder, Garrecht Volkslogger, IMI Erixx, NT Easy, Zander/SDI 941. These had low private security key lengths and could not be updated to current Specification standards.

2.2.2 Level 2 FR reduced to Level 3. The Scheffel Themi has several non-compliances with the current Specification, and the manufacturer is no longer active.

2.2.3 Level 2 FR - approval withdrawn. The Peschges VP8 is a 1997 design with many non-compliances with the current Specification, there is no facility to make electronic flight declarations, and the manufacturer is no longer an active company.

2.2.4 Summary. Level 1 FR types were reduced from 38 to 26, Level 2 increased from 3 to 14 (with old Level 1 types), Level 3 remaining the same at 21 FR types.

2.2.5 Implementation. Affected manufacturers were contacted (where they still exist) and given the opportunity to update their FRs. After a period in which manufacturers could make proposals, revised IGC-approval documents were published giving notice that the above changes would take place on 1 January 2020. Reductions in approval levels became effective on that date.

3. **Future editing of IGC-approval documents**. The above process showed that the detail in other IGC-approval documents is out of date, including FAI/IGC/FR web references and manufacturer details. In 2020 it is intended to progressively work through all old IGC-approval documents and update these items.

4. **Analysis of IGC Files**. In August 2019 Dr John Wharington and Matt Gage forwarded a draft 18-page paper to ANDS and GFAC in which GPS altitudes in files from IGC-approved Flight Recorders were analysed. Dr Wharington is a member of GFAC, and both authors are members of the Gliding Federation of Australia (GFA). This paper documented several problems in GPS altitude figures in IGC files which are summarised below.

4.1 Wharington/Gage Paper. This comprehensive and detailed paper shows that many IGC-approved Flight Recorders use a Geoid earth model for GPS altitude rather than the WGS84 Ellipsoid. Before this, ANDS and GFAC understood that GPS receiver modules used the WGS Ellipsoid as their altitude reference, because the Ellipsoid is a simple geometric figure compared to more complex mathematical models such as one of many different Geoids (see para 4.4).

4.2 GPS Altitude Zero Datum. In the IGC Flight Recorder Technical Specification and Sporting Code Annexes B and C, the zero GPS altitude datum has always been defined as the WGS84 Ellipsoid, a simple geometric model with precise equator and polar radii. A Geoid earth model is not used because it is considerably more complex, based on equal gravitational force. It is therefore close to mean sea level (MSL) which varies across the earth depending on local gravity which depends on factors such as mountain ranges, ocean depths, etc, see para 4.4.

4.3 GPS altitudes in IGC files. In the early days of IGC FRs, there were many examples of erratic GPS altitudes in IGC files where lat/long data showed normal accuracy. This was because the design of low-cost GPS modules use in FRs paid little attention to processing altitude compared to horizontal position. With more modern GPS modules that output better altitude figures, even with perfect GPS reception and altitude processing by the GPS module, vertical error will be between about 1.8 and 2.2 times greater than horizontal error. This is because the angle of the position lines from GPS satellites is better for horizontal rather than vertical position. For instance, if horizontal error is 10 metres (32.8ft), it is likely that vertical error will be between 18 and 22 metres (59 to 72 ft). In addition, the satellites used for fixes will constantly vary as they rise and fall with respect to the horizon, and different FR and antenna systems in gliders will cause different satellites to be processed, particularly those near to the horizon. These effects will result in different GPS altitudes in IGC files, including from gliders that are close to each other, for instance in a thermal in which angle of bank may also be a factor because GPS reception will vary depending on the polar diagram and gain of the individual glider's GPS antenna system at different bank angles. Different horizontal positions will also be recorded but of less magnitude than in altitude. Fortunately, in current IGC flight validation, GPS altitude has no function except for the special case of High Altitude Flight Recorders (HAFR) used above 15,000 metres, for instance by the Perlan project. For these reasons, before the Wharington/Gage paper, GFAC tests for IGC-approval did not include GPS altitude except for HAFRs. In the future, GPS altitude will be tested with respect to the WGS ellipsoid and it is regretted that this was not done before.

4.4 Geoids and the WGS84 Ellipsoid. ICAO document 9674, the WGS84 Manual, is a complex 138 page document, and defines many things including an equipotential geoid as well as an ellipsoid. The WGS84 Geoid is an irregular surface that varies from the WGS84 Ellipsoid by plus 65 metres (213ft) south of Iceland to minus 102 metres (335ft) south of India (total variation 167m (548ft)), with fairly random variations in between due to local gravity which depends on factors such as thickness and density of the earth's crust.

An irregular shape like the WGS84 Geoid is significantly more difficult to model mathematically than an ellipsoid. In addition, a number of different geoids are defined, and 30 are listed on the US National Geodetic Survey (NGS) web site. Finally, Geoid figures at different Lat/longs will vary between different types of FR depending on how closely the particular Geoid is modelled in the FR firmware.

4.4.1 IGC FR GPS altitude datum. As there are many different geoids, to avoid confusion between which one we could use there is no reason to change the IGC FR GPS altitude datum from the WGS84 ellipsoid. Therefore, IGC-approved FR manufacturers currently using a geoid in their IGC files have been asked to change to the WGS84 Ellipsoid at their next system update and to encourage existing FR owners to carry out the update. LXNAV and Naviter updated to the WGS84 Ellipsoid in December 2019 (including the LXNAV HAFRs), LX Navigation has responded positively, and other manufacturers are expected to follow. Some FR manufacturers are no longer in business and where a Geoid model was used this will continue, but as GPS altitude is not used for IGC performances (other than HAFRs) this will have little effect. For analysis of GPS altitudes as discussed in theWharington/Gage paper, it is not difficult to apply an approximate geoid/ellipsoid offset where necessary, so that for analysis purposes all altitude figures can be with respect to the same zero-datum.

5. **Conclusion**.
Important GFAC issues at the end of 2019 are covered above, and an update will be given to the Plenary in Budapest.

Ian W Strachan
Chairman IGC GNSS Flight Recorder Approval Committee (GFAC)

Annex: Current GFAC membership

Annex to GFAC Report for the 2010 IGC Plenary Agenda

Current Structure of GFAC

Members - in alphabetical order of family name

Angel Casado PhD (Spain)
Miguel Madinabeitia MSc (Spain)
Peter Purdie BSc (UK)
Ian Strachan FRAeS (UK, Chairman)
Hans Trautenberg PhD (Germany)
John Wharington PhD (Australia)

GFAC member Tim Shirley (Australia) retired in March 2019 and was replaced by John Wharington as listed above. Thanks are due to Tim for his contribution over many years.

Technical Advisors

Dickie Feakes, Bicester Aviation Services (UK)
Tim Newport-Peace, Specialist Systems (UK)
