FAI Sporting Code

Fédération
Aéronautique
Internationale

Section 3 – Gliding

Annex C
Official Observer & Pilot Guide

Avenue Mon-Repos 24
CH-1005 Lausanne
(Switzerland)
Tél.: +41(0) 21/345.10.70
Fax: +41(0) 21/345.10.77
E-mail: sec@fai.org
Web: www.fai.org

2010 Edition

Valid from 1 October 2010

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

Avenue Mon Repos 2, CH 1005 – Lausanne, Switzerland
http://www.fai.org e-mail: *sec@fai.org*

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]. Permission and authority to exploit any rights to any commercial activity at such events, including but not limited to advertising at or for such events, use of the event name or logo for merchandising purposes and use of any sound and/or image, whether recorded electronically or otherwise or transmitted in real time, must be sought by way of prior agreement with the FAI. This includes specifically all rights to the use of any material, electronic or other, that form 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] is authorised to negotiate prior agreements on behalf of FAI with FAI Members or other entities as appropriate, of the transfer of all or parts of the rights to any FAI International Sporting Event (except World Air Games events[9]) which is organised wholly or partly under the Sporting Code section[10] for which that Commission is responsible[11]. Any such transfer of rights shall be by "Organiser Agreement"[12] as specified in the current FAI Bylaws Chapter 1, para 1.2 *Rules for Transfer of Rights to FAI International Sporting Events.*

Any person or legal entity accepting 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 formal transfer of rights has been established, FAI retains 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, and always reserves itself the right to have any and all parts of any event recorded, filmed and/or photographed for such use, without charge.

1 FAI Statutes, Chapter 1, para 1.6
2 FAI Sporting Code, General Section, Chapter 3, para 3.1.3
3 FAI Statutes, Chapter 1, para 1.8.1
4 FAI Statutes, Chapter 5, paras 5.1.1.2, 5.5, 5.6, and 5.6.1.6
5 FAI Bylaws, Chapter 1, para 1.2.1
6 FAI Statutes, Chapter 2, para 2.3.2.2.5
7 FAI Bylaws, Chapter 1, para 1.2.3
8 FAI Statutes, Chapter 5, paras 5.1.1.2, 5.5, 5.6, and 5.6.1.6
9 FAI Sporting Code, General Section, Chapter 3, para 3.1.7
10 FAI Sporting Code, General Section, Chapter 1, paras 1.2 and 1.4
11 FAI Statutes, Chapter 5, para 5.6.3
12 FAI Bylaws, Chapter 1, para 1.2.2

TABLE of CONTENTS


You are here
GIL PARCELL

Official Observer & Pilot Guide

GENERAL

1.1 Purpose of the Annex This Annex has been prepared to assist Official Observers (OOs) and pilots interpret the rules in the Sporting Code Section 3 for gliders and motor gliders. It amplifies these rules, gives guidance on how to comply with them, and recommends procedures for the operation of equipment used to provide evidence for flights.

Suggested improvements to the text the Annex will always be seriously considered. Send proposed amendments to the IGC Sporting Code committee either directly or through the FAI Secretariat in Lausanne, preferably in the format used in the text. When an amended version of an earlier year's Annex is published, substantive changes are indicated by a vertical line to the right of any affected paragraph.

1.2 The Sporting Code The 2009 edition is a major rewrite to update rules on flight evidence. Although simplicity was a goal, the Code is not simple because it covers all badge and record types and allows the pilot to gather flight evidence in alternate ways with various data recording equipment. As a result, how one is to respond to the Code requirements can be confusing. If you think that any text in the Code is capable of more than one interpretation, the *most straightforward* interpretation is the correct one.

Misinterpretation of the Code may arise from reading a portion of text in isolation, without referring to the very specifically worded definitions of the terms being used. For example, Chapter 2 specifies the distances required for various badge legs, but how these distances are to be achieved are defined in SC3-1.4.3 to 1.4.6.

If you find any part of the Code text unclear, pass your concern to the IGC Sporting Code committee.

1.3 A word on claims processing The introductory philosophy on page (iii) of the Code states: "*When processing the evidence supplied, OOs and the NAC should ensure that these rules are applied in the spirit of fair play and competition."* The ratification process determines if the claimed task conforms to the rules. Incorrect or incomplete evidence can often be corrected. Simple errors in pilot-input information with flight recorders are another example (see para 10.3). At times, although the evidence presented cannot support the stated claim, the pilot may not have realised that it is sufficient for another category of badge or record. OOs and National Claims Officers are encouraged to take the position that, while ensuring the rules are met, their goal is to make awards, not turn them down for minor errors or oversights that do not affect the proof of a soaring performance.

1.4 NAC recommended practices The National Airsport Control (NAC) is the organisation that accredits a country's delegate to the IGC. It maintains control of its national soaring Claims Officer, OOs, data analysts and barograph calibration labs, and has the final responsibility for the flight analysis process and the integrity and accuracy of data that it ratifies. The NAC maintains a list of "GPS position recorders" that it accepts, badge claim forms, may hold a national turn point list, and may have their own locally-modified IGC record forms that incorporate national-only record types.

There is only one NAC for each member of the FAI; however, the NAC may delegate to another organisation in its country part of its sporting powers. (GS 1.3.2). Where appropriate in this document and in the Sporting Code, "NAC" means the NAC or a delegated organisation. Some practices that the NAC may involve itself in are:

a. *OO training* A NAC should establish requirements for becoming an OO such as holding a badge leg or having an association with the sport for some minimum time. A NAC may find it useful to maintain material that assists beginning OOs to gain knowledge of the Code such as self-help tests.

b. *OO control and tracking* A NAC needs to maintain a list of its OOs so, for example, it can distribute information to them on changes to IGC badge and record procedures or national factors that will influence badge and record flights. Such a list is best maintained by the national Claims Officer who must know if an OO named on a claim is valid.

c. *Senior OO* A NAC may authorise only selected OOs to ratify record flights within its jurisdiction. The NAC may specify the amount and type of experience required for this senior position, but full knowledge of FR data analysis should be part of it. The position of Senior OO may also refer to an experienced club OO who can check that claims from club pilots/OOs are error-free before they go to the Claims Officer. This greatly reduces a Claims Officer's workload.

d. *National procedures for data analysis* As GPS position recorders and flight analysis software is now established technology, most OOs should be able to do the basic data analysis required to verify a normal badge claim. The NAC should identify experienced Data Analysts to assist in analysis of flight files and important claims like world records. A list of programs that are designed to use the IGC file format is maintained by the GNSS Flight Recorder Approval Committee (GFAC) and is on the IGC web page.

1.5 Official Observer duties The OO has the important responsibility of being the FAI's field representative. The OO ensures that the flight is controlled in accordance with the Sporting Code requirements, and that evidence is gathered and prepared in such a manner that later study of it by a disinterested examiner, usually the national Claims Officer, will leave no doubt that a claimed achievement was met. The function of the OO is first, to verify that a pilot has completed what is claimed, and second, to verify that the claim matches the Code requirements for a given badge, diploma, or record.

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, and to reject or refer to higher authority a claim that does not appear to fulfill the rules. Aside from giving the Claims Officer unnecessary work, an OO should never pass a poorly prepared claim to the Claims Officer in the hope it will be accepted. The Code standards are the foundation of recognized achievement in soaring, so a rejected "almost good enough" flight will be valuable experience for the pilot.

1.6 Terminology Where the abbreviation "FR" is used in the Sporting Code and here, it refers to flight recorders that have IGC-approval (para 6.2) after testing by the GNSS Flight Recorder Approval Committee (GFAC). Other GPS units that are approved by individual NACs for Silver and Gold badge use are termed "position recorders".

1.7 National records The only interest the FAI has in national records is that a world record must first be ratified as a national record. A NAC may have additional record types or classes or accept different forms of evidence; but a national record that leads to a claim for a world record must conform fully to the Sporting Code.

1.8 Measurement accuracy and precision A device may display measurements to a larger number of significant figures than its sensor can detect. A digital barograph may show altitude values to the nearest metre, but its pressure sensor may only be capable of resolving height to within about 30 metres (especially at high altitudes). In this case, the FR pressure height readout value is *not* valid to this level of accuracy. The reverse case is a sensor or processor that is more precise than its data readout; for example, a digital clock that displays time to the nearest minute while its internal counter is operating to the microsecond. Don't introduce more precision to a calculated value than the recording devices used can detect.

a. *Distance calculation* Remember that if FR or GPS position recorder data is used to calculate distance, the official distance for the flight may be a lesser value. Refer to SC3-1.3.9 and 4.4.2. If necessary, the geodesic distance may be determined using a stand-alone calculating program that can be downloaded from the FAI web site at <*http://www.fai.org/distance_calculation/*>.

b. *Measurement accuracy for badge claims* For badge distance claims, the OO is certifying that a specified distance has been *exceeded*. Where this is clearly so, it is not essential to measure the distance with the same accuracy as for a record – for example, the simple FAI sphere calculation would be adequate. The argument can be extended to calculating a height gain, where a clear excess may not require access to the barograph's calibration certificate.

c. *Altitude accuracy* Dynamic pressure errors, errors associated with reading barograms (stand-alone or incorporated in the FR), producing a barograph calibration trace, and (if necessary) constructing a calibration graph – all these introduce uncertainty in the precise height achieved, regardless of calculations to the metre. The resulting gain or absolute altitude value should be rounded off to the nearest 10 metres. This satisfies the 1% accuracy requirement for Silver gains, and is proportionately better for other badges.

d. *Conversion factor error* Exact conversion factors should be in all intermediate calculations, then round off the final result to the precision of the least accurate data. Stating that a distance was “about 1100 feet” means that it could be anywhere from 1050 to 1150 feet. Only the first three figures are significant, therefore the phrase “about 1100 feet (335.3 metres)” is nonsensical – this conversion to metric has improved the precision of the value to four significant figures. Such misuse is often seen on altitude gain claims. This conversion example should be rounded off to 335 metres.

HEIGHT PROBLEMS

2.1 The 1% rule – height loss is limited for tasks under 100 km (SC3-4.4.3b)

For distance flights less than 100 km, the maximum height loss cannot be more than 1% of the distance flown. No margin is allowed – exceeding 1% invalidates the flight. Be especially aware of this when the finish point or the possibility of landing is at a lower altitude than the start. A Silver badge distance flight that is exactly 50 km can have a loss of height from start to finish of no more than 500 metres. A 60 km flight is allowed 600 metres and so on up to a 100 km flight. For pilots using altimeters that display altitude in feet, Table A below will be of assistance in determining the maximum height loss for these short flights.

TABLE A Maximum allowable 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

If you are planning a Silver distance flight using the rule that allows distance to be claimed from one leg of a longer flight, should note that the 1% rule applies to the total distance flown (if less than 100 kilometres), not just the leg of the flight that is more than 50 kilometres. However, to be cautious, you should use a start height that will allow a valid claim even if you landed just after the 50 kilometre leg was flown.

Remember that you can select a position fix in the flight recorder data as a “remote” finish. See paragraph 4.4. If you plan to use such a finish, take care that the 1% rule is not broken.

2.2 Height penalty – for distance flights over 100 km (SC3-4.4.3a) For flights greater than 100 km, there is a penalty on the claimed distance if the loss of height exceeds 1000m so that there can be no benefit to deliberately starting a task with excess height. This penalty, now 100 times the excess height loss, has increased over time to keep pace with the increasing performance of gliders. If a loss of height is 1257 metres, for example, then the distance flown is reduced by 100 times 257 metres or 25.7 kilometres.

2.3 Measurement of absolute pressure – the altitude correction formula (SC3-4.4.5)

To make this correction, the OO must determine the “standard altitude” for the airfield at the time the flight is made. This can be done by recording the airfield elevation indicated on an altimeter when it is set to 29.92 "Hg or 1013.2 millibars. Averaging several altimeters will give greater accuracy. Alternately, the nearest weather station (within the same air mass) will be able to provide its station pressure at the time of the flight and its elevation. Converting the station pressure to altitude from Standard Atmosphere tables will allow the correction to be calculated. The formula is best understood by considering it in two steps:

a. *Corrected altitude* = *measured altitude (from the barogram) + correction*

b. *Correction* = *field elevation – standard altitude* (with altimeter set at 29.92"/1013 mb), or
= *weather station elevation – station pressure* (converted to height)

If the atmospheric pressure was below Standard at the time of the flight, the correction will be negative, and the corrected altitude will be less than the measured altitude, ie. the barograph was “reading” too high.

TASK CONSIDERATIONS

3.1 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 or even cancel your planned flight, may result in weak or missing evidence, and accounts for most rejected claims. Your preparation of *impeccable* evidence requires some care and time. Time is invariably in short supply on the morning of the "big flight". Anticipate the day and plan for it during your off-season – this will go a long way towards having a successful flight.

a. Study the *current* Sporting Code to be aware of the requirements for a given flight, and discuss your planned flight with the OO. See the Appendix 2 documentation checklist.

b. Be completely familiar with your flight recorder and the loading of the declaration and turn point 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. Store all your task planning documents in a separate folder and keep it handy. Record forms are available on the IGC web site.

d. Plan several tasks for different meteorological conditions and have them loaded in your FR or available on your computer. Finally, prepare and use a task checklist.

3.2 Pilot hints for the Silver badge flight The Silver distance flight is the "leaving the nest" adventure. It is intended to be a *solitary* accomplishment; the "no-help-or-guidance" note in SC3-2.1.1a means even help or assistance from other Silver distance hopefuls that day, and it means no team flying.

a. The big problems associated with the Silver duration flight are:
   • *A full bladder or dehydration* This is *not* a choice; don't become dehydrated to avoid the distraction of a full bladder. Drink excess fluids first thing in the morning to become fully hydrated, then empty your bladder just before take-off. Hydrating yourself before flight will significantly delay the need for fluids. Carry sufficient water on the flight for the temperature conditions and have a method of urine disposal.
   • *Boredom* Boredom will cause 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 10 kilometre goal flight, etc.
   • *Reluctance to fly away from the field* You can't stay up if you don't go to the lift. Fly five to ten kilometres from the field – the club single-seat glider can go that far. Then, get high and stay high.

b. Any completed leg of more than 50 km or a landing point 50 or more kilometres from an achieved TP of an incomplete distance flight qualifies for Silver distance. Note that the 1% rule or distance penalty rules apply to the *entire* flight from release to landing, not just to the leg on which the distance is claimed. The distance requirement may be met, for example, by an out and return flight of over 100 kilometres, the distance being measured from the turn point back to the home airfield. This is often done to maintain a "normal" release height when the TP elevation is lower than the launch point. However, the claimable distance begins only when the turn point is reached – you could soar 99 kilometres without being able to claim a Silver distance.

c. Another possibility is a 'thin' triangle flight with two turn points over 50 kilometres apart and with the airfield somewhere between. The advantage here is that you can always be fairly close to the airfield.

3.3 Common badge flight errors OOs reject many claims as a result of common errors of pilots trying their first badge flights. Here are some flight preparation or execution factors that can result in your claim failing.

a. You did not get an OO to brief you on the usual task pitfalls *before* you attempt a specific task.

b. You flew a distance task with no planning and then expected that an OO would find a way to make the flight fit the Code requirements.

c. You did not complete a declaration if your task had turn points.

d. You did not make a paper declaration when using a GPS position recorder for a distance flight.

e. You did not know the maximum height you could be towed to on an under-100 km distance task. This is particularly important if it is possible that the landing could be at a lower elevation than your take-off point.

f. You declared your task using a club FR, but you did not ensure that you and your glider were input as well as the task – it still contained the glider and the name of the last person who used it.

g. You declared a start point but did not fly into its OZ before you began your task.

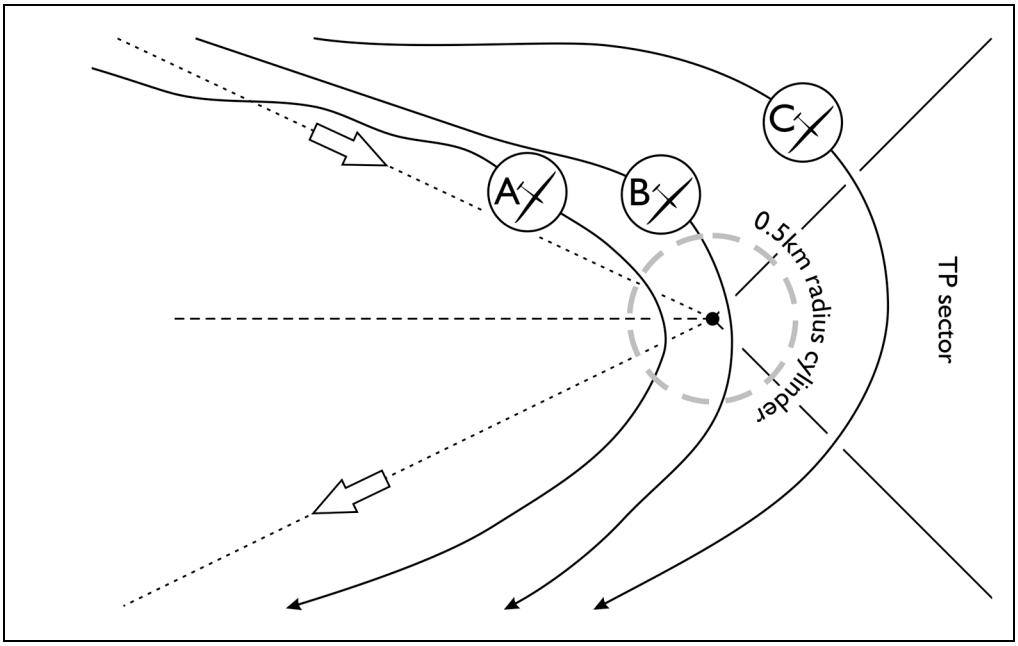
h. You are a beginner in the use of the FR and did not practice using it to make sure you got into the OZ of your intended TP, or your FR was configured to sound a TP entry alert for a cylinder OZ, so you turned away on course at the start before entering a needed sector OZ.

i. After the flight, the OO was not available so you took the FR out of the glider and gave it to him later that day. (See para 7.2 – the OO *must* have control of the FR after landing until the flight data is downloaded.)

j. Your OO did not keep a copy of your flight file and the original was contaminated in the process of being converted to an .igc file using *SeeYou*, for example. (A file stored on the OLC website will not validate.)

3.4 Flight into the observation zone A way point is reached only when the pilot has evidence of being within its Observation Zone, or that a start or finish line has been crossed. Either the sector or the cylinder OZ may be used for a turn point on a given flight, but the cylinder OZ cannot be used as a start and/or finish OZ. The cylinder OZ may have some advantages given that only distance from the turn point is a factor (not position also) – but this OZ could severely limit a pilot's opportunity to achieve a TP if it were under weather, for example.

The illustration below shows three valid tracks into a sector OZ. Pilot A just makes it into the 0.5 km radius cylinder and has a 1 km distance penalty at this turn point. Pilot B records points in the cylinder and the sector. Pilot C makes a wide sweep round the TP. There's no limit to the depth of the sector – the pilot can go any distance beyond the TP.



3.5 Notes on declarations

a. If you wish to make a "last minute" badge task change in the busy period just before take-off, making a new *written* declaration will avoid possible input errors in an FR. However, note the timing warning in para 6.3a (see the Appendix 4 declaration form). A written declaration is always required when using a GPS position recorder. For record flights, the electronic declaration in an FR is the *only* acceptable form of evidence.

b. Do not to abbreviate the names of way points unless the abbreviation is included in a list of way points that has been published prior to the flight. This is required so there is no confusion as to the precise way point that an abbreviation refers to. Wherever possible, latitude and longitude coordinates should be used to identify a way point and, when used, these coordinates become the official location of the way point.

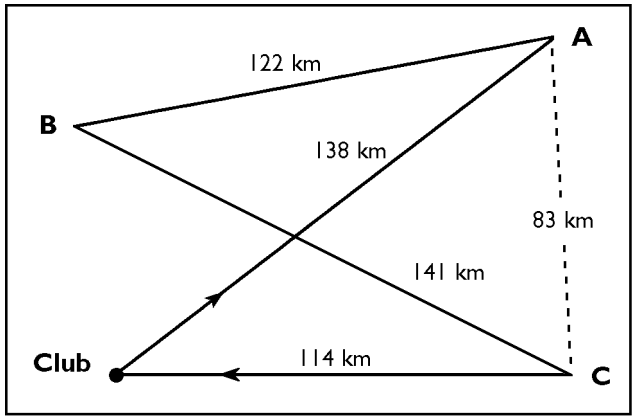
3.6 Claiming more than one soaring performance from a flight A flight may satisfy the requirements for more than one badge leg or record. Always consider the potential for alternate or additional task claims when selecting turn points, as this allows the pilot to make useful in-flight decisions on task selection depending on the soaring conditions. This planning is especially useful for Gold/ Diamond Goal distance flights.

For example, the course shown below is declared (club/A/B/C/club). If this flight is completed, the following badge tasks have been achieved:

a. *Diamond and Gold distance* – 515 km (club/A/B/C/club)

b. *Diamond Goal distance* – 346 km (A/B/C)

This course meets the 3TP triangle definition of SC3-1.4.6b(i). If flown in reverse, it would meet the 3TP distance definition of SC3-1.4.4a.



3.7 Abandonment of a turn point or the failure of a declared task (SC3-1.4.1a)

A failed declared task (often from the inability to reach a turn point, or not flying into the OZ of a turn point) may still fulfill the requirements of another soaring performance – look for what was achieved on a flight rather than focus on the failure. A flight is to be treated as undeclared following the last achieved turn point, except that a closed course flight may be claimed if the declared finish is achieved and qualifies as a goal. An exceptionally long flight may also qualify as a free distance record. Sample scenarios are:

a. If, on a triangle distance task using two TPs, the first TP were missed or was unattainable, the pilot could claim a 3TP Distance badge task (start, second TP, to finish).

b. If, on a triangle distance task using two TPs, the second TP were missed or was unattainable, the pilot could claim as a 3TP distance flight.

c. If an out & return flight is invalidated by an exit from the start OZ sector more than 1000 metres from the start point, or a triangle flight is invalidated by failure to enter a turn point OZ, the course flown in either case may be credited as a 3TP distance flight.

3.8 Three TP distance task The essence of this task is that the set of three declared TPs and the course between any or all of them is completely optional, except that TPs must be at least 10 km apart, and at least one TP must be used. Any start is permitted.

3.9 Free record flights (SC3-1.4.6) For free distance record flights, the way points are declared *after* the flight is done. A normal declaration is still made before the flight that includes the usual non-flight information, but task way points can be omitted. The pilot is free to fly anywhere between take-off and landing and, after the flight, select fixes from the position evidence to be the declared way points of the soaring performance. See para 4.4 for details on selecting fixes. A free record flight may also be claimed from a failed declared flight or by extending the turn position of a completed declared flight.

START and FINISH CONSIDERATIONS

4.1 Start / finish evidence The start and finish have three parameters associated with each of them:

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 point OZ is entered, 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 the exit of the OZ of the start point or the time at a fix selected as a start.	*The finish time* is the actual time of landing or MoP restart, or the time at the finish fix, or on entering the OZ of the finish point.
The start height is measured at the same place as the start time.	*The finish height* is measu6red at the same place as the finish time.

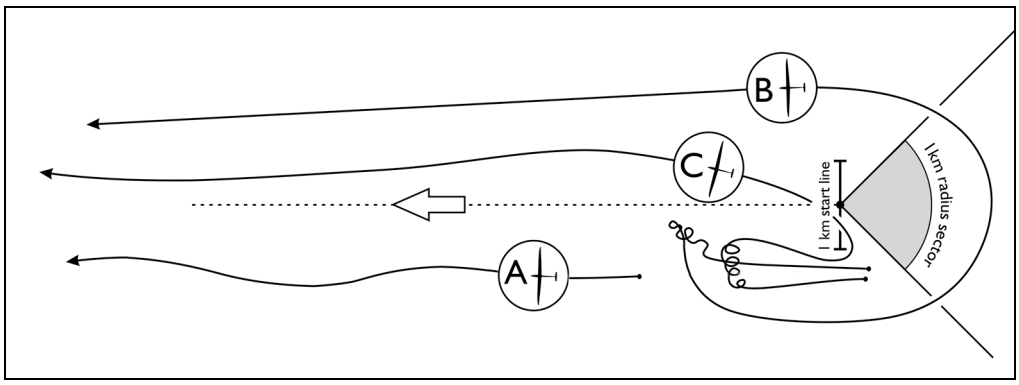
4.2 Start and finish options The start and finish of a badge or record flight are the places where misunderstanding may occur because of the several alternatives available. The start holds much potential for error or miscalculation of position or height that will negate the remainder of the flight. The Code gives several choices for starting (SC3-1.2.8) and finishing (SC3-1.2.11). See also the Task Table at the end of SC3 Chapter 1.

a. Distance-to-a-goal tasks require crossing a start line or leaving a start sector OZ within 1000m of the start point and crossing the finish line or entering the finish OZ within 1000m of the finish point. The cylinder OZ cannot be used for a start (para 1.2.5).

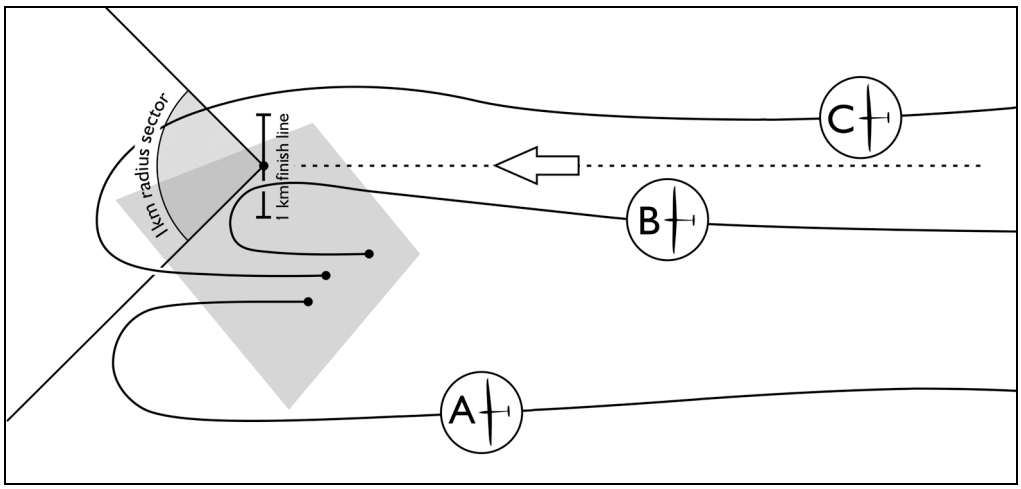
b. For the Diamond goal badge leg, any speed record, and any out-and-return or triangle distance record the start/finish requirements are identical, but the start and finish points must be one in the same so that the course is "closed".

c. When any of the above courses is declared but no turn point is rounded, straight distance for badge purposes may be claimed using a start at release or by the exit from any point of the Start OZ, followed by any type of finish.

4.3 Starting examples In the illustration below, Pilot A is towed about 4 km down track and starts from the point of release. The task must be at least 4 km longer than required and not be a Diamond goal. Pilot B releases, climbs in lift and then makes a start from the sector. Since he wasn't within 1 km of the start point he also can't claim a Diamond goal. Pilot C releases, climbs and makes a start by crossing the 1 km long start line. He can claim anything if he completes the task.



4.4 Finishing examples In the illustration below, a diamond-shaped airfield has the finish point on the north side. Pilot A lands without crossing the finish line or entering the finish sector. He can't claim a goal or closed circuit flight. He *can* choose any point on his circuit rather than his landing position as his finish if it helps with the 1% rule. Pilot B crosses the finish line but doesn't enter the sector. The point he crosses the line is his finish position and height. Pilot C enters the sector within 1 km of the finish point. Any logged point within the 1 km radius sector can be used to determine the finish time and altitude for a goal or closed circuit flight. If pilots B and C are on distance flights they can choose any logged point as their finish point. Note that if the wind is in the other direction, it will be difficult to land straight ahead and cross the finish line or enter the sector – a better finish point should have been chosen.



4.5 The "virtual" finish option A position (fix) from the FR data may be selected post-flight as an in-flight finish point. A virtual finish allows the pilot to:

a. have the same loss of height calculation for a distance flight in a pure glider as a motor glider that restarts its MoP (the pure glider is not constrained to land in order to finish).

b. establish a goal flight finish that is within the required 1000m of the goal even if the initial entry into the OZ was greater than that. You could use the 1000m entry point to establish the loss of height for the flight.

c. establish a finish point whose elevation does not incur a loss of height penalty.

d. attain a valid finish then, for safety or convenience, land at a point outside the finish OZ.

To make effective use of a virtual finish, you need to plan for the possibility that it will be required. For example, you may choose to climb to any height before starting to allow for a safe early height to a task, but you will then need to determine the lowest finish altitude that will incur no penalty.

If the glider is too low on nearing the finish of a task that allows for little or no height penalty, you may pull up or thermal within the finish OZ until the loss of height from the start drops to an acceptable value and use the time at this point as the finish time.

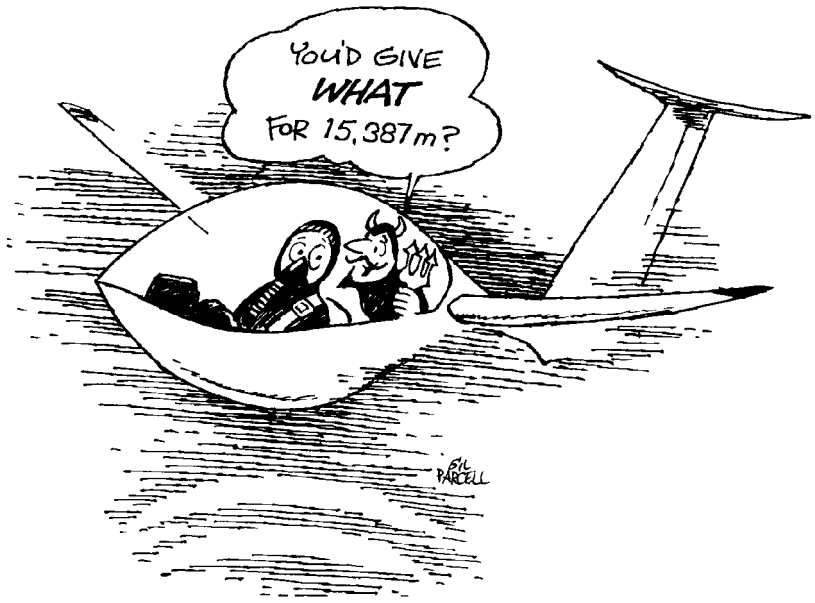
BAROGRAPH EVIDENCE

5.1 Barograph information A barograph records air pressure against time and is required for all badge and record flights except for duration flights under observation by an OO. All FRs incorporate a pressure recording barograph (Appendix 5, para 1.5 refers). The GPS-derived height can only be used for proof of flight continuity. A stand-alone mechanical barograph is now usually used only in conjunction with GPS position recorders. If an electronic barograph is used (only height data being recorded against time) on a flight for an altitude claim, the pilot and OO should proceed as in using a mechanical barograph. The barogram can provide the following information:

a. *Altitude* The barogram can be used to establish height, subject to the pressure errors noted in para 1.8b and corrections described in para 12.8. Calibration traces are usually recorded directly in height, making this conversion unnecessary.

b. *Continuity* The barogram ensures that the recorded task is a single flight.

c. *Duration* The barogram may be used to determine the duration of a flight in the case where the OO does not witness the landing provided that the OO calibrates of the barograph rotation rate.



5.2 Trace continuity (SC3-4.3.3) If the barograph drum stopped rotating, duration evidence would be invalid if the barograph was also being used for time measurement. Normally, even a temporary stop will also invalidate other evidence unless the OO can verify that critical data points and flight continuity are evident from the working portion of the barogram. An *interruption* of the trace may limit the height gain that may be claimed, and could invalidate continuity of flight evidence (see para 10.4c for FR missed fixes).

GPS POSITION RECORDERS and IGC APPROVED FLIGHT RECORDERS

6.1 GPS position recorders These recorders may be used for evidence of horizontal position for Silver and Gold badges in accordance with the SC3 Chapter 4 Appendix. For altitude measurement, refer to para A-7 of that Appendix. Address queries on GPS systems to the GFAC chairman <*ian@ukiws.demon.co.uk*>, and on Sporting Code rules to the chairman of the Sporting Code committee <*106025.2661@compuserve.com*>.

Position recorder approvals by a NAC shall include any operating limitations it intends to apply in order that a given unit conforms to the Sporting Code, such as requiring certain switches or buttons to be sealed or placing it out of reach of the crew. The associated software approved by the NAC to download and later to validate flight data shall also be specified.

Before issuing an approval, NACs must send to the GFAC chairman the internet link to the GPS unit operating manual, the proposed operating limitations, and a copy of the download/validation software with some specimen flight data files. This will enable the GFAC to compile a global list of the types of position recorders used by all NACs, how they are to be operated, typical flight data files produced, and what download/ validation software is used. The GFAC will also be able to inform the NAC of any approval problem the NAC may have missed. The data will be posted on the IGC GNSS web pages for use by other NACs and for general information. NACs may approve a PR based on another NAC's approval.

6.2 IGC-approved flight recorders 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 flight recorders is in Chapter 1 of Annex B to the Sporting Code. See <*www.fai.org/gliding/sporting_code/sc3b*>.

a. *IGC-approval documents* FRs must be operated in accordance with the IGC-approval document for the type of recorder used (Appendix 4, para 1.3). Pilots should obtain a copy 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 e-mail mailing list <*igcdiscuss@fai.org*> and on the international newsgroup <*rec.aviation.soaring*>. The current version of all IGC-approval documents is available at <*www.fai.org/gliding/gnss/igc_approved_frs.pdf*>.

b. *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 to the FAI/IGC document, *Technical Specification for IGC-approved GNSS Flight Recorders*. *See <www.fai.org/gliding/system/files/tech_spec_gnss.pdf>.* 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. *Downloading* Downloading after a flight is either to a computer or, with some FRs, direct to a storage device such as a memory stick or card. Downloading 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 are freeware and available from the IGC GNSS 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 downloading, or for some recorders that download initially in binary format, *conv-xxx.exe* for converting from binary to the .igc format.

d. *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 together with the FR manufacturer's IGC-XXX.DLL file in the same directory (see c above). For older recorders where there is no DLL file, the FR short program file *vali-xxx.exe* carries out the Vali function.

6.3 Electronic flight declarations (SC3-4.2) Many 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 4, para 1.4) and an accurate real-time clock, the declaration does not need to be witnessed by an OO. An electronic declaration can be updated by a later one or by a subsequent written declaration.

a. *Way point declaration* The .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 types of FRs store the latest turn-on time as the waypoint declaration time. If these FRs are switched on after a paper declaration has been made, the declaration in the FR becomes the "latest" one again – nullifying the written one. If you are writing a last-minute paper declaration and you are unsure how the FR acts, make sure that the FR is ON at the time.

b. *Other declaration data* Other data required by SC3-4.2.1 is at the beginning of the .igc file. This can be seen when viewed in text format. For example, the first line of a .igc file (after the initial letter A) shows the 3-letter code for the recorder manufacturer followed by the three-character serial number of the FR.

c. *The header record* The remainder of the required data is in the H- (Header) record that starts on the second line of a .igc file. H-record lines that list information on components within the FR begin with "HF" and cannot be altered. Other lines beginning with "HF" list the pilot name(s), the glider type and identification – this data *must* be correctly entered in the FR before takeoff. Not all NACs issue competition numbers or require them to be unique to a glider – the glider registration or its serial number must then be used.

   Some older recorders may not have enough available lines or characters to enter comprehensive declaration data. For instance, for two-seat flights using an FR that has only one field for pilot name, enter the name of the second pilot/crew after that for the pilot-in-command, shortening both names as needed. However, full names are to be used on the claim documents. In all cases of .igc file data, it must be possible to unambiguously identify the pilot or pilots and the individual glider.

   A few older recorders allow the OO or pilot to enter H-record data *after* flight. These lines start with the letters HO (for OO entries) or HP (for pilot entries) and are not protected by the Vali check (para 6.2d above). Therefore, all H-record data required for declarations must appear in lines that start with the letters HF (not any that start HO or HP), and the .igc file must pass the Vali check.

6.4 Pilot and glider data Pilot and glider data is not definitive until confirmed by independent evidence taken at take-off and landing. When any shared FR is used, care must be taken when inputting pilot and glider data that the information is correct and not that from a previous use. If input errors are found, the OO should be guided by para 10.3.

6.5 Sampling rate settings (SC3-4.3.1) The GPS sampling rate is chosen through the set-up menu of the FR. Most FRs allow selection of a longer fix interval for flight between waypoints and a shorter interval for use near waypoints. An interval of 20 seconds or less allows turning to be seen in flight analysis software (so long as care is taken that the FR memory won't fill on an long flight task). A faster setting should be used near OZs. This is done automatically in some FRs, or after pressing the Pilot Event (PEV) button that starts a set of fast-fixes. A fast-fix interval of 1 or 2 seconds is recommended to ensure that a fix is recorded within an OZ.

6.6 Missed fixes Some fixes may be missed or be assessed as spurious (see para 10.5 for a description of data anomalies). Where valid position data does not appear in the recording, the fixes must show pressure altitude to prove flight continuity. Missed position fixes from an otherwise continuous trace that lowers the actual sampling rate to less than once per minute (for example, because of short term attitude or GPS system anomalies) is normally acceptable provided that an intermediate landing and take-off was not possible.

6.7 Barograph calibration requirements Altitude and height gain claims require calibration data to be applied to the critical altitudes in the flight performance concerned. Speed or distance claims need calibration data for calculating the altitude difference of the glider at the start and finish points. Also, the NAC or FAI may wish to compare pressure altitudes recorded on the FR at take-off and landing with atmospheric pressures (QNH) recorded by a local meteorological office at the time of the flight. See SC3-4.4.4 for the recalibration interval for all barograph types.

Pilots are advised to have a calibration carried out as given by the manufacturer or a NAC-approved calibrator before an FR is used on a record or badge flight. Barograph calibrations for use in assessing FAI badge and record flights must be carried out by persons or organisations approved by your NAC, using approved equipment and methodology. The .igc file of the calibration must be kept. For flight recorders, the calibration method is con-

tained in the approval document of each type of IGC-approved FR or, alternately, as here in Section 11. For mechanical barographs, use the method given in Section 13.

a. *Pressure units* The standard metric unit used in measuring atmospheric pressure is the hectopascal (HPa). Millibars (mb) are numerically the same as HPa. Inches of mercury ("Hg) may also be used. Calibrations must be to the ICAO International Standard Atmosphere (ISA). This is an atmospheric temperature and pressure structure close to the average real atmosphere at mid-latitudes and is the international standard for calibrating pressure altimeters used in civil and military aircraft and by Air Traffic authorities worldwide. It assumes sea level conditions of 15°C and an atmospheric pressure of 760mm of mercury (29.921 inches or 1013.25 HPa/mb). Above sea level, it assumes a constant temperature lapse rate of 6.5°C per 1000m (1.98°C or 3.56°F per 1000 feet) rise in height, up to an altitude of 11,000m, above which the ICAO ISA assumes a constant temperature of -56.5°C.

b. *Calibration equipment accuracy* The equipment used for calibration must be capable of holding the pressure in a vacuum chamber steady within 0.35 HPa for about 2 minutes, and the overall accuracy of the pressure measuring equipment should be within 0.70 HPa after taking temperature and other corrections into account.

c. *Calibration period* The required calibration period is given in SC3-4.4.4. If a barogram is being used only to prove flight continuity (such as for a distance or duration claim), the barograph does not have to be in calibration. Calibration is required if the start height or release height has to be verified.

FLIGHT RECORDERS – INSTALLATION

7.1 Fitting the flight recorder to the glider Any limitations or conditions for an FR installation will be given in its approval document. For flight safety, the position of displays and operating buttons and controls (including switching by touch-sensitive screens) used in single seat gliders should be close to sight lines used for pilot lookout and scan for other aircraft.

a. *Connection to ports and antenna* Approval documents generally do not require the sealing of any ports, plugs, or cable connections. If the FR is connected to the static port tubing (where allowed by its IGC approval) the OO should ensure that there are no connections in the tubing that could allow alteration of the static pressure and thereby give a false barograph reading. No attempt must be made to insert unauthorised data into the FR or inject data into the antenna if it is accessible in flight.

b. *Flight recorders using the Environmental Noise Level (ENL) system* The FR must be placed so that engine noise is clearly received when the engine is giving power. The FR should not be covered or insulated, even if automatic gain would continue to ensure high ENL readings under power.

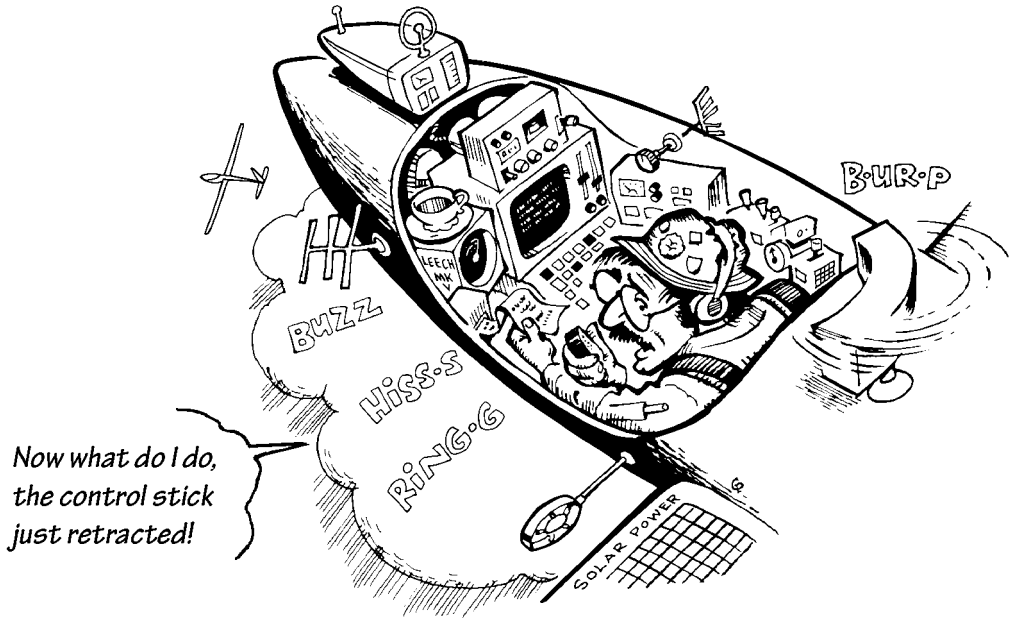
7.2 Installation checks There must be unambiguous evidence that every FR present in the glider for the flight concerned was correctly installed as in 7.1 above, and with any other provisions of its IGC-approval. This check can be achieved visually either immediately before take-off or immediately after landing, or by sealing the FR to the glider at any time or date before take-off and checking the seal after landing. If observation of installation before take-off or at landing cannot be met (such as the absence of an OO before take-off), the FR must be sealed to the glider structure by an OO at any time or date before flight.

Sealing of FRs, GPS position recorders, barographs, etc. to the glider structure must be acceptable to the NAC. A seal must be applied and marked in a manner giving unambiguous proof after the flight that it has not been compromised. and the OO must be able to identify the seal afterwards.

The pilot must ensure that an OO has checked the placement of the equipment in the glider and how it is fitted. Either of two methods may be used:

a. either a preflight check of the installation must be made and the glider must be under continual observation by the OO until it takes off on the claimed flight, or

b. an OO must witness the landing and have the glider under continual observation until the FR installation is checked. This is not only to ensure that the installation is in accordance with the rules, but also to ensure that another FR has not been substituted before the data is downloaded to a computer after flight.



FLIGHT RECORDERS – PILOT ACTION

8.1 Witness of take-off and landing, independent of the FR The pilot must ensure that the time and point of take-off and the landing has been witnessed and recorded for comparison with the FR data. If not witnessed by an 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 an OO.

8.2 FR sampling rate selection The pilot should set the sampling rate as given in para 6.5.

8.3 Observation zones OZ type is *not* part of a flight declaration, even though the pilot can select the OZ type to set into the FR. If the sector OZ was set into the FR and the pilot missed entering it at a turn point, the soaring performance will still have been completed if the pilot was within the cylinder OZ, that is, within 500 metres of the turn point. In this case, however, the leg distance must be reduced in accordance with SC3-1.3.7. Beware, as this could negate a badge flight that was within 1 or 2 km of the minimum distance for that badge leg. Remember that a cylinder OZ cannot be used for a start/finish point.

SC3-4.5.2b defines valid fixes, but all fixes (valid or otherwise) in or near the OZ should be assessed. 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 indicate OZ entry with a tone, but only post-flight analysis of the .igc file can prove presence in the OZ. You should fly into the OZ for several fixes before turning for the next leg. As GPS fixes may be lost at high bank angles, depending on the antenna mounting, extreme maneuvers should be delayed until valid fixes have been recorded in the OZ.

8.4 After flight After the flight, the pilot must not alter the installation of or remove the FR (or any other flight data recording equipment) until it is witnessed by an OO. Doing so compromises the OO's control of the flight. The OO's control of the FR is not compromised if the pilot enters a new declaration prior to the flight or a subsequent flight if the first one fails.

FLIGHT RECORDERS – OO ACTION

9.1 Downloading the flight data file Download 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 a memory stick, the flight data may be downloaded at the glider without disturbing the installation of the FR. If this cannot be done, the OO shall check and break any seal to the glider, and take the FR to a computer to download the flight data. Where more than one FR is carried, each one must be checked to ensure the last declaration, either electronic or written, applies to the flight (see para 6.3a).

If the OO is not familiar with the actions required, the pilot or another person may download the data while the OO witnesses the process. Security is maintained by electronic coding embedded in the FR and in downloaded .igc files that can be independently checked later through the IGC Vali program (see para 6.2d).

a. *Data download method* The method for each type of FR is given in its IGC approval document (6.2a) that is available at <www.fai.org/gliding/gnss>. The FR types, their manufacturers, IGC approval dates and a history of the use of GNSS in IGC, are listed in <*www.fai.org/gliding/system/files/ igc_approved_frs.pdf*>.

b. *IGC file name* An .igc file has the format "YMDCXXXF.IGC", where Y=year, M=month, D=day, C=manufacturer, XXX=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 (see table below). Where numbers over 9 apply, such as in months and days, 10 is coded as A, 11 as B, etc. There is also a long file format with data in the same sequence, such as 2009-05-21-XXX-SSS-01.IGC.

9.2 OO's copy of the data 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. The OO may keep the data files for the flight on any industry-standard storage media that the pilot cannot access. The OO must be able to positively identify the flight data files as being from the flight concerned. These files shall be retained by the OO for later checking and analysis under the procedures of the authority validating the flight. Copies of all files must be forwarded by the OO to the validating authority, the OO keeping the original files. 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. The copies must be kept by the OO at least until the flight has been validated.

9.3 FR manufacturer's codes The GFAC allocates both one- and three-letter codes to manufacturers of FRs. The current codes are in the table above. The one-letter code is used in the short .igc file name after the three characters for the date (ex: 967L = 2009, June, 7, LX Navigation). The 3-letter code is used in the long version of the file name above and also in the first line of the file itself. The definitive list is in the FR Specification document, App 1, para 2.5.6, see <*www.fai.org/gliding/gnss/tech_spec_gnss.asp*>.

Manufacturer	Three	One	Manufacturer	Three	One
Aircotec	ACT	I	New Technologies	NTE	N
Cambridge	CAM	C	Nielson Kellerman	NKL	K
Data Swan/DSX	DSX	D	Peschges	PES	P
EW Electronics	EWA	E	Print Technik	PRT	R
Filser	FIL	F	Scheffel	SCH	H
Flarm	FLA	G	Streamline Data	SDI	S
Garrecht	GCS	A	Triadis	TRI	T
IMI Gliding	IMI	M	Zander	ZAN	Z
LX Navigation	LXN	L	Other	XXX	X

9.4 Potential data download problems Some programs other than the IGC download utilities (para 6.2c) are able to download data from FRs. but they might not produce complete .igc files that will pass the Vali check. Also, some older types of FR 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 download utilities. After downloading the .igc file, *immediately* check it with the Vali program (para 6.2d) to see if it passes. If there is a problem, go back to the FR and download again.

FLIGHT RECORDERS – DATA ANALYSIS

10.1 Data analyst The flight data from the master file held by the OO after flight is sent by the OO to a GPS data analyst (DA). An OO is not necessarily a NAC-approved data analyst but some DAs may also be OOs. The NAC is finally responsible for the analysis process and the integrity and accuracy of data that it validates. The Vali program can be used at any time to check the integrity of .igc files. If the Vali check fails, the .igc file may have been altered, the FR may be insecure, an unsecure "fast download" may have be done (an option in some utilities), or a program other than the free IGC download utilities may have been used. Where a DA is not

available on the flying site, the claim forms should be completed as far as possible and sent to the DA who will complete them and forward them to the NAC, checking back with the site OO(s) as necessary. The DA should use the FR manufacturer's Vali program to check .igc files before the claim is sent to the NAC.

10.2 Analysis of flight data Flight data is to be examined as a whole, and all fixes (valid or otherwise) must be taken into account, particularly those in or near Observation Zones. The data analyst approved by the NAC will then evaluate the flight. Analysis for flight validation will be through a program approved by the relevant NAC – see the gliding/ GNSS web site under "Software". In addition to checking the flight data, before a soaring performance is officially validated, the validation authority must check that the .igc file passes the Vali check.

10.3 Reconciling FR input errors Pilot name and/or glider information input errors can occur, particularly when club FRs are used by inexperienced badge pilots. However, in the spirit of para 1.3, if indisputable flight evidence is available as required in SC3-4.5.6b, the OO should explain the circumstances of the error to the NAC, which may accept or reject the claim as it sees fit. Such error correction should be limited to Silver and Gold badge evidence.

10.4 Flight analysis software In any flight analysis software, a barograph presentation (vertical data with time) must be available showing both pressure and GPS altitude, and for motor gliders, MoP operation must be shown as part of the vertical data display. The automatic functions of analysis programs (such as waypoint OZ presence and engine on/off thresholds) should be checked manually, inspecting the relevant data if there is any doubt whether the particular automatic function positively identifies the threshold concerned.

The OO's checks of rules and procedures include the following:

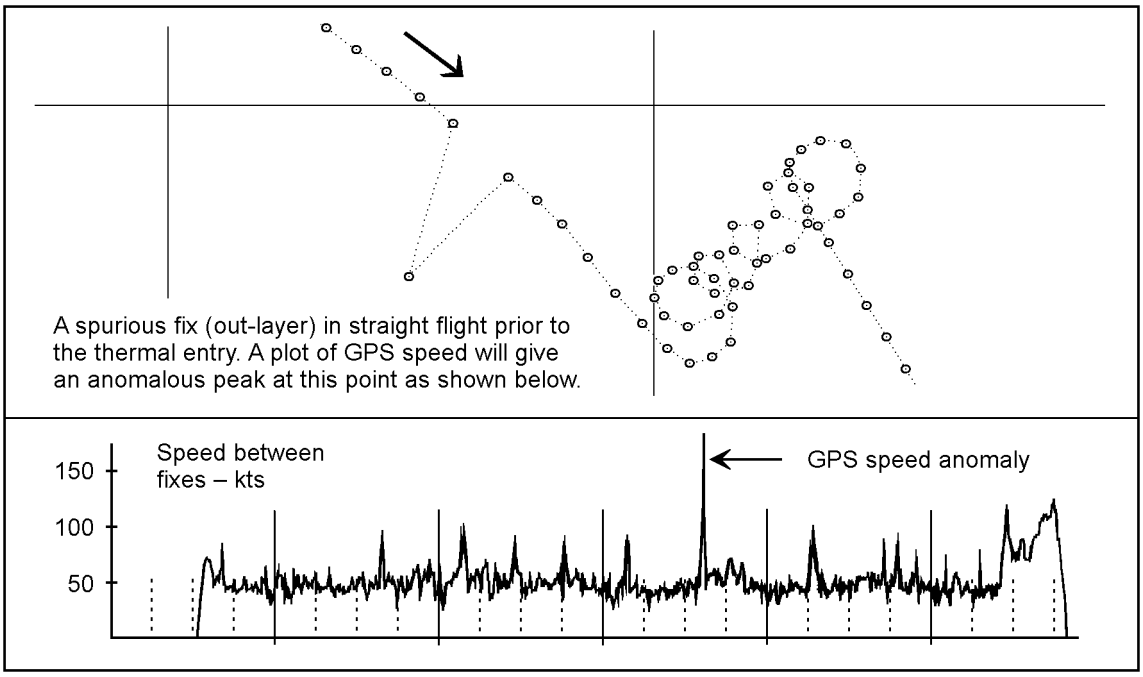
a. evidence of flight continuity and the shape of the flight course,
b. valid start and finish,
c. proof of presence in OZ (para 8.3 for fixes, para 10.5 for how to handle any circles of probability),
d. similarity of GPS and pressure altitude traces with time,
e. altitude difference and/or altitude penalty,
f. course distance and speed (SC3 rules),
g. electronic security (use of the Vali program).

10.5 Data anomalies In the event of any inconsistency, anomaly, or gap in data files, the NAC shall consult specialists in the field to determine if there is a satisfactory explanation, and whether the flight performance may be validated despite the anomaly. In the first instance, contact the chairman of GFAC and send 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 examined it in text format.

a. *Complete loss of data* If all FR data 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 or barograph. 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. The OO or analyst should approach all interruptions of FR recordings with skeptical caution.

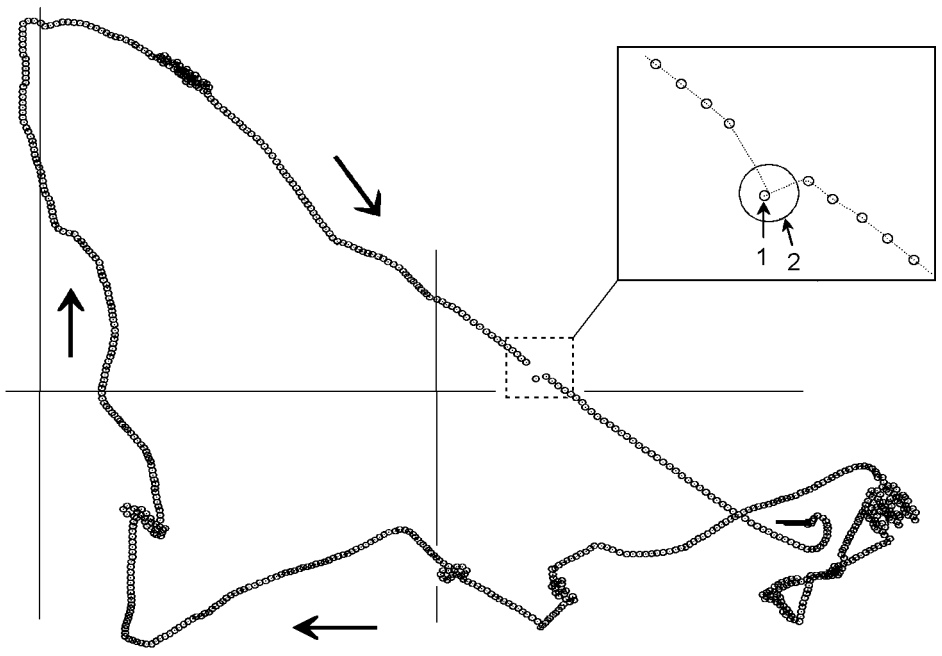
b. *Breaks in fixes and missed fixes* Fix breaks or side-steps should be investigated. Missed fixes are assessed in the same way as a break in the trace of a mechanical barograph; one must judge if the evidence of flight continuity remains incontrovertible. Analyse the time, altitude and position of 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 prove flight continuity, although without fixes the evidence of presence in an OZ will be lost.

c. *Spurious fixes* Spurious fixes may occur that show anomalous positions in a fix sequence, and must be ignored in OZ validation. The indication that a fix is spurious is a large change of position that cannot be explained by a likely change of ground speed. The diagram below shows that they are easy to see and reject for the purposes of flight validation. Possible factors are reduction of signal due to turning flight (when antenna alignment is off vertical), or errors induced by RF energy transmissions from the glider resulting from poor RF shielding in the cockpit.



A spurious fix (out-layer) in straight flight prior to the thermal entry. A plot of GPS speed will give an anomalous peak at this point as shown below.

10.6 Circles of probability A circle of probability shall not be used for adjusting the likely place of a position fix for OZ validation purposes. A valid fix shall always be taken to be at the centre of any such probability circle for the purpose of OZ validation. Data analysts should view the tracks in and out of OZs in the display mode that does not show probability circles, as this display mode is less cluttered.



GPS position data from a 100 km triangle flight. There were two spurious fixes on the final glide (1 and 2) with different size probability (EPE) circles. GPS fix rate is 4 seconds.

FLIGHT RECORDERS – CALIBRATION PROCEDURE

11.1 Flight recorder initial setup by manufacturer The FR manufacturer is expected to set up the pressure altitude sensor to the criteria in SC3B-2.6.1 which states: electronic sensors used inside electronic barographs generally have factory-adjustable settings for sea level pressure and also a gain setting for the rest of the altitude range. These must be set so that the output corresponds closely to the ICAO Standard Atmosphere.

Large corrections should not apply after initial calibrations, because outputs of electronic barographs are converted directly to metres or feet. On set-up and calibration before or immediately after initial sale, it is expected that the sea level setting will correspond to the required ISA (1013.2 HPa) within 1.0 HPa, up to an altitude of 2000 metres within 3.0 HPa, and within one percent of altitude above.

11.2 Preparation The calibrator should, if possible, be familiar with the type of FR being calibrated, but it is appreciated that technicians in civil aviation and military instrument sections will usually follow their normal calibration procedures and expect that once the FR is switched on, it will record appropriately. Given this, it is up to the pilot to set up the FR beforehand. Some older FRs have to be set to a special calibration mode, and some require a password to be inserted so that pressure recording can start in the absence of GPS fixes. Details on calibrations are at the end of Annex B in the IGC approval document for the type of recorder concerned. The recording interval should be set to 1–2 seconds. If the FR has no internal battery capable of running it during the calibration, use a power source such as a gel-cell battery placed in the altitude chamber with the FR.

11.3 Calibration

a. Place the FR in the calibration chamber. Increase the pressure altitude about 1000 feet (300 metres), hold for 1 minute, then return to ambient. This is to ensure that the flight recorder starts recording. Most FRs will begin recording either just after being switched on, or when a pressure change is detected (typically a change in pressure altitude of 1 m/sec for 5 seconds).

b. Adjust the chamber pressure to the ICAO ISA sea level value of 1013.2 HPa. Depending on the actual ambient pressure, it may be necessary to hold a positive pressure in the chamber.

c. The actual calibration can now begin. If a metric calibration is being made, use intervals of 500m for the first 2000m and 1000m steps thereafter. If using feet, use altitude steps of 1000 feet for the first 6000 feet and 2000-foot steps thereafter. Hold each step for at least one minute. All calibration points, including the 1013.2 HPa sea level datum, should be approached from a lower pressure altitude (by decreasing the pressure). After the maximum altitude has been reached, slowly reduce the pressure in the chamber to ambient.

d. Download the .igc file for the calibration in the normal way and use the data to produce a calibration table of ISA altitudes against corrections (see below). Keep the .igc file for record purposes and supply it with the calibration table where this is sent to other people.

11.4 Recording of calibration data

a. SC3B-2.6.1 states that after the calibration, the data file containing the pressure steps shall be transferred to a computer as if it were flight data. The stabilised pressure immediately before the altitude is changed to the next level shall be taken as the appropriate value unless the calibrator certifies otherwise. The IGC-format calibration data file will then be analysed, compared to the calibration pressure steps, and a correction table produced and authenticated by a NAC-approved person, preferably the calibrator. The data file must be analysed and authenticated by a NAC-approved person if the calibrator is not NAC-approved.

b. The correction table will list true ICAO ISA against indicated altitudes. The table can then be used to adjust critical pressure altitudes recorded during a soaring performance such as take-off, start and landing altitudes for altitude differences, for comparison with independently recorded air pressure (QNH) readings, and low and high points on gain-of-height and altitude claims.

c. Some FRs can display pressure altitude directly on a screen. This data cannot be used for calibration purposes because it is unlikely that the figures will be the same as those recorded in the .igc file. Only the .igc file data can be used In analysing altitudes on flights.

d. OOs responsible for validating later flights may wish to see the calibration file when assessing any claim that is made with the instrument being calibrated. Therefore, a copy of the calibration .igc file must be

retained at least until the calibration becomes out of date. Retain the calibration at the calibration organisation or, where calibration is at civil aviation and military instrument sections, the supervising OO should retain the .igc file and the calibration table.

11.5 Sample calibration table A calibration table such as shown below should show the following information: recorder model and serial number, place and date of calibration, type and serial number of the reference calibration equipment, name and signature of the calibrating officer.

Barograph calibration table

Flight recorder type / model / serial no. .....

Name / place of calibration facility .....

Flight recorder calibrated against:

Reference manometer type / model / ser no. ..... ,

on ..... [date] in accordance with

FAI Sporting Code Section 3, Gliding, Annex C, Flight Recorder Calibration Procedure.

QFE = 1010.1 HPa T = 14°C

The manometer readings have been corrected for temperature.

As this is a FAI/IGC-approved FR, the .igc calibration file is held on record at this facility.

Manometer (ft ref to 1013.2 HPa)	*FR reads (ft)*	*Correction (ft)*
0	10	-10
1000	1005	-5
2000	2000	0
3000	2975	+25
4000	3950	+50
5000	4950	+50
6000	5920	+80
8000	7910	+90
10000	9910	+90
12000	11910	+90
14000	13890	+110
16000	15865	+135
18000	17860	+140
20000	19865	+135
22000	21885	+115
24000	23880	+120
26000	25925	+75
28000	27890	+110
30000	29875	+125
32000	31875	+125
34000	33925	+75

[Name/Signature] ..... [date] .....

Authorised calibrator for the National Aero Club of [country]

MECHANICAL BAROGRAPHS – FLIGHT PREPARATION

12.1 Pre-flight A barograph is required to record height evidence when a GPS position recorder is being used for Silver and Gold badge tasks.

a. For mechanical barographs, attach the foil or paper strip to the drum. Ensure it cannot slip on the drum if held by tape rather than a hold-down bar. If foil, use a heavy-duty thickness, as thin foil may tear from the handling it gets. If a flight is likely to require more than one rotation of the barograph, then the foil or paper should be attached to the drum so that the recording needle can pass smoothly over the hold-down bar or overlapping paper without interruption. It is preferable to use fresh foil or paper for each flight; however, more than one flight can be recorded on the barogram (example: a relaunch for a task attempt). Paragraph 12.3d refers to multiple flight traces. If you use foil, smoke it evenly and *lightly*, or it may tend to flake when disturbed. A small piece of solid camphor is ideal for smoking, and a candle also works.

b. Attach the drum, ensuring that it is correctly keyed to the mechanism. Fully wind the spring. Check that the rotation rate (if adjustable) is suitable for the flight. The 4-hour rate is preferred with a Winter barograph, as it allows an accurate analysis of important elements of the trace such as the release and low points. The 2-hour rate can result in overlap of the trace, and the 10-hour rate compresses the trace so much a low point “notch” may be unreadable. Pilots should test the actual running time of a barograph when set at the faster rates to ensure that it will not run down and stop on a long flight.

c. Just prior to the flight, turn on the barograph, rotate the drum *once* to scribe a baseline trace for the day which will be related to the airport elevation, and have the OO place an OO identification mark on the drum. With the barograph ON and the recording needle positioned to minimize interference with the hold-down bar, tape, or foil/paper edge, gently flick the recording needle up about 6mm (1/4 inch). Record the time this “pre-flight timing mark” was made and leave the barograph ON. Finally, seal the barograph in such a manner that no one can tamper with the trace, then initial or mark the seal.

d. The OO will check the storage of the barograph. It must be inaccessible to the pilot or passenger (if any). Ensure that the barograph is placed so that a bump cannot turn it off, that the stowing process itself does not switch it off, or that it isn’t stowed with the stylus side on the bottom, which could cause interruptions in the trace. *Leave the barograph on* – the chief cause of barograph failure is “finger trouble”.

12.2 In-flight Ensure a clear low point is recorded on the barograph following the release. If the release occurs in lift, dive the glider and/or open the spoilers for a short time to allow an *obvious* notch of about 50 metres or so to be easily visible on the trace (if you are too fast, the barograph will not have time to react). This notch sets the low point of a wave flight, or the start height of a distance flight to determine if any height penalty is to be applied. Failing to notch the trace is a common error at the start of the task because of the added pilot workload that may occur at this time, yet it must be remembered. The OO should record the take-off time, the tow release time (if possible), the tow plane landing time, and the start time (if applicable). Knowledge of tow duration is very useful in estimating starting altitude on a barogram if a good notch is not present.

12.3 Post-flight

a. After landing, the pilot should let the barograph run for a few minutes to allow the landing site air pressure to settle and be recorded clearly. The barograph should then be turned off so that handling shocks and transportation will not confuse the trace.

b. An OO must then take charge of the barograph as outlined in 7.2. The OO will carefully remove the drum and inspect the barogram to verify that release and/or subsequent low point is shown clearly. If it is not, proceed to instructions in para 12.4 *before* continuing with the following steps.

c. Add the information to the barogram listed in SC3-5.3.3. Other data may be added such as: OO’s name (print), badge leg or record being claimed, indication of release, low, high, and landing point, take-off site, etc. *(but do not let any mark touch the flight trace)*. Do not add any altitude values to the trace, they cannot be accurately known until the barogram has been evaluated using the calibration graph.

d. If there is evidence of more than one flight on the barogram, the OO must be able to clearly identify each part of the barogram and is to mark the part(s) subject to claims with the name(s) of the pilot(s). There must be positive evidence to associate pilots making claims with the particular parts of the barogram, such as from club launch and landing logs, or from other witnesses who saw the claimant(s) launch and land.

e. Smoked foil barograms must be "fixed" *after* the information is added. This fixing is best done by coating the foil (while on the drum) with a spray lacquer. Use a *light* first coat, as a heavy initial spray could obliterate the trace. Test spray on an unused area of the barogram first.

f. After fixing, the OO evaluates the barogram for the heights of interest. This requires the use of a *calibration graph* of the barograph prepared from a current *calibration trace.* If required by the NAC, the *original* calibration graph and its trace should be submitted with the claim – not a photocopy. This requirement is often waived by NACs for badge height gains clearly in excess of the required minimum and loss-of-height clearly below the allowed maximum. Now, if the barograph is not being used for some time, allow it to unwind as a kindness to the mechanism.

12.4 Evaluating a release point not evident on the barogram When the tow duration is not known to the satisfaction of the OO and release is not evident on the barogram, distance and duration claims must be disallowed. In other instances, the following procedure can be used to estimate the release time / altitude for any badge claim. This is *the most important reason* why the pilot should ensure that the barogram is notched after release, and why the OO should always closely monitor the beginning of each flight under their supervision.

With the barograph OFF and the barogram still attached to the drum, wind the barograph and reinstall the drum. Manually rotate the drum so the recording needle is directly over the arc scribed at the pre-flight timing mark (para 12.1c). If no timing mark was made, position the recording needle over the trace, where take-off appears to have taken place.) Gather OO timing notes on take-off and release times, and calculate the elapsed time between the timing mark (if none, take-off) to release. Turn the barograph ON. After an elapsed time equal to the observed flight duration of the tow, jog the stylus so that it marks across the flight trace. Turn the barograph off, and return to para 12.3c to complete post-flight procedures.

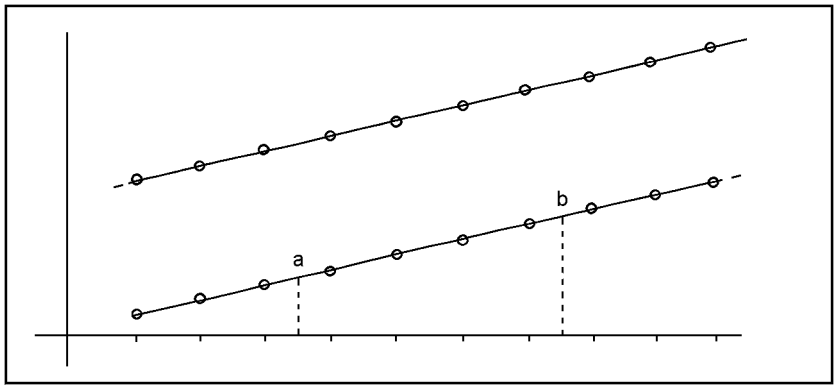
12.5 Duration evaluation The barogram may be used to determine duration, and is required if direct timing was not done because the landing was made where or when the OO was not present. In this case, the OO will proceed as follows:

a. Position the barograph drum to a point where the stylus can be carefully deflected to touch the trace at the glider release point. The stylus is then rotated down and a small mark made across the baseline. The barograph is then rewound and restarted with the drum initially positioned as above, and timing begun with an accurate time piece. The time is again noted when the drum has rotated to a position where the stylus meets the landing point on the trace, and the duration determined. For rotation rate calibration, small marks may be added to the trace at even time intervals by jogging the stylus point slightly.

b. If the release point is not evident on the barogram, time the trace from take-off to landing and subtract the recorded tow duration. If the procedure used in para 12.4 has been used to estimate the release time on the barogram, the OO must disallow the claim if the duration does not clearly exceed 5 hours.

12.6 Height gain evaluation With the barograph calibration graph below (see para 13.3 on construction), one may use dividers to determine pressure altitude, corrected for instrument error in the following manner:

a. Place a protective sheet of clear plastic over the flight barogram and, with a right triangle reference to determine true vertical, place one divider point on the appropriate reference line and the other on the trace at the low point to be evaluated. Transfer the divider measurement to the calibration graph, as shown at "a" below, and read calibrated pressure altitude from the numbers displayed below the horizontal axis. Repeat the process for the high point, as shown at "b".



b. If pre- and post-flight baselines recorded at the same airfield are essentially the same, distance above the appropriate reference line on the flight barogram, the above method is equally applicable for determining gain of height and loss of height as well. If same-site pre- and post-flight baselines differ *or* the landing took place at a location where the elevation is lower or higher than the take-off site, the height reached should be measured from the start (take-off) pressure, and see para 12.7 below.

12.7 Absolute height evaluation for barograph and FR data The following is one method to correct barograph or FR recorded data for both instrument error and nonstandard pressure, whether the latter is due to diurnal pressure changes at the take-off and landing site or different air mass characteristics at separate take-off and landing sites.

a. Use the appropriate method in para 2.3 or 12.8 to determine calibrated pressure altitude at the preflight baseline. *Subtract* this figure from the elevation of the take-off site (a negative number may result). Note the take-off time. Repeat this step for the post-flight baseline; jot down landing time.

Determine whether the in-flight event(s) to be evaluated occurred nearer take-off time or landing time, then:

b. For any event near take-off time, *add* the number found in (a) to the calibrated altitude for that event.
c. For any event near landing time, *add* the number found in (b) to the calibrated altitude for that event.

These calculations yield altitude corrected for both instrument error and non-standard pressure. This is sufficient in most cases for badge and distance or speed record purposes, given that pressure corrections are based on pre- and post-flight "baselines" recorded by a calibrated instrument at a known field elevation.

12.8 Correcting numeric altitude data for instrument error When FR or electronic barograph 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 (150 metres) was recorded by the FR before take-off where the site elevation is actually 798 feet msl (243 metres).

Metric units

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

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

English units

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

X = 2000 – (2100–492) • ((2000–0) / (2100–98))
X = 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 30 metres (100 feet), it would be preferable to calculate absolute altitudes following the guidance in para 11.6.

MECHANICAL BAROGRAPHS – CALIBRATION PROCEDURE

13.1 Preparation

a. Attach the appropriate recording medium to the barograph, making sure that it is in contact with the base and surface of the drum and avoiding a spiral wind where applicable. For smoked foils, ensure the soot film is not too thick as this will lead to a coarse, irregular trace. Wind the barograph, set it to its fastest rotation rate, and inscribe a baseline (no baseline is required for the Peravia and Aerograf barographs).

b. When the barograph is placed in the vacuum chamber, a vibrator should be used if one is available to apply low amplitude vibrations during calibration (about 0.1 mm or 0.004 inch peak-to-peak at approximately 20 Hz). This prevents system friction or linkage slack from affecting the trace.

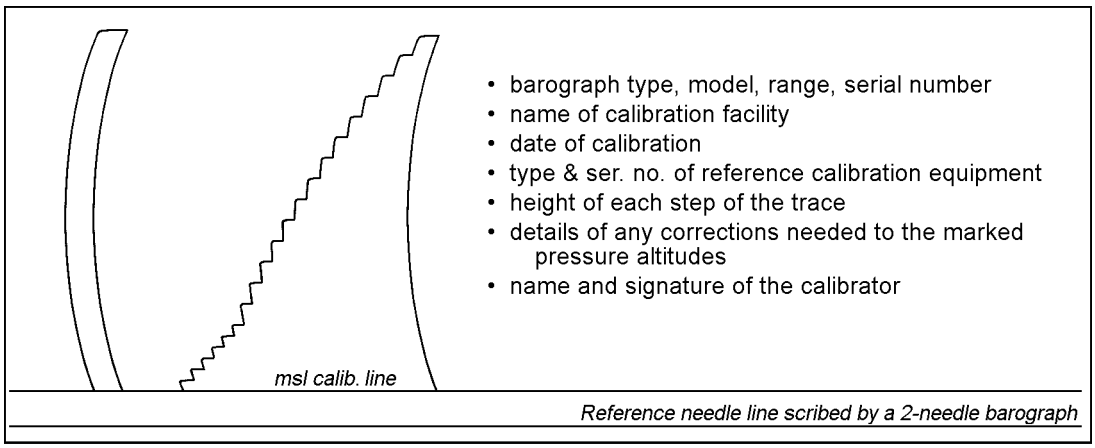
c. Evacuate the chamber to the full range of the barograph, hold until the trace stabilizes, then return to ambient. This ensures the bellows and mechanical linkage are sound, and that a suitable trace is being made.

d. By reference to the calibration manometer, adjust the chamber pressure to 1013.2 HPa. Depending on the actual ambient pressure, it may be necessary to hold a positive pressure in the chamber.

13.2 Calibration

a. Proceed with the actual calibration using altitude steps of 1000 feet for the first 6000 feet and 2000-foot steps thereafter. In metric, the intervals should be 500m for the first 2000m and 1000m steps thereafter. Hold each step for at least two minutes. All calibration points, including the 1013.2 HPa reference, must be approached from a lower pressure altitude (by decreasing the pressure). After maximum altitude has been reached, slowly reduce chamber pressure to ambient.

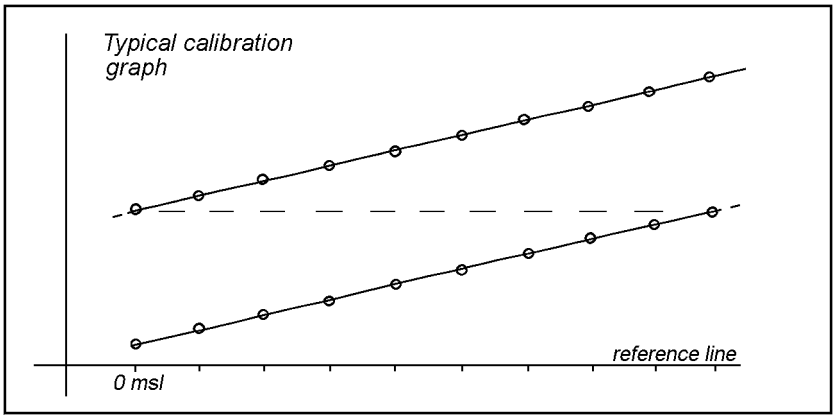
b. A trace will resemble the one below, either with the information shown added, or printed on a separate certificate that identifies the trace. If a smoked foil has been used, "fix" it with a thin coat of spray lacquer.



13.3 Calibration graph In order to evaluate heights from a barograph trace (see para 11.4), the OO will need to prepare a calibration graph from the data on the calibration trace. Graphing programs are available to output a best-fit graph from the calibration data points. If you are constructing the graph, use good quality graph paper with fine graduations. A pair of dividers and a small plastic square is required.

a. Draw a horizontal line near the lower edge of the graph paper. For a double-needle barograph, this reference line represents the line scribed by the *fixed needle* during calibration; for a single-needle barograph, this reference line represents the lower edge of the barograph's calibration paper or foil. Starting with 0 feet MSL at far left, label the horizontal scale at a suitable scale (1 cm per 200m or 1 inch per 500 feet, for example), with altitude increments increasing to the right. The graph may be "folded" (as shown below) to fit a single sheet of graph paper.

b. Using a pair of dividers to measure the deflection of each step of the calibration trace, transfer these distances with the dividers to the calibration graph at the position corresponding to the appropriate pressure values on the horizontal axis. Use the small plastic triangle to ensure that the divider is at right angles to the baseline. Finally, draw a smooth line through these points, averaging any scatter in point position about the line. For most barographs this line will be almost straight. Your graph will resemble the one below.



MOTOR GLIDERS

14.1 Means of Propulsion (MoP) record for motor gliders The MoP must either be sealed or inoperative, or an approved MoP recording system used. This system will be described in the IGC-approval document (6.2a) for the particular type of flight recorder. For motor gliders in which the MoP produces substantial acoustic noise when producing forward thrust, the Environmental Noise Level (ENL) system is used. Older FRs may have other MoP recording systems, for instance using vibration sensors or microswitches, but these may have limitations (given in the specific IGC-approval document) that make them less convenient to use than the ENL system.

ENL systems are self-contained inside the FR and need no external connections. An ENL value is recorded with each fix and the system can be regarded as self-checking with each fix. The environmental noise at the FR can be seen across the whole flight. Therefore, an engine run after the flight is not needed to validate the system. ENL systems in new types of FRs are tested by the GFAC and adjusted until the system differentiates between MoP operation and other noises produced in gliding flight.

14.2 MoP recording systems

a. *Environmental Noise Level (ENL) system* These systems produce ENL values between 000 and 999 (except the Cambridge 10, 20, and 25 that have a maximum ENL of 195). Analysis of the noise signature represented by the ENL values enable the OO to determine whether the MoP was operated. In the .igc file format, the three ENL digits are generally added at the end of the data stream for each fix. The system is designed to emphasize engine noise while producing positive but low ENL values in normal quiet gliding flight. More exact figures for the type of FR concerned are given in Annex B of its IGC-approval document.

b. *Low noise engines – electric and others* Some engine/propeller combinations do not produce enough acoustic noise for ENL systems to record figures that are clearly above normal soaring noise levels. The provisions of SC3 Annex B-1.4.2.4 then apply, requiring recording of an additional variable on the .igc file that is proportional to engine RPM, using the RPM three letter code as defined in the FR specification.

14.3 ENL figures – engine off ENL figures between 000 and 999, found during GFAC testing before IGC approval, are listed in the IGC approval document of the FR concerned. These figures are definitive, others given below are general approximations. Pilots should ensure that the FR to be used on a task to be claimed produces similar figures; if not, the FR should be returned to it's manufacturer to have the ENL system re-set.

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

b. *In flight* Values under about 100 indicate normal gliding flight. In a high speed glide or in an aerodynamically noisy glider, ENL may rise to 150. After launch, flight near powered aircraft should be avoided. Spins and stall buffet produce higher ENL values, particularly if the engine-doors vibrate due to disturbed airflow at the stall – 500 has been recorded in a spin. If the engine is on a retractable pylon, a high ENL reading will be shown when flying with the pylon up and engine off due to the high aerodynamic noise.

> *Warning* Flight with canopy side vent(s) open can produce a low "organ pipe" note, particularly at high speed or with sideslip, where ENL figures us high as 600 have been recorded. If the glider is climbing, this can be assessed as 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.

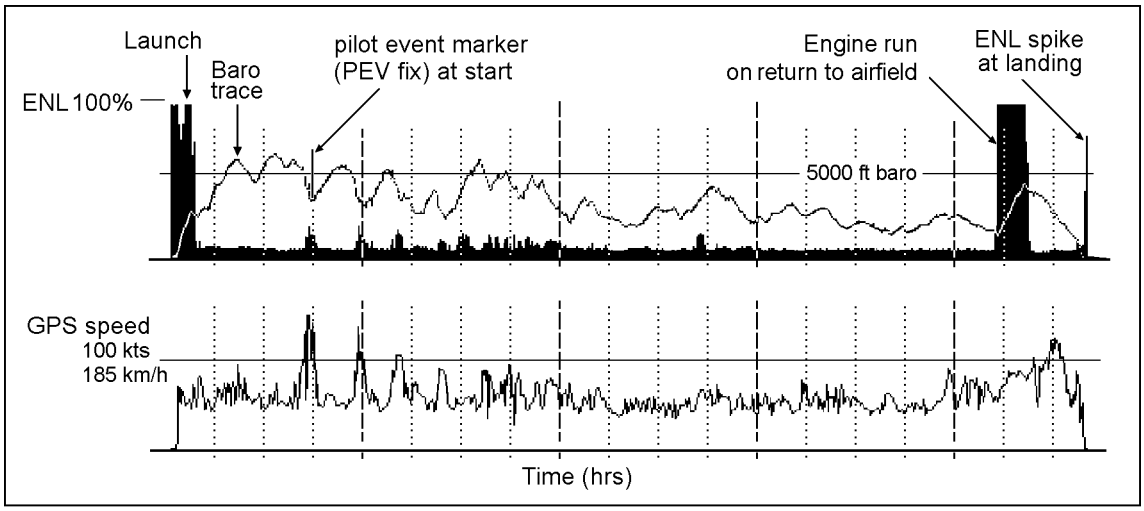
c. *Landing approach* ENL values are higher on an approach from noise due to undercarriage, sideslip, etc. because the glider is no longer aerodynamically clean. Short term peaks due to specific actions such as opening air brakes will be noted as well. ENL values of up to 400 have been recorded, although 200 is more typical in an aerodynamically noisy glider, and 50 in a quiet machine.

d. *Take-off and 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.

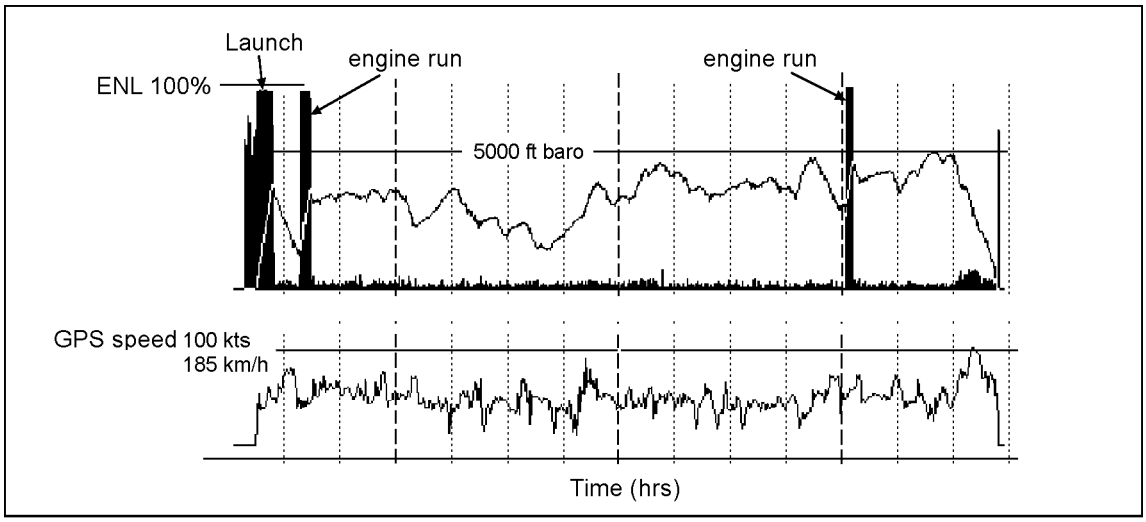
14.4 ENL figures – engine on During engine running at climb power, an increase to over 700 ENL is expected. Over 900 is typical for a two-stroke engine, and over 700 for a 4-stroke. Values over 900 have been recorded with a two-stroke engine running at full power. During engine running, these high ENLs are produced for a significant time during climbing flight and can therefore be attributed to engine running rather than soaring.

14.5 ENL analysis It is normally easy to see when an engine has been running. Other data, such as rates of climb and ground speed, will indicate whether or not non-atmospheric energy is being added. Short term peaks in ENL (10 seconds or so) may be due to the other factors mentioned above such as undercarriage and/or air brake movement, sideslip, open direct vision panel/sideslip, the nearby passage of a powered aircraft, etc. If in doubt, e-mail the .igc file to the GFAC chairman at <*ian@ukiws.demon.co.uk*> for further analysis and advice.

14.6 Sample ENL systems data ENL data is shown below, using the presentation from one of the many analysis programs designed to work with the .igc file format. Here, the ENL values are shown as solid black bars whose height correspond to the ENL values at each fix. These are synchronised with the barograph trace from the FR pressure altitude sensor. A separate graph of speed with time is included, and this is helpful in identifying why ENL values have varied during normal gliding flight, such as explaining higher ENL values at higher speeds.



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



ENL levels in black with altitude and groundspeed traces. From a flight with an engine run at launch and two shorter engine run during the flight.

Appendices

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

FAI BADGE DOCUMENTATION

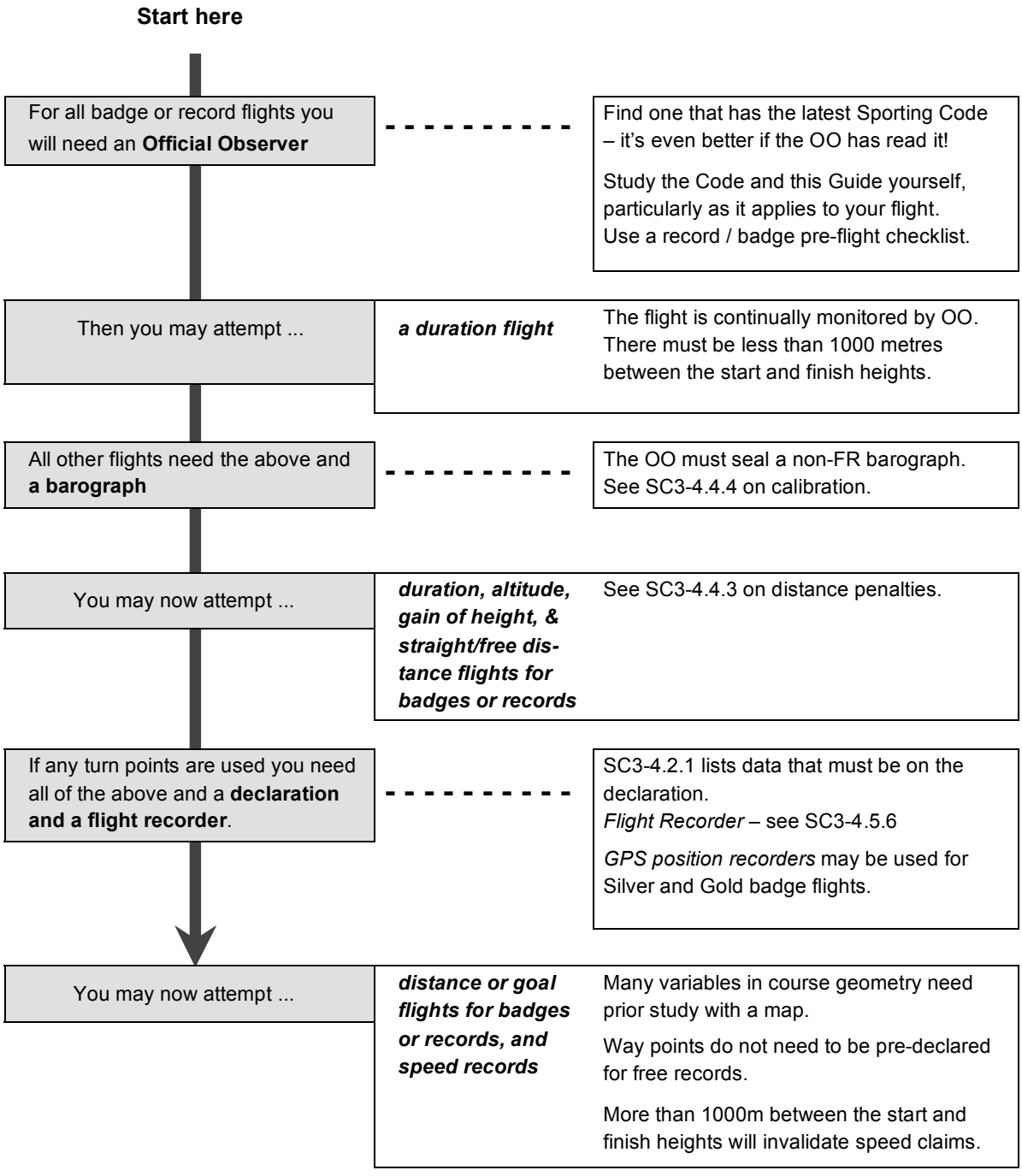
Documentation required is indicated by an asterisk *	Flight barogram	Baro. calibration certificate	Difference of height certificate	Flight declaration	Landing certificate	Aerotow/release certificate	GPS position evidence
Silver Height	*	*				*	
Silver/Gold Duration	***1**		*		***2**	*	
Silver Distance	*	**5**	*	***3**	*	*	***3**
Gold/Diamond Height	*	*				*	
Gold/Diamond Distance	*	**5**	*	***4**	*	*	***4**
Diamond Goal	*	**5**	*	*	*	*	*
Diploma Flights	*	**5**	*	***4**	*	*	***4**

Notes:

1. Not required if continually observed.
2. Required if landing not witnessed by OO.
3. Required if a declared departure or finishing point is used.
4. Not required for straight distance.
5. May be required if an accurate loss of height calculation is critical to the claim.

Appendix 3

BADGE or RECORD FLIGHT PROCEDURES FLOWCHART



Get a landing certificate signed by an OO or two witnesses. Badge and record flights require different forms.

Appendix 4

FLIGHT DECLARATION

If this declaration is being made to replace an electronic one, ensure that the time of this declaration is *after* the time on the declaration stored in the FR being used. Warning: some IGC-approved FRs make turn-on time of the FR the declaration time. If you are unsure, turn on the FR *before* the time recorded on this declaration.

Date ..... ***Time*** .....

Pilot ..... **Name(s) (print)**
(& crew)

..... **Signature of PiC**

Glider… ..... **Type & Registration**

FR .... **Type & Serial no.**
(main) **(backup – if any)**

Start PT ....
Describe way points with an existing TP code/list name, or with coordinates

TP 1 .....

TP 2 .....

TP 3 / Goal /
or Finish PT .....

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

..... **Signature**

I hereby certify that the above declaration was completed in my presence.

Appendix 5

Principles of Global Navigation Satellite Systems and IGC-approved GPS flight recorders

IGC web site: <*http://www.fai.org/gliding/gnss*>
IGC GPS software site: <*http://www.fai.org/gliding /gnss/freeware.asp*>
There is extensive information on GNSS systems on the web.

1.1 Terminology

The term Global Navigation Satellite System (GNSS) is a generic term for any satellite-based system that enables receivers to display accurate position data on the earth's surface. GNSS includes the USA GPS system, Russian GLONASS, European Galileo, and any future system. IGC-approved flight recorders (FRs) use the GPS system at present. An FR is a sealed unit with a GNSS receiver and capable of recording data including 3-D fixes, time and other data, that can be downloaded after flight in the .igc file format. The use of the English words "logger" or "data logger" is uncommon other languages, so the term "flight recorder" is used by the FAI and IGC.

1.2 GPS position, height, and timing accuracy

Average horizontal position error measured to date by GFAC has been about 11.4m, based on thousands of samples. Tests are done by fitting FRs to vehicles, driving over several accurately surveyed points close to 51N 001W and measuring the difference from the survey data. If the points are limited to those with completely clear horizons, the average error lowers to about 7.5m. Since FRs are not usually checked by professional avionics engineers or installed in gliders to commercial standards, the higher figure may be more typical. In any case, such figures are well within the requirement for validation of OZ entry.

Vertical (altitude) accuracy is less than horizontal accuracy because of the angles of the position lines needed for an altitude fix. At best, GNSS altitude errors will be about twice those for horizontal position. GFAC tests have shown that it is possible to have accurate fixes in lat/long, but poor accuracy in GPS altitude, or even an obvious GPS altitude anomaly or complete altitude unlock. The latter would be indicated in an .igc file by the GPS altitude figure showing zero or baseline.

FRs have an internal clock that maintains continuous date and time even when the FR is switched off or is operating in pure pressure altitude mode due to any failure to receive GPS data. On receiving satellite signals, FRs maintain time to better than a nanosecond since GNSS system operation uses very accurate time differences in the receipt of signals from the satellites 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. Annex B contains the rules and procedures for the use of GNSS recorders. Each flight recorder given IGC-approval is accorded a security level allocation and permitted usage 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 and 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 all the provisions of the IGC specification. These may not be used for world records.

c. *IGC approval for badge flights up to Diamond only* Flight recorders with less rigorous standards than either a or b (they may use an external GPS receiver, for example).

A list of these FRs is published on the gliding/gnss 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" that discusses connections to the FR, security (physical and electronic), installation in the glider, motor glider aspects (if any), 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 opening the case or attempting to do so), the internal security mechanism will erase the electronic key used to validate the integrity of the .igc files. These files will continue to be produced, but will be marked as "unsecure" and will fail the Vali test (6.2.d). Individual Vali programs originate from the FR manufacturers and are coded to recognise the correct digital signature from each manufacturer's FRs.

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, the ground level pressure for the time and places of takeoff and landing, exact positions at takeoff 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, the wind structure with altitude. These can be used for checking against 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, but may be used for evidence of flight continuity if the pressure altitude trace has failed.

GPS position recorders (see SC3, Chapter 4 Appendix), where they record altitude at all, may record altitude above an approximate sea level surface known in the WGS84 manual as the WGS84 Geoid. Some units that incorporate a pressure altitude sensor may mix GPS altitude and pressure altitude data, for instance, in order to produce approximate height above ground.

b. *Pressure altitude* Pressure altitude, universally used in aviation, references the ICAO International Standard Atmosphere with a 1013.25 HPa sea level datum. As this is the IGC standard for measurement of altitude, a pressure altitude sensor is also required within the FR. This enables pressure altitude recording to continue in the event of GPS failure. The pressure altitude sensor in a FR is temperature compensated and is set by the sensor and FR manufacturer to the ICAO ISA. A sea level baseline setting and a setting for gain with altitude are usually available for adjustment. The FR manufacturer should adjust these settings for minimum errors before sale (see para 11.1).

INDEX