Fédération Aéronautique Internationale

Section 3 – Gliding

Annex C
Official Observer & Pilot Guide

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current to the 2019 Sporting Code

23 November 2019 revision

FEDERATION AERONAUTIQUE INTERNATIONALE

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Rights to FAI international sporting events

All international sporting events organised wholly or partly under the rules of the Fédération Aéronautique Internationale (FAI) Sporting Code[1] are termed *FAI International Sporting Events*[2]. Under the FAI Statutes[3], FAI owns and controls all rights relating to FAI International Sporting Events. FAI Members[4] shall, within their national territories[5], enforce FAI ownership of FAI International Sporting Events and require them to be registered in the FAI Sporting Calendar[6].

An event organiser who wishes to exploit rights to any commercial activity at such events shall seek prior agreement with FAI. The rights owned by FAI which may, by agreement, be transferred to event organisers include, but are not limited to advertising at or for FAI events, use of the event name or logo for merchandising purposes and use of any sound, image, program and/or data, whether recorded electronically or otherwise or transmitted in real time. This includes specifically all rights to the use of any material, electronic or other, including software that forms part of any method or system for judging, scoring, performance evaluation or information utilised in any FAI International Sporting Event[7].

Each FAI Air Sport Commission[8] may negotiate agreements, with FAI Members or other entities authorised by the appropriate FAI Member, for the transfer of all or parts of the rights to any FAI International Sporting Event (except World Air Games events[9]) in the discipline[10], for which it is responsible[11] or waive the rights. Any such agreement or waiver, after approval by the appropriate Air Sport Commission President, shall be signed by FAI Officers[12].

Any person or legal entity that accepts responsibility for organising an FAI Sporting Event, whether or not by written agreement, in doing so also accepts the proprietary rights of FAI as stated above. Where no transfer of rights has been agreed in writing, FAI shall retain all rights to the event. Regardless of any agreement or transfer of rights, FAI shall have, free of charge for its own archival and/or promotional use, full access to any sound and/or visual images of any FAI Sporting Event. The FAI also reserves the right to arrange at its own expense for any and all parts of any event to be recorded.

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1 FAI Statutes, ... Chapter 1, ... para. 1.6
2 FAI Sporting Code, Gen. Section, ... Chapter 4, ... para 4.1.2
3 FAI Statutes, ... Chapter 1, ... para 1.8.1
4 FAI Statutes, ... Chapter 2, ... para 2.1.1; 2.4.2; 2.5.2 and 2.7.2
5 FAI By-Laws, ... Chapter 1, ... para 1.2.1
6 FAI Statutes, ... Chapter 2, ... para 2.4.2.2.5
7 FAI By-Laws, ... Chapter 1, ... paras 1.2.2 to 1.2.5
8 FAI Statutes, ... Chapter 5, ... paras 5.1.1, 5.2, 5.2.3 and 5..2.3.3
9 FAI Sporting Code, Gen. Section, ... Chapter 4, ... para 4.1.5
10 FAI Sporting Code, Gen. Section, ... Chapter 2, ... para 2.2.
11 FAI Statutes, ... Chapter 5, ... para 5.2.3.3.7
12 FAI Statutes, ... Chapter 6, ... para 6.1.2.1.3

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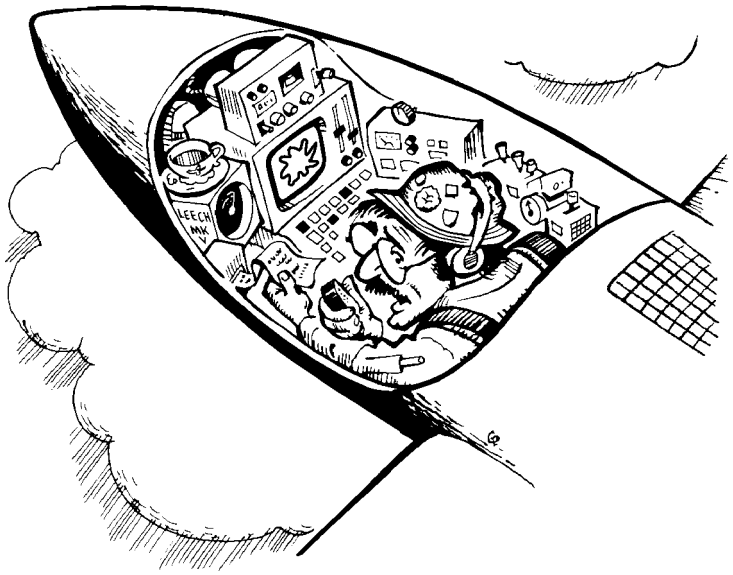
Note
Annex C may be revised more than once a year when improvements or additional information regarding the best way to follow the Sporting Code are brought to the attention of the Sporting Code committee. The latest release date is shown under the Sporting Code date on the cover page.

A vertical line to the right of any paragraph indicates a notable change in the subject material from the previous Annex. Minor text editing is not so marked.

What do I do now, the control stick just retracted ?!



The modern cockpit.

Official Observer & Pilot Guide

GENERAL

1.1 Purpose of this Annex The Annex assists pilots and Official Observers (OOs) to interpret the rules of the Sporting Code. It amplifies these rules and gives guidance on how to comply with them, and recommends procedures for the operation of equipment used to provide evidence for flights. However, nothing in the Annex overrules the Code. Changes to the Annex do not require formal IGC approval.

Although clarity and simplicity is the goal of the Sporting Code, how one is to respond to the requirements may be confusing. If you think that any part of the Code is capable of more than one interpretation, pass your concern to the IGC Sporting Code committee chairman at *igc-sporting-code@fai.org*. Suggested improvements to the text will always be given consideration.

1.2 The National Airsport Control (NAC) A NAC administers FAI air sports in its country. It may delegate to another organisation such as its national gliding association that part of its sporting powers. In the Code and this Annex, "NAC" means the NAC or its delegated organisation. Its responsibilities are to:

a. Maintain control of its national Claims Officer, OOs, data analysts, and FR pressure calibration labs.

b. Have responsibility for the integrity and accuracy of data that it ratifies.

c. Maintain a list of position recorders (PRs) that it accepts or has tested. Approval documents for PRs that comply with the Sporting Code will be posted on the IGC website by GFAC.

d. Transmit to the FAI data on completed Diamond badges and Diploma flights.

e. Submit notice of record claims to the FAI (see SC3-3.5), prepare and forward complete record claim documentation to reach the FAI within the normal time limit of 120 days.

f. Modify IGC record forms to incorporate national-only record types, and may maintain a national turn point list.

g. Maintain a badge claim form and registers of national badge leg, badge, FAI Diploma, and record flight achievement.

1.3 NAC – Recommended Practices

a. *OO appointment and training* NACs should establish requirements for becoming an OO, such as holding a Silver badge as a minimum or having an association with the sport for some minimum time. It is useful to issue guidance material, self-help tests, etc. to assist new OOs gain knowledge of the Code and allow experienced OOs to stay current on changes to the rules.

b. *OO control and tracking* As a minimum, each NAC should maintain a list of its current OOs and their contact information, enabling the distribution of information on changes to badge and record procedures or national factors that will influence badge and record flights.

c. *Preliminary review of claim* In the interest of efficient processing of record and badge claims, a NAC may allow specified persons to perform a "first look" review of e-mailed flight data and pertinent scanned documents, if any, such as a paper declaration. The .igc file(s) for a flight should be submitted to the Claims Officer by the OO soon after the flight as an obvious problem may then be noted that could shorten or eliminate processing time and effort. This preliminary review can be performed at the level of the Claims Officer or a NAC-appointed data analyst. Badge claims may also be prescreened at the club level by an experienced "senior" OO, which can reduce a Claims Officer's workload by correcting errors in a claim form or not forwarding invalid ones.

d. *NAC jurisdiction* The relationship between an "organizing NAC" and a "controlling NAC" is given in SC3-4.1. A claim by a pilot who is a member of another NAC must be certified by the OO who, prior to the flight, has been approved in writing by the host country (controlling) NAC (SC3-4.1b). The OO shall send the completed claim to the controlling NAC for a check for compliance with national aeronautical rules who, in turn, will forward the claim to the organizing NAC.

An OO who is a member of another NAC wishing to act on badge or record claims must apply to the host NAC for permission to act within its jurisdiction. Simple e-mail communication between the host

NAC's National Claims Officer and the foreign OO is suggested; however, the host NAC is under no obligation to accept such a request. They may require that the OO have some minimum level of local knowledge for such approval.

e. *Acting for World or Continental Records* OOs acting for World or Continental records must have prior written approval from their organizing NAC and from the controlling NAC for flights outside his own jurisdiction (see SC3-4.2.3b).

f. *Position Recorder approval* When a PR has been used, its status should be checked by both the host and controlling NACs. Clearly, the claim may be approved if both NACs have approved the device and the conditions of approval are similar. In any other case, the NACs should confer and the controlling NAC may proceed as it sees fit.

1.4 Official Observer duties An OO has the responsibility of being the FAI's "field representative". An OO ensures that the flight is controlled in accordance with Code requirements, and that the required flight evidence is gathered and prepared in such a manner that later study of it by an independent examiner (usually the national Claims Officer), will leave no doubt that the claimed achievement was met.

The OO must act independently and without favour, and be familiar with the definitions in Chapter 1 of the Sporting Code. The ability to correctly interpret the Code is important – it is even more important for the OO to pay careful attention to detail and have the integrity to never approve a claim unless satisfied it is correct and complete. The OO can refer a claim to higher authority if there is some question that the flight does not fulfill the rules. The Code standards are the foundation of soaring achievement, so a rejected badge or record claim is a cautionary learning experience for the pilot. Note that although references in this Annex are made to "the OO", any number of OOs may be involved in the control of a given claim.

1.5 National records A NAC may have additional record types or classes and accept different forms of evidence for them; however a flight that leads to a claim for a World or Continental record must conform fully to the Sporting Code.

1.6 Measurement accuracy and precision

a. *Precision errors* Do not introduce more precision to a calculated value than the recording devices can detect. A flight recorder (FR) may record altitude values to the nearest metre, but its pressure sensor is not capable of resolving height to that precision, especially at high altitude.

Use of a conversion factor cannot add precision. Recorded values should be used in all intermediate calculations, but the final result must be rounded to the precision of the *least accurate* data. Such misuse is often seen on altitude gain claims.

Dynamic pressure errors, errors associated with reading FR barograms, and (if necessary) drawing a calibration graph – all these introduce uncertainty in the precise height achieved. This height *cannot* be accurate to the metre, regardless of the calculations. The resulting gain or absolute altitude value should be rounded down to the nearest 10 metres. If a second set of air pressure data was recorded, the worse case height reading is to be taken as the performance.

b. *Measurement accuracy* Badge claims are certified for performances that *exceed* a specified minimum, so the distance calculated by common flight analysis software is normally sufficient. If there is any question as to the distance meeting a badge requirement, then use the FAI World Distance Calculator below.

c. *Badge distance calculation* First, find the course distance by using evaluation software set to the WGS84 earth model or by calculating the sum of course "leg" distances, each determined by the FAI World Distance Calculator set to the WGS 84 earth model. This calculator may be used online or downloaded from https://www.fai.org/page/world-distance-calculator. Next, determine if a loss-of-height (LoH) and/or cylinder correction applies; if so, find their sum. Finally, calculate the official distance = course distance – (LoH + cylinder corrections).

d. *Pressure and GNSS altitudes* Both pressure and GNSS altitudes are recorded in files from IGC-approved FRs in the form of figures in each fix line. Pressure altitudes comply with the ICAO International Standard Atmosphere (ISA), which has a zero pressure altitude datum of 1013.25 millibars. The IGC zero GNSS altitude datum is the surface of the WGS84 ellipsoid. With increased altitude, the resolution and accuracy of pressure altitude reduces due to lower air density, but the resolution and accuracy of GNSS altitude is maintained. For this reason, High Altitude Flight Recorders (HAFRs), now required for altitude record attempts above 15,000 metres, are designed to output particularly accurate GNSS altitudes in their .igc files. See Appendix 6 to this annex, also Annex B to the Sporting Code (SC3B) on IGC-approved FRs, and the IGC FR Technical Specification.

1.7 Responsibility for following flight regulations (SC3-4.4.2a) The pilot-in-command is responsible for following general and local regulations as well as the glider's technical limitations, and shall certify this for the claimed performance. The OO must not certify a claim for a flight that was performed illegally, therefore knowledge of local regulations is required. This is particularly important for OOs acting in a foreign country. The legal definition of "local sunset" is an example for a record distance claim. It is for this reason that the local NAC must approve OOs acting in their jurisdiction and process record claims from them (SC3-4.1b).

TASK CONSIDERATIONS

2.1 Pilot preparation The most valuable thing you can do to meet the requirements of a task is to carefully *prepare* for the intended flight. Lack of preparation may seriously delay your planned flight, may result in the missing or faulty evidence that accounts for most rejected claims, and demonstrates a less than professional attitude towards your flying. Your preparation of *impeccable* evidence requires some care and time, so anticipate the day and plan for it during the off-season – this will go a long way towards your success. Equally important, are you yourself physically and mentally ready for a flight that may last all day?

a. Study the *current* Sporting Code to understand the requirements for the task (the Chapter 1 task table is particularly useful), and discuss your planned flight with an OO. On-Line-Contest rules *do not* apply. For example, a flight in which the OLC scores one of its legs as being over 50 km doesn't necessarily qualify as a Silver distance flight.

b. Be completely familiar with your flight recorder and the loading of the declaration and task data. Practice with the recorder on local flights before trusting yourself to use it correctly for a badge flight.

c. Have only the *current* badge, record, and other flight forms on hand.

d. Keep your task-planning documents in a separate folder, keep it handy, and review your plans regularly. Plan several tasks for different meteorological conditions and have them loaded in your FR or available on your computer. Make and use a checklist.

2.2 The Silver duration flight A duration flight is often unplanned – a fun flight may turn into a badge opportunity with no FR/PR on board. If so, make sure that an OO is made aware of this so that the flight can be monitored. The big problems associated with the Silver duration flight are:

a. *Boredom* Boredom causes loss of concentration and thermalling skills. Set a series of "mini-tasks" for yourself: an efficient climb, using every bit of some weak lift, a series of 10 km goal flights, etc.

b. *Reluctance to fly away from the field* You cannot stay up if you don't go to the lift. Fly 10 km from the field – your glider can go that far. Get high and stay high.

c. *A full bladder or dehydration* This is *NOT* a choice; do not allow yourself to become dehydrated to avoid the distraction of a full bladder. If you feel thirsty, you have waited too long to drink and are already dehydrated. Drink an excess of fluid first thing in the morning then empty your bladder shortly before take-off. Being fully hydrating before flight will delay the need for fluids; the water you carry on the flight is there to maintain the hydration level you had at launch. Carry sufficient water for the temperature conditions and use a workable method of urine disposal.

2.3 The Silver distance flight The Silver distance is a "leaving the nest" adventure, intended to get you away from your home airfield and to plan for a potential land-out. The "no-help-or-guidance" note in SC3-2.2.1a applies, meaning even help from other Silver distance hopefuls that day, or team flying. Now, any finish fix at least 50 km from your release point or MoP stop *and* your launch point will be required, *regardless of any other turn points that may be declared, or the success or not of a greater task.* Any longer task is evaluated separately, on its own merits.

When Silver distance is the only objective, plan a finish fix a bit more than 50 km from the beginning of the take-off roll, so you have some flexibility in where to release. If a finish fix is planned 55 km from the beginning of the take-off roll, then release can be anywhere within 5 km of the airfield.

For all Silver distance claims, the maximum LoH permitted for a flight over 100 km is calculated as in paragraph 3.2, and the maximum LoH permitted for a flight under 100 km is calculated as in 3.1. If the Loss of Height (LoH) between release and the selected finish fix is excessive, then choose another fix that is within the LoH limits. Common flight analysis software can be used to find the beginning of the take-off roll at launch. 2.14 gives Instructions.

2.4 Cross-country courses The general types of courses available for badges and records are:

a. Courses that *require* start and finish line crossings and turn points, if any, used in the declared order:

- Goal Distance for records only – no TPs may be declared or claimed.
- Out & return courses for Diamond Goal, distance or speed records – only one TP is declared.
- Triangle courses in two variants for Diamond Goal and Triangle distance or speed records:

  If two TPs are declared, distance is measured start/finish point-TP1-TP2-start/finish point.

  If three TPs are declared, distance is measured TP1-TP2-TP3-TP1, the sum of *triangle legs.*

b. Tasks that *don't require* start and finish line crossing or the use of declared TPs in declared order.

- Straight Distance for Silver Distance, requires a flight of at least 50 km from release to a finish fix which is also at least 50 km from the beginning of the take-off roll.
- Straight Distance for Gold, Diamond or Diploma distance may be claimed from release *or* a declared start point, to landing, a finish fix, or declared finish point.
- 3 TP Distance for Gold, Diamond and Diploma Distance as well as records, provides for:

  A start at release or MoP stop, or crossing the start line at the declared start point.

  At least 1 and no more than 3 declared TPs used in any order.

  A finish may be claimed at landing, a finish fix or crossing the finish line at the declared finish point.
- Free distance records do not require declared way points; fixes selected post-flight are usually claimed as way points. The pilot may claim a declared way point in its order of use.

In both broad categories above, a turn point can have the same coordinates as the start or finish point and, if a turn point is to be used twice it must be listed twice in the declaration.

2.5 Loss of Height (LoH) considerations

a. When planning any task course, always be aware of the max LoH you can incur before it nullifies the badge or record attempt. More detail is given in 3.2 and 4.5.

b. Do not assume that the LoH value calculated by common flight analysis software is accurate. (Other software analysis problems are described in 10.8.) If an excessive LoH is indicated, examine closely the waypoint fixes selected by the software. Selecting a different waypoint for a free distance task claim can minimize or eliminate a LoH penalty.

2.6 Common badge flight errors OOs reject many claims as a result of common errors on badge flights. Here are some flight preparation or execution factors that can result in your claim failing:

a. You flew it with no planning, and then expected that the OO would find a way after the flight to make it fit the badge requirements.

b. You did not ask for a briefing on the usual task pitfalls *before* you attempted a specific task.

c. You did not complete an Internet or paper declaration when using a PR for a distance flight.

d. You did not know the maximum height you could be towed to on an under-100 km distance task. This is particularly important if the landing elevation becomes your finish fix and it is at a lower elevation than your take-off point. Conversely, if you choose a high tow, then you must know the minimum height allowed at your finish point. See the table in 3.1.

e. You did not confirm that the FR(s) being used on your flight had your name and the correct glider information stored. Refer to 2.7 below.

f. You are a beginner in the use of the FR and did not practice using it to make sure you entered the OZ of your intended TP, or your FR was configured to sound a TP entry alert for a cylinder OZ, so you turned away on course before you entered the sector OZ that was needed for your task distance.

g. You took the FR out of the glider, or downloaded the .igc file, or removed an SD card and gave it to the OO later that day. See 9.2 – the OO *must* control the FR after landing until the .igc file is down-loaded. This mistake is easy to make if you flew a club glider that will then be used for another task.

h. Your OO did not keep a copy of the flight file and the original was contaminated. A link to a file on the OLC is not sufficient as it *will not* validate.

2.7 Notes on declarations If you are new to flight recorders in general or to a particular FR or linked device, make some practice flights before a badge attempt – it is the best way to avoid declaration problems. Enter a declaration each time you fly, and check it carefully post-flight to make sure the correct data appears where it belongs in the .igc file. However, for Silver and Gold claims only, an error in pilot-entered pilot and aircraft data can be remedied as described at 6.5. The structure of FR declarations is described in 6.4. Consider the following:

a. A declaration is not required for duration claims when the OO certifies basic pilot and glider data (SC3-4.4.2d).

b. It is now common for more than one device capable of acting as an FR to be installed in the glider, even though it may not be its primary use, a FLARM for example. It is also possible that a pilot may not be aware of what devices in a club ship can act as an FR. Therefore, prior to a flight for a badge or record claim, the pilot must specify to the OO what units they intend to use and which contain the flight declaration. *Only these unit(s) inspected (controlled) by the OO before the flight can be used in the claim (SC3-20b)*.

c. When more than one FR/PR installed in the glider is to be used, the task declaration (except for the recorded time of declaration) must be identical in each device. Any difference in the declaration between FRs could be grounds for refusing the claim.

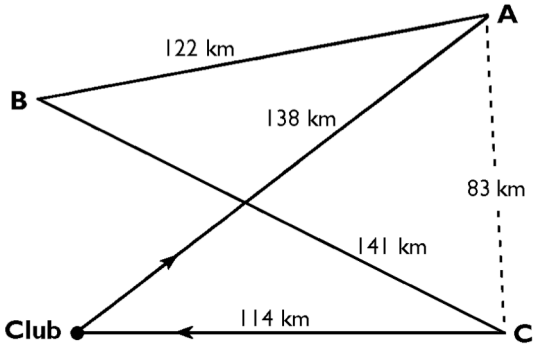
d. A pilot using an FR/flight computer system may be rushed before take-off and confuse its "declaration" and "navigation" functions. If you wish to make a last minute change to a Silver or Gold badge task, writing a new Internet or paper declaration is an option. Note the timing warning in para 6.4a. An Internet or paper declaration is *always* required when using a PR, and a declaration input into an FR is the *only* acceptable means of data entry for record attempts.

e. Compatibility problems can arise between an FR linked to a third-party PDA or flight computer. The end result may be a flawed declaration, and it could be difficult or impossible to determine whether the FR, the software, or user procedures are responsible. If a flawed declaration appears to be due to a fault or anomaly in the FR, report it promptly to the FR manufacturer and copy the GFAC chairman, currently *ian@ukiws.demon.co.uk*.

2.8 Internet declarations (SC3-2.3a) A NAC may accept declarations sent via internet, either by e-mail or to an approved website if it has this method in place. The OO must be satisfied the declaration is valid by inspecting its time stamp. The time stamping is performed automatically by servers and can be checked in e-mail headers or server logs. Any solution chosen by the NAC or OO should clearly show the declaration time stamp. Note that e-mail headers contain several time stamps from each server accessed; they should be checked to select the correct one. Date and time shown next to the sender/subject in e-mail readers is not to be trusted.

2.9 Claiming more than one soaring performance

A flight may satisfy the requirements for more than one badge leg or record, and claiming a declared task does not prevent the pilot from also claiming straight distance from release to a finish fix. Planning a task begins with the selection of turn points that accomplish your chief objective but may also provide for an alternate or additional claim. This may also allow you to make useful in-flight decisions on course selection. Examine the course shown here (club/A/B/C/club). If this declared flight is completed, *all* the following badge tasks can be claimed:



a. *Silver distance* – 138 km (club/A)
If the pilot abandoned this flight more than 50 km from the club, Silver distance is achieved by claiming straight distance from the shorter of the release and the take-off points to the finish fix.

b. *Gold Distance and Diamond Goal distance* – 346 km (A/B/C/A)
Note that the A-club-C legs indirectly complete the A-C leg of the ABC triangle.

c. *Diamond distance* – 515 km (club/A/B/C/club)

2.10 Abandoned turn points and other declared task problems A task not flown as declared might meet the requirements of another soaring performance – so rather than focusing on the failure, look for what was achieved. In the above example, if the turn points were not used in declared order, Diamond Goal is not possible, but these claims are:

a. Silver Distance 114 km (club/C) claimed as Straight Distance; indeed, flying from "club" about half way to either "A" or "C" gives a Silver Distance.

b. Gold Distance 335 km (club/A/C/club) could be claimed as 3TP Distance.

c. Diamond Distance 515 km (club/C/B/A/club) could be claimed as 3TP Distance.

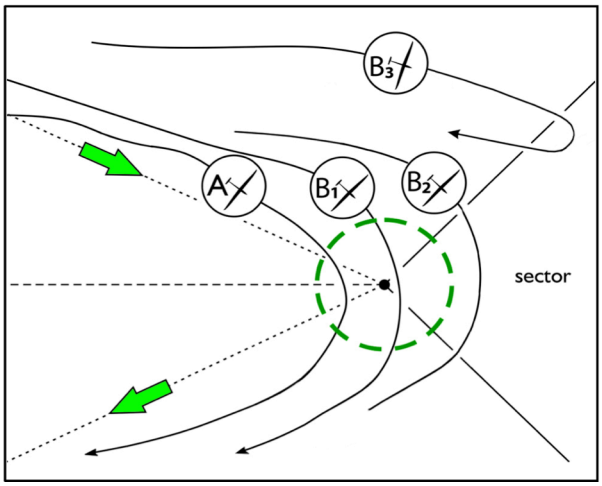
2.11 Limit on declared turn points You are not allowed to declare more TPs than the claimed task requires. For example, an Out-and-Return task must have only one declared TP, and a Goal Distance task must have none – and neither task can be claimed from a portion of a triangle or 3TP distance course. The Task Table at the end of Chapter 1 of the Code will assist your planning.

2.12 Turn point observation zones The cylinder or sector observation zone is the airspace the glider must enter in order to claim a TP. If multiple TPs are attempted, the pilot may use the same OZ type at each TP, or use different OZ types, in any combination.

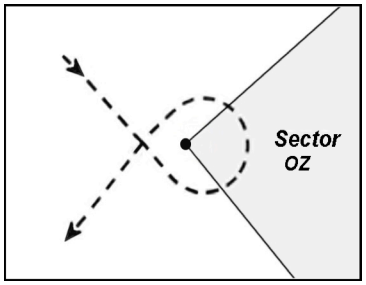
a. **Cylinder OZ** A cylinder of unlimited height, with a radius of 500 m, centered on the TP.

- *Advantage* This type of OZ has no directional limitations. The pilot may proceed to any other TP, or to the finish point, a finish fix or landing location.
- *Disadvantages* Not a good choice if there is traffic or adverse weather at or near the TP, and for each TP achieved only by cylinder *without rounding the TP* a cylinder correction of 1 km is deducted from course distance (see "A" at right below).

b. **Sector OZ** A quadrant of unlimited radius, centered on the extended bi-sector of inbound and outbound course legs. Note that the orientation of this sector depends on the order in which turn points are *used*, not necessarily as declared, and the type of start and finish.



- *Advantages* It is a large "target," with room to avoid weather and traffic, and if the task is flown as declared, entering through one border and exiting through the other provides a good deal of flexibility for different start and finish options (B1 and B2 in the illustration).
- *Disadvantages* If weather requires entering and exiting the sector through the same boundary (B3 above), there is little flexibility for using an amended TP order, choosing a finish fix, or a finish at landing.



c. **Sector OZ variant**

- *Advantages* You can use TPs in any order, and use any type of start or finish without cylinder correction penalties.
- *Disadvantages* It takes more time and requires greater accuracy to circle the TP with fixes.

2.13 Free record flights Declared waypoints are not required for these distance tasks, but are not excluded either. A normal declaration is still made before the flight that includes the pilot's name and glider information. The pilot is free to fly anywhere between take-off and landing and, after the flight, select fixes from the position data to be the way points claimed for the soaring performance. However, it is a common tactic to claim fixes just past the turn points of a suitable declared task, thereby earning two records for the same flight. See 4.5 for details on selecting fixes.

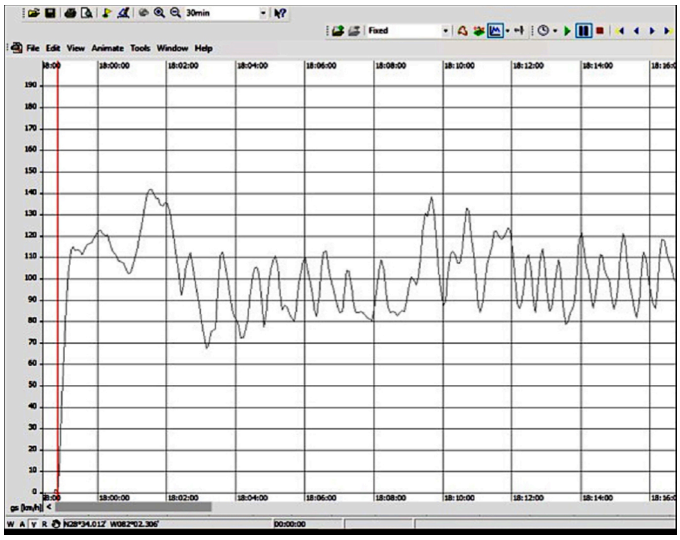
2.14 Finding the beginning of the take-off roll

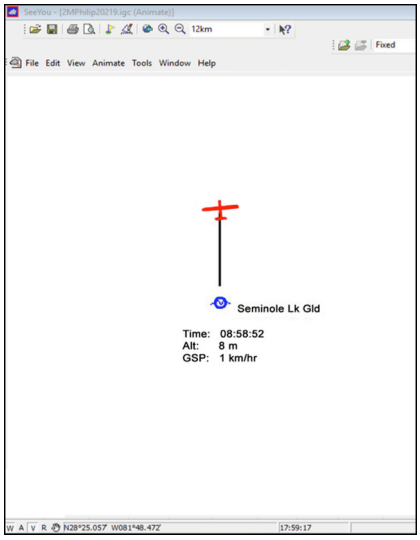
a. Open your flight analysis software and open a graph of "Ground Speed" or "Altitude" and change the time interval to the shortest possible setting. Scroll to the extreme left edge of the graph.

b. Click the charted data at the left side of the graph below, then switch to the overhead ("Route") view.

c. Advance the glider icon several fixes, then guide the cursor along that track to find the first fix in motion. (The software used at right below displays a pop-up window showing the time and other data recorded at individual fixes.)

d. Use software options to confirm the distance from release to the finish fix is at least 50 km. However, if it's not clear the take-off roll began at least 50 km from the finish fix, jot down the time when the take-off roll began, open the .igc file in a text editor and copy the coordinates recorded at that time *and at the finish fix*. Use the FAI Distance Calculator https://www.fai.org/page/world-distance-calculator to determine whether the finish fix is at least 50 km from the beginning of the take-off roll.





HEIGHT FACTORS

3.1 The 1% rule – Loss of Height (LoH) for tasks less than 100 km For distance flights less than 100 km, the maximum LoH using air pressure data cannot be more than 1**%** of the distance flown or [1% of the distance less 100m] using PR GPS height data. No margin is allowed – any excess will invalidate the flight. Be especially aware of this when the finish point or the possibility of landing is at a lower elevation than the start. A Silver badge distance flight that is exactly 50 km from the release can have a LoH of no more than 500m and this increases up to 1000m for a 100 km flight. For pilots having altimeters displaying altitude in feet, Table A will assist in determining the maximum LoH for these short tasks.

TABLE A Maximum barometric height losses for distances less than 100 km

km	ft	*km*	ft	*km*	ft	*km*	ft	*km*	ft
50	1640	*60*	1968	*70*	2296	*80*	2624	*90*	2952
52	1706	*62*	2034	*72*	2362	*82*	2690	*92*	3018
54	1771	*64*	2099	*74*	2427	*84*	2755	*94*	3083
56	1837	*66*	2165	*76*	2493	*86*	2821	*96*	3149
58	1902	*68*	2230	*78*	2559	*88*	2887	*98*	3215

3.2 Height correction – distance flights over 100 km For these flights, an adjustment to the claimed distance is applied if the Loss of Height exceeds 1000 metres in order that there is no benefit to starting a task with excess height. A correction of 100 times the excess LoH must be subtracted from the achieved course distance. If the LoH on your flight was 1157m, then the distance flown is reduced by 100 x 157m or 15.7 km. Note that the official distance for the course might also have a cylinder OZ correction(s) applied per SC3-1.3.6.

3.3 Height measurement by PRs Some PRs can record both pressure and GPS altitude, but where pressure altitude is not recorded, GPS height may be used for Silver and Gold Badge claims provided that there is a margin of 100m over the required gain of height for Silver and Gold altitude, and 100m under the LoH for Silver and Gold distance claims. A Gold altitude claim would require a GPS height gain of at least 3100m, and a 65 km flight would require a loss of GPS height of no more than ([65 km x 1**%**] – 100m) or 550m. If the altimeter displays altitude in feet, refer to Table A above, subtracting an additional 328 feet, to determine the maximum LoH when GPS height evidence is used.

Even if a PR does have a pressure sensor incorporated, it is not required to be used for altitude evidence; GPS height may be used with the added 100 metre margin included. This allows a PR to be used if it has no valid calibration.

3.4 Correcting pressure altitude data for instrument error When FR calibration is done numerically, linear interpolation may be used to correct for instrument error and the result is "calibrated pressure altitude." In the example below, 492 feet (150m) was recorded by the FR before take-off where the site elevation is actually 798 feet msl (243m).

Metric units	
Lab altitude	FR altitude
0	30
X	**150**
609	641

X = 609 – (641-150) • ((609-0)/(641-30))
= 120 metres

English units	
Lab altitude	FR altitude
0	98
X	**492**
2000	2100

X = 2000 – (2100-492) • ((2000-0)/(2100-98))
= 394 feet

The same method can be applied to FR-recorded altitudes at release, start, low point, high point, and finish, but if the pre- and post-flight baseline data points differ from actual field elevation(s) by more than 30m (100 feet), it would be preferable to calculate absolute altitudes following the guidance in 3.5 below.

3.5 Measurement of altitude – the pressure correction formula (SC3-3.3.3)
This correction is required to determine the specific altitude for a fix. FRs record altitude values referenced to the standard ISA pressure of 1013.25 hPa (29.92 "Hg). You need to find reference pressure at your selected flight fix, but as pressure changes constantly over time and distance, this is practically impossible, so the closest possible approximation shall be used. If the fix is close to take-off or landing, values from respective ground baselines are a good choice. In other cases, an "educated guess" should be performed using all data available, especially synoptic maps and pressure logs from nearby stations. This information should be copied right after the flight was performed, as it might be difficult to obtain it weeks later.

Establishing the correction value is easier when using the atmospheric pressure ground baseline at a known elevation – no conversion from height to pressure is required. First, apply the instrument error correction to the baseline value (see 3.5). Then calculate the correction:

pressure correction [m] = known elevation [m] – calibrated pressure baseline altitude from FR [m]

When raw pressure values are used, convert them to height units. A lapse rate of 1 hPa per 9m is acceptable for elevations up to 1000m (or 1"Hg / 1000 ft). So, if the QNH were 1020, the correction would then be:

(1020 – 1013.25) x 9 = 61m (and the value is negative if the QNH is less than standard ISA pressure). However, it's better to use official ISA calculators or tables:

pressure correction [m] = known ground pressure reduced to sea level (QNH) in hPa – (1013.25 x ISA pressure lapse rate)

Finally, to calculate corrected altitude for the fix in question, apply both the instrument error correction as in 3.5 above and the pressure correction to the raw altitude value from the FR:

altitude [m] = calibrated pressure altitude from FR [m] + pressure correction [m]

3.6 High altitude flight recorders (HAFRs) HAFRs are special FRs designed for use above 15,000 metres where GPS altitude evidence is used rather than pressure altitude, because pressure altitude has progressively lower resolution at such high altitudes. The use of HAFRs and data handling is described in Appendix 6.

START and FINISH CONSIDERATIONS

4.1 Start and finish parameters The start and finish each have three associated parameters:

The start position is where the release or stopping the MoP took place or is the declared start point. It is used in calculating the task distance.	*The finish position* is where the landing or restarting the MoP took place, the declared finish line is crossed, or a virtual finish point fix is selected. It is used in calculating the task distance.

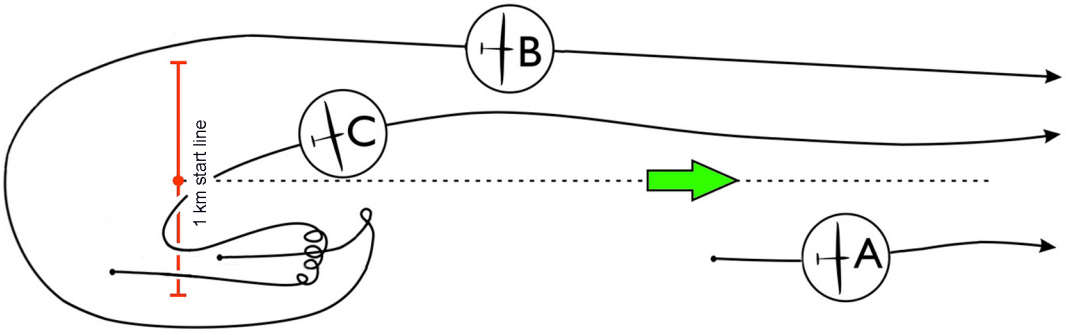
The start time is the actual time of release or MoP shut down, or at crossing the start line, or the time at a fix selected as the start.	*The finish time* is the actual time of landing or MoP restart, crossing the finish line, or the time of a claimed finish fix.
The start height is measured at the same place as the start position.	*The finish height* is measured at the same place as the finish position.

4.2 Start and finish options The start and finish of a badge or record flight are the places where mistakes may occur because of the several alternatives available. The start holds much potential for error or miscalculation of position or height that could negate the remainder of the flight. The Code gives several choices for starting (SC3-1.3.1) and finishing (SC3-1.3.2). See also the Task Table at the end of SC3 Chapter 1.

a. Lack of clear low point following the launch could result in a claim being denied or heavily penalized due to uncertainty in determining the Loss of Height (LoH). This is usually not a problem with a winch launch or stopping an engine. For an aerotow, make a rapid turn immediately after release. After a tow into wave lift, make a rapid turn or descend for at least 20 m for a positive start point to register on your FR/PR.

b. Start and finish line crossings are required for a distance to a goal flight, or at the single start/finish point declared for a closed course including Diamond goal, an out & return, and a triangle speed or distance record flight. Note that the finish line is perpendicular to the finish leg so it may be rotated with respect to the start line. When any of the above courses is declared but no turn point is rounded, straight distance may be claimed using a start at release, followed by any type of finish.

c. You *must* be aware of how much LoH between start and finish you can have before your planned task fails due to an LoH correction. Review the 1% rule (3.1) when the task is less than 100 km.



4.3 Starting examples

a. Pilot A is towed about 2 km down track and releases. Straight distance from that release point can be claimed for a badge (other than Silver distance) or for any free distance record.

b. Pilot B releases, climbs and then goes back behind the start line but does not cross it when heading out on course. The declared start point cannot be claimed, therefore only straight distance or free distance tasks can be claimed from the release point.

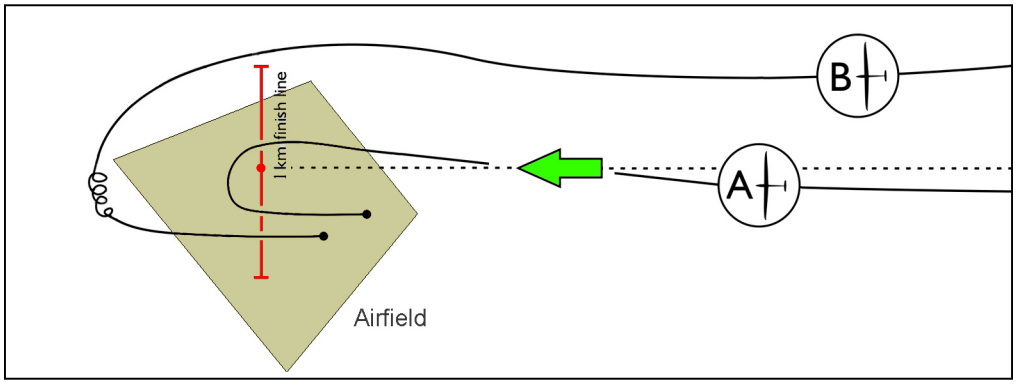
c. Pilot C releases and crosses the start line, but decides his height is insufficient, so climbs then starts again. He can claim any task completed, and claims the last crossing as the start time.

4.4 Finishing examples

The finish line can be crossed more than once. Cross again if you were low the first time and would suffer an unacceptable loss of height correction for a distance task or invalidate a speed task. It is useful to have a finish point at the approach end of your planned landing field, or at the intersection of two runways so that the line can be crossed from a landing on either runway. In the diagram below:

a. Pilot A crosses the finish line correctly. The point he crosses the line is his finish position and height.

b. Pilot B crosses to the right of the finish line, thermalled (see below), then crossed the finish line again to land, but from the wrong direction. Pilot B has not completed his declared finish, but the finish point could be a fix selected at some point behind the finish line if a finish fix is allowed.



4.5 Virtual finish A fix may be selected post-flight from the FR data as an in-flight finish point. A virtual finish allows the pilot to: use the same loss of height calculation for a distance flight in a pure glider as a motor glider that restarts its MoP, or claim a finish fix that will minimize or eliminate a LoH correction, or attain a valid finish then land elsewhere for safety or convenience. To use a virtual finish effectively, you must plan that it may be needed. For example, you may climb to any height before starting to allow for a safe height for an early departure on a task, but you will then need to determine the lowest finish altitude that will incur no penalty. Similarly, if you are too low at the finish of a task that allows for little or no LoH correction to be required, you may climb after crossing the finish line until the LoH from the start drops to an acceptable value and then cross the finish line again.

PRESSURE ALTITUDE EVIDENCE

5.1 Pressure data The pressure altitude function of an FR records air pressure against time and is required for all badge and record flights except for duration flights under observation. All FRs record air pressure (Appendix 5-1.5 refers) and some PRs. It can provide the following data:

a. *Altitude* The air pressure data can be used to establish height, subject to the inherent errors noted in 1.6a and corrections described in 3.5, calibrated to the ICAO International Standard Atmosphere (ISA). However, calibrations are usually recorded directly in height units, making this conversion unnecessary.

b. *Continuity* The pressure data will show that there was no intermediate landing in the declared task.

c. *Duration* The pressure data may be used to determine the duration of a flight when no OO has witnessed the landing.

5.2 Calibration requirements The calibration procedure for FRs is in SC3B-2.1.1 to the Sporting Code on the IGC and GFAC web sites. Altitude and height gain claims require calibration data to the ICAO ISA to be applied to the critical altitudes of the flight performance. Speed or distance claims need calibration data for calculating the altitude difference of the glider at the start and finish points (task loss of height). Also, the NAC or FAI may wish to compare pressure altitudes recorded on the FR at take-off and landing with atmospheric pressures (QNH) recorded by a local meteorological office at the time of the flight. The required calibration period is given in SC3-2.4.6 or 3.3.5.

If pressure data is being used just to establish flight continuity (such as for a distance or duration claim), the FR pressure sensor can be out of calibration. When multiple FRs are used, only the one submitted for data analysis needs to be calibrated. If out of date, it will need to be calibrated post-flight.

POSITION RECORDERS and IGC-APPROVED FLIGHT RECORDERS

6.1 Flight Recorder and Position Recorder documents All official documents related to FR or PRs are on the IGC website, *https://fai.org/igc-documents* and the IGC Flight Recorder Approval Committee (GFAC) website, *www.ukiws.demon.co.uk/GFAC/*

An FR must be operated in accordance with its IGC-approval (Appendix 5-1.3). Pilots should obtain a copy of the approval document for the FR they use, and study it and any user manual from the manufacturer before flights that will need to be officially validated. Notice of initial issue or amendments to existing IGC-approvals is posted on the *<rec.aviation.soaring>* newsgroup, on the e-mail mailing list *igc-discuss@fai.org* and on *https://fai.org/igc-documents* .

6.2 Position Recorders (PRs) This type of recorder may be used for height and position evidence for Silver and Gold badges in accordance with SC3-2.5. Each type of PR must be individually approved by a NAC through a PR-approval document. A NAC must be satisfied that a PR complies with the Code before accepting a model for use based on another NAC's approval. A method for testing a PR by a NAC for its approval is given in Appendix 5-1.6c. Approval documents shall include any operating limitations needed to enable a given unit to conform to the Code. See other items on the IGC web page for PRs such as a specimen PR approval document.

a. *OO procedures* As PRs are not as secure as FRs, OOs should perform all procedures carefully. Study the PR's approval document, which gives advice on pre- and after-flight procedures, down-loading, and general security. Follow as much as possible the security checking steps pertaining to FRs given in 10.2. Independent data for the positions of take-off and landing is required either from the OO, or club flight operations log (refer to 8.2). These positions should closely compare with the positions recorded for take-off and landing in the .igc file.

b. *Pilot procedures* Pilots are advised to retain the flight data in the PR memory as long as possible, so that a further file download is still possible if the OO has concerns about the flight.

6.3 Flight recorders (FRs) The principles and technology related to the GPS system on which flight recorders operate is outlined in Appendix 5. Full details of the IGC-approval process for FRs is in Chapter 1 of Annex B to the Sporting Code on the IGC GFAC web site.

a. *IGC flight data file* Data is in the IGC format in a file with a ".igc" suffix. Details of the .igc file format is in Appendix 1 of the FAI/IGC document, *Technical Specification for IGC-approved GNSS Flight Recorders* on the IGC GFAC web site.

b. *Transferring* Transferring data after a flight is either to a computer or, with some FRs, direct to a storage device such as a memory stick or card. Transferring to a computer should use the FR manufacturer's IGC-XXX.DLL file together with the IGC Shell program (XXX is the 3-letter code for the FR manufacturer). Both files are on the IGC GFAC web site, as is the FR manufacturer's short program files for older recorders that have no DLL file. Use the file *data-xxx.exe* for transferring data, or for some recorders that download initially in binary format, *conv-xxx.exe* for converting from binary to the .igc format. An .igc file uses ASCII text characters and can be viewed with any text editor, for instance to check the data that was input for the declaration.

c. *Validation of .igc files* The IGC electronic validation system ("Vali") checks .igc files for integrity. The Vali check ensures that the .igc file has originated from a serviceable and sealed FR and that it is *exactly* the same as downloaded – if just one data character is changed, the check will fail. The check is made by using the Vali function of the IGC Shell program available on the GFAC webpage, (go to *http://www.ukiws.demon.co.uk/GFAC/* and select "Links to programs for validation"*)* together with the FR manufacturer's IGC-XXX.DLL file in the same directory (see c above). For older FRs having no DLL file, the FR short program file *vali-xxx.exe* carries out the Vali function.

6.4 Flight recorder declarations Flight recorders have the facility to enter the data required for a flight declaration; this appears in the .igc file. Since FRs have both physical and electronic security (Appendix 5-1.4) and an accurate real-time clock, the declaration does not need to be witnessed by the OO. *However, the OO still has to witness that the FR is in the glider and is the one used for the flight.* An FR declaration can be superseded by a later one, or by a subsequent paper / internet declaration for Silver or Gold badge flights.

a. *Way point declaration* An .igc file stores waypoint location on lines that start with the letter C (the C-record). Where the FR has this capability and the pilot has entered such data, the date/time that the way points were declared is shown in the first line of the C-record.

WARNING *Some older FRs store the latest turn-on time as the waypoint declaration time. If these FRs are switched on after a paper/internet declaration has been made, the declaration in the FR becomes the "latest" one again – nullifying the written one. If you are making a last minute paper/internet declaration and you are unsure how the FR acts, ensure that the FR is ON at the time.*

b. *The "A" record* The first line of an .igc file begins with an "A", followed by a three-character code for the recorder manufacturer, then by the recorder's serial number. The A-record in its entirety can be seen when the file is viewed in text format.

WARNING *When the "A" is followed immediately by an "X", this indicates either:*
- *FR recorded data was amended and saved using software not subject to IGC approval, or*
- *a PR was used, in which case a written declaration is required.*

c. *The header record* The remainder of the declaration data is in the H (Header) record that starts on the second line of the .igc file. H-record lines that list information on components within the FR begin with “HF” and cannot be altered. The line beginning with “HFPLT” lists the pilot name; in newer FRs a line beginning with “HFCM2” is provided for the name of a crew member. The lines beginning with “HFGTY” and “HFGID” are for glider type and identification, respectively. If two pilots are aboard for a record claim, but an FR provides only one line for both names, enter the name of both pilots, shortening each as necessary.

A few older recorders allow H-record pilot and aircraft data to be entered *after* the flight. These lines start with the letters HO (for OO entries) or HP (for pilot entries) and will not cause the data file to fail the Vali check (6.3d above). Therefore, all data files must be reviewed by analysis software and in text format, all H-record data required for declarations must appear in lines that start with the letters HF (*not* with any that start HO or HP), and the .igc file must pass the Vali check.

WARNING *The HO and HP issue described above can result from transferring the declaration data to an FR using a device and/or software not subject to IGC approval. Test as needed to make sure any such device and software are compatible with the FR in use.*

d. The B record contains a variable number of data blocks depending on the FR. The leading data blocks store the basic time and position data. The spaces between the sample data blocks below have been added for clarity.

TIME	LATITUDE	LONGITUDE	P Alt	GPS Alt	
B 205248	49 39 410N	114 01 107W	A02743	02780	….
B 205259	49 39 489N	114 01 014W	A02778	02820	….
B 205311	49 39 481N	114 01 064W	A02819	02860	….

6.5 Pilot and glider data Pilot and glider data *must* be correct in all certificates and FRs used for a record claim, and Diamond and Diploma claims. Pilot and glider data stored in a PR or FR is not definitive until confirmed by the OO from independent evidence taken at take-off and landing. Pilot name and/or glider information input errors are made even by experienced pilots with their own gliders and FRs.

WARNING! *Many FR manufacturers provide for entering pilot name(s) and aircraft data using “set-up” procedures that are completely separate from those used to declare the task … and in many cases, accessing the “set up“ menu is not at all intuitive.*

If indisputable evidence for the actual pilot and the glider flown is available, the correct data may be certified by the OO per SC3-4.4.1. Such correction is limited to Silver and Gold badge claims. Such certification is expected to be of an exceptional nature; it should not become “standard practice” for pilots by OOs.

6.6 Sampling rate The GPS sampling rate is set in the set-up menu of the FR. As modern FRs have abundant memory, using a setting of 4-5 seconds or less allows a good presentation of the track for analysis purposes. As a normal thermal turn takes about 20 seconds, setting the sampling rate to 4 or 5 seconds will have turns appearing square to pentagonal in the graphical output of a flight, making the turns reasonably clear and it allows you to easily examine them for consistent thermalling technique.

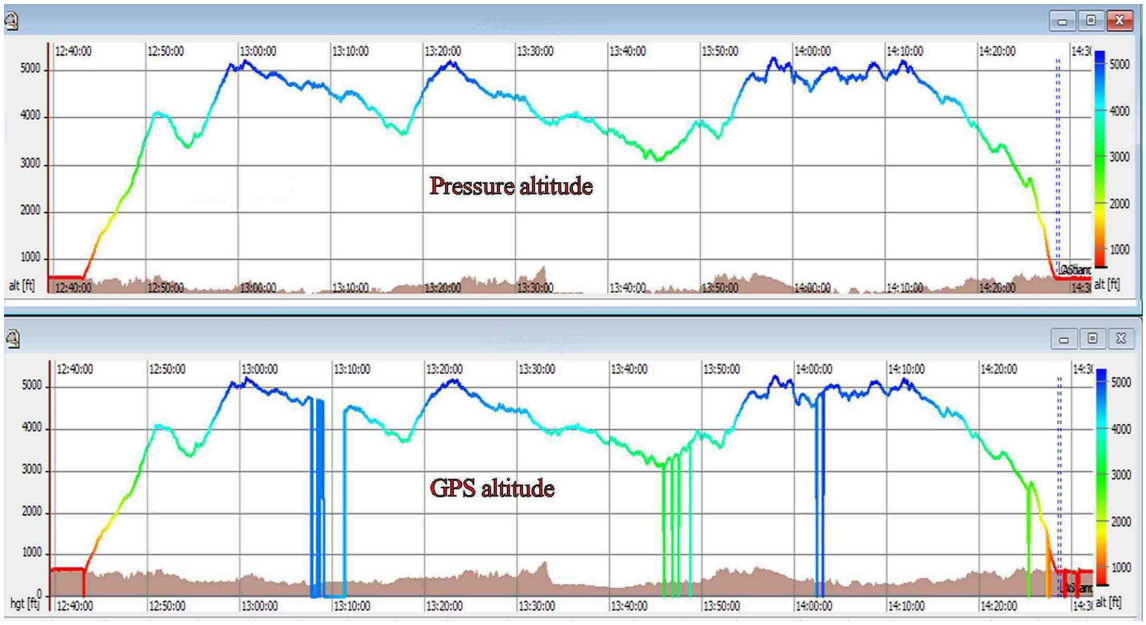
Most FRs also provide for the selection of a short interval for use near waypoints. A fast-fix interval of 1 or 2 seconds is recommended to ensure that a fix is recorded within an OZ. This occurs automatically in some FRs, or after pressing a Pilot Event (PEV) button.

6.7 Missed fixes Some fixes may be missed or be assessed as spurious (see 10.7 for a description of anomalies). Where valid position data does not appear in the recording, the fixes must show pressure altitude to prove flight continuity. Missed fixes from an otherwise continuous trace that lowers the actual sampling rate to less than once per minute (for example, because of short term pressure attitude or GPS system anomalies) is acceptable provided that an intermediate landing and take-off was not possible.

FLIGHT RECORDERS – INSTALLATION

7.1 Installing the FR Following the instructions should avoid common problems, but there is no substitute for testing your installation before attempting a badge or record flight. Any limitations or conditions for a FR or PR installation will be given in its approval document. For flight safety, the position of displays and operating buttons and controls (including switching by touch screens) used in single seat gliders should be close to sight lines used for lookout and scan for other aircraft.

7.2 Antenna placement Look carefully at the instructions for fitting and placing the antenna in the specification for the flight recorder and, if necessary, the specification for the type of antenna used. The following general advice applies, unless the specification for your equipment says something else. This pair of graphs from an actual .igc file is an example of GPS altitude dropout due to poor antenna positioning or performance.



a. *General* The antenna should be clear of any object except attachments that are part of its design, and the antenna itself should not touch anything. In particular, metal or carbon fibre objects should not be between the antenna and a clear horizon (glass fibre and Kevlar do not reduce signal strength very much). For FRs mounted in instrument panels, the antenna should be placed on top of the panel rather than inside or underneath it, but may be covered to prevent overheating in the sun (check that the cover and any paint used do not reduce the GPS signal).

Antennas should not be mounted on conductive material (metal, carbon fibre) unless the signal is improved by or requires a ground plane (see the antenna's specification). The distance to other antennas such as for a second FR or radio should be over 25 cm (about 10 inches) if possible, to reduce the possibility of mutual interference. ***Safety note:*** When an antenna is mounted on a canopy, a connector should be used that will separate under tension (such as an SMB design) if the canopy must be jettisoned.

b. *Antenna cable and connectors* The cable and connectors between the antenna and the FR should be matched to the characteristics of the antenna and FR. In general, the cable should be no longer than necessary and be of high quality (bearing in mind that some cables may be of a specific length matched to the system and should not be shortened). Extra connectors should be avoided because each connector will cause a loss in signal strength.

c. *Graphs of GPS altitude* The graphs above show where signal strength was low at the recorder and GPS altitude recording was lost for part of the trace. This can be seen where the GPS altitude in the .igc file falls to zero (in accordance with the FR specification for loss of signal). In these cases there may be a 2D fix (if Lat/Long recording continues) or no fix at all; in either case pressure altitude recording will continue. In the case of no fix, a turn point could be lost. If a pilot sees a GPS altitude graph like this, corrective action should be taken starting with checking the antenna position and performance.

7.3 Installation checks by the OO There must be unambiguous evidence that every FR or PR present in the glider for the flight concerned was correctly installed as in 7.1 above with either of two provisions described in the FR's IGC approval document. In summary, those provisions are:

a. *Sealing* At any date and time before the flight, the OO may seal the FR to the glider structure in a manner acceptable to the NAC if it is possible that no OO will be present when the launch takes place. The seal must provided unambiguous proof after the flight that the seal has not been compromised, and the seal must be able to be identified afterwards.

b. *Pre- or post-flight installation check* On the date of flight, the OO performs either:

- a preflight check of the FR installation, noting the date and time it was performed. The glider must then be under continual observation by the OO until it takes off on the claimed flight, or
- witnesses the landing and has the glider under continual observation until the installation of the FR is checked.

FLIGHT RECORDERS – PILOT ACTION

8.1 Before flight Work with your OO to ensure that the declaration loaded into the FR is correct in all aspects for the planned task. However, that does not make the OO responsible for a denied claim if the declaration is incorrect. If there is more than one FR in the glider, inform the OO on which device(s) are to record the task, that is, are to be controlled by the OO per SC3-2.0b or 3.0e.

8.2 Independent evidence of take-off Ensure that the time and point of take-off has been witnessed and recorded for comparison with the FR or PR data. If not witnessed by the OO, times may be confirmed by checking the official log of take-offs and landings, or by evidence from a reliable witness that is countersigned later by the OO.

8.3 Observation zone considerations OZ type is *not* part of a flight declaration, even though you can select an OZ type in the FR. If the sector OZ was set into the FR and you missed entering it at a turn point, the soaring performance will still have been completed if you were within the cylinder OZ. In this case the leg distance must be reduced in accordance with SC3-1.3.6. However, this could negate a badge flight that was within 1 or 2 km of the minimum distance for that badge leg.

Between 5 and 10 valid fixes on both sides of the fix or fixes used for verifying presence in the OZ should be at the time interval setting used for the OZ (the fast rate in FRs that have this facility). Some FRs mark OZ entry with a tone, but only analysis of the .igc file can prove your presence in the OZ. Fly into the OZ for several fixes before turning for the next leg. As GPS fixes may be lost at high bank angles, extreme maneuvers should be delayed until valid fixes have been recorded in the OZ.

8.4 After flight You ***must not*** remove the FR (or any other flight data recording equipment) or download the .igc file or remove an SD card containing the .icg file without the OO being present. This is an easy mistake for a pilot new to their use for badge flights. Doing so compromises the OO's control of the flight, which will invalidate the claim. However, control of the FR is not compromised if the pilot enters a new declaration prior to the flight or for a subsequent flight.

8.5 Checking FR file output Before making a flight for which a claim might be made, check previous .igc files to ensure that they comply with IGC rules and procedures and that file recording is not flawed. For example, there have been cases where, due to poor antenna position or performance, altitude dropout has occurred while lat/long recording continued. A high-gain GPS antenna should be used and its position in the cockpit and cabling to recorders should be checked (see 7.2a and 3b). Motor glider pilots should check that forward engine thrust is clearly differentiated from gliding flight, see Chapter 11. Use more than one fully tested FR when making record attempts.

FLIGHT RECORDERS & POSITION RECORDERS – OO ACTION

9.1 Prior to flight OO's should work with the pilot to ensure that the declaration loaded into the FR is correct in all aspects for the planned task. If there is more than one FR in the glider, make a list of which device(s) named by the pilot are to record the task per SC3-2.0b or 3.0e. An OO should act as a mentor to the new badge pilot, reviewing the common errors given in 2.6 that are likely to spoil a claim.

9.2 Transferring the flight data file The OO must be able to identify the flight data files as being from the flight concerned. The OO shall transfer the flight data file as soon as practicable after landing, *especially* if the pilot, glider, or task is to change for the next flight. If a laptop computer is available or the FR downloads directly to portable storage media such as an SD stick, the flight data may be transferred without disturbing the installation of the FR. If this cannot be done, the OO shall check and break any seal to the glider, then take the FR to a computer to transfer the flight data. If more than one FR is carried, each must be checked to ensure that the declaration, either in the FR or written, applies to the flight.

If the OO is not familiar with the procedure required, the pilot or another person may transfer the data while witnessed by the OO. Security is maintained by the coding embedded in the FR and in downloaded .igc files that can be checked later through the IGC Vali program (see 6.3c).

a. *Data transfer method* The method for each type of FR is given in its IGC-approval document (6.3a) that is available at *www.fai.org/igc-documents*, then look for "IGC-approval Documents for all IGC-approved Flight Recorders". The FR types, their manufacturers, IGC approval dates and a history of the use of GPS in IGC, are listed in *www.ukiws.demon.co.uk/GFAC/igc_approved_frs.pdf*.

b. *IGC file name* The original .igc file name format is "YMDCSSSF.IGC", where Y=year, M=month, D=day, C=manufacturer, SSS=FR serial number, and F = flight number of the day (full key, Appendix 1 to the IGC Flight Recorder specification). Where an intermediate manufacturer's binary file is also produced, it will have the name YMDCSSSF.XXX, where XXX is the IGC 3-letter code for the FR manufacturer. For numbers over 9 such as in months and days, 10 is coded as A, 11 as B, etc. For new FR manufacturers and types of FR, the IGC long file name is used with data in the same sequence, for example, 2009-05-21-XXX-SSS-01.IGC.

9.3 Data transfer problems Common flight analysis programs such as *SeeYou* can download the .igc file from the FR, but they might not produce a file that will pass the Vali check – nevertheless use the manufacturer's recommended method of transferring data from the FR as the first step. E-mailing a file may also corrupt it – but if you do plan to e-mail it, first ZIP the file as a precaution.

Some older FRs do not store separate .igc file header data for each flight but use the last data entered for previous .igc files in the FR memory. To minimise the possibility of corrupt or inaccurate files, use the IGC utilities. After downloading the .igc file, *immediately* check it with the Vali program. If there is a problem, go back to the FR and download again.

9.4 OO's copy of flight data Save the data files for the flight on any storage media that the pilot cannot access. A copy of the file(s) for the flight data – both the binary (if produced) and the .igc file(s) – shall be retained by the OO for later analysis under the procedures of the authority validating the flight. If the FR produces a binary file, a valid .igc file can be re-created from the binary – this can be critical if there is any difficulty with the .igc file first sent to the validating authority.

9.5 Modified .igc files "L" records in an .igc file are "comment" lines that can be added and changed post-flight without affecting the file security. They are used by *SeeYou* (and possibly other software) to store the declaration if it's edited post-flight. The original declaration (the "C" records) is preserved while modified declaration is stored (in "L" records) also. When opening a file, *SeeYou* uses the "L" declaration, if found, NOT the original. While this is logical and convenient, it allows deliberate or accidental modification of the declaration, which is likely to be overlooked by the analyst.

The best practice to avoid this problem is to *always* use original .igc file as directly transferred from a FR or PR, and use the "Restore" button under Task definition to re-read "C" records.

FLIGHT RECORDERS & POSITION RECORDERS – DATA ANALYSIS

10.1 Transfer and validation of flight data files No brand of evaluation software is approved or preferred by the FAI, but currently, several freeware flight evaluation options exist. See the list in Appendix 8 (copied from *Analysis Programs for IGC Flight DataFiles* on the GFAC website).

Evaluation software is popular for its scalable view of the flight track, 3-D animation features, and detailed flight statistics, but note that they are not always completely accurate (see 10.8). They provide a variety of user settings in support of "what if" analysis, task planning functions and claim review for OLC, other online forums, and FAI badges and records as well. Some companies offer optional PDA and/or smart phone apps that provide navigation support in flight.

In any flight evaluation software, both pressure and GPS altitude and, for motor gliders, MoP operation must be shown as part of the vertical data displayed. The automatic functions of evaluation programs (such as waypoint OZ presence and engine on/off thresholds) should be checked manually, inspecting the relevant data if there is any doubt that the given automatic function positively identifies the threshold concerned.

10.2 Security checking *Checking the security of the file is the first step in data analysis*. The flight data transferred by or under the supervision of the OO becomes the master .igc file to be retained by that OO on memory media. This requires the appropriate software, preferably the FR manufacturer's current "freeware" on the IGC website. With a successful security check, copies of the master file can be made for evaluation (keep them in a location separate from the master file.) A data file can fail security for a number of reasons:

a. a power surge during transfer,

b. a download using software other than the IGC-approved freeware,

c. the FR's internal security switch has been breached, or

d. the data file was amended during or after flight.

In most cases, as long as the original file is still in the FR, a fresh data transfer might solve the problem and allow examining the claim to proceed. If a fresh transfer is not possible or it also fails security, the data file may be sent as an e-mail attachment to the National Claims Officer. If the cause of the failure can be determined, the problem can probably be remedied for future flights. Although the flight can be evaluated for other purposes, no badge or record can be claimed if a data file doesn't pass the required security.

Badge or record evaluation *must* use an exact copy of the OO's master file, unchanged by *any* means. Using common analysis software, it is possible to change and save task information in an amended data file that will pass security. This can fool the casual reviewer, but is clearly shown in "L" records appearing at the end of the data file, after the "G" record.

10.3 Assisting the OO After the OO has checked data file security and verified that the data file is complete, the OO may request and receive assistance if needed from another OO or from a NAC-appointed Data Analyst for help with problems encountered during flight evaluation. The analyst does not need to be the OO or approve badge or record claims, but his or her expertise can be important for a detailed evaluation.

10.4 Basic evaluation of flight data using graphic software Use an overhead view of the entire flight to see the general shape of the course, and use graphs of altitude and MoP data to verify continuity of flight. Toggle between these views and zoom in as needed to check for:

a. clear evidence of release or MoP stop. Make note of time, altitude and location

b. airspace concerns, if any

c. valid start and finish procedures

d. time and altitude at start and finish points and at fixes yielding the best gain of height

e. proof of presence in turn point OZ (see 8.2 for free record fixes)

f. similarity of GPS and pressure altitude traces with time, course distance, and speed.

When more than one FR has recorded the flight, their ground tracks will appear nearly identical in analysis software, but the fixes recorded will not be absolutely identical since the antennas of the two FRs are not in the same location, they are not typically recording at exactly the same times, they may be accessing different satellites, and different model FRs may be using different algorithms to process data.

10.5 Altitude loss/gain evaluation When a gain or loss of altitude is to be evaluated, the same pressure reference should be used to establish the maximum and minimum values. It means that only instrument error (see 3.5) needs to be corrected. Correction for non-standard pressure is not critical and not required, as it is applied same way to both extremities. Diurnal or geographical changes of pressure should be ignored. They may work in favor or against the final result.

10.6 Absolute altitude evaluation The pressure-corrected altitude value for a fix is only needed for absolute altitude records. If a corrected altitude is to be established, reference pressure data should be taken from the take-off or landing baselines, whichever is closer to the tested fix. Be prudent when using take-off/landing site elevations for reference as most airfields are not perfectly level and one end of the runway may be several metres higher than the other. If quality meteorological data is available (especially QNH reports from nearby stations), an interpolation of reference pressure data can be performed to obtain even more accurate results.

Altitude records exceeding 15,000 metres must use GPS altitude with respect to the WGS84 Ellipsoid as the data source (SC3-3.5.3b). Great accuracy in the FR barometric reading is not required in this case since it is only supporting the GPS data.

10.7 Data anomalies In the event of any inconsistency or gap in the data, the NAC shall consult specialists to determine if there is a satisfactory explanation, and whether the flight performance may be validated despite the anomaly. Contact the GFAC chairman, sending the .igc and other files concerned. If in doubt, the original file downloaded from the FR should be used and the analysis process repeated. Try using a different program to analyse the .igc file, and also examine it in text format.

a. *Complete loss of data* The OO or analyst should examine all interruptions of FR recordings with skeptical caution. If all FR data is lost for a period of time, other evidence must conclusively

show that flight continuity was maintained and, in the case of a motor glider, that the MoP was not operated during the loss. The altitudes at beginning and end of the loss must be considered, together with other evidence such as a second FR. Without such evidence, validation should not be given when data interruption is in excess of 5 minutes, and for motor gliders this period should not exceed 1 minute for pylon-mounted MoPs and 20 seconds for non-pylon mounted MoPs.

b. *Breaks in fixes and missed fixes* Fix breaks or sidesteps should be investigated; one must judge if the evidence of flight continuity remains incontrovertible. Analyse the time, altitude and position of the last and next valid data. Lack of any data for 5 minutes would not normally invalidate a flight, but lack of any data over 10 minutes would be questionable. In the case of an FR, pressure altitude data should continue to be recorded and will prove flight continuity, although evidence of presence in an OZ could be lost.

10.8 Evaluation software problems There are several ways in which any brand of evaluation software can incorrectly evaluate a flight. Check user settings during each new evaluation. Some settings, such as units of measure, map display, etc. are retained until changed; but many others revert to the program default when another data file is loaded. The data analyst must be familiar with both the Code and the software being used, particularly for distance claims. The following areas should be carefully checked:

a. *Flight track details/problems to consider.*

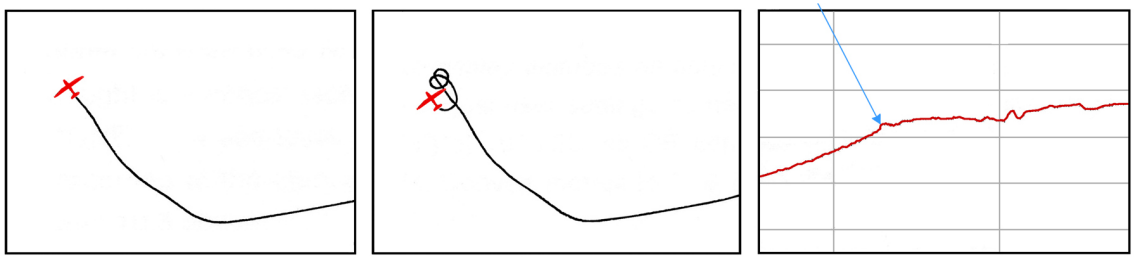
- a declared start or finish point is not achieved,
- release or MoP stop is a viable alternative to the declared start point,
- a turn point is skipped or used out of declared order, or
- a finish fix is a viable alternative to the declared finish point.

To remedy these, access the declaration screen displayed by software and amend the task or use the "map edit" function as needed.

b. *Confirm or correct the software-calculated release time* For aerotows in particular, this may be calculated incorrectly. Check the overhead view and altitude data for changes in rate of climb, turn radius and speed. A combination of these will typically reveal where – in light winds – the pilot released, slowed to minimum sink speed and began thermalling. See graphic on the following page.

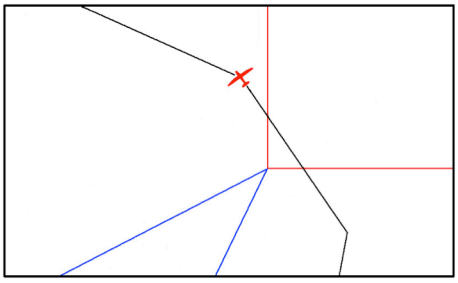
In ridge or wave lift, the pilot may release and simply bear to the left or right. On or off tow, speed will decrease with any turn into the wind, and towing through rotor turbulence can easily be mistaken for the release. In these cases, familiarity with local procedures and displaying the flight over a satellite map can help clarify where release occurred.

Ground track on aerotow *Turn radius while thermalling* *Thermalling turn begins here*



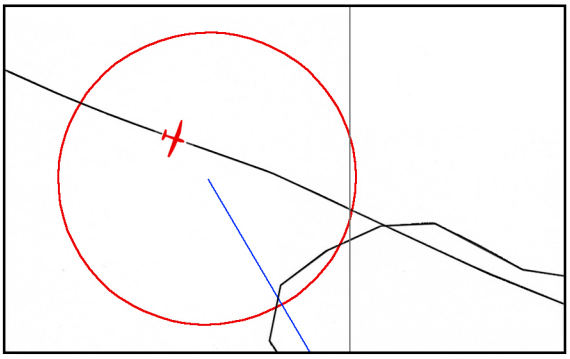
c. *Some software may not reliably credit TPs achieved by ground track only.*

A TP has been achieved when a straight line drawn between consecutive fixes passes *through* the OZ. This is uncommon, but it's wise to take a close look at TPs to make sure each is credited properly. Software statistics might report the turn point illustrated as "not rounded" but the user can see it was achieved.

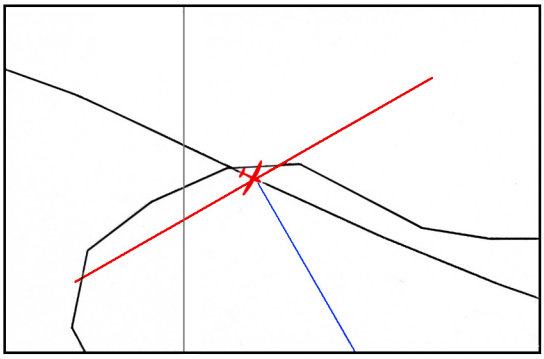


d. *Claim problems associated with free records.*
Some software will "optimize" closed courses for free records using a software-calculated start/finish location rather than a start fix. Examine the track for a start fix that also yields a viable finish. In most cases such a fix is within 5 km of the software-calculated location.

Default display uses a no longer valid start OZ



Manual editing and a start fix solves the problem



e. *Some software does NOT by default display altitudes as actually recorded in flight* When gain or loss of height is a critical factor of the flight, adjust user settings to make sure altitude is displayed as "QNE" at a sea-level pressure ("hPa") of 1013.25 mb *or* consult the .igc file to determine the altitudes recorded at the start and finish times. Convert metres to feet if necessary and proceed as in 10.6.

f. *An "optimized" flight involving a Loss-of-Height correction* This problem is corrected by finding a lower start fix. A more rigorous technique (e.g. finding the best *pair* of start and finish fixes within 30 minutes of those selected by software) can yield better distance, but can be time consuming to find.

GLIDERS WITH ENGINES

11.1 ENL and MOP numbers in the .igc file An IGC-approved engine recording system must be used, as described below and in the IGC-approval document (see Appendix 5-1.3) for the particular type of Flight Recorder (FR).

a. *The Environmental Noise Level (ENL) system* This is contained within the FR and needs no external connection. An ENL value is recorded on each line of fix data in the .igc file as a 3-digit number between 000 and 999. The ENL system is sensitive to low frequency acoustic noise at a peak frequency between about 100 and 200 Hz and was originally designed for engines that produce high values of low frequency noise, such as the two-stroke piston engines used in many gliders. High ENL figures have also been shown when running Forward Electric System (FES) engine and propeller systems when the FR is in the instrument panel just behind the engine.

b. *.igc file MOP figures for low ENL engines* Some engines do not produce enough low-frequency acoustic noise for an ENL system to clearly differentiate between engine running and soaring flight, particularly when the FR is at the front of the cockpit. These include rear-mounted electric, jet, and some rear-mounted four-stroke engines. In these cases, either (1) an extra MoP sensor must be fitted, designed to record the running of these types of engines or, (2) the complete FR with its ENL sensor may be mounted closer to the source of engine noise if this can be shown to clearly indicate any forward engine thrust. Values from an extra MoP sensor are recorded as a 3-digit MOP code number between 000 and 999 in addition to the three ENL numbers. The type of MOP sensor is shown in the MOP line in the .igc file header record and may sense sound (at high or low frequencies), electric current, fuel flow, etc. See also SC3 Annex B-1.4.2.4.

11.2 ENL figures – engine on An ENL of over 700 is expected when the engine is running at climb power. Over 900 is typical for a two-stroke engine, and over 700 for a nose mounted 4-stroke. Values of 999 have been recorded with a two-stroke engine running at full power, and over 900 for a Forward Electric System (FES) with the FR close behind it. These high ENLs are produced for a significant time during a climb and can therefore be attributed to engine running.

11.3 ENL figures – engine off ENL figures found during GFAC testing before IGC approval, are listed in the approval document of the FR concerned. Other ENL figures given below are a general indication.

a. *Winch and aerotow launches* ENL values are typically up to 300 for winch and 200 for aerotow, depending on speed, whether canopy panel(s) are open, and any sideslip.

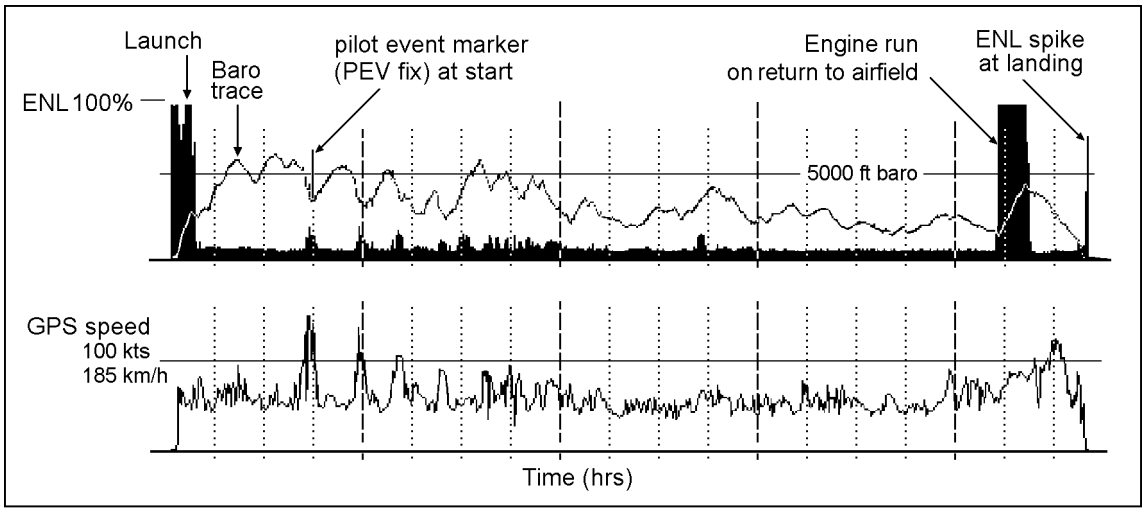
b. *After Launch* Values under about 100 indicate normal gliding flight. In a high speed glide or in an aerodynamically noisy glider, ENL may rise to about 250. Flight near powered aircraft should be avoided. The vario audio could be recorded as ENL if its speaker is close to the ENL sensor. Flight with canopy vents open can produce a low frequency "organ pipe" note, particularly with sideslip or a

high airspeed – ENL figures may be as high as 600. If the glider is climbing with any canopy panel(s) open, high ENL can be mistaken for engine running. Pilots should avoid these conditions, and if loud cockpit noise is experienced during soaring flight, change conditions to reduce it so that it only lasts for a short time. Other high-ENL conditions include a stall buffet that can produce higher ENL values, particularly if engine doors vibrate, and if the engine is on a retractable pylon, high ENL may be shown when flying with the pylon up and engine off due to high aerodynamic noise.

c. *Landing approach* ENL values are higher on an approach due to noise due to undercarriage, air-brakes, flap, sideslip, etc. ENL values of up to 400 have been recorded, although 200 is more typical in an aerodynamically noisy glider, and 50 in a quiet machine.

d. *Take-off / landing* During ground contact at take-off and landing, short duration ENL "spikes" up to about 600 have been recorded due to wheel noises or, on landing, initial contact with the ground.

11.4 Sample ENL data ENL data is shown below from one of the many analysis programs designed for the .igc file format. Here, the ENL values are highlighted as solid black bars whose height corresponds to the ENL values at each fix. They are shown on the same axis as the trace from the FR pressure altitude sensor. A separate graph of speed is included, and this is helpful in identifying why ENL values have varied during normal gliding flight, such as higher ENL values at higher speeds shown by the solid black peaks in the top graph that match the times of high speed.



ENL levels are shown in black, overlaid on the altitude trace with GPS-derived groundspeed below.

11.5 ENL analysis With an FR system that is correctly installed, it is normally not difficult to see when an engine has been running. Other data such as rates of climb and ground speed will indicate whether or not energy is being added other than by soaring. Short-term peaks in ENL (10 seconds or so) may be due to the other factors mentioned above such as undercarriage or airbrake/flap movement, sideslip, open canopy panels, nearby powered aircraft, etc.

11.6 MoP data This data is generally from a sensor external to the FR and connected to it by cable. This enables the sensor to be positioned in the optimum place to receive a high signal when any forward thrust is produced. In some cases the sensor may be inside the FR but have different characteristics to the ENL system, and such a MoP system must have shown in GFAC tests that it produces reliable indications of any forward thrust before IGC-approval is granted.

a. *Type of MoP sensor* The type of sensor (where fitted) is identified in an additional MOP line in the .igc file header record. The sensor may record acoustic noise, current flow (electric engine), fuel flow (piston or jet engine), or any other engine-related function that is IGC-approved for this purpose.

b. *Jet engine acoustic MoP sensors* Acoustic MoP sensors designed to be positioned near the jet-pipe of jet engines generally sense high frequency noise with a peak sensitivity from 2 to 5 KHz.

c. *MOP system testing and IGC-approval* An example of the MoP system for a particular type of FR is tested by the IGC GNSS FR Approval Committee (GFAC) and details are in the FR's IGC-approval document. Pilots and glider owners must check that the system in their individual glider is recording figures similar to those in the appropriate IGC-approval document. See 11.7 below.

11.7 Engine recording – pilot / owner responsibilities Pilots/owners of gliders with engines of any type should check that figures in .igc files produced by their individual recorder installation, particularly for ENL (and MOP, where fitted), indicate a clear difference between engine-off flight and any time where the engine produces positive thrust.

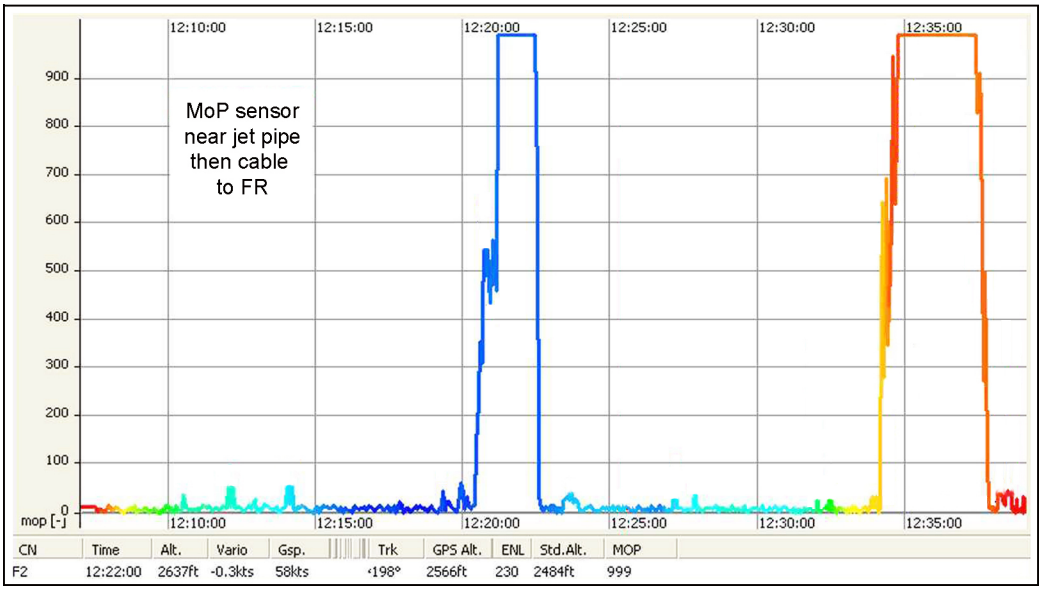
a. *ENL and MOP figures* The three ENL figures (and the three extra MOP figures where available) in each .igc file fix line should be similar to those found in GFAC tests and listed in the IGC-approval document for the type of FR and engine sensor concerned. In general, figures with engine-off during soaring flight should not exceed 400 (normally much less), and figures when the engine produces forward thrust should not be less than 700. If either the ENL or MOP values are outside these margins, there is a risk that glide performances may not be able to be validated – see below.

b. *Checking individual glider installations* Pilots are cautioned that flight claims have been rejected in the past where installations of FR engine recording systems in individual gliders fail to differentiate clearly between engine-on and engine-off conditions. This may be either (1) because use of engine does not produce high enough ENL / MOP figures in the .igc file, or (2) because the particular installation allows unwanted high figures to be recorded in gliding flight that could be confused with use of engine. Pilots are also advised that any change that could affect the engine recording system in an individual glider can alter the ENL / MOP readings, and before attempting a flight that requires validation, pilots should check that their current system clearly differentiates between engine-off and forward-thrust.

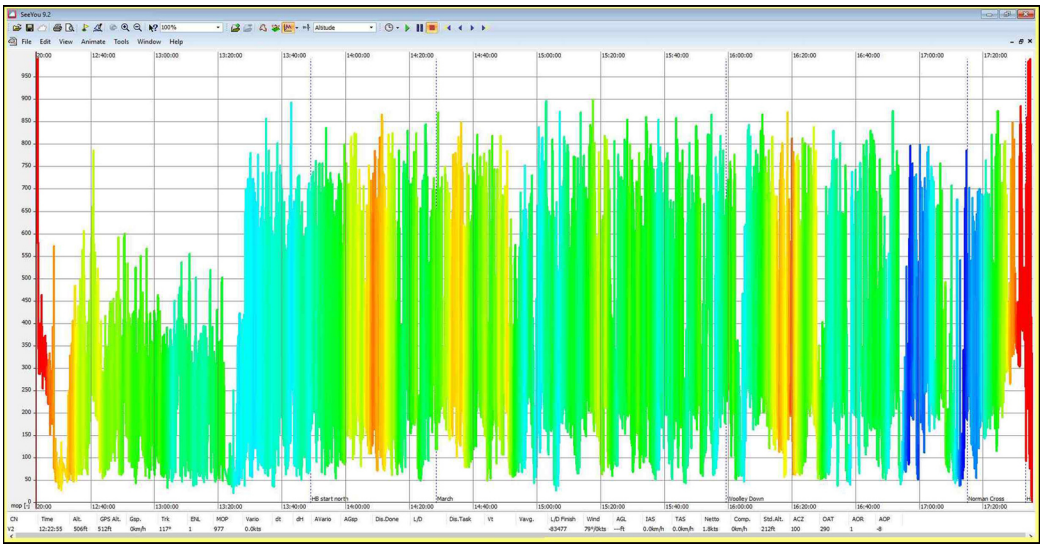
Some specific conditions that have been found are:

i. Unwanted high ENL in gliding flight With cockpit-mounted ENL systems, pilots should avoid flight conditions that produce high ENL figures in gliding flight with the particular glider installation. Such conditions may include flight with canopy panels open, particularly with sideslip when thermalling, and at high speed. In some gliders, flight with canopy panels open can produce an “organ pipe” noise at some speeds that records as high ENL, so opening them at such speeds should be avoided. High ENL can also occur with operation of airbrakes and undercarriage, but as this is normally when descending before landing this is normally easy to distinguish from engine running.

ii. Unwanted high MOP values in gliding flight In some systems that record high-frequency sound, high values have been found in gliding flight because the sensor has been placed where high frequency sound is present, probably due to vibration at certain airspeeds of the structure that the sensor has been mounted on. In such cases the sensor mounting must be changed or the sensor moved to another position so that low values are recorded in gliding flight, but the sensor is still close enough to the engine so that high values are recorded with forward engine thrust. The diagrams below show graphs from a good MoP sensor installation and an installation that is unacceptable and cannot be used for validation of a gliding flight.



.igc file MOP values showing two examples of jet engine running.



Example of .igc file MOP graph from a jet engine installation shows unwanted HF noise. The sensor must be moved.

11.8 Pilot/owner actions if .igc files do not clearly show engine use If ENL or MOP values in an .igc file make it difficult for an OO to distinguish between engine-off flight and flight with forward engine thrust, such as if ENL and MOP figures are found to be significantly different to those mentioned above, then action must be taken before flight validations are compromised.

Possible corrective actions include:

a. moving the engine sensor to a more favourable position to record use of engine (where the MoP sensor is separate from the main FR), or

b. moving the whole FR to a more favourable position (where this is possible with a small FR), or

c returning the recorder and/or the engine sensor to the manufacturer or his authorised agent for the ENL and/or MoP systems to be re-set.

Appendix 1

COMMON CONVERSION FACTORS

DISTANCE	1	inch	=	25.4	millimetre (exactly)
		foot	=	0.3048	metre
		mile (nautical)	=	1852	metre (exactly)
		kilometre	=	3280.84	feet
		mile (statute)	=	5280	feet (exactly)
		mile (statute)	=	1.6093	kilometres
		mile (nautical)	=	1.1508	miles (statute)
SPEED	1	foot/second	=	0.3048	metres/second
		metre/sec	=	3.6	kilometres/hour
		metre/sec	=	1.9438	knots
		metre/sec	=	2.2369	miles/hour
		mile/hour	=	1.6093	kilometres/hour
		knot	=	1.8520	kilometres/hour
		knot	=	1.1508	miles/hour
		knot	=	101.2686	feet/minute
		mile/hour	=	1.4667	feet/second
PRESSURE	1	atü	=	15	psi (for tire pressure)
		psi	=	6.8948	kilopascals (kPa)
		atmosphere	=	101.3325	kilopascals
		atmosphere	=	1013.325	hectopascals (hPa) or millibars
		atmosphere	=	29.9213	inches Hg (0°C)
		inch Hg (0°C)	=	33.8639	millibars (mb)
		millibar	=	0.7501	millimetres Hg
VOLUME	1	gallon (Imp)	=	1.2009	gallons (US)
		gallon (US)	=	3.7854	litres
		gallon (Imp)	=	4.5459	litres
MISC.	1	gallon (Imp)	=	10	lbs water (15°C)

as a rough approximation:
100 ft/min = 1 knot = 0.5 metre/sec

Appendix 2

Planning for FAI flight claims

Pre-flight preparations

PILOT 1 Verify each FR or PR being used is properly approved and running current "firmware". Inform the OO on which devices are to record the flight if more than one is in the glider.

2 Arrange for the OO or any other person monitoring flights to observe your take-off and make note of the specific aircraft you are flying.

3 Make sure your declaration includes all required information (see SC3-2.3 for badges and 3.2 for records).

4 If your task may require accurate height determination, ensure that your FR calibration is current.

OO 1 List each FR/PR being used for the flight. For each one, follow its approval document procedures for checking the device installation before take-off. The OO may be required to perform a pre-flight installation check, or seal the FR/PR to the glider, *and* maintain a continual watch of the aircraft until take-off.

2 If a written declaration is being used for a badge claim, you must sign it and add the date and time of signing. Submit the original with claim materials.

Post-flight actions performed as soon as possible after landing

PILOT 1 If an OO sealed the FR or PR to the glider before flight but he or she is not present at landing, contact that OO and arrange a time and location for him/her to perform the required post-flight inspection of the FR and the seal(s).

OO 1 Perform a post-flight installation check of each FR/PR, as directed in its approval document. Depending on the approval document provisions, the OO may be required to be present at the landing *and* maintain a continual watch of the aircraft until a post-flight installation check is performed.

2 Transfer the FR/PR data or supervise as the pilot does it. Using the manufacturer's IGC-approved software is recommended.

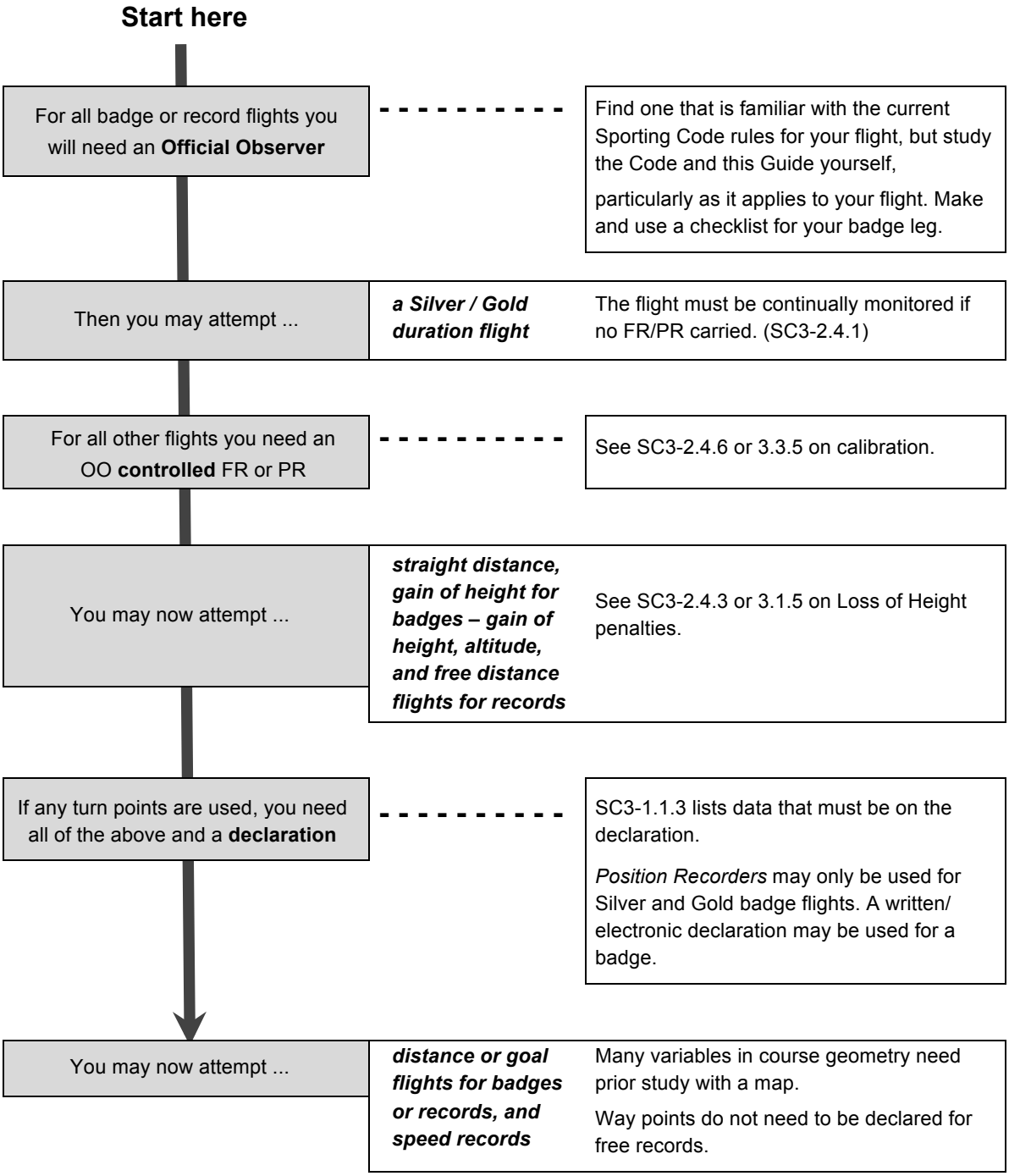
3 Take charge of the data file and perform the required security check as soon as possible and retain for evaluation. Make copies of the original file for the pilot. If the data file does not pass security, perform or supervise a fresh download or transfer as applicable, following approval document procedures and making sure the device running the down-load software is connected to a reliable power source.

4 Determine if FR calibration is current and if the claim requires a current calibration.

5 Refer to SC3-4.3 and 4.4 as needed to verify all required OO procedures were followed.

Appendix 3

BADGE / RECORD FLIGHT PROCEDURES FLOWCHART



Appendix 4

FLIGHT DECLARATION

This declaration or an equivalent is required if a Position Recorder is being used (SC3-2.3a).

The last written or internet declaration made before take-off is the only one valid for a given flight. *Warning:* some IGC-approved FRs make turn-on time of the FR the declaration time. To avoid problems, turn on the FR *before* the OO signs below.

Declaration date/time .....

Pilot ..... **Name (print)**

Glider ..... **Type & Registration**

FR/PR .... **Type & Serial no.**
#1 **#2**

Start point .....
Way point coordinates only

TP 1 .....

TP 2 .....

TP 3 .....

Finish point .....

.....
Signature of Pilot-in-Command

I hereby certify that I received and reviewed this form at the date and time below.

O.O. ..... **Name (print)**

..... **Date/ time**

Appendix 5

IGC-approved GNSS flight recorders and Global Navigation Satellite Systems

References: IGC web site: <*www.fai.org/gliding*>
IGC GNSS document site: <*www.fai.org/igc-documents*> then look for Flight Recorders
Chairman, IGC GNSS Flight Recorder Approval Committee (GFAC): <*ian@ukiws.demon.co.uk*>
Extensive information on GNSS systems is on the web:
for instance: *https://en.wikipedia.org/wiki/Satellite_navigation*

1.1 Terminology The title Global Navigation Satellite System (GNSS) is a generic term for any satellite-based system that enables receivers on or near to the Earth's surface to display accurate position data such as latitude, longitude and altitude. GNS Systems include the USA GPS, Russian GLONASS, European Galileo, Chinese Beidou 2, and any future systems. IGC-approved flight recorders (FRs) and NAC-approved position recorders (PRs) currently use the USA GPS system. An IGC-approved FR is a specially sealed unit with a GPS receiver, capable of recording 3D fixes, time and other data, that can be downloaded after flight to a PC in the IGC file format. The lower level PR may lack some features and is restricted in the types of flights for which it can be used (see XXX). As the words "logger" or "data logger" may be confusing when translated into other languages, the term "flight recorder" (FR) is the official term used by the IGC and FAI.

1.2 Position, height, and timing accuracy Overall average horizontal position error measured to date by GFAC is about 11 metres based on thousands of samples, although more recent IGC FR designs have averaged between 6 and 7 metres in good reception conditions. Tests are done by carrying the FR in a vehicle, driving over several accurately surveyed points, and recording the difference.

a. Vertical (altitude) figures using GPS in IGC files are with respect to the surface of the WGS84 Ellipsoid. GPS altitude accuracy is less than horizontal accuracy because of the shallower angles of the position lines needed for an altitude fix, and GPS altitude errors are generally about twice those for horizontal position. GFAC tests have also shown that it is possible to have accurate fixes in lat/long, but poor accuracy in GPS altitude, an obvious GPS altitude anomaly, or even complete altitude unlock. These are indicated in an IGC file either by a zero GPS altitude figure, or an obvious "spike" in GPS altitude, when lat/long positions continue to show a smooth track.

b. FRs have an internal clock powered by a small sustainer battery inside the FR that maintains continuous date and time even when the FR is switched off. The internal clock also gives accurate time in .igc files when the FR is operating in pure pressure altitude mode if there is a failure to receive or process GPS data.

c. GNSS systems have very accurate digital clocks so that the time differences between signals from different satellites can be used to calculate position on the surface of the earth.

1.3 Rules for the use of FRs and levels of IGC approval Current rules are in the Sporting Code (SC3), its annexes (SC3A, B, and C), in the IGC *Specification for IGC-approved GNSS Flight Recorders*, and in other IGC documents and information. All are available on the IGC web pages. Use of FRs in IGC competitions and championships is covered in Annex A to the Code (SC3A). Annex B (SC3B) contains the rules and procedures for the use of GNSS recorders. Each flight recorder is given an IGC-approval as listed below:

a. *IGC approval for all flights* Flight recorders that comply with all provisions of the FR specification at the time the approval document is issued. They may be used for all record, diploma, and badge flights.

b. *IGC approval for badge and diploma flights* Flight recorders that do not fully comply with some of the provisions of the IGC specification. These may not be used for world records.

c. *IGC approval for Silver or Gold badge flights* Flight recorders with less rigorous standards than either a or b.

A list of all IGC-approved FRs is published on the IGC gliding documents web page, with links to the IGC-approval documents for each FR. Each document has an introductory section, manufacturer contact details, description of the hardware, firmware and software, followed by "Conditions of Approval", connections to the FR,

security (physical and electronic), installation in the glider, motor glider aspects, sealing requirements (if any), and methods for downloading and analysis of flight data. Two annexes follow, Annex A with notes for pilots and FR owners, Annex B with notes for OOs and other people concerned with validating a flight, including barograph calibrators.

1.4 Physical and electronic security

a. *Physical security* An internal security mechanism activates if the FR case is opened. A silver coloured tamper-evident manufacturer's seal is normally fitted over one or more of the case securing screws.

b. *Electronic security* If the FR has been tampered with (such as by unauthorised opening of the case or attempting to do so), the internal security mechanism will erase the electronic key used to validate the integrity of subsequent IGC files. These files will continue to be produced, but will be marked as "unsecure" and will fail the IGC Vali test (6.3.c). Individual Vali programs originate from the FR manufacturers, are checked by GFAC for Sporting Code compliance and are coded to recognise the correct digital signature from each FR.

c. *Other flight data checks* Detection of alteration or artificial manufacture of data can also be helped by analysing features that can be checked from independent sources. These include wind drift in thermals, independent evidence of the ground level pressure for the time and places of take-off and landing, exact positions at take-off and landing, comparison with other flight records from the day and locality concerned, etc. The nearest meteorological office will have past records of ground level pressures and the wind structure with altitude. This independent data can be used for checking against the FR flight data that is being investigated.

d. *Flight recorder found to be unsealed* If either physical or electronic security is found to have failed, the FR must be returned to the manufacturer or his appointed agent for investigation and resealing. A statement by the owner of the FR should be included on how the unit became unsealed.

1.5 Altitude sensing and recording

a. *GPS altitude* The GPS altitude computed and recorded in an FR is the vertical distance above the WGS84 ellipsoid. Because of the difference to pressure altitude, GPS altitude figures must not be used for gain/ loss of height or absolute altitude calculations (except above 15,000 metres in the case of an IGC-approved High Altitude Flight Recorder), but may be used for evidence of flight continuity if the pressure altitude trace has failed.

b. Position Recorders Where the lower technical standard PRs record altitude at all, they may record altitude above an approximate sea level surface known as the WGS84 Geoid, an approximate sea level surface. Some PRs with a pressure altitude sensor may mix GPS altitude and pressure altitude data, for instance, to produce approximate height above ground.

c. *Pressure altitude* Pressure altitude is with reference to the International Standard Atmosphere (ISA) having a sea level datum of 1013.25 hectoPascals (hPa) / millibars (mb). As this is the IGC standard for measurement of altitude, a pressure altitude sensor is required in IGC-approved FRs. This enables pressure altitude recording to continue in the event of GPS failure or short-term unlock. The pressure altitude sensor in a FR is temperature compensated and is set by the sensor and FR manufacturer to the ISA. A sea level baseline setting and a setting for gain with altitude are usually available for adjustment and IGC procedures require the FR manufacturer to adjust these settings for minimum error before sale (see SC3B-2.1.1).

1.6 Position Recorders – IGC file format and testing Because PRs are simpler than flight recorders, some data fields may not be present. Pressure altitude in the .igc file is recorded as zero unless it is derived from a pressure sensor that is in the PR (not always the case).

a. *Analysis*. The .igc file produced by the device should be capable of analysis by a recognised and publically or commercially available analysis program. The analysis program should be specified in the NAC's approval document.

b. *Validation* The method of ensuring the integrity of the .igc file should be specified in the approval document, including details of the validation system that will identify any changes to the .igc file made after the initial download. Any changes detected after this transfer will invalidate the data. In this event, a further transfer should take place under close OO supervision and the .igc file analysed again.

c. *Testing* The recommended testing process for an NAC's PR is to make several test flights, comparing the device against an FR having IGC approval to see that there is no material difference in the results between them.

d. *Predicted fixes* The GFAC test for “predicted” fixes should be carried out to ensure that the PR only records fixes using real satellite data and doesn’t generate them (SC3-2.5e refers). A vehicle containing a PR is driven over a well-marked 90° feature such as a road junction, to mark the feature on the .igc file. Where fix rate can be changed, a fast fix rate such as one per second should be used. The feature is then approached again at a high but safe speed. When nearly at the feature, the GPS antenna is disconnected or, for units with internal antennas, the complete PR is covered so that GPS signals are blocked (for instance by aluminum foil). The .igc file must show that on the second run, no fixes were projected beyond the feature. In addition, the GPS fixes at the right angle (the drive with the antenna connected can be repeated several times) should be compared with the lat/long of the feature from *Google Earth* of the road or other junction to demonstrate fix accuracy and that the WGS84 datum is used by the PR system.

e. *Flight tests* The PR should be flown together with an FR and the data from the two .igc files compared. In particular, the shape of the GPS altitude graph with time should be relatively smooth with no “spikes” or other short-term variations.

f. *Information for GFAC* Before issuing an approval for a PR, NACs must send the GFAC chairman the following information (current email *ian@ukiws.demon.co.uk)* :

- the Internet link to the PR’s operating manual,
- the proposed operating limitations,
- a copy of the download and .igc file validation systems,
- sample .igc files.

This will enable GFAC to provide the NAC with expert advice including information on the PR’s .igc file structure and any SC3 requirement that may have been missed. If the PR can be shown to comply with IGC rules and procedures for PRs, the final approval will be posted on the IGC web site.

Appendix 6

High altitude flight recorders (HAFR)

1.1 An IGC HAFR is a flight recorder designed, tested, and having an IGC-approval document that covers altitude performances above 15,000 metres as well as normal FR functions at lower altitudes. As part of the initial IGC-approval process, GPS altitudes in IGC files from a HAFR recorder type are checked for anomalies. After IGC-approval as a HAFR, where the top height is above 15,000 metres, GPS altitude above the WGS84 Ellipsoid from the HAFR's IGC file is used for absolute altitude and gain-of-height records instead of pressure altitude, subject to other IGC procedures for HAFRs. Other references on HAFRs include: SC3-3.3.3b, SC3B-2.1.2.2, and the IGC FR Specification document.

1.2 Checks of altitude data

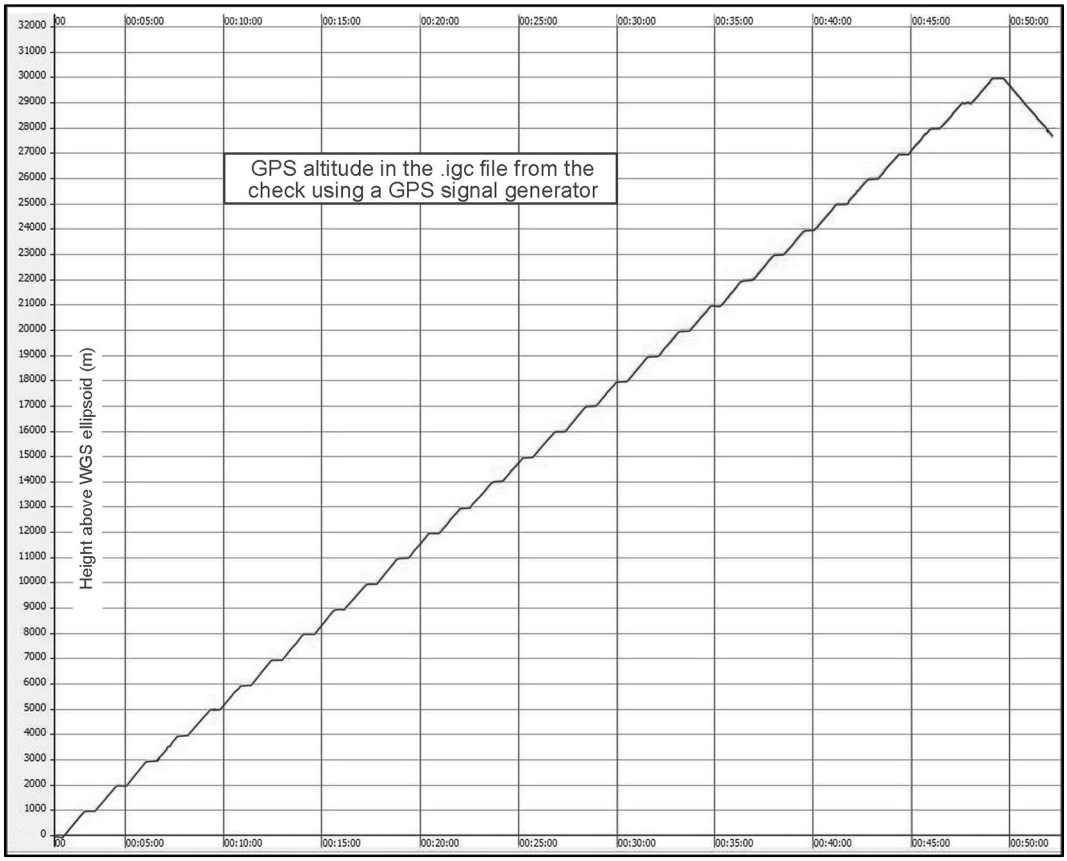
a. *Pressure altitude calibrations* For distance and speed records, the pressure altitude function of a HAFR must be calibrated in a similar way to other FRs (within 5 years before the flight and 2 months after). For altitude records below 15,000 metres, both calibrations are required, with the less favourable of the two used for the calculations. For altitude records above 15,000 metres, the 5-year pre-flight calibration is required, but there is no requirement for a post-flight pressure altitude calibration because GPS altitude will be used for the claim.

b. *Checking GPS altitudes in the IGC file* For claims above 15,000 metres, an independent check of the GPS altitude figures in the IGC file from the HAFR used for the claim must be carried out using a high quality GPS signal generator at a NAC-approved facility, within similar timescales to pressure altitude calibrations. This is to check that no fault has developed in the way GPS altitude is processed by the HAFR before the figures are placed in the IGC file. The preflight check must be within 5 years of the claim flight, but where a claim flight is at a location remote from facilities for checking GPS altitude, the 2-month period for after-flight checks begins when the HAFR is returned to a location at which these facilities are available.

c. *Independent check of GPS altitude figures in the IGC file* At a NAC-approved facility, a high quality GPS signal generator must be used to input a series of exact GPS altitudes above the WGS84 Ellipsoid to the antenna connector of the HAFR being tested, in a series of steps similar to those used for pressure altitude calibrations. At a minimum, the steps must cover either side of any low and high point that is to be claimed and the height of these steps must not exceed 1000 metres. The type of signal generator, its specification or other document showing its accuracy and performance, the identity of the tester and head of the testing team shall be recorded. The GPS conditions modelled should be appropriate to the region of the altitude record flight using factors such as latitude, number of satellites likely to be in view, and predicted ionospheric conditions. Examples of tables and graphs from such tests are shown for a specimen HAFR type ABC, serial number XYZ.

1.3 Signal generator output The input of the exact GPS altitudes above the WGS84 Ellipsoid in the steps in the graph are compared to the GPS altitude figures in the IGC file, using one of the analysis programs for IGC files. The signal generator should be set to give exact figures at each step (such as each 1000 metres), so that it easy for the figures in the IGC file to show any differences. The graph of altitude steps is then turned into a table of corrections to GPS altitudes in the IGC file to obtain the exact altitudes that were produced by the GPS signal generator. This table is then used to correct absolute altitude and gain-of-height figures from the claim flight in a similar way to the corrections applied to pressure altitude after a calibration in a pressure chamber.

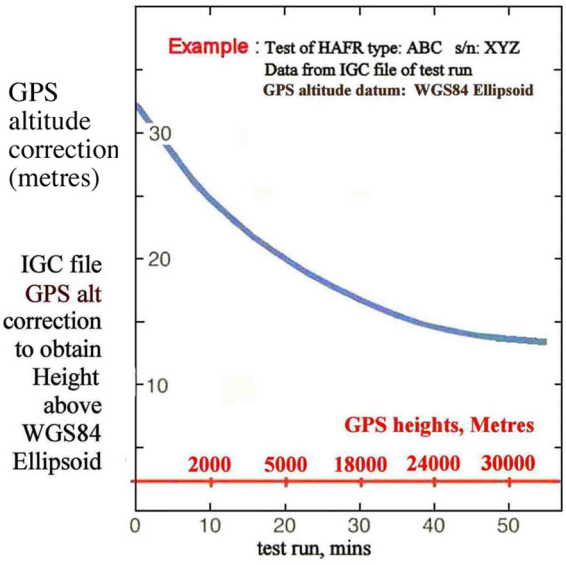
Differences between GPS altitudes in the IGC file and the exact altitudes from the signal generator are due to the processing of the GPS signal within the GPS receiver in the HAFR, followed by further processing within the recorder to place GPS altitude figures in the IGC file. This results in a corrected GPS altitude that must be used for altitude performances above 15,000 metres. The differences in the table shown are from a real HAFR test and are small, but with other types of HAFR the differences could be larger. There is also the possibility that the figures could differ from tests made several years before, due to processing being affected by updates to the HAFR or the development of faults in the FR. Since the corrected figures will be used directly for world or national records, these pre-and after-flight GPS altitude checks ensure as far as possible that there are no anomalies in the figures to be validated as an absolute altitude or gain-of-height record.



Sample HAFR check on GPS altitude – HAFR type ABC, Serial no. XYZ

Example - Table of GPS altitudes - HAFR test with GPS Signal Generator		
HAFR: Type: ABC	Serial Number (from IGC file name): XYZ	
Test organisation:		
Date of test:		
Name of Tester or Head of Test Team:		
GPS Signal Generator used, type:		
SigGenSpecification, Ref:		
SigGen Certificate of Performance, Ref:		
GPS Altitude zero datum used: WGS84 Ellipsoid (ref: IGC FR Specification)		
Signal Generator figure above WGS84 Ellipsoid metres	**IGC File GPS Altitude metres**	**Correction in metres to be applied to figure in IGC file to obtain altitude above WGS84 Ellipsoid**
0	-32	32
1000	972	28
2000	1975	25
3000	2977	23
4000	3978	22
5000	4979	21
6000	5979	21
7000	6980	20
8000	7980	20
9000	8980	20
10000	9981	19
11000	10981	19
12000	11981	19
13000	12982	18
14000	13982	18
15000	14982	18
16000	15983	17
17000	16983	17
18000	17983	17
19000	18984	16
20000	19984	16
21000	20984	16
22000	21984	16
23000	22985	15
24000	23985	15
25000	24985	15
26000	25985	15
27000	26986	14
28000	27986	14
29000	28986	14
30000	29986	14

Table of GPS altitudes from test of IGC HAFR with GPS signal generator



Appendix 7

Evaluation method if task not flown – or claimed – as declared

The graphics shown below were created using one of the popular brands of graphic software used by soaring pilots. Similar options are believed to exist in others listed at

www.ukiws.demon.co.uk/GFAC/documents/analysis%20programs%20for%20igc%20flight%20data%20files.pdf

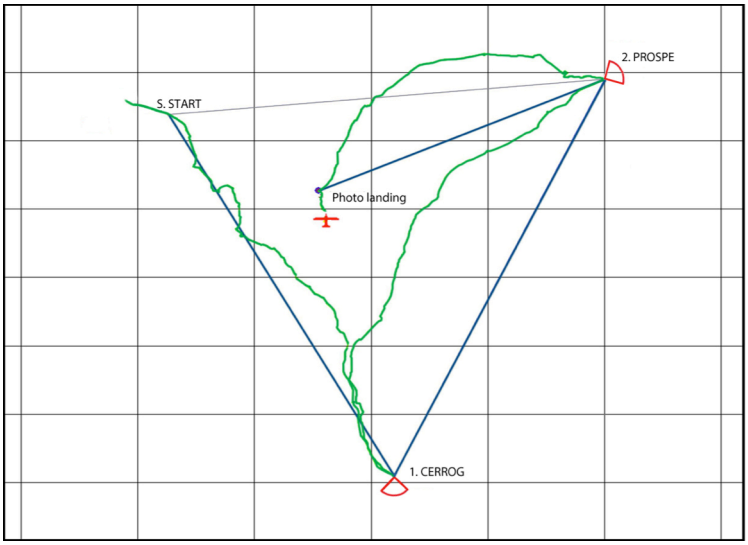
Graphic evaluation software is great for reviewing many or most tasks, particularly those flown as declared. In other cases, a variety of user setting adjustments are needed to evaluate such things as:

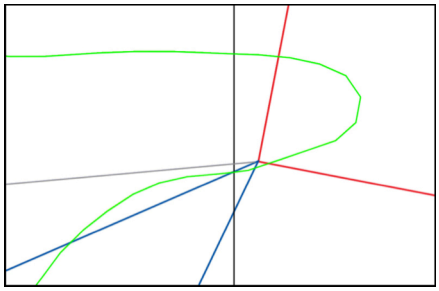
- A start at release where permitted – this may add distance and/or minimize or eliminate a Loss of Height penalty.
- Turn points used out of order, or a turn point skipped altogether.
- A finish fix – as with a start at release, this can also add distance or address Loss of Height problems.
- More challenging: for an outlanding, the claim reviewer should check both the landing location and a near-by finish fix if needed to minimize Loss of Height and maximize the distance that can be claimed.

The first step in evaluating any of the above is to determine whether/how OZ Sector orientation may be affected. If the only issue is turn point use order, skip ahead to "Step 4" and edit the "task declaration" as needed to set things straight.

For a start at release, the use of a finish fix or a finish at landing, the steps outlined below will guide you through the process of (1) isolating the location of interest, (2) editing the task, and (3) reviewing the results. The following example explains how to evaluate an outlanding.

Below, the graphic software shows landing approximately 95 km off the declared last leg course line, but it does not display the OZ at the last TP as the task was actually flown, and a "photo landing" is credited as the finish. This isn't what the Sporting Code requires, so there's some work to do to determine what distance the pilot may be able to claim.





Note: The software, by default, displays the OZ sector at the last TP *as declared,* barely entered through one boundary and exiting through the other. The problem – this software generated OZ does not reflect the task as flown.

Step 1 **Open the data file in a text editor** Scroll as needed to find the end of the landing roll, shown in **bold** below. (Spaces between data blocks added below for clarity.)

	TIME	LATITUDE	LONGITUDE	P Alt	GPS Alt	
B	024627	38 29 510N	118 23 778W	A01352	01430	….
B	024632	38 29 576N	118 23 802W	A01352	01430	….
B	024637	38 29 645N	118 23 817W	A01352	01430	….
B	**024642**	***38 29 715N***	***118 23 842W***	**A01354**	**01430**	**This is end of the landing roll**
B	024647	38 29 715N	118 23 842W	A01354	01430	….
B	024652	38 29 715N	118 23 842W	A01354	01430	….
B	024657	38 29 715N	118 23 842W	A01354	01430	….

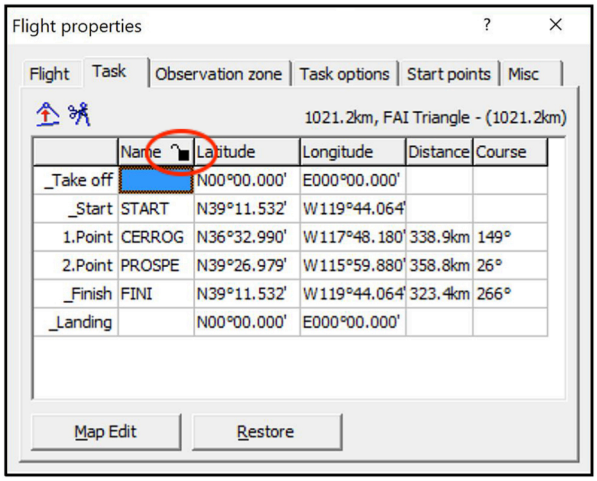
Step 2 Check for Loss of Height issues This applies *only* to landing evaluations and Free Distance start and finish fixes. If it is clear a Loss of Height penalty will result from claiming a finish at landing, go back to the overhead graphic and look for a nearby finish fix that minimizes or eliminates this. (A similar process does NOT apply when release is claimed as the start point – release altitude is release altitude!)

Step 3 Jot down coordinates at the location of interest Set the software defaults to DD.MM.mmm for coordinate display, so you can simply transcribe data from the .igc file!

38 29.715 N 118 23.842 W

Step 4 Open data file in graphic software; select user options to edit the Task

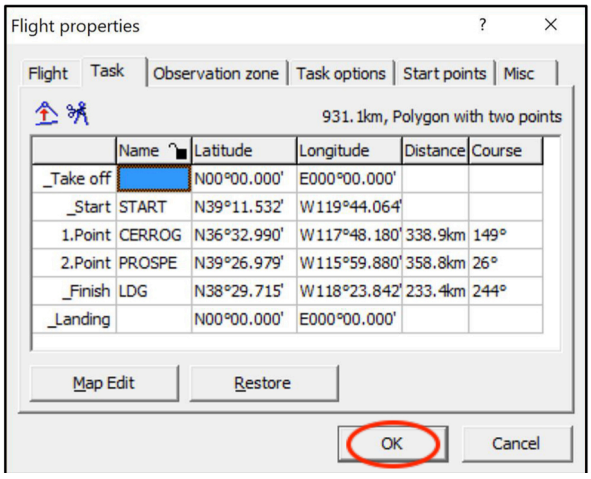
Unlock the task by clicking on the “lock” symbol



1021.2km, FAI Triangle - (1021.2km)

	Name	Latitude	Longitude	Distance	Course
_Take off		N00°00.000'	E000°00.000'		
_Start	START	N39°11.532'	W119°44.064'		
1.Point	CERROG	N36°32.990'	W117°48.180'	338.9km	149°
2.Point	PROSPE	N39°26.979'	W115°59.880'	358.8km	26°
_Finish	FINI	N39°11.532'	W119°44.064'	323.4km	266°
_Landing		N00°00.000'	E000°00.000'		

Transcribe the landing coordinates to the proper line

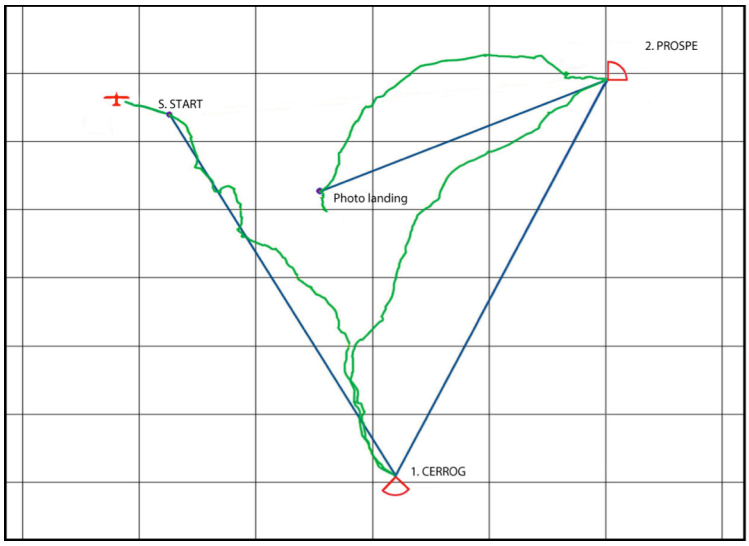


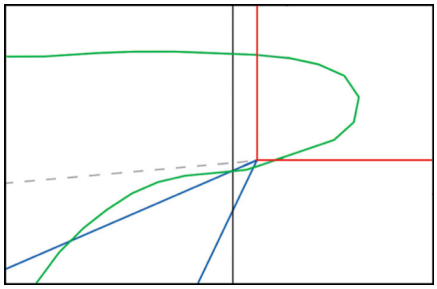
931.1km, Polygon with two points

	Name	Latitude	Longitude	Distance	Course
_Take off		N00°00.000'	E000°00.000'		
_Start	START	N39°11.532'	W119°44.064'		
1.Point	CERROG	N36°32.990'	W117°48.180'	338.9km	149°
2.Point	PROSPE	N39°26.979'	W115°59.880'	358.8km	26°
_Finish	LDG	N38°29.715'	W118°23.842'	233.4km	244°
_Landing		N00°00.000'	E000°00.000'		

Double check the accuracy, the click “OK”

Graphic software after task editing. The viability of the last turn point is confirmed – note that the OZ has shifted.





Still plenty of fixes in the OZ Sector!

Now, the Sector is displayed as required by SC3–1.2.6b, “centered on the extended bi-sector of the inbound and outbound Legs.” (The software, by default, continues to refer to a photo landing – not quite right.)

Appendix 8

Flight Analysis Software

Information date: 29 May 2018

The analysis programs listed here are ones that have notified to the IGC that use the .igc file format. They are for information only and no IGC or FAI approval or preference is implied. Their use with .igc format flight data files is a matter between the program maker or supplier and the user or customer.

In addition to analysing the flight data for reaching waypoints, calculating distance, etc, a validation (Vali) check of the structure of the .igc file must be made before a flight performance can be approved to the standards of the IGC. This file validation process ensures that the file being analysed comes from a serviceable, secure flight recorder, the file is not corrupted, and is identical to when it was downloaded.

The .igc file Vali check uses the latest version of the Data Link Library (DLL) file from the flight recorder manufacturer (DLLs are available on the IGC and GFAC web pages), together with a program that processes it. Some of the programs below can carry out this check; if in doubt use the Vali function in the IGC Shell program that is available free on the IGC and GFAC web pages together with the latest version of FR manufacturers' DLL files. See:

www.ukiws.demon.co.uk/GFAC/downloads.htm or
www.fai.org/igc-documents , then select "Flight Recorders", then "IGC Shell Program".

For the programs listed below, please report any dead links, changed references or any other programs capable of analysing .igc file data not listed here to the IGC GNSS Flight Recorder Approval Committee (GFAC) Chairman, Ian Strachan, at: ian@ukiws.demon.co.uk

	Program Name	*Web reference*
1.	Claim Check	http://badgeflight.com
2.	GPS Visualizer	www.gpsvisualizer.com
3.	KFlog	www.kflog.org
4.	SeeYou	www.naviter.com/products/seeyou
5.	StrePla	www.strepla.de
6.	TaskNAV	www.tasknav.com
7.	WinPilot	www.winpilot.com
8.	IGC Webview	http://glidingweb.org/IgcWebview

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