FAI Sporting Code

Fédération
Aéronautique
Internationale

Section 3 – Gliding
Annex C

Official Observer & Pilot Guide

2000 Edition – AL8

This amendment is valid from 1 October 2007

*The FAI Sporting Code for gliders (SC3)
sets out the rules and procedures to be used
to verify soaring performances.*

*Annex C provides support and examples
of means by which the letter and spirit of
the Sporting Code may be met.*

FÉDÉRATION AÉRONAUTIQUE INTERNATIONALE

Avenue Mon Repos 24
CH 1005 - Lausanne
Switzerland

http://www.fai.org
e-mail: *sec@fai.org*

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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

Amendment list (AL) record

Amendments are published by the FAI Secretariat, acting for the International Gliding Commis–sion (IGC). Within nations, the organisation responsible for National Airsport Control (NAC) for gliding is then responsible for distributing amendments to all holders of this annex to Section 3 of the Sporting Code (SC3).

Amendments should be proposed to the IGC specialist dealing with this document either directly or through the FAI Secretariat in Lausanne (address below), preferably in the format used in the text of this annex.

When individual amendments have been made to the text of this Annex, a copy of the amendment list instructions should be inserted before this page so that, at a later date, the subjects of the amendment may be easily identified. Alternatively, users may download the amended Annex from the document page of the FAI web site. Amendments to the text will be indicated by a vertical line to the right of any paragraph that has been changed.

AL #	Action date of AL	Amended by (signature)	Name	Date amended
1	1 Oct 2000	AL1 are original pages		
2	1 Oct 2001	all changes incorporated		
3	1 Oct 2002	all changes incorporated		
4	1 Oct 2003	all changes incorporated		
5	1 Oct 2004	all changes incorporated		
6	1 Oct 2005	all changes incorporated		
7	1 Oct 2006	no changes made		
8	1 Oct 2007	all changes incorporated		

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Appendices

THE
OFFICIAL
OBSERVER

Official Observer & Pilot Guide

GENERAL

1.0   Purpose of Annex

This annex is published to assist OOs and pilots to interpret the rules that are set out in the Sporting Code Section 3 for gliders and motor gliders. The methods and interpretations presented are not necessarily the only correct solutions, but are in common use. The content of this annex does not have the authority of the rules, but can be used to help interpret them in normal situations.

1.1   The Sporting Code

The redrafting of the text of the 1999 Sporting Code for gliding was done with the goal of making it as understandable and simple in structure as possible. This was done by redesigning the format and rewriting the content. If you think a passage of text is capable of being interpreted in more than one way, the *most straightforward* interpretation is the correct one, not the obscure one that a lawyer may find.

However, misinterpretation of the Code may arise from reading a portion of the 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 1.4.4 to 1.4.6.

Although simplicity was a goal, the Code is complicated because it covers all badge and record types and allows the pilot to gather flight evidence in alternate ways. As a result, how one is to respond to the Code requirements can be confusing. If you find that any part of the Code does not meet the goals above, pass your concern to the IGC Sporting Code specialist – suggested improvements to the text will always be seriously considered for future amendments.

1.2   A word on claims processing

The introductory philosophy on the opening page of the Code states: "*When processing the evidence supplied, OOs and the National Airsport Control (NAC) should ensure that these rules are applied in the spirit of fair play and competition.*" The homologation process determines if the claimed task conforms to the rules. Often, incorrect or incomplete evidence can be corrected. At times, although the supplied evidence cannot support the stated claim, the pilot may not have realised that it is sufficient for another category of record or badge. 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 bureaucratic reasons or oversights that do not affect the proof of a performance.

1.3   Official Observer's duties (SC3-5.1.2)

The Official Observer has the very important responsibility of being the FAI's field representative. The OO guarantees that the requirements of the Code have been met in a claim for an FAI award, badge or record. The OO ensures that the flight is controlled to FAI standards, and that evidence is gathered and prepared in such a manner that later study of it by a disinterested examiner will leave no doubt that a claimed achievement was met. The "disinterested examiner" is usually the claims officer of one's NAC.

Where many claims are being forwarded, it is helpful to catch any documentation errors early by passing claims through a local "senior" OO. This helps to maintain a consistent standard of claims preparation, thereby reducing the workload of the national claims officer.

The OO must act independently and without favour, and be familiar with the basic definitions in Chapter 1 of the Code. A sound knowledge of the rules is important – it is even more important to pay careful attention to details 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 fulfil the rules. An OO should not pass a poorly prepared claim to their NAC in the hope that it will be accepted. Performance standards are the foundation of recognized achievement in soaring, so a rejected "almost good enough" flight will be valuable experience for the pilot.

1.4   Pilot preparation

The most valuable thing a pilot can do to meet the requirements of a badge or record task is to make careful *preparation.* Lack of preparation results in weak evidence, accounts for most rejected claims, and may seriously delay or even cancel your planned flight. Your preparation of *impeccable* evidence requires some care and time, and time is invariably in short supply on the morning of the "big flight". Therefore, anticipate the day and prepare for it – this will go a long way towards a successful flight. Consider the following:

a.   Study the *current* FAI Sporting Code to be aware of the requirements for a given flight and discuss your planned flight with your OO. See documentation list in Appendix 4.

b.   If you are using a camera and barograph for flight evidence, always have a barograph prepared for flight, and have a fresh roll of film available for the camera. Practice turn point photography to check out the camera and especially your own flying techniques around the turn point.

c.   If you are using an FR for evidence, be completely familiar with the equipment and the loading of turn point data. Use the FR on several local flights before trusting yourself to use it correctly for an important flight.

d.   Always have landing cards, flight declaration and *the most current version* of other badge or record forms. Keep all this material in a separate container and keep it handy. Record forms are available on the IGC web site. NACs hold badge claim forms and may have their own locally-modified record forms.

e.   Study possible tasks beforehand and prepare maps for them or load them into your FR.

f.   Prepare and use a task checklist.

1.5   Extraneous flight data

It is permissible for flight evidence to contain data unrelated to the soaring performance claimed. Examples of unrelated data are: flight recorder data of a previous flight (where this storage is possible), a flight trace of a prior flight on a barogram, photographs of unclaimed turn points, or "sightseeing" photos.

1.6   Accuracy and precision of measurements (SC3-4.4.4)

A device may display measurements to a larger number of significant figures than its sensor can detect. For example, a digital barograph may give altitude readings to the nearest metre, but its pressure sensor may only be capable of resolving height to within about 30 metres (especially at high altitudes). So although a FR height readout can be displayed to the nearest metre or foot, it is *not* valid to this level of accuracy. The reverse case is where the sensor or processor is more accurate than the data readout such as a digital clock which displays time to the nearest minute while its internal counter is operating to an accuracy and resolution of less than a microsecond.

a.   *Map errors*
Direct distance measurement on a map is limited by the errors inherent in determining a position on a map. The principle position errors are plotting distortion, reproduction errors, and reading errors. The combined errors will limit the accuracy to about plus or minus 500 metres on a 1:500,000 scale map, making it unsuitable for official absolute measurements. See Appendix 9 for more detail.

b.   *Measurement accuracy for badge claims*
For badge distance claims, the OO is certifying that a defined distance has been *exceeded*. Where it has been clearly exceeded, it is not essential to measure the actual distance with the same accuracy as for a record. For example, it would be sufficient to measure from a new 1:500,000 or smaller scale air map. The argument can be extended to certifying a height gain.

c. *Round-off error*

Rounding the result of a calculation can introduce an error up to one-half the value of the decimal position being rounded. So, if a calculation is required to be accurate to one decimal place, all intermediate calculations must be made to two decimal places and the rounding done only to the final result. An example of intermediate rounding-off errors giving a "false" Gold distance is shown in Appendix 9.

d. *Altitude error*

Due to dynamic pressure errors, errors associated with reading barograms, producing a barograph calibration trace, and (where necessary) constructing a calibration graph, there is considerable uncertainty in the true height achieved. Therefore, the calculated height gain or absolute altitude should be rounded off to the nearest 10 metres. This rounding will satisfy the FAI's 1% accuracy requirement for Silver gains, and is proportionately better for the other badges.

e. *Time measurement*

Speed records must be timed to at least the nearest 5 seconds (SC3-Table 3). Timing to the nearest second is preferable. As speed records are quoted to the nearest 0.1 km/h, for a speed of 100 km/h this implies an accuracy of 0.1%, which over a 100 km course equals timing precision of 4 seconds. For example, as speed records must be exceeded by 1 km/h, then a 100 km triangle record of 153.3 km/h would have to be raised to 154.3 km/h, a time differential of only 15.3 seconds over 100 km. A timepiece reading to the nearest second is therefore required.

1.7 Equipment sealing

The sealing method for cameras, barographs, flight recorders, etc. to structure must be acceptable to the NAC and the IGC. It must be possible for the OO to identify the seal afterwards. A seal must be applied and marked in a manner such that there is incontrovertible proof after the flight that it has not been compromised, such as by marking it with the glider registration, the date, time and OO's name, signature, or OO identification number. Tape that can be peeled off and refitted is not satisfactory. Adhesive paper tape is suitable for most applications.

1.8 National records

The FAI has no particular interest in national records other than the need for a world record to also be a national record. A NAC may add further record types or classes to their national record list and even accept different forms of evidence; however, a national record that leads to a claim for a world record must conform to the Sporting Code.

HEIGHT PROBLEMS

2.1 Height penalty – for distance flights over 100 km (SC3-4.4.2a)

For distance flights greater than 100 kilometres, because of the possibility of the landing or finish point being at a much lower altitude than the start, the Code places a penalty on the distance claimed if the loss of height exceeds 1000 metres. This penalty has increased over the years to keep pace with the increasing performance of gliders so that there is no benefit to deliberately starting a task with excess height. It is now 100 times the excess height loss. If a loss of height is 1257 metres, for example, then the distance flown is reduced by 100 times 257 metres, or 25.7 km. It is because of this limit on height loss that there is the requirement to record the start height and the finish height even if the finish is the landing point.

2.2 The 1% rule – height loss is limited for tasks under 100 km (SC3-4.4.2b)

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% will invalidate the flight. A Silver badge distance flight, for instance that was exactly 50 km long, 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 where the maximum of 1000 metres is allowed. For pilots using altimeters calibrated in feet, Table A will be of assistance in determining the maximum start heights above ground for short – usually Silver distance – flights (if the finish is the landing point).

TABLE A	Maximum allowable height losses for distances under 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
								100	3281

Pilots attempting a Silver distance flight, and utilising the rule that allows the 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 km) not just the leg of the flight that is more than 50 km. It would be logical to use a start height that would still allow a claim to be made even if an outlanding occurred just after the 50 km distance has been flown.

2.3 Height evidence for world record attempts (SC3-3.0.3)

The restriction to the use of flight recorder evidence for world record attempts extends to absolute altitude and gain of height flights as well, notwithstanding the accepted accuracy and security of electronic barographs. The FR data should substantiate the claimed height and the GNSS derived altitude trace should closely follow the barograph trace as supporting evidence.

2.4 Measurement of absolute pressure – the altitude correction formula (SC3-4.4.8)

To make this correction, the Official Observer 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 the altimeter when it is set to 29.92 "Hg or 1013.2 millibars. Averaging several altimeters will give greater accuracy. Alternately, the closest 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, i.e. the barograph was "reading" too high.

START AND FINISH CONSIDERATIONS

3.1 The start and finish alternatives

The start and finish of a badge or record flight are the places where misunderstanding may occur as there are several alternatives which can be used. It has been the experience of OOs and NACs that the start can hold the greatest possibility for error or miscalculation of position or height and thereby negate the pilot's effort for the remainder of the flight.

	The start (SC3-1.1.7)	The finish (SC3-1.1.11)
1	release	landing
2	leaving a start point OZ	entering a finish point OZ
3	crossing a start line	crossing a finish line
4	shutting down a MoP	starting a MoP

The Code gives four methods of starting and finishing to choose from. Any start method can be used with any finish method. The first and fourth alternatives can be considered equivalent, and do not normally need to be pre-declared. The exceptions are a goal flight where the finish point is declared, or a closed course flight in which the nomination of "point of release" as the start/finish point will meet the declaration requirement. The second and third methods of starting always require pre-declaration of the start point (except for free distance flights). Note that there is no observation zone associated with a start or finish when a start line or finish line is used for a flight.

3.2   Start and finish evidence – normal case

The start and finish have three parameters associated with each of them that normally are measured together at a single point: position, time, and height.

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 or is the declared finish point. It is used in calculating the task distance.
The start time is the actual time of release or MoP shut down, or the time the glider crosses the start line or exits the OZ of the start point.	*The finish time* is the actual time of landing or MoP restart, or the time the glider crosses the finish line or enters the OZ of the finish point.
The start height is measured at the same place as the start time.	*The finish height* is measured at the same place as the finish time.

3.3   Start and finish loss of height evidence – camera use

When using a declared start point out of sight of an OO, the camera equipped pilot is at a disadvantage as it is difficult to provide evidence of one's height on leaving the start point OZ. To correct this problem for *distance flights* only, the height at the time of *release or stopping the MoP* may be used as the start height (SC3-1.4.7). The release point or stopping of MoP can be anywhere. The height loss for penalty purposes will be measured to the elevation of the finish point, not the height of the glider at the finish point, again because the glider's finish height cannot be measured. The start point for distance measurement is the point originally declared and the finish is either the landing point or the declared finish point.

No time measurement is needed for a distance flight. While this alternative is designed to help those using photography, there is no restriction on using a flight recorder for evidence.

3.4   The canopy mark

The mark placed on the canopy will appear as an out of focus shadow on the photograph when the distance from the lens to the canopy is not close to the focal length of the lens. The OO verifies that this shadow matches the shape and orientation of the mark, and that it appears on the declaration photo and all way point photos (the post-flight photos of the glider are not always taken with the camera mounted). A common error is to make the mark too light or narrow with the result that it does not appear on the photo. The mark should be opaque and not less than 3mm wide. When using a new camera, the pilot is strongly advised to confirm the visibility of canopy marks by taking test photos.

3.5   Start and finish evidence – flight recorder use

An error in starting or finishing could result in a loss of height sufficient to invalidate a speed flight or cause an unwanted height penalty. In this case, the start height and time may be selected after the flight from the *most favourable fix* within the OZ before crossing the start line or OZ boundary. The result is a valid start with a time "penalty" on a speed task and with in-flight control over a height penalty on a distance task. The pilot may climb to any height before starting a task, but will then need to calculate the minimum 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 the pilot may pull up or thermal within the finish OZ until the loss of height from the start drops to 1000 metres and use this time as

the finish time. If, after the flight, the loss of height was still excessive, the start time and height may be taken from a fix within the OZ at which the loss of height was 1000 metres.

3.6   Release point and stopping MoP starts (SC3-1.1.8a)

If the release point is also the start point, to achieve a closed course flight with a legal finish the pilot must fly back into the OZ of the release point (now centred on the last leg), or land, in either case to a position within 1000 metres of the release point. Alternatively, the finish may be a finish line at the goal. If the pilot releases over the airfield, landing on the airfield qualifies as a closed course flight.

ASPECTS OF TASK SELECTION

4.1   Mixed proof of being in observation zone (SC3-4.6.2f)

The three methods of proof of being in an observation zone are not exclusive – one method may be used to back up another during a soaring performance. If, for example, an interruption in flight recorder data causes turn point information to be lost, a photograph can be used to supply the proof. *However*, this back-up evidence must still obey the Sporting Code requirements; for example, the photo must be a part of a complete photographic sequence.

4.2   Turn point sequence and non-turnpoint photos (SC3-4.2.1e)

When using photographic position evidence (SC3-4.6.3b), the declaration defines the order in which required photographs must appear on a film strip. This does not exclude other sightseeing photos or TP photos that are not relevant to the claimed performance from appearing on the film strip (see para 1.5) as long as the declared sequence is maintained.

4.3   Free record flights (SC3-1.4.3)

The difference between free distance records and other flights is the use of way points that are declared *after* the flight is done. However, free distance may be claimed from a course that includes achieved declared turn points. Note the essential difference from a flight qualifying for a badge where way points must be declared (except for a release start or a landing finish, where applicable).

The pilot is free to fly anywhere he wishes between take-off and landing and, after the flight, select from the position evidence the points he wishes to declare as way points of the soaring performance. A normal "declaration" must still be made before the flight containing all the usual non-flight information, but the task way points are omitted. Any fix on the FR evidence at or after release may be selected to be any way point of the soaring performance, and the pilot is considered to be exactly over (hence within) the observation zone of that point. See SC3-4.6.2f(iii).

4.4   Abandonment or failure of a declared task (SC3-4.2.2b)

A failed declared task (usually the inability to reach a turn point or not being within the OZ of a turn point) can still fulfill the requirements of a lesser soaring performance. The principle is that the flight is 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. Two sample scenarios of the latter are:

a.   *Out and Return distance task*
     If the declared TP for this task was unattainable, the pilot may claim a free O&R record distance performance on selecting the most distant FR fix from the start point.

b.   *Triangle distance task using 2 TPs*
     If the first TP were missed or was unattainable the pilot could claim: either a free 3 TP or a free O&R distance record using any TP achieved on the flight, and a 3 TP distance badge task (start, second TP, to finish).

     If the second TP were missed or was unattainable the pilot could claim: either an O&R or a free O&R record distance to any attained TP, or a free 3 TP record distance using the first TP and any other point as the second TP.

4.5   Claiming more than one soaring performance from a single flight (SC3-2.0.1 & 3.0.2)

A flight may satisfy the requirements for more than one badge. Always consider the potential for alternate badge or record claims when selecting task turn points, as this allows the pilot to make useful in-flight decisions on task selection depending on the soaring conditions. For example, the course shown here is declared (club/A/B/C/club). If this task is completed, the following badge performances have been achieved:

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

b. *Diamond goal and Gold distance* – 346 km (A/B/C)

This course meets the 3TP triangle definition of SC3-1.4.6b(i). If flown in the reverse direction, it would meet the 3TP distance definition of SC3-1.4.5b.
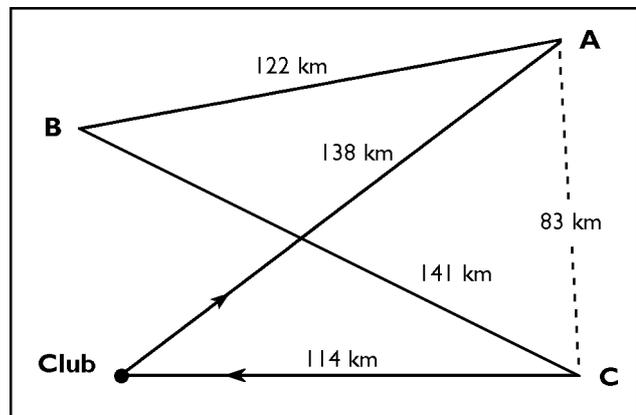
4.6   Choice of observation zone

There are two observation zone shapes; the traditional sector OZ, and the new cylinder (or "beer can") OZ that requires FR use. The sector OZ is unlimited in distance from its turn point within the sector boundaries, while the cylinder OZ area is limited to within 500 metres of the turn point. The cylinder OZ has some advantages, as when declaring a badge or record in conjunction with a competition flight, and some FRs only allow this sector to be used, but the cylinder OZ can severely restrict a pilot's chances of achieving a pre-declared turn point.

It is important to note that if, for example, a pilot had the sector OZ set into the FR and missed entering one of them, the soaring performance will still have been completed provided the pilot was within 500 metres of *all* TPs. One can have one OZ type set into the FR but actually meet the requirement of the other – OZ type is *not* part of a flight declaration. (See also para 9.2b.)

4.7   Observation zone procedures (SC3-4.6.2f)

A way point is reached only when the pilot has evidence of being within its observation zone as illustrated below. Acceptable evidence is either a valid photograph within a sector OZ, a valid FR fix recorded within either OZ, or a straight line that passes through an OZ and joins two consecutive valid FR fixes (see para 9.2 for more FR information related to OZs). Failure to get valid OZ evidence is likely to be for one of two reasons:

a. When using FR evidence, the pilot has the FR set to too slow a recording rate and no valid fix is shown within the OZ (see para 9.2a). A FIX INTERVAL OF 10 SECONDS OR LESS IS STRONGLY RECOMMENDED. It is also possible (but less likely using current receivers) to lose lock on the GPS satellites in a steep bank (see paras 7.2 and 13.8b). The minimum sampling rate of once per minute specified in the Code refers the setting in the FR for the fix interval which will be recorded in the IGC flight data file. Missed position fixes from an otherwise continuous trace that lowers the actual sampling rate to less than once per minute (for example, because of instantaneous attitude or GPS system anomalies) is normally acceptable.

b. When using camera evidence, the pilot takes the photo before entering a sector OZ. There is always the urge to rush – when you are sure that a photo can be taken, wait for a few more seconds. Then take a second one. OOs examining camera evidence almost never see a photo taken too late. See section 16 on photo interpretation. Note: the track of the glider into the OZ does not need to go "around" the turn point. The pilot only has to provide evidence that the glider crossed into any part of the observation zone.

90° observation zone – no limit on distance from TP

courseline bisector

A valid track into a sector OZ – flight recorder or camera evidence allowed.

500m

TP

A valid track into a cylinder OZ – flight recorder use only.
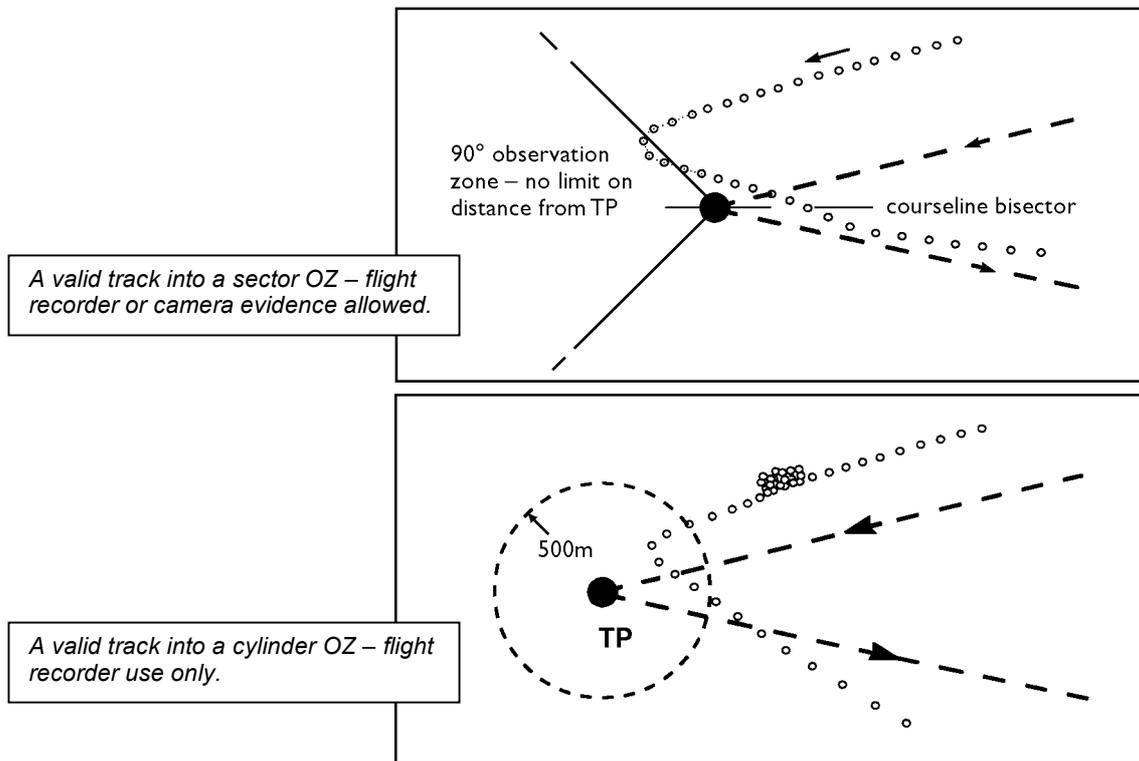
4.8   Achieving a goal – the 1000 metre requirement

A straight distance to a goal requires the finish to be within 1000m of the goal. For a closed course goal flight, the start and finish points are one and the same. If the start is from the release point or by crossing a start line, the finish point is the release point (or the point at which the MoP was stopped) or the centre point of the start line. When a declared start point is used, the start of the performance is marked by crossing the OZ boundary *within 1000m* of the declared start point. Since a sector OZ can extend a great distance, this restriction is needed to ensure that a closed course is "closed". Completion of a closed course goal flight is proved by evidence that the glider reentered the OZ of the start/finish point or crossed the finish line (thus completing the performance) *and* was within 1000m of the start/finish point (thus completing the minimum distance requirement of SC3-4.3.4c). Both conditions must be met for a flying finish.

If a camera is being used on a badge flight, position is less certain. The onus is still on the pilot to produce satisfactory photo evidence of being within the start/finish sector OZ at a position within 1000m of the start/finish point or past the finish line. If there can be *any* argument about the evidence establishing this, then "satisfactory" has not been met. If the pilot has any doubts about his ability to take a satisfactory start or finish photo, then one of the other methods of starting/finishing should be used – in general this will entail landing within 1000 metres of the start/finish point.*)*

BAROGRAPH EVIDENCE

5.1   The elements of barographic proof

A barograph records air pressure against time and is required for all badge and record flights except for duration flights under continual observation by an OO. The barogram produced provides proof of any or all of three elements of a flight profile:

a.   *Altitude*   The barogram trace can be used to establish the height (subject to the altitude errors noted in paragraph 1.6d) using standard pressure/height tables. Calibration traces are often recorded directly in height, making this conversion unnecessary.

b.   *Continuity*   The barogram ensures that the recorded task is on 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 of the glider. Calibration of the barograph rotation rate by the OO is required.

5.2 Trace continuity (SC3-4.3.5)

a. A *stoppage* of drum rotation will invalidate duration evidence when the barograph is used for time measurement. Even a temporary stoppage will also normally invalidate other evidence unless the OO can verify that critical data points and flight continuity are evident from the working portion of the barogram.

b. An *interruption* of the trace may, if not invalidating the barogram, at least limit the claimable height gain, and could invalidate continuity of flight evidence (see para 13.8b for FR missed fixes). If a trace is likely to occur over more than one rotation of a mechanical barograph, then the foil should be attached to the drum so that the hold-down bar (if used) will not interrupt the trace. One end of the foil may be attached in such a way that it covers the hold-down bar. Alternatively, the complete drum including the trace showing over the hold-down bar may be submitted as evidence.

5.3 Flight recorder barograph evidence

The digital altitude data supplied by a GNSS receiver is a calculated height above a mathematically defined surface. See Appendix 6, para 1.3 for details. Flight recorders incorporate an additional sensor to record pressure altitude which allows a barogram to be produced which conforms to the Code.

GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) and FLIGHT RECORDERS

6.0 General

By definition (SC3-1.3.5), the use of the term "flight recorder" or "FR" means an IGC-approved GNSS flight recorder. Information on the characteristics of GNSS systems and flight recorders designed to record such information and related IGC web site references is in Appendix 6 of this Annex. Sections 6 to 10 following is guidance for pilots and owners of flight recorders, and then Sections 11 to 13 aid officials concerned with the validation of flights.

6.1 IGC-approval document

A flight recorder can only be used in accordance with its IGC approval document; for example, not all FRs are approved to validate world record flights. There are three levels of approval:

a. valid for world record, diploma, and badge flights,
b. valid for diploma and badge flights,
c. valid for badge flights up to and including Diamond.

Appendix 6 has further detail. Pilots and owners are advised to obtain a copy of the IGC-approval document (see Appendix 6 para 2.3) for the type of flight recorder to be used, and to study it carefully before using the equipment for a flight that may need to be officially validated. The latest versions of all of these documents are available through the gliding/GNSS web site. Any updates or amendments are posted by the FAI on the IGC e-mail mailing list, the web pages being amended at the same time. See also:

<http://www.fai.org/gliding/gnss/igc_approved_frs.pdf>

6.2 Calibration of barograph function

Pilots are advised to have a calibration carried out either by the manufacturer or by a NAC-approved calibrator before any FR is used for a claimed flight performance. See Appendix 9. A valid IGC-format file showing the pressure steps used in the calibration must be recorded and kept (SC3B chapter 2). Altitude and height claims require a calibration for the flight performance concerned, and speed and distance claims need a calibration for calculating the altitude difference of the glider at the start and finish points. Also, the NAC or FAI may wish to compare pressure altitudes recorded on the FR at take-off and landing with atmospheric pressures (QNH) for the appropriate times recorded by a

local meteorological office. For the maximum intervals between calibrations, see SC3-4.4.7, and note that for IGC-approved electronic barographs and flight recorders, the maximum interval before a flight needing a calibration is 24 months compared to 12 months with other types of barograph.

6.3   The required geodetic datum for flight data
The WGS84 Geodetic Datum shall be set for all lat/long data that is recorded and transferred after flight for analysis (SC3-4.6.4). This is a requirement – FR data is invalid otherwise. See Appendix 9 for background information on geodetic datums.

6.4   Maps using local Geodetic Datums
The lat/long or other grid on local maps may be used to derive the coordinates of way points, but the GD used in the construction of such maps is unlikely to be WGS84 and probably is a local datum. The map GD should be noted and the map coordinates transformed to WGS84 latitudes and longitudes using a transformation program. A copy of the USGS MADTRAN (Map Datum Transformation) program is available as freeware on the FAI/IGC site for software given earlier, and several other transformation programs are commercially available.

6.5   National turn point lists
National lists of turn and other points should have the lat/longs calculated to the WGS84 Datum. These lat/long figures may then be used directly for flights to IGC WGS84 lat/long criteria and be used without the need to transform them between GDs. Such WGS84 lat/longs can be used in flight with FRs that have a display of way points, and also for use in any post-flight analysis program where the way point lat/long data will be examined as the basis for observation zone validation.

FLIGHT RECORDER SETTINGS

7.1   Fix interval settings
GNSS and pressure altitude data is recorded in the form of regular fixes, the interval (sampling rate) being chosen through the setup menu of the FR. Many FRs have a cruise setting for use between way points and a fast fix facility for use near observation zones and/or after pressing the Pilot Event (PEV) button.

a.   *Maximum fix interval setting*   For a flight to be validated to IGC rules, the setting for fix interval (sampling rate) must not be greater than one minute (SC3-4.3.1). If a setting is made in excess of this, the flight will not be validated. Note that these are settings rather than actual fixes (but see para 13.8b for missed fixes).

b.   *Setting between way points*   For cruising flight between way points, a smaller interval than the maximum is recommended so that maneuvers such as thermalling turns can be seen on the analysis screen. 10 to 20 seconds has been found to be suitable, and does not use up as much memory as a more frequent setting for the whole flight.

c.   *Setting near way points*   A more frequent fix interval is recommended near a way point to ensure that a fix is recorded within its observation zone (see para 9.2).

7.2   Missed fixes
It is accepted that, for a number of reasons, a number of fixes may be missed or be assessed as spurious (see para 13.8 for a description of data anomalies). Any discontinuity in valid fixes actually obtained should be backed up by the pressure altitude trace, which in a FR is designed to continue if GNSS fixing is lost, and so prove flight continuity. However, observation zones require valid lat/long fixes and if these are not present, presence in the OZ cannot be validated.

Most GNSS antennas are directional and are mounted for optimum performance when the glider is in straight and level flight. Therefore, high angles of bank may cause the GNSS to unlock and fixes to be missed. In order to ensure OZ validation, any maneuvers should be delayed until valid fixes have already been recorded in the OZ.

7.3 Geodetic Datum

Values for entered lat/long data such as for start, turn and finish points, must be calculated and entered to the WGS84 Geodetic Datum. Most FRs are designed only to record fixes with respect to this datum, so no action is required except to ensure that lat/long position inputs are also to WGS84 and not to a local map datum. A free GD conversion utility is available (see para 6.4). However, some FRs allow different local datums to be set and you must ensure that the WGS84 datum is used for flights to be validated to IGC rules.

7.4 Electronic flight declarations

Most FRs have the facility to enter a flight declaration which then appears on the flight data file with the date and time of entry. Since FRs have both physical and electronic security (Appendix 6 para 1.7) and a Real-Time Clock (RTC) (Appendix 6 para 1.8) such a declaration does not need to be witnessed by an OO (SC3-4.2). For free record declarations see paragraph 4.3.

An electronic declaration can be superseded by a later one or a subsequent written declaration. WARNING – if you are writing a "last-minute" paper declaration, the FR *must* be active at the time. If the FR is switched on after the paper declaration is complete, the FR declaration then becomes the "latest" one – nullifying the written version.

INSTALLATION of the FLIGHT RECORDER in GLIDERS

8.1 Fitting the flight recorder to the glider

Any limitations or conditions will be given in the IGC-approval for the type of FR, such as those that will apply to the use of a vibration sensor for engine power recording (Appendix 7 para 1.3). Also, the position of any displays and operating buttons and controls (including switching by touch-sensitive screens) used in flight in single seat gliders should be close to sight lines used for pilot lookout and scan for other aircraft and gliders.

a. *Connection to ports and antenna*
Approval documents generally do not require the sealing of any ports, plugs, or cable connections, but no attempt must be made to pass unauthorised data into the FR. If the GPS antenna is accessible to the crew in flight, no attempt must be made to inject data. Any abuse may lead to a future requirement for sealing of cable connections and/or to place the antenna out of reach of the flight crew. If the FR is connected to the static port tubing (where this is 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 FR barograph reading.

b. *Flight recorders using the Engine 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, although even so, automatic gain should continue to ensure high ENL readings under power.

8.2 Check of installation for the flight concerned

There must be incontrovertible evidence that the FR was present in the glider for the flight concerned, and was correctly installed in accordance with para 8.1 above and any other provisions in the IGC-approval for the type of FR (such as rigid mounting for FRs with vibration sensors). This check can be achieved either by observation 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. More than one FR may be installed for a flight. For their evidence to be valid, each must have a level of IGC approval suitable for the intent of the flight (i.e. badges up to Diamonds, diplomas, or World records.)

a. *Official Observer's checks*
The pilot must ensure that an OO has checked the placement of the equipment in the glider and how it is fitted. If it may be difficult to obtain an OO immediately before take-off, or to witness the landing, pilots are advised to ask an OO to seal the FR to the glider, and this can be done at any time or date before flight. See the next paragraph.

b. *Observation of installation before take-off or at landing*
For non-sealed installations, either a preflight check of the installation must be made and the glider must be under continuous observation by the OO until it takes off on the claimed flight, or an OO must witness the landing and have the glider under continuous observation until the FR installation is checked. This is not only to ensure that the installation is in accordance with the rules, but also to show that another FR has not been substituted before the data is transferred to a computer after flight.

c. *Sealing to the glider*
If the terms of para 8.2b above cannot be met (such as the absence of an OO before take-off), the FR must be sealed to the glider by an OO at any time or date before flight (see para 1.7). The OO must seal the FR to glider parts that are part of the minimum standard for flight. If the FR is sealed to a removable part such as the canopy frame, instrument panel, or a centre-section bulkhead fitting, and if such a part is transferred between gliders, any FR seal for the previous glider must be removed.

FLIGHT RECORDER PROCEDURES – TAKE-OFF, FLIGHT, LANDING

9.1 Witness of take-off and landing
The pilot must ensure that the time and point of take-off and also of the landing has been witnessed and recorded for comparison with that recorded by the FR. See para 11.3.

9.2 Observation zones
Many FRs have a "fast fixing" mode that either operates automatically when a set way point is approached, or operates after pressing the Pilot Event (PEV) button. Pilots should set a short sample interval in the vicinity of an OZ to ensure that a short period in the zone results in proof of presence, and also to allow for any loss of fixing or spurious fixes (this might occur at high bank angles). Where the fast-fix interval can be pre-set by the pilot, short intervals such as 4, 2 or even 1 second may be chosen, and the zone flown accordingly.

a. *Validation of presence in an observation zone*
At least one valid lat/long fix must be in the OZ or a straight line joining two consecutive valid fixes must pass through it. In this case, the glider should not be judged to have been in the OZ if the pilot could have avoided the zone within the fix interval being used. Note that all fixes (valid or otherwise) in or near the OZ should be assessed. Also, 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).

b. *Shape of observation zones*
The observation zone is either a 90-degree sector (SC3-1.2.9) in which distance from the way point is unlimited within the sector, or a cylinder (SC3-1.2.10) in which the OZ area is limited to 0.5 kilometres of the way point. The two types of OZ are mutually exclusive; only one type may be used for all waypoints requiring OZs on any given flight. When fixes are detected in the area, the FR may indicate "presence in the zone" to the pilot, by visual or audio means. However, such indications have no status in terms of the validation of the flight, which depends only on the IGC criteria given above in para 9.2a.

c. *GNSS accuracy with respect to the observation zone*
Where a GNSS system has a display of position with respect to a way point, both the way point position and the glider position will be affected in the same way by GPS errors (Appendix 6 para 1.3b). In that respect, as far as the pilot is concerned, a GNSS system is self-compensating for GNSS accuracy errors providing that:

• the system has a cockpit display of the way point to be reached and the glider
  position (or the distance and bearing between the two),
• the way point has been entered in the FR memory to the correct lat/long and

Geodetic Datum (WGS84 for FAI/IGC flights),

- the pilot makes the correct allowance for the shape of the OZ that will be used to validate the way point, and flies accordingly.

9.3 High engine-off ENL events in motor gliders

It should be noted that side-slipping with the cockpit direct vision panel open can produce a low frequency sound (an organ pipe note) that will register as high ENL. This should be avoided if possible, so that the ENL figures while on task are not questioned. Spins and stall buffet also produce higher-than-normal ENL values, particularly in motor gliders if the engine bay doors flutter (vibrate noisily). Flight close to powered aircraft should also be avoided, except for normal aerotow launches. Other cockpit noises will produce ENL readings; avoid those that could be mistaken for use of the engine. Generally the frequency filtering built in to the FR will avoid any problems. For ENL figures that have been recorded on GFAC tests, see para 15.3. More exact figures for the type of FR concerned are given in Annex B of its IGC-approval document.

FLIGHT RECORDER PROCEDURES – AFTER LANDING

10.1 OO's check of installation and witness of data transfer

The pilot must not alter the installation or remove the FR from the glider until an OO has witnessed its installation to the glider. The OO will carry out the actions given in paragraphs 12.1 and 12.2, and the OO's copy of the transferred flight data will be sent to the authority validating the flight. The OO does not personally have to transfer the data from the FR, but witnesses the transfer and takes or is given a copy on electronic media.

Where more than one FR is carried, each one must be checked to ensure the last declaration made before take-off is applied to the flight. This may be an electronic or a written declaration, whichever is closest to the take-off time. *(Note the timing warning given in para 7.4.)* Some pilots may prefer to make a written declaration even though carrying a flight recorder or recorders to avoid making electronic changes at a busy period before take-off. Pilots would be well advised to prepare and use a declaration form that ensures that all the required data required is included. (See SC3 4.1 and sample form in Appendix 10 in this Annex). Different rules may apply for competition flights, for which a central data transfer facility may be used, but where a flight may be claimed which has to conform to IGC record and badge rules, the above continues to apply.

10.2 Analysis of flight data

Analysis for flight validation will be through a program approved by the relevant NAC. For a list of programs notified to IGC that analyse and present data using the IGC file format, see the gliding/GNSS web site under SOFTWARE. In addition to checking the flight data, before a flight performance is officially validated, the validation authority will check that the IGC file is valid and unaltered by the use of an authorised copy of the VALI-XXX.EXE short program file. The VALI file must be the current version and have originated from the FAI/IGC ftp site given earlier, or from the FR manufacturer. More detail is given in para 13.7.

FLIGHT VALIDATION GUIDANCE for OFFICIAL OBSERVERS and OFFICIALS

11.1 General

Although the following paragraphs give particular guidance for OOs and other officials, some rules and procedures are given elsewhere such as in other sections of the Sporting Code and its annexes (including the rest of this Annex), the *"Technical Specification for IGC-approved GNSS Flight Recorders"*, and other documents which may be issued by the FAI and/or the IGC in hard copy or on the FAI/IGC web pages. Particularly, OOs and officials are referred to the earlier Sections 6 to 10 on guidance for pilots and owners of flight recorders, and to Appendix 6 that presents an overview of GNSS systems.

11.2 OO's flight recorder certificate

An OO shall witness and record the position of the FR in the glider, the type and serial number of the FR, the glider type and registration, date and time. The installation must be in accordance with the provisions of para 8.2.

a. *OO's sealing of the FR to the glider*
   Before flight, if requested, the OO shall then seal the FR to the glider in a way acceptable to his NAC and to IGC, and such sealing may be at any time or date before flight.

b. *Sealing not used*
   In this case, either a preflight check of the installation must be made after which the glider must be under continual observation by an OO until it takes off on the claimed flight, or 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 correct, but that another FR has not been substituted in the glider before the OO witnesses the transfer of data from the FR to a computer.

11.3 Witness of take-off and landing, independent of the flight recorder

Both the time and point of take-off and landing shall be recorded by an OO, an Air Traffic Controller or other official log of take-offs and landings, or by evidence from a reliable witness countersigned later by an OO. This will be compared to the take-off data on the FR record.

OFFICIAL OBSERVER PROCEDURES FOLLOWING LANDING

12.1 Checking the flight recorder installation

As soon as practicable after landing, an OO shall inspect the installation of the FR in the glider (including any sealing to the glider), so that this can be compared to the check described in para 11.2. The transfer of flight data shall then take place.

12.2 Transferring the flight data

If a laptop computer is available, the flight data may be transferred at the glider without disturbing the installation of the FR. If a laptop computer is not available, the OO shall check and break any sealing to the glider, and take the FR to a computer. If the OO is not familiar with the actions required, the pilot or another person may transfer the data while the OO witnesses the process. Security is maintained by electronic coding embedded in the FR that is independently checked later at the NAC (and at the FAI if the claim goes to them).

Different rules may apply for competition flights, for which a central data transfer facility may be used, but for flights to IGC record and badge rules, the above must be followed.

a. *Data transfer method*
   The method for each type of FR is given in its approval document, but will include connecting a computer to the main FR module's data port, and using a current version of the short program file DATA-XXX.EXE, where XXX is the FR manufacturer's three-letter code (list in para 12.2c). This file is available free from the IGC GNSS site for software: *ftp://www.fai.org/gliding/software/*

gps/pc, or through a link from *fai.org/gliding/gnss*. Alternatively, use a current version of the manufacturer's full computer program (if there is one), following the instructions given in the menu.

The program file DATA-XXX.EXE can be executed on either a diskette or on the computer hard disk. The software version is shown at the top of the menu (see under software on page 1 of each IGC-approval document, which gives the relevant versions). This program file executes in the normal way such as by typing DATA-XXX, enter, at a DOS prompt, or by double-clicking "DATA-XXX" in a file list (File Manager/Windows Explorer, etc). If settings such as the COM port, baud rate, etc. need to be changed, the help menu is accessed by typing the file name, space, hyphen, then the letter "h".

b. *IGC file produced*
This process will automatically produce an *.IGC-format flight data file having the file name YMDCXXXF.FIL and 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 FR Specification). Where numbers over 9 apply, such as in months and days, 10 is coded as A, 11 as B, 12 as C, etc. With some FRs, a file in the manufacturer's binary format will be produced before this (binary) data is converted to the IGC ASCII text format using the CONV-XXX.EXE program.

c. *FR manufacturer's codes*
GFAC allocates both one- and three-letter codes to manufacturers of IGC-approved recorders and some potential manufacturers. The one-letter code is used in the IGC flight data DOS file name after the three characters for the date (ex: 367C = Cambridge, 2003, June 7). The three-letter code is used in the full file name and is also in the file header information on the line with the individual three-character serial number of a particular recorder. It is also normally used as the suffix for binary data files (where these are produced). Currently, these codes are as follows (the definitive list is on the IGC website in FR Specification document, App 1, para 2.5.6): *AL8*

Manufacturer	Three	One	Manufacturer	Three	One	
Aircotec	ACT	I	New Technologies	NTE	N	
Cambridge Inc	CAM	C	Peschges	PES	P	
Cambridge LLC	CLC	M	Print Technik	PRT	R	
EW Electronics	EWA	E	Scheffel	SCH	H	
Filser	FIL	F	Streamline Data	SDI	S	
Flarm	FLA	G	Zander	ZAN	Z	
Garrecht	GCS	A	Other	XXX	X	
LX Navigation	LXN	L				*AL8*

12.3 OO's copy of the data

A copy of both the binary (if produced) and IGC format files shall be retained securely by the OO such as by immediately copying them to a separate diskette or PC card, or by the use of the hard disk on a computer to which the pilot does not have access. These files shall be retained by the OO in safekeeping for later checking and analysis under the procedures of the authority validating the flight. The IGC format file must be forwarded to the organisation validating the flight, and if a manufacturer's format (binary) file is also produced by the recorder system, this should also be forwarded. The IGC format can be re-created from the binary file and this can be critical if there is any difficulty in interpreting the original IGC format data.

12.4 Storage media

The OO may keep the required data files on a diskette or other industry-standard portable storage media. The hard disk of a computer may also be used but the OO must be able to positively identify the flight data files as being from the flight concerned. If data is sent to other authorities, the OO should keep a copy of the original data files (both the manufacturer's format, if there is one, and the IGC format) in case of any later problems with the data sent. The copies should be kept at least until the flight is validated.

ANALYSIS OF FLIGHT RECORDER DATA

13.1 NAC-approved Data Analysts

The flight data from the master file held by the OO after flight is sent by the OO to a GNSS Data Analyst (DA) approved for that purpose by the "National Airsport Control" (NAC) concerned. The NAC will normally be the gliding organisation in the nation that sends the national delegate to IGC meetings. The DA may be at the headquarters of the NAC itself, or the NAC may delegate to DAs at larger clubs or regions. 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.

13.2 Data Analyst not on site

Where an NAC-approved Data Analyst 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. Modified claim forms may be needed for the situation where a DA is not available at the site concerned. The DA may use the FR manufacturer's VALI program (para 13.7) to check flight data files before the flight performance is finally validated by the NAC.

13.3 Analysis of flight data files

Transmission of data for analysis may be by physical or electronic means as long as the integrity of the data is preserved. This will be checked at the NAC by the use of the appropriate VALI program. The Data Analyst approved by the NAC will then evaluate the flight using an analysis program approved by the NAC concerned (list, see the IGC GNSS web site under SOFTWARE). 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.

13.4 National procedures for analysis

NACs decide on the exact procedures to apply in their Nations, and which data analysis pro

grams they will approve for flight validation purposes. A list of programs that are designed to use the IGC file format is maintained by GFAC and is on the IGC web page.

13.5 Analysis programs

These show flight data on screen in the form of a map or lat/long grid with the fixes overlaid. Also, a "barograph" presentation must be available showing both pressure and GNSS altitude against real time. Although the times in the IGC file are in UTC, the analysis program may have a local time correction that can be entered so that the screen displays local time. In the case of motor gliders, a record of Means-of-Propulsion operation must be shown as part of the barograph screen. Printouts of screen presentations may also be useful, particularly where a claim may be under discussion by officials. In order for scores to be produced quickly in competitions, programs may be used that automatically check for flight continuity, anomalies, and presence in OZs without the need for manual inspection of the fixes on printouts or a monitor. However, for FAI record and badge flights to be validated to SC3 rules, the screen presentation of all of the data must be checked. It is recommended that any provision for automatic anomaly detection include the calculation of ground speed between successive positions from data samples, with a view to automatically detecting unlikely figures.

Checks of rules and procedures include checks for the following:
  a. evidence of flight continuity,
  b. shape of the flight course,
  c. valid start and finish,
  d. proof of presence in observation zones (para 9.2a for fixes, para 13.9 for
      how to handle any circles of probability),
  e. similarity of GNSS and pressure altitude traces with time,
  f. altitude difference and/or altitude penalty,
  g. course distance and speed (SC3 rules),
  h. electronic security (use of the VALI program).

13.6 Pilot and glider details

The pilot's name and glider details, which appear in the flight file, are entered by the pilot and are not definitive unless confirmed by independent evidence. Several pilots may use a glider, and the FR may have recorded the name of a different person from the actual pilot. This is unfortunate, and very probably would invalidate the flight unless evidence of the real pilot is unquestionable and is noted after the FR declaration is made. The definitive data on glider type and registration and the identity of its flight crew is from independent evidence taken at take-off and landing (para 11.3).

### 13.7 Check of electronic security - the VALI program file

In addition to checking the flight data, an authenticated version of the file VALI-XXX.EXE shall be used by the NAC and by FAI (if the data goes to them) to check the electronic security coding, that the FR had not been interfered with, and that the flight data in the *.igc file has not been altered since it was transferred from the FR. The version number of the VALI file is shown at the top of the screen when the file is executed. The latest version should be used and is available from the IGC GNSS site for software: <*ftp://www.fai.org/gliding/software/gps/pc*> or through a link from <*fai.org/gliding/gnss*>.

At the appropriate prompt or run function, type VALI-XXX.EXE (for XXX use the manufacturer's three letter code, see Appendix 6 para 2.5b) followed by a space and the name of the IGC file to be checked. A message signifying data integrity should appear, not one indicating lack of data integrity. In the latter case, the validating authority must investigate the reason, and report the circumstances to the chairman of GFAC and the NAC. It should be noted that GFAC tests include ensuring that the change of a single character in an otherwise-correct IGC file will cause the VALI program to fail as indicated above.

13.8 Anomalies in data files

In the event of any anomaly, inconsistency, or gap in data files, the NAC shall consult specialists in the field in order to determine whether there is a satisfactory explanation, and whether the flight performance may be validated despite the anomaly. If a NAC wishes to take outside advice, the chairman of GFAC maintains a list of such specialists. Any possibility of deliberate alteration of data shall be investigated, and, if substantiated, the results reported to the president of IGC and the chairman of GFAC. If in doubt, the original file transferred from the FR should be used and the analysis process repeated, if necessary, using the FR manufacturer's analysis program (if there is one) with the original file, or using a different analysis program with the IGC data file. The latter can also be inspected using an ASCII text editor.

a. *Breaks in fixes*   Breaks or side-steps in fixes should be investigated even if they occur between way points.

A 5 minute break in GPS fixes – flight continuity was shown by the FR pressure altitude data.
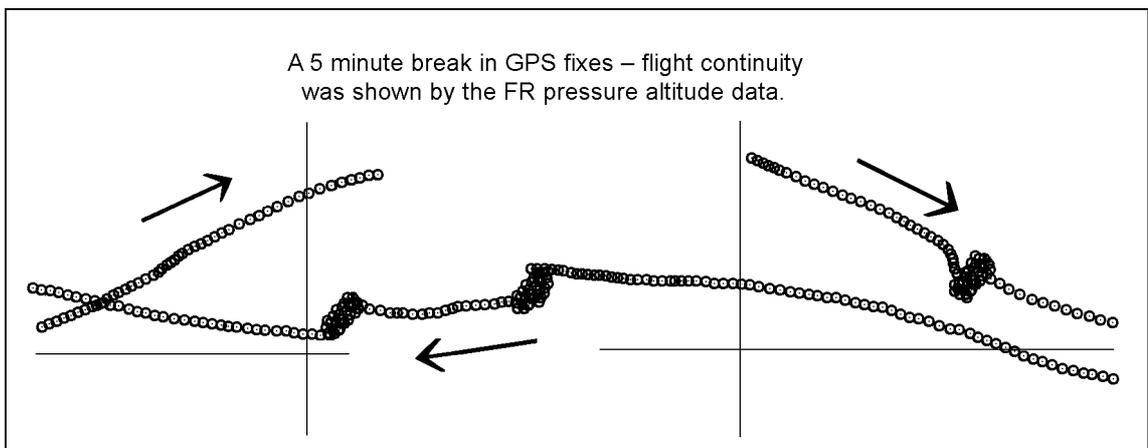
b. *Missed fixes*   The 1-minute maximum is the setting within the FR, and if occasional fixes are missed, this does not in itself invalidate the flight data. Missed fixes are assessed in the same way as a short break in the trace of a mechanical barograph. A judgement has to be made by the authority validating the flight as to whether there continues to be incontrovertible evidence of flight continuity (no intermediate landing). This is done by analysing the time, altitude and

position of the last and next valid data. As a guide, lack of any data for 5 minutes would not normally invalidate a flight, but lack of any data for 10 minutes or more would make validation questionable. In the case of an approved FR, if a break in GNSS fixing occurs, pressure altitude data (Appendix 6 para 1.10) should continue to be recorded and prove flight continuity, although without fixes the evidence of presence in an observation zone will be lost.

GPS fix rate − 4 seconds

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. See paragraph 13.9.
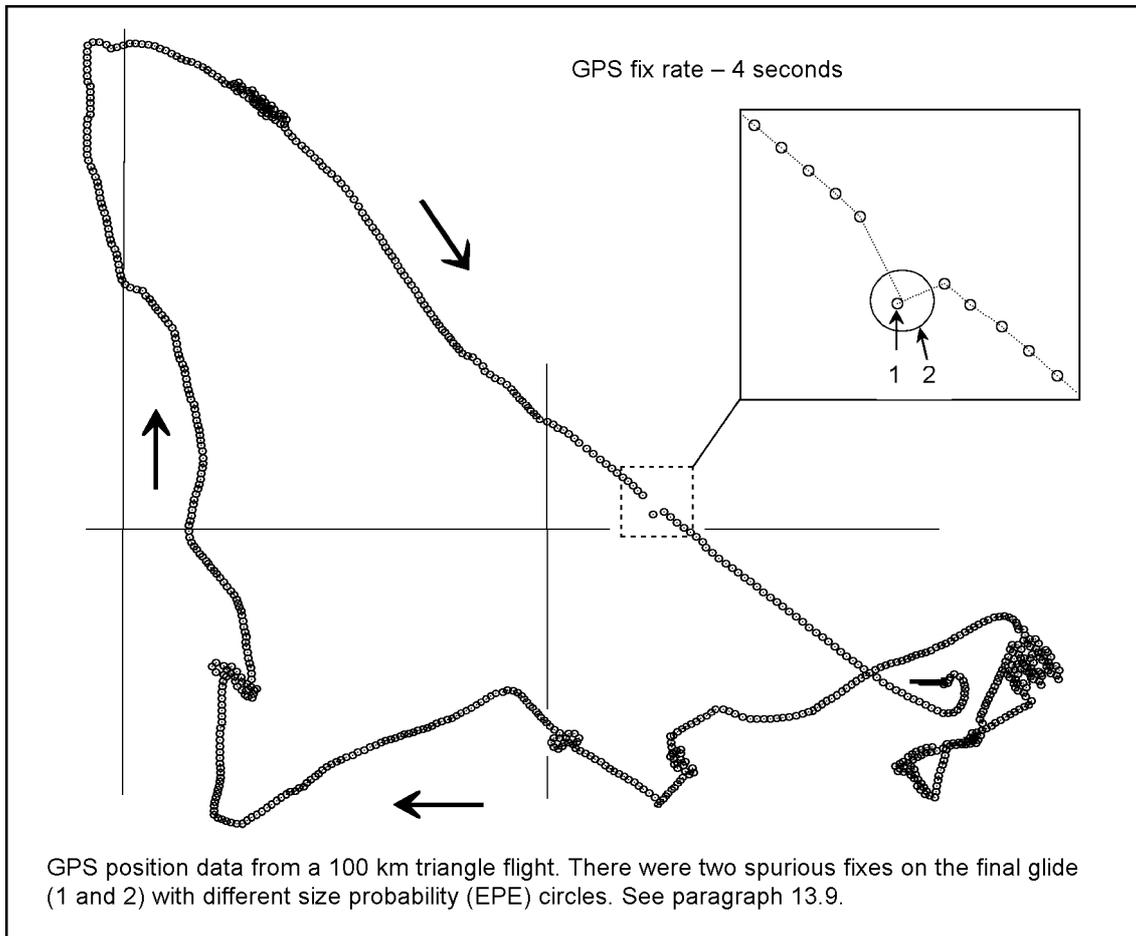
c. *Spurious fixes* Spurious fixes are those that show anomalous positions in a sequence of fixes, and shall be ignored for the purpose of OZ validation. They occur because some short-term anomalies (side-steps) occasionally occur in the fix sequence. The indication that a fix is spurious is a large change of position compared to adjacent positions that cannot be explained by a likely change of ground speed. Two examples are shown in the diagrams. The incidence of spurious fixes is uncommon however, even in the most frequent occurrences, they occur not more than about 1 in a 1000 fixes. The diagrams below show that they are easy to pick out and reject for the purposes of flight validation. Recent improvements in GNSS receivers allow locking on to more satellites simultaneously and so give better fix accuracy and fewer anomalies.

Spurious side-steps of position have been recorded with fixes having both large and small probability circles. Possible factors are: satellite changeover at that time, reduction of signal gain due to turning flight (antenna alignment off vertical), or errors induced by RF energy either from outside the glider or transmissions from the glider resulting from poor RF shielding in the cockpit.

d. *Complete loss of data* If a FR recording is interrupted and all FR data lost for a period, evidence must be available to show that flight continuity was maintained, and also in the case of a motor glider, that the MoP was not operated during the period of the FR interruption. The altitudes at beginning and end of the loss must be considered, together with positive evidence from other sources, such as a second recorder, barograph, etc. Such evidence must be from equipment that fulfills IGC standards of security, sealing, etc. Without such positive evidence, validation should not be given when the interruption to the data is in excess of 5 minutes, and for motor gliders this period should not exceed one minute for pylon mounted MoPs and 20 sec-

onds for non-pylon mounted MoPs. These are guidelines; circumstances could dictate shorter or even (unusually) longer times. The OO or analyst should approach all interruptions to FR recordings with skeptical caution.

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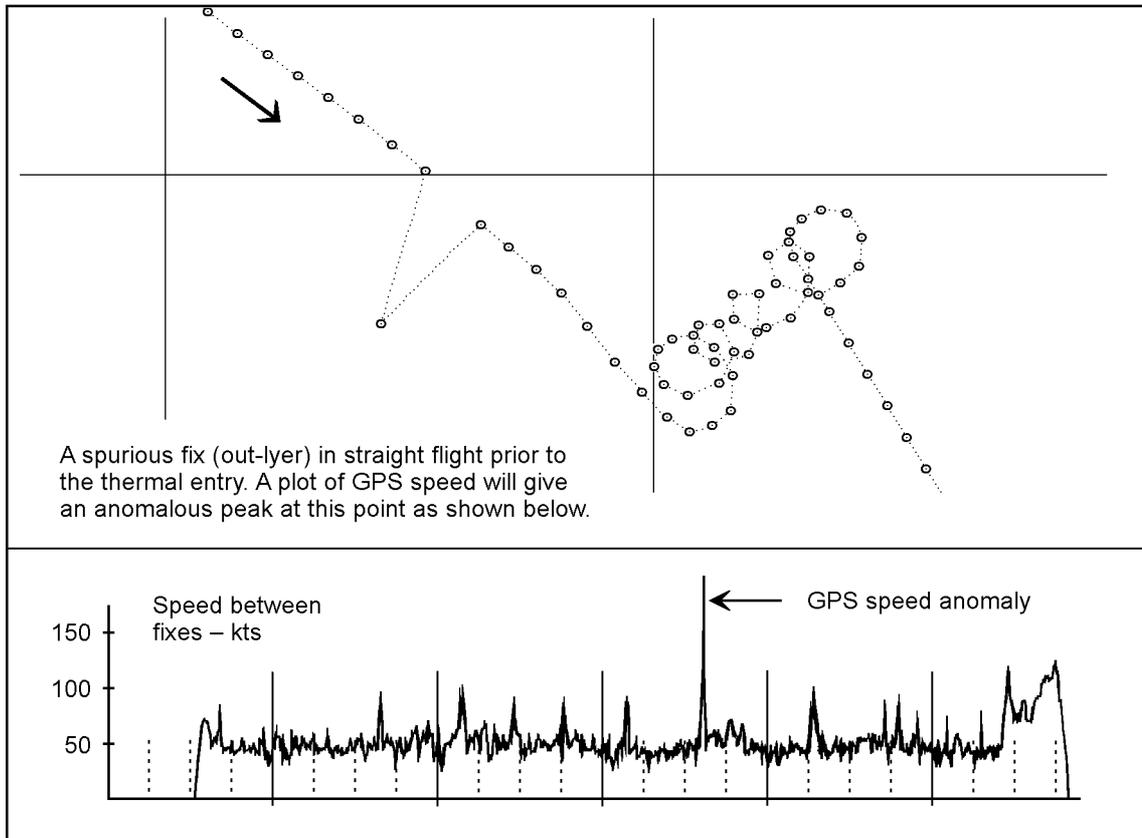
13.9 Circles of probability

A circle of probability that may be generated by the FR shall not be used for adjusting the likely place of a position fix for OZ validation purposes. Probability circles are not a mandatory part of the IGC FR Specification, but are available in the US GPS system and are sometimes a facility available from an FR. A valid fix shall always be taken to be at the centre of any such probability circle for the purpose of OZ validation. Generally these circles are to a 2-sigma (95.5%) probability. 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.

MECHANICAL BAROGRAPH PROCEDURES

14.1 Pre-flight preparation

a. Affix the foil or paper strip to the barograph drum. Ensure that it cannot slip on the drum if it is to be held by tape rather than a hold-down bar. If you use foil, get the *heavy duty* thickness; thin foil may not survive the handling it gets between barogram inspection and filing with the NAC.

b. 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 or kerosene lamp also works.

c. Load the drum and ensure the mechanism is fully wound and the rotation rate (if adjustable) is suitable for the flight. With a Winter barograph, the 4-hour rate is preferred as it allows an accurate analysis of important elements of the trace such as the release and low points. The 2 hour rate could produce a confusing overlap of the trace, and the 10 hour rate compresses the trace so much that vital information such as a low point "notch" may be unreadable. It is useful to test

the actual running time of the barograph when set at the different rates (especially the fastest one) to ensure that it will not run down and stop on a long flight.

d. 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 place an OO identification mark on the drum. Leave the drum so positioned that the hold-down bar, tape, or foil/paper edge will not interfere with recording a critical portion of flight such as the release point. Finally, seal the barograph in such a manner that no one can tamper with the trace, and initial or mark the seal (see para 1.7).

e. 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 as this could cause interruptions in the trace. *Leave the barograph on* – the chief cause of barograph failure is "finger trouble".

f. For general tidiness if nothing else, use fresh foil or paper for each flight; however, it is permissible for more than one flight to be recorded on the barogram (example: a relaunch for a task attempt). Paragraph 14.3c refers to multiple flight traces.

14.2 In-flight procedures

a. At and following the launch, 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 the tow duration is very useful in estimating starting altitude on a barogram if a good notch is not present. See paragraph 14.6 for the procedure to be followed when a low point after release is not evident.

b. The pilot should ensure that a clear low point is recorded on the barograph following release to enable the starting altitude to be determined. If the release occurs in lift, it will be necessary to 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 won't have time to react). This notch is needed to set 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 the most common error made at the start of the task because of all the external factors and high workload that may occur at this time, yet it must be remembered.

14.3 Post-flight procedures

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. It must be returned to the OO who sealed it *as soon as possible*, still in a sealed condition.

b. On verifying the seal as the one he marked, the OO will carefully remove the drum and add the information to the barogram listed in SC3-6.1. 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)*. Don't add any altitudes to the trace – they cannot be accurately determined until after the barogram has been evaluated using the calibration graph.

c. 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.

d. 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 finish. Be careful. Use a *fine* first

coat, as a heavy initial spray may obliterate the trace. Test spray on an unused area of the barogram first.

e. 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.* The *original* cali-bration graph and its trace should be submitted with the claim, since photocopies are rarely dimensionally identical. This requirement is often waived by NACs for badge height gains that are well in excess of the required minimum, but the NAC may still require the original calibration graph and trace if the barogram is questionable.

f. When the barograph is not being used for some time, it should be allowed to unwind as a kind-ness to the spring mechanism.

14.4 Height gain evaluation

With the barograph calibration graph below at hand (see Appendix 8 para 3.3 on construction), one may evaluate the height attained on any part of the barogram in the following manner:

a. On the calibration graph, draw a horizontal baseline which intersects the calibration curve at the airfield elevation.

A – take-off location baseline.
B – standard air pressure corresponding to the airfield elevation.
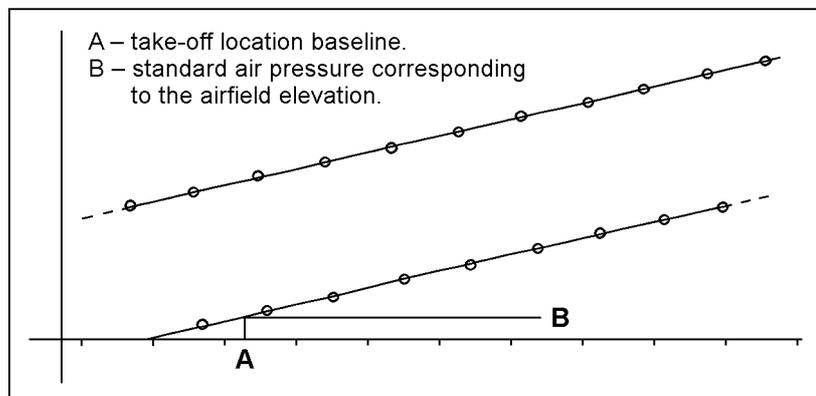
b. With dividers, measure the distance from the baseline of the barogram to the height point in question, ensuring that the dividers are perpendicular to the baseline (a small plastic triangle may be used as a guide).

c. Using this divider setting, find where on the graph this same distance exists between the curve and the "airfield" baseline constructed in (a) above; again be sure that the dividers are perpen-dicular to the baseline. Read off the altitude or air pressure on the horizontal axis. If pressure is being measured, convert it to its corresponding altitude.

14.5 Absolute height evaluation

If an absolute altitude is to be determined, then the error resulting from the difference between the actual and the "standard" atmosphere on the given day must be factored out of the calculation. This is done by using the calibration graph baseline rather than the airfield baseline to find the pres-sure height of the airfield and the high point of the flight similar to 14.4b and 14.4c above. Then to find the absolute altitude, subtract the airfield pressure height from the high point and add the actual air-field elevation.

14.6 No low point on the barogram

If there is no discernible low point on an altitude gain flight, the OO may restart the barograph at the take-off point and, after an elapsed time equal to the observed flight duration of the tow, jog the stylus so that it marks across the flight trace. Measure the low point height at this mark. Determining the altitude of crossing a start gate for a speed record attempt is another situation in which there is not likely to be a clear low point on the trace. If the tow duration is not known accurately to the satisfaction of the OO, then the claim must be disallowed.

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 a flight under supervision.

14.7 Duration evaluation

The barogram may be used to determine duration, and indeed is required for a duration performance 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. Unseal the barograph and position the drum to a point where the stylus can be carefully deflected so as to touch the trace at the glider release point. The stylus is then rotated down and a small mark made across the baseline.

b. 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.

c. For rotation rate calibration, small marks may be added to the trace at even time intervals by jogging the stylus point slightly.

d. If, for a duration flight, the release is not evident on the barogram, time the trace from take-off to landing and subtract the recorded tow duration.

MOTOR GLIDER CONSIDERATIONS

15.1 Means of Propulsion (MoP) record for motor gliders

The MoP must either be sealed or inoperative, or an approved MoP recording system used. This will be described in the IGC-approval document for the particular type of GNSS FR. See Appendix 7 for more information on MoP recording systems and the diagrams at the end of typical ENL traces with time.

15.2 Engine noise level (ENL) system

In the case of the preferred ENL system, a microphone and filtering system records an ENL value with each fix up to a maximum of 999. ENL values recorded in GFAC tests are given below, in the sequence of a flight. The system used in Cambridge 10, 20 and 25 FRs gives ENL values out of a maximum of 200 rather than 999, and the figures given below should be adjusted accordingly. Actual figures measured from the Cambridge series of GNSS FRs are given in Annex B of the appropriate IGC-approval document.

a. *ENL during launching*
During winch and aerotow launches, higher ENL values are to be expected than when soaring, typically up to 300 for winch and 200 for aerotow. On one winch launch an ENL reading of 450 was recorded, due to a fast launch with sideslip.

b. *ENL during engine running*
During engine running at climb power, an increase to over 700 ENL is expected. Over 800 is typical for a two-stroke engine, 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, and when altitude and speed are analysed it can be seen that substantial energy is being added, which can therefore be attributed to energy not associated with soaring. Wankel (rotary) and electric engines have not been tested. There is no reason to believe that Wankel engines will not produce similar values to 4-strokes, but if an electric engine is to be used, please contact GFAC as soon as possible so that tests can be carried out.

c. *ENL during gliding flight*
ENL readings of less than 050 indicate normal gliding flight in a quiet cockpit environment. In a high-speed glide or in an aerodynamically noisy glider, ENL may increase to about 100. Short

periods of higher ENL while gliding (up to about 300 ENL) may indicate aerodynamic noises such as that due to air brakes, lowering the undercarriage, sideslip, etc, and are normal before landing. In particular, sideslipping with the cockpit direct vision panel open can produce low frequency noise (organ pipe effect) and ENL readings of up to 400 have been recorded. High ENL may also be recorded during stalling and spinning, particularly if the engine doors flutter or vibrate (move slightly in and out due to stall buffet, producing a clattering noise). A value of 477 has been recorded in a spin. Finally, if the engine is mounted 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.

d. *ENL during the approach to land*
ENL values are always higher on a landing approach due to aerodynamic noises such as due to air brakes, undercarriage, sideslip, etc. Short term peaks due to specific actions such as opening air brakes, lowering undercarriage, etc., will be noted as well as a generally higher level of ENL because the glider is no longer aerodynamically clean. 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.

e. *ENL during landing* During ground contact during take-off and landing, short duration ENL readings up to about 550 have been recorded due to wheel rumble; unlike engine running these last only for a short time, showing a short spike on the noise/time trace.

15.3 ENL analysis

It is normally easy to see when an engine has been running and when it has not. 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.

15.4 Sample data from ENL systems

ENL data is shown below, using the presentation from one of the many analysis programs designed to work with the IGC file format. In this presentation, the ENL values are shown as solid black bars whose height represents the recorded ENL values for each fix. These are synchronised with the conventional barograph trace from the pressure altitude sensor in the recorder. A separate graph of speed with time is included, and this is often a help in identifying why ENL values have varied during normal gliding flight.
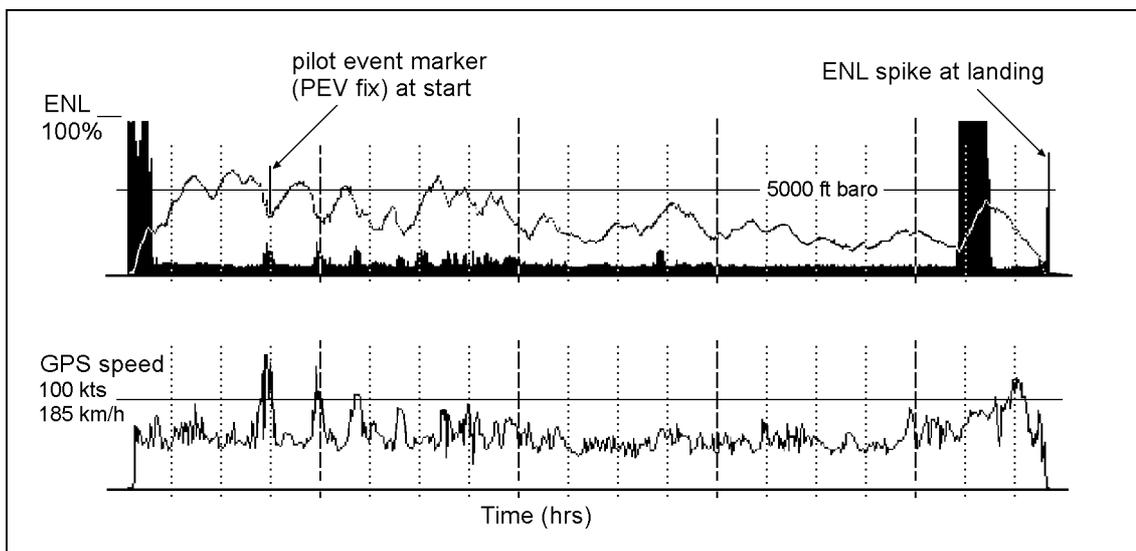
Cambridge ENL system showing engine runs on take-off and after 4.3 hours of flight.
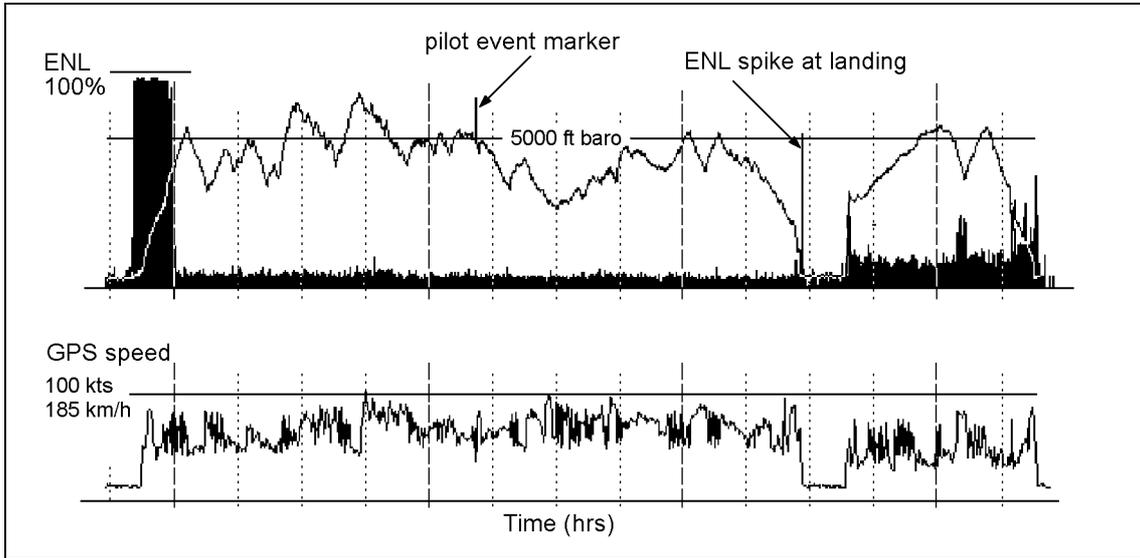
Garrecht system showing ENL levels from a Motor-Nimbus flight.
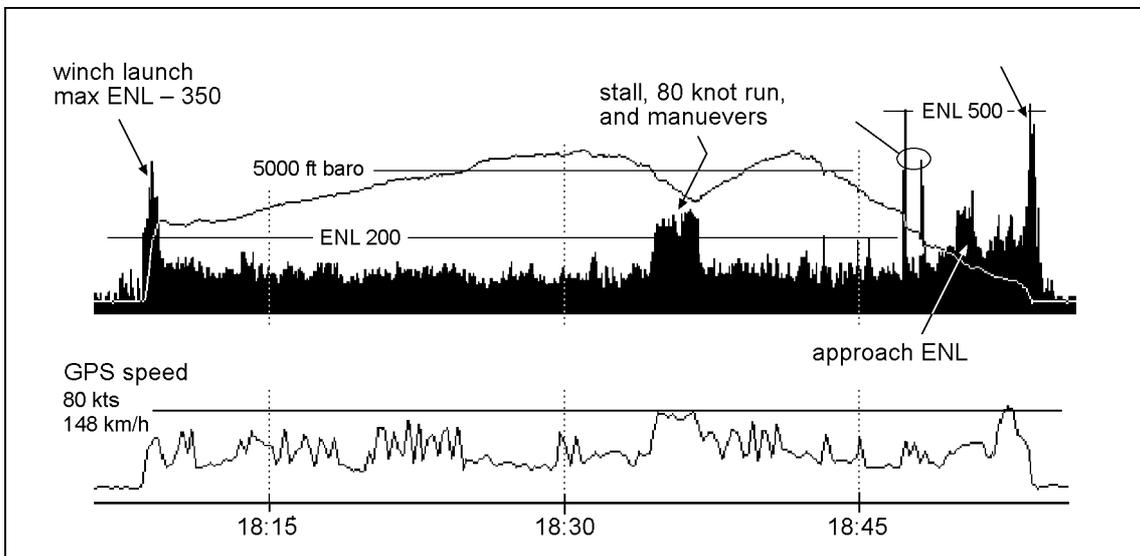
*Garrecht system showing ENL levels from a Grob Acro flight with a winch launch and flight maneuvers.*
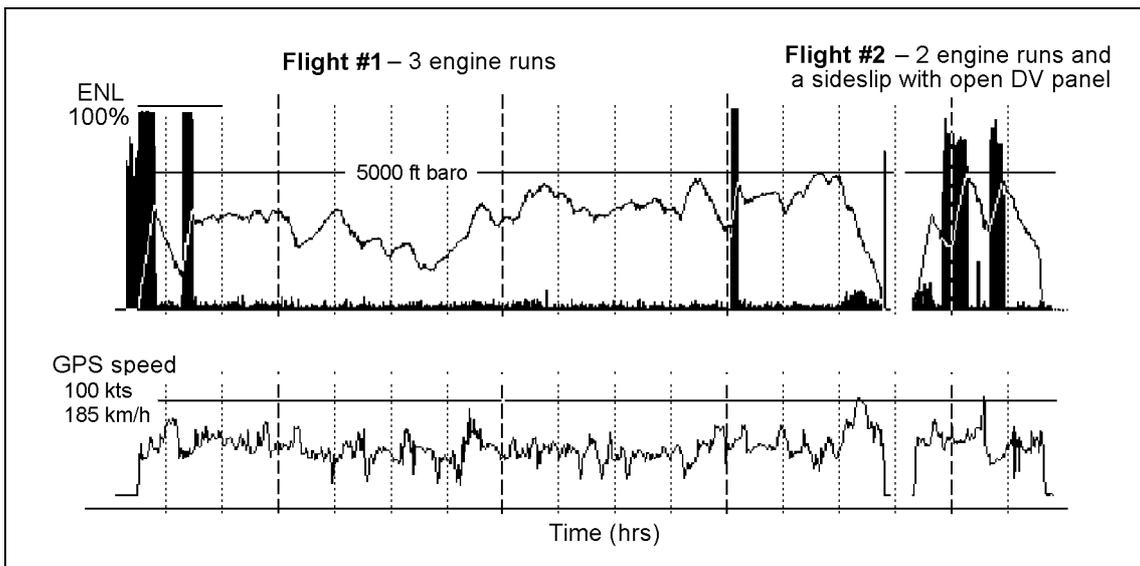
*LX Nav ENL system (fitted to Filser, LNX, and SDI flight recorders).*
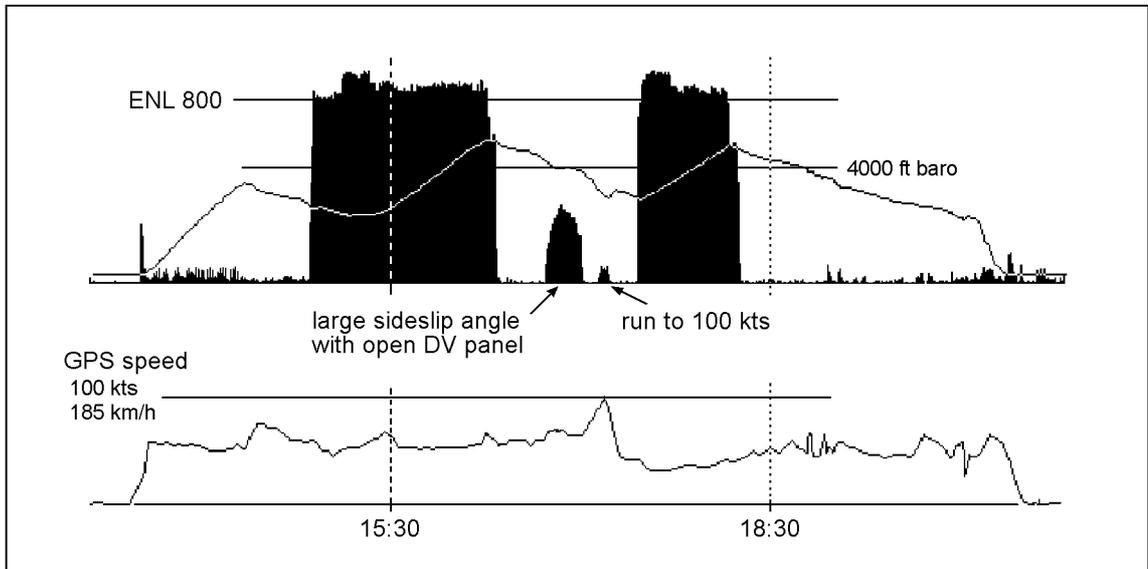
Filser LX5000 *flight recorder showing ENL levels from a flight with an aerotow, engine run, sideslip with open direct vision panel, and a second engine run.*

## PHOTO-INTERPRETATION TECHNIQUES

16.0 General
The photo-interpretation methods below may be used to find the position of a glider from turn point photographs and a sufficiently detailed topographic map of the turn point area.

16.1 Circular features
On a photograph, a circular feature on the ground will appear as an ellipse. The glider's position will be on the downward extension of the short axis of the ellipse.

16.2 Transferring a line from the map to a turn point photo
Since the turn point area within a TP photo is viewed obliquely, the distortions of scale that are evident can make the accurate transfer of a line drawn on a map (such as an observation zone boundary line) onto the TP photo somewhat difficult. But, if a road grid is visible in the TP photo that the line in question crosses, another rule of perspective drawing will help: the intersection of the diagonals of a rectangle will cross at the centre of the rectangle, both on the map and in the distorted rectangle shown in an oblique photograph.

Transferring a line from a map to a turn point photo by using the construction of successively smaller rectangles as a guide.
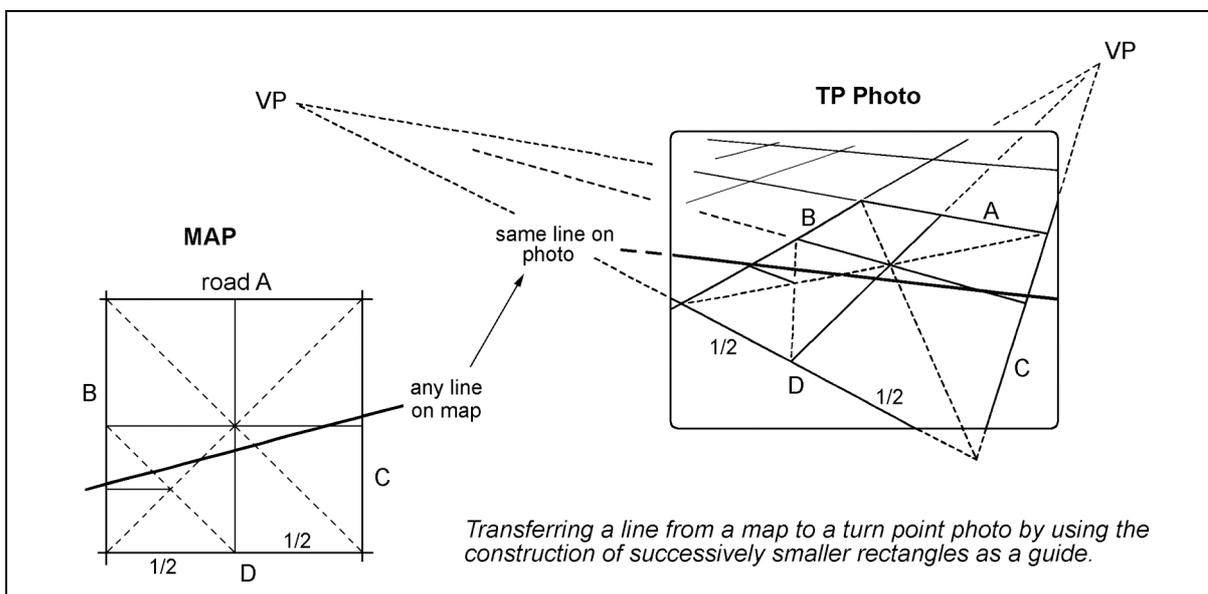
Secondly, a line constructed through this point and one of the rectangle's vanishing points will divide the side of the rectangle in half. With only a couple of repetitions of this method of subdivisions, one is able to make a fairly accurate estimate of the inter-section of the road and the given line, and thereby transfer the line (such as an observation zone boundary) from map to TP photo.

16.3 Apparent angle of observation zone boundary

When a turn point photo has no usable vertical features, this method is valuable and depends on the way in which angles are affected by perspective. Plot the two boundaries of the observation zone onto the TP photo (use the above method if required). Now, if the glider is in a position directly over the TP or along either boundary, the angle between the lines will appear to be 90 degrees. If the angle at which the lines converge is *less* than 90 degrees, the glider is *outside* the zone. If this angle is *more* than 90 degrees, the glider is *inside* the zone. This perspective effect is most apparent when the angle of view down to the turn point is relatively shallow. This method may be in error by up to a few degrees as the image of the TP is located further from the centre of the photo, in which case it would be unwise to draw conclusions if the measured angle was close to 90 degrees. The figure illustrates this perspective effect.

The observation zone boundary lines meet at an apparent angle greater than 90 degrees in the TP photo, hence the glider is within the sector.

130°

Observation

Zone
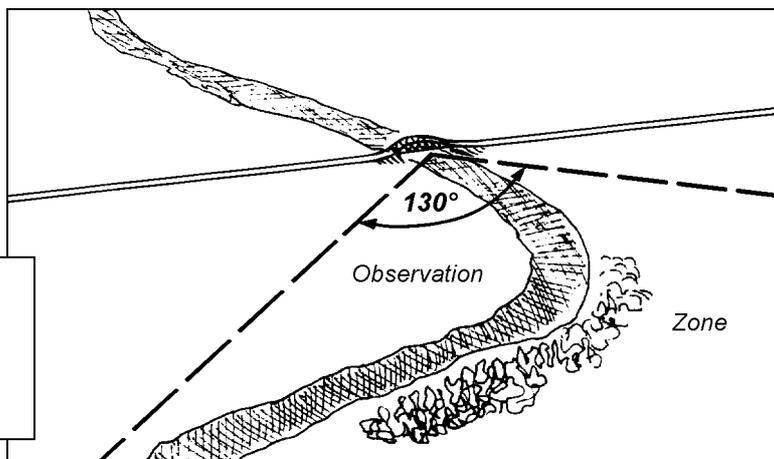
16.4 Vertical features

A vertical feature in a turn point photograph will always point (from its top to its base) to the ground position over which the photo was taken. Lines drawn downwards from more than one feature will intersect at the glider's position. If these features are not too close (causing the extended lines to have only a small angle between them), the position error will be acceptable. Where there are "indistinct" vertical features such as trees, an estimate of their orientation will suggest a position accurately enough if the glider is well within the zone. But even one strong vertical feature can place the glider on a line which will prove it was in the zone even though its exact position is indeterminate.

The glider's position is at the inter-section of the lines extended downwards from vertical objects within the turn point photo.
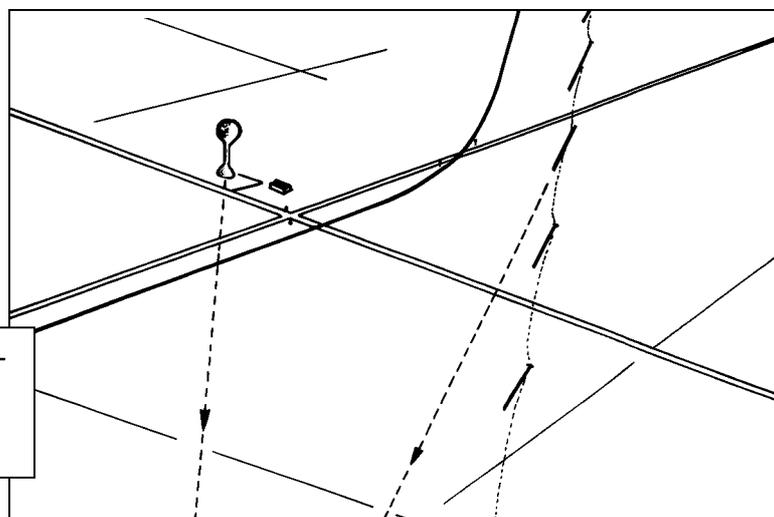
16.5 Vertical areas

This is a simple method of determining where a glider *is not*. Then, by the process of elimination, one may narrow the area in which the glider was located. This method does require that the TP photo be sharp, and large enough that the sides of prominent features are visible. Examine the sides of features such as bridges, buildings along a straight road, etc. If a side is visible, then the entire area of the photograph behind that vertical face may be eliminated. Other similar areas transferred to a map will narrow the glider's location. This procedure is most effective when one considers features that are oriented generally top to bottom in the TP photo as fairly large areas can be eliminated close to the glider's true position.

16.6 Use of the horizon

If the horizon appears in the turn point photo, then a line drawn at right angles to the horizon and passing through the *centre* of the TP photo will pass through the position of the glider, that is, the glider's position will be somewhere along this line. Usually, of course, the horizon is not shown within the TP photo; however, the position of the horizon may be determined if the photo contains some parallel, horizontal features such as a grid of roads. Remember that a rule of perspective says that parallel lines on level ground will appear to meet at a "vanishing point" on the horizon. Attach the TP photo in question to a larger sheet of paper, then extend the converging lines of any parallel features within the TP photo until they meet. If two or more sets of parallel features are within the photo, the line joining the vanishing points will define the horizon as shown in the diagram. A position line of the glider may then be constructed. If a second position line is available (from the above "vertical features" method for example), then the position of the glider may be pinpointed.

Constructing the horizon line.
The glider is located somewhere
on the "position line " CN.
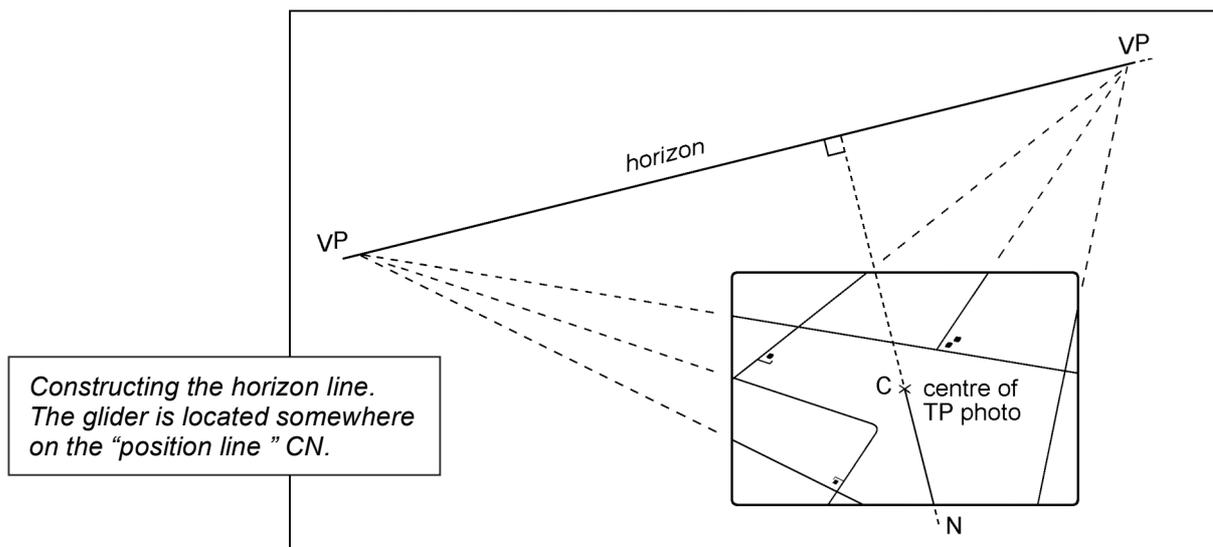
16.7 OO procedures

OOs certifying photographic evidence must be satisfied that the photos show the correct points, and that at least one photo of each point was taken from within the defined observation zone. OOs should never simply rely on memory. For comparison with the photos, a recent 1:50,000 topographic map should be used if available, although for TPs with particularly clear features together with recent photos of the TP in question, a recent 1:250,000 air map or a current detailed road map book (commonly available in many countries), may be used to assist interpretation. Some useful principles to follow are:

a. View the film impartially and with a skeptical eye. It is up to the pilot to prove to you that he was there, and pilots sometimes (in good faith) make mistakes and go to the wrong turn point. Highway junctions are an example where there are many cases of pilots taking photographs of a nearby junction. Even very experienced pilots have made such mistakes. Take nothing on trust.

b. Find at least four, and preferably six clear, independent features on the photo being assessed which tally with the map.

c. Make sure that there are no significant features on the frame that are *not* on the map that cannot be explained (such as by recent building or other development).

d. View adjacent photos in the sequence (even if outside the OZ) to confirm features that may not be clear on the photo being assessed. This may also give an indication of glider track in or out of the zone that may be useful in marginal cases.

e. In all except the most straightforward cases, draw the OZ on the map that you are using for assessment in order to compare it accurately with the photos. To avoid marking original maps, use a transparent overlay with the zone marked on it.

APPENDICES

Appendix 1

COMMON CONVERSION FACTORS

DISTANCE	1	foot	=	0.3048	metre
		mile (nautical)	=	1852.0000	metre
		kilometre	=	3280.8	feet
		mile (statute)	=	5280	feet
		mile (statute)	=	1.6093	kilometres
		mile (nautical)	=	1.1508	miles (statute)
		centimetre	=	5	kilometres (on 1:500,000 map)
		inch	=	4	miles (on 1:250,000 map)
		degree	=	111.1949	kilometres (great circle arc)
		minute	=	1	nautical mile (great circle arc)
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)
		atmosphere	=	29.9213	inches Hg (0°C)
		atmosphere	=	1013.325	millibars
		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 = 1/2 metre/sec

Appendix 2

CALCULATION of GEODESIC DISTANCE

The calculation of distances on the surface of a sphere is relatively straightforward (see Appendix 3) but for accuracy, the FAI has adopted an earth model that more closely represents the actual shape of the earth. The earth is modelled by a slightly flattened sphere – an ellipsoid – in which the length of the straight line from the North Pole to the South Pole is slightly less than the diameter of the equator. Such a figure (an ellipsoid of revolution), is generated by rotating an ellipse about the north–south axis. The radius of the equator, denoted by *a*, is called the s*emi-major axis*, and the distance of each pole from the earth's centre *(b)* the *semi-minor axis*. The *flattening (f)* is defined as the difference between *a* and *b* divided by *a*, or *f* = (*a* – *b*)/*a*. As *f* is such a small number, it is usual to specify the *inverse flattening (1/f)* rather than *f*. The WGS84 ellipsoid is defined by

$$a = 6{,}378{,}137.00 \text{ m} \quad \text{and} \quad 1/f = 298.257223563, \quad \text{giving } b = 6{,}356{,}752.31 \text{ m}$$

It is not possible to give a simple closed formula for distances on the surface of an ellipsoid, like the great circle formula for the sphere. Accurate calculations must be done by starting from an approximation and refining it to the desired accuracy by iterating through a sequence of calculations. Several procedures ("algorithms") for performing these calculations have been published. One of the best is that proposed by Vincenty. A concise description of this algorithm can be found on-line in the "Geocentric Datum of Australia Technical Manual" under :

http://www.icsm.gov.au/icsm/gda/gdatm/gdav2.2.pdf

Fortunately, there are free software tools available which implement the Vincenty algorithm – the following list is by no means exhaustive.

- A Javascript program by Ed Williams for computing distances and courses between two points with a variety of earth models (including "user defined") is provided on line under:
    http://williams.best.vwh.net/gccalc.htm

    The units kilometres, nautical miles, or statute miles may be selected. The program also gives the starting great circle course for the forward and return trip. There is also another program on the same page which calculates the geographic coordinates of a point, given its distance and heading from a specified point.

- A slightly simplified version of the above program, offering only the "FAI sphere" and WGS84, can be found at the FAI site and may be used on line or downloaded for local use:
    http://www.fai.org/distance_calculation/

- The "Geocentric Datum of Australia Technical Manual" (see above) also contains MS Excel spreadsheets for the calculations. These can be downloaded separately in a .zip file:
    http://www.icsm.gov.au/icsm/gda/gdatm/gdaexcel.zip

- Yet another on-line calculator is provided by "Geoscience Australia":
    http://www.ga.gov.au/nmd/geodesy/datums/vincenty_inverse.jsp

- A freeware distance and heading calculator (GeoidTest) for the FAI sphere and WGS84 can be downloaded from:
    http://www.soaringpilotsoftware.com/programs/GeoidTest.zip

    This is a stand alone Windows program by Tony Lu, who adopted Ed Williams' code to C++. Tony has also kindly provided a .zip file with his classes and definitions:
   *http://www.soaringpilotsoftware.com/programs/Geoid.zip*

    These may be of use to programmers who wish to include WGS84 distance calculation in flight analysis or scoring programs.

Appendix 3

CALCULATION of GREAT CIRCLE DISTANCE

As noted in Appendix 2, the calculation of distances on the surface of a sphere is relatively straight-forward. Where the distance measured only has to exceed a specific distance as in a badge flight and a precise official distance is not essential, a calculation using the sphere may be utilised providing the error involved is clearly less than the excess distance. The distance error between the sphere and the geoid calculations is typically within ±0.5%.

Many distance calculation programs in existence up to 2002 use this form of calculation but it may also be performed with any (real or simulated) pocket calculator which has the standard trigonometric functions.
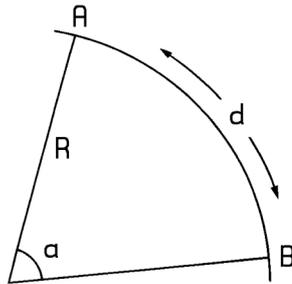
Suppose we want the distance d between two points, A and B, with the geographical coordinates (latitude A, longitude A) and (latitude B, longitude B) respectively, on the surface of a sphere with the radius R. The formula is:

$$\mathbf{d} = 111.195 \; \text{acos} \left[\sin(latA) \sin(latB) + \cos(latA) \cos(latB) \cos(lonA - lonB) \right]$$

In the FAI spherical earth model, the radius is taken to be R = 6371.0 km or 111.195 km/degree.

Appendix 4

FAI BADGE DOCUMENTATION

Documentation required is indicated by an asterisk *

		A	B	C	D	E	F	G	H
A. portion of map with flight courseline									
B. flight barogram									
C. baro. calibration certificate (SC3-6.3)									
D. difference of height certificate									
E. flight declaration									
F. landing certificate									
G. aerotow/release certificate									
H. position evidence (GPS/photos)									
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 observed throughout.
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 5

BADGE or RECORD FLIGHT PROCEDURES FLOWCHART

Start here

For all badge or record flights you will need an **Official Observer**	Find one that has the latest Sporting Code – it's even better if the OO has read it! Study the Code yourself, particularly as it applies to your flight. Use a record/ badge pre-flight checklist.

	a duration flight	The glider is continually in view. There must be less than 1000 metres between the start and finish heights.
Then you may attempt ...		

All other flights need the above plus **a barograph**	The OO must seal a non-FR barograph. See SC3-4.4.7 on calibration.

	duration, altitude, gain of height, & straight/free distance flights for badges or records	See SC3-4.4.2 on distance penalties.
You may now attempt ...		

If any turn points are used you need all of the above plus a **declaration and a camera or flight recorder**.	SC3-4.2.1 lists data that must be on the declaration. *Camera* – See SC3-4.6.3a OO must place a random mark on canopy in front of the lens. For record attempt, FR is required. Know the turn point OZ rules. *Flight Recorder* – see SC3-4.6.4a

	distance or goal flights for badges or records and speed records	Many variables in course geometry that needs prior study with a map. Only the way points don't need to be pre-declared for free records. See SC3-1.4.3b &1.4.6b for triangle flight geometry. 1000 metres or more between the start and finish heights will invalidate speed claims.
You may now attempt ...		

Get a landing certificate signed by an OO or two witnesses. If you are using camera evidence, photograph the glider (showing tail registration) at the landing location, re-photograph the declaration with landing time on it. Note that badge and record flights require different forms.

For World record attempts, only flight recorder evidence is acceptable.

For NACs that allow camera evidence for <u>national</u> records, speed records will require proof of accuracy for the timing device being used (see SC3-4.4.6).

Appendix 6

Principles of Global Navigation Satellite Systems (GNSS) and IGC-Approved GNSS Flight Recorders

References: IGC web site: *<http://www.fai.org/gliding/gnss>*, with links to the sites below: Site for downloading free IGC GNSS software: *<http://www.fai.org/gliding /gnss/freeware.asp>*

1.1 Terminology

The term Global Navigation Satellite System (GNSS) is a generic term for any system based on satellites that enables ground-based receivers to display accurate position data on the earth's surface. The term GNSS includes the US GPS system, the Russian GLONASS system, the projected European Galileo system, and future systems. A GNSS Flight Recorder or GNSS FR is a system designed for use in the air where the GNSS receiver unit connects to a memory designed for recording large amounts of 4-D fix and other data. A GNSS FR that has been tested and approved to IGC standards is called an IGC-approved GNSS FR, but the shorter terms GNSS FR or just "FR" are often used and imply an IGC-approved system unless the context indicates otherwise. The terms "GNSS FR" and "FR" are used by FAI and IGC because the words "logger" or "datalogger" can be confusing in languages other than English; and in English "logger" and "datalogger" are not precise terms describing a satellite-based navigation system. Also, the terms "logger" and "datalogger" are neither defined nor used in the Sporting Code.

1.2 Principle of GNSS operation

Current systems use time-difference calculations from a constellation of satellites in earth orbit, based on highly accurate atomic clocks in each satellite. The time difference between when a signal is sent from the satellite until it is received on the ground produces a spherical line of position in space. The receiver's internal processing may discard some data such as from those satellites at very low angles to the local horizon, where distortion of the position-line information may reduce potential accuracy. With respect to a ground observer the satellites are constantly in motion, some rising above the horizon, some nearly overhead (for the US GPS system, up to 55 degrees latitude) and some falling below the other horizon.

1.3 GPS accuracy

The IGC GFA Committee (see para 2.1 below) carries out ongoing tests on the accuracy of GNSS FRs that are submitted for IGC-approval. So far, all FRs submitted have used the US GPS system. Tests are carried out from a moving ground vehicle that is driven over one of several accurately surveyed points, which brings into action any averaging algorithms that would be active in flight.

Before 1 May 2000, when the US government withdrew the deliberate Selective Availability (SA) error, these tests showed an overall accuracy in lat/long of 44.0 metres from a sample of about 2500 tests. These included about 40 individual GNSS FRs of 19 types from 9 manufacturers, involving 12 types of GPS boards from 5 board manufacturers. With GPS boards that have the capability to lock on to about 12 satellites at one time, the lat/long accuracy average was 36.3 metres from a sample size of about 1500 tests. Since the withdrawal of SA, average accuracy has increased to 10–13 metres with 12 channel boards. Accuracy in a N/S direction is less than E/W except on the equator, and the difference increases with latitude. Reception conditions in the glider are now more critical than before if the benefit of this increased accuracy is to be achieved.

a. *Vertical (altitude) accuracy*
   This is less than accuracy in horizontal position. This is because good altitude data requires position-lines at small angles to the local horizon, and due to atmospheric distortions this is the least accurate data. Also, in GPS receivers the altitude is calculated from a separate set of algorithms and position-lines from those algorithms and position-lines used for the lat/long

position; data from different sets of satellites may be used and a single 3-D fix is not calculated, but separate horizontal and vertical fixes. Therefore, there is not necessarily a direct read-across from horizontal to vertical accuracy for each fix, only in statistical terms over many fixes. In extreme cases it is possible to have perfectly good and accurate lat/long fixes, and poor accuracy (or even a GPS altitude unlock) in GPS altitude. The latter will be indicated in the IGC data file by the GPS altitude figure showing zero or baseline. Tests with the US GPS system at latitudes of about 50 degrees have shown that the standard deviation (a statistical term referring to a 68% probability) for altitude errors is about 1.75 (175%) of that for lat/long position. For more detail on altitude measurement see paragraphs 1.9 and 1.10.

b. *GPS Selective Availability (SA) error*
Until 1 May 2000, the GPS system managers applied the so-called Selective Availability (SA) error. This was achieved by dithering the time so it was not completely accurate (by a few nanoseconds). This was so that users who did not have the appropriate USA Department of Defense codes could not exploit the full accuracy of the system (which could be used for military purposes such as missile guidance). SA caused a random wander around a correct position and reduced the accuracy of an individual fix from about 10 metres to the figures quoted above for April 2000 and before. SA was withdrawn globally on 1 May 2000 but the US Presidential statement said, "we have demonstrated the capability to selectively deny GPS signals on a regional basis when our national security is threatened".

1.4 Rules for the use of flight recorders
After the successful use of GNSS FRs in the World Gliding Championships in New Zealand in January 1995, IGC formulated rules for their general use that took effect later in 1995. Current rules are available on the FAI/IGC web sites and include various paragraphs in the FAI Sporting Code Section 3 (Gliding) (SC3), its annexes (SC3A, B and C), in the IGC FR *Specification for IGC-approved GNSS Flight Recorders*, and in other IGC documents and information.

1.5 Levels of IGC flight recorder approval
The IGC has established three levels of security for flight recorder data. Each flight recorder model is allocated to one of these levels on approval by the GNSS Flight Recorder Approval Committee (GFAC). The criteria for the security level allocation and the permitted usage are listed below:

a. *IGC approval for all flights*
Flight recorders that comply with all the provisions of the FR specification at the time the approval document is issued. These 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 only*
Flight recorders with less rigorous standards than either a or b (they may use an external GNSS receiver, for example). These have a limited approval for Silver, Gold, and Diamond badge flights only.

1.6 Features of IGC-approved GNSS flight recorders
These FRs have features not present in earlier recording methods such as cameras and drum-type barographs. This means that they can be used in a more versatile way than earlier systems, and need less checking by OOs both before and after a flight that is to be claimed. For instance, the presence of an OO is not necessarily required on the field before take-off. These features are described in 1.7 to 1.10 below.

1.7 Physical and electronic security

a. *Physical security*

An internal security mechanism is included that activates if the case of the FR is opened. In addition, a silver-coloured tamper-evident seal with the manufacturer's name 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 trying to open the case), the internal security device will operate and erase the electronic key that is used to validate the integrity of flight data files. If the FR has a screen, the security system will also cause a message to be displayed during all future start-up sequences saying that the unit is unsealed or insecure. All subsequent flight data files will fail the IGC VALI (validate) test for security, with most FRs any data in the memory will be lost, and settings will revert to defaults. However, the flight data files will continue to be produced, but marked as insecure in their security record. The VALI test will also fail if the IGC data file has been altered in any way after transfer from the FR to a computer. The higher level of security referred to in paragraph 1.5a involves what are known as asymmetric algorithms and is to a level known as RSA or equivalent.

A security record is automatically placed by the GNSS FR system at the end of each IGC format file (the G-record). This security record contains a multi-character digital signature, the key to which is only known to the FR manufacturer. The correct VALI program also originates from the FR manufacturer and is coded to recognise the correct digital signatures from that manufacturer's FRs. This VALI program checks the security signature and authenticates the file as genuine and its data as unaltered since being transferred from the FR. A change of only one character in the flight data in an otherwise valid IGC file will cause the VALI check to fail, and this is one of the tests carried out by GFAC.

c. *Other checks of flight data*

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, pressure altitude, exact positions at take-off and landing, comparison with other flight records from the day and locality concerned, etc. Official meteorological records and observations are kept for long periods. The nearest meteorological office will have past records of the wind structure with altitude, and the surface pressure. 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 should be included on how the unit became unsealed.

e. *Checks before re-sealing*

Whenever any unit is resealed, the manufacturer or agent must carry out positive checks on the internal program and wiring, and ensure that they work normally. Where internal components are programmable (such as PROM) they must be rewritten rather than just checked, in order to protect against hidden viruses or trojans. If any evidence is found of tampering or unauthorised modification, a report must be made by the manufacturer or agent to the Chairman of GFAC and to the NAC of the owner. The IGC approval of that individual unit will be withdrawn until the unit is re-set and certified to be to the IGC-approved standard.

1.8 Continuous Real-Time Clock (RTC)

Like a computer, an electronic clock maintains continuous date and time even when the FR is switched off or is operating in pure barograph (pressure altitude) mode due to a failure to receive GNSS data for any reason. This is automatically updated to high accuracy when the GNSS is locked on. Since the very principle of GNSS is time difference (paragraph 1.2), all GNSS units

when receiving satellite signals, maintain time accurate to better than a nanosecond as part of their method of operation.

1.9 Digital GNSS altitude

The output of GNSS altitude is either as true altitude above the selected ellipsoid (the WGS84 ellipsoid for FAI/IGC evidence), or true altitude above an approximate sea level surface known as the Geoid (for instance, the WGS84 Geoid is an irregular surface of equal gravitational potential which varies from the WGS84 ellipsoid by between +65 and −102 metres). GNSS altitude is therefore not the same as the pressure altitude that is used universally in aviation. The GNSS altitude record may be used for evidence of flight continuity if the pressure altitude trace has failed. Altitude accuracy is less than lat/long accuracy (para 1.3a).

1.10 Digital pressure altitude

This facility is part of the *"Specification for an IGC-approved GNSS FR"* and is recorded with each fix. The GNSS receiver board itself does not record pressure altitude and so it is not a feature of stand-alone hand-held GNSS equipment such as the Garmin range. An extra sensor is therefore required in an IGC-approved FR, and recording of pressure altitude continues even if GNSS fixing is lost or the GNSS system fails to produce fixes at all. Electronic sensors (transducers) using piezoelectric devices are used rather than the partially evacuated aneroid capsules used in drum-type barographs. These pressure altitude transducers are temperature compensated and have factory settings for base pressure and for gain with altitude. These settings are adjusted by the FR manufacturer before sale for minimum errors when a barograph calibration is carried out (Appendix 9, para 1.4).

A FR is a barograph in its own right and the usual IGC rules and procedures for barographs apply. The electronic pressure sensor in the FR is set up accurately before initial sale by the FR manufacturer to the International Standard Atmosphere (ISA) required by FAI and IGC.

IGC GNSS FLIGHT RECORDER APPROVAL COMMITTEE (GFAC)

2.1 Members of GFAC are appointed annually at the plenary IGC meeting and should have some technical knowledge of GNSS systems. The terms of reference of GFAC are in Chapter 1 of Annex B to the Code. The task of GFAC is to test FRs and electronic barographs for their suitability for documenting flights according to the IGC rules and Specification, and to issue approval documents on behalf of IGC. FAI, IGC and their agents and officials take no responsibility for, and have no liability for, how such equipment is used for purposes other than making a record of the flight. They have no liability for the use by pilots in activities such as navigation, airspace avoidance, terrain avoidance, or any matters concerning flight safety.

2.2 GFAC tests

These are concerned primarily with conformity with the IGC Specification, particularly on accuracy of data, security, data transfer to computers, conversion to and conformity with the standard IGC file format (sample test schedule, Appendix 2 to the IGC FR Specification). Other aspects of the equipment may not be tested and are a matter between the FR manufacturer and its customers. The following documents are issued or coordinated by GFAC on behalf of IGC, and are posted on the FAI gliding/GNSS web pages.

2.3 IGC-approval documents for flight recorders

A list of IGC-approved FRs is published on the gliding/gnss web page, with links to the individual IGC-approval document for each type of FR. Each IGC-approval document takes a similar form, an introductory section, manufacturers contact details, description of the hardware (including major subassemblies such as the GPS board and pressure altitude sensor used), firmware and software, followed by "Conditions of Approval" that includes paragraphs on connections to the FR, security (physical and electronic), installation in the glider, motor glider aspects (if any), sealing requirements (if any), and methods for transfer and analysis of flight data. Two annexes

follow, Annex A with notes for pilots and FR owners, Annex B with notes for Official Observers and other people concerned with validating a flight including barograph calibrators.

2.4 A list of analysis software

This lists analysis programs notified to IGC that are capable of reading and displaying flights using FR data in the IGC ASCII file format. No IGC approval or guarantee of quality or facilities is implied, the list is published for information only and normal commercial considerations apply.

2.5 Free short program files

These are provided for all types of IGC-approved GNSS FR and are available from the FAI/IGC ftp site and via a link from the gliding/gnss site. They are for data transfer from the FR to a computer (DATA.EXE), conversion to IGC format (CONV.EXE) from a manufacturer's proprietary format (if the manufacturer has one, some transfer from the FR directly to the IGC format), and validation of the electronic security of the IGC format flight data file (VALI.EXE).

Pilots, OOs, NACs, gliding clubs, etc. are encouraged to take copies. Pilots and OOs on the field particularly need the appropriate DATA.EXE program for the transfer of flight data from a FR to a computer, so that pilots needing an OO to take charge of the flight data for a flight that is to be claimed, can do so as soon as possible after the flight without the need for other programs or computers. Officials and organisations checking and validating flight data should have a copy of the latest VALI.EXE file for that type of FR, so that the IGC flight data file can be checked for valid and unaltered data.

Appendix 7

MOTOR GLIDER MoP RECORDING

1.1   MoP systems   A number of types of sensors for Means of Propulsion systems are in use, although the Engine Noise Level (ENL) system is preferred. This is because, once it has been tested by GFAC and the gain and filter characteristics adjusted and established as being satisfactory, it has been shown to work well and needs no external connections to the FR. It is also self-checking with each fix and does not require an engine run after the flight, since an ENL value is recorded with each fix. MoP recording systems include:

1.2   Engine Noise Level (ENL) system   A microphone and frequency filter and weighting system automatically produces an ENL value between 000 and 999. However, the Cambridge ENL system (designed in 1994 before the IGC Specification was published) has a maximum ENL of 200. In each case, analysis of the noise signature represented by the ENL values will enable the OO to determine whether the MoP was operated, only the scaling differs. 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 but at the same time produce positive but low ENL values in normal quiet gliding flight. The FR should be positioned in the glider so that it can receive a high level of engine and/or propeller noise when power is being generated. GFAC has tested the FR in motor gliders with two-stroke and 4-stroke engines, but not with Wankel or electric power sources. For ENL figures which have been recorded on GFAC tests, see the general guidance for OOs in paragraph 15.2. More exact figures for the type of FR concerned are given in Annex B of its IGC-approval document. If an electric engine is to be used, GFAC should be notified beforehand so that ENL values can be found by flight test and the optimal MoP recording system recommended.

1.3   Vibration system   This is similar to the ENL system except that a vibration sensor is used instead of a noise sensor. The disadvantage is that the FR must be firmly secured to a rigid surface in the glider that can be shown to transmit engine vibration to the FR. An engine run must be carried out both before and after the flight performance to show that the FR has not been moved and that the sensor is still detecting use of engine power. If an electric engine is to be used, the paragraph immediately above applies.

1.4   Voltage system   Here a voltage generated by engine running is recorded as additional data at the end of each fix. The voltage source may be from the engine electrical generator circuit, or from a magnetic insert in the propeller assembly. Cable connections between the FR and the voltage source must either be unbroken or have any breaks of joints sealed by an OO, and it must be arranged so that any failure of the system including a break in the wiring, will register as if the MoP was operating. An engine run must be recorded both before start and after the flight performance to show that the system is working as intended.

1.5   Microswitch system   Here the FR records whether a microswitch is made or broken. The microswitch is located so that it is operated by a function connected to the use of engine. This can be the opening and closing of engine-bay doors, the erection of the engine pylon, etc. Such systems must record the MoP as potentially active on the IGC data file for the whole time for which the MoP is capable of thrust. For instance, a short spike input registering only the opening of engine bay doors is not adequate, the microswitch operation should be translated into a continuous engine record on the IGC file, until a further cycle of door operation is used to cancel the engine record. Cable connections between the FR and the microswitch must either be unbroken or have any breaks of joints sealed by an OO, and it must be arranged so that any failure of the system including a break in the wiring, will register as if the MoP was operating. An engine operation must be recorded both before start and after the flight performance to show that the microswitch is working as intended.

Appendix 8

CALIBRATION of BAROGRAPHS

1.1 General

Barograph calibrations for use in assessing FAI badge and record flights must be carried out by persons or organisations approved by the appropriate National Aero Club (NAC), using approved equipment and methodology. For flight recorders, the method is contained in the approval document of each type of IGC-approved FR. For mechanical barographs, use the method given in this Appendix.

a. *Pressure units*
   The standard SI metric unit used in measuring atmospheric pressure is the hectopascal (HPa). Units of millibars (mb) or inches of mercury ("Hg) may also appear according to national usage. Calibrations are to be made to the International Civil Aviation Organisation (ICAO) "Standard Atmosphere" *(ICAO Document 7488, tables 3 and 4)*. Standard atmospheric pressure is 1013.2 HPa, 1013.2 mb, or 29.921 "Hg.

b *Barometer correction factors*
   A barometer, being a pressure sensor, will only read altitude correctly under standard atmosphere conditions. Above sea level and at any and/or temperature, corrections must be applied. Although the corrections are small, possibly only one or two hectopascals, their importance must be realized. Most manufacturers provide tables with their barometers from which the corrections can be obtained.

c. *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.

d. *Calibration period*
   The required calibration period is given in SC3-4.4.7. If a barogram is being used only to prove the continuity of a flight (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.

Electronic Flight Recorders

2.1 Flight recorder manufacturer's initial setup
   a. 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.

   b. Large corrections should not apply after initial calibrations, because outputs of electronic barographs are in metres or feet directly, not simply the distance of a needle on a drum. 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 that.

2.2 Preparation

The calibrator must be familiar with the type of FR being calibrated. Calibration details are at the end of Annex B in the IGC approval document for the type of recorder concerned. If necessary, ensure that the unit is placed into height recording mode. The recording interval should be set to 5 seconds at most, preferably to 1–2 seconds. The available memory capacity of those units that

do not have "wrap-around" memory should be checked to ensure that there is sufficient memory available for the calibration. If the FR has no internal battery capable of running it during the calibration, attach it to a power source such as a gel cell battery placed in the altitude chamber with the FR.

2.3   Calibration procedure

a.   Place the barograph 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 activates. Most FRs 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). No GPS fixes are required for a pressure altitude trace to be produced; however, some early types of FRs require a password to be inserted so that pressure recording can start in the absence of GPS fixes.

b.   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.

c.   The actual calibration can now be carried out. Use altitude steps of 1000 feet for the first 6000 feet and 2000-foot steps thereafter. If a metric calibration is being made, use intervals of 500 metres for the first 2000 metres and 1000 metre steps thereafter. Hold each step for at least one minute. All calibration points, including the 1013.2 HPa reference, must 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.

2.4   Recording of calibration data

a.   SC3B-2.6.1 states: 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. In the event that the calibrator is not NAC-approved, then the data file must be analysed and authenticated by a suitably qualified NAC-approved person.

b.   The correction table will list true 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 atmospheric pressure (QNH) readings, and low and high points on gain-of-height and altitude claims.

c.   The .igc record of the calibration will always be in metres and may be converted to feet if necessary. Some FRs can display pressure altitude directly. Unless the calibrating officer is familiar with the particular model, the height displayed should not be used as the recorded altitude for calibration purposes since some FRs do not necessarily reference the displayed height to 1013.2 HPa. However, the height recorded in the .igc file is always referenced to 1013.2 HPa.

d.   A copy of the calibration .igc file should either be retained by the calibration station or transferred to a disc and retained with the recorder. The reason for this is that the FAI may wish to see the .igc calibration file when assessing any record claim that is made with the instrument being calibrated.

2.5 Sample calibration table

A calibration table should show the following information:

a. Recorder type, model and serial number
b. Place of calibration
c. Date of calibration
d. Type and serial number of the reference calibration equipment
e. 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 3, Annex C, Appendix 8.

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

3.1   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. If a smoked foil is the recording medium, take care to 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 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 pressure. This ensures that 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.

3.2   Calibration procedure

a.   Proceed with the actual calibration using altitude steps of 1000 feet for the first 6000 feet and 2000-foot steps thereafter. If a metric calibration is being made, then the intervals should be 500 metres for the first 2000 metres and 1000 metres 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 the maximum altitude has been reached, slowly reduce chamber pressure to ambient.

b.   A typical trace will resemble the one below, either with the information shown added, or printed on a separate certificate that identifies the given trace.

c.   If a smoked foil has been used, fix it with a thin coat of spray lacquer.

- barograph type, model, range, serial number
- name of calibration facility
- date of calibration
- type & ser. no. of reference calibration equipment
- height of each step of the trace
- details of any corrections needed to the marked pressure altitudes
- name and signature of the calibrator
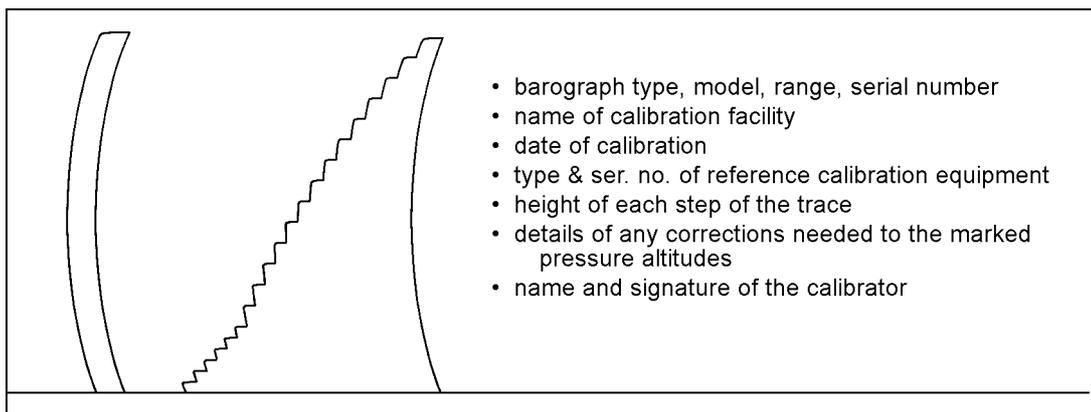
3.3   Calibration graph

In order to evaluate heights from a barograph trace (see para 14.4), 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. For most barographs the graph is likely to be linear or nearly so. If you are constructing the graph, use good quality graph paper graduated in millimetres or at least 20 lines/inch. A pair of dividers and a small plastic square is required.

a. Draw the axes of the graph, the vertical scale representing stylus deflection, and the horizontal measuring height. The horizontal scale should be expanded as much as possible for accuracy in reading off the height (1 cm per 250 m or 1000 ft is suitable, for example). The graph may be "folded" as shown below to fit a single sheet of graph paper.

Typical calibration trace

Height units
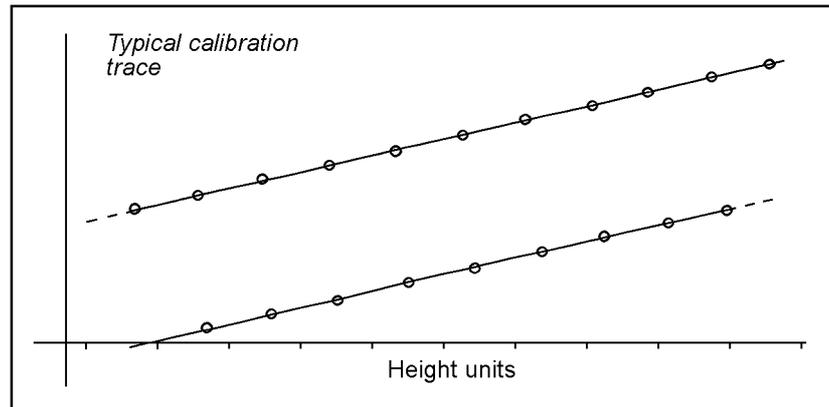
b. Now, using a pair of dividers to measure the deflection of each step of the calibration trace, transfer these distances with the dividers to the calibration graph at the position corresponding to the appropriate pressure values on the horizontal axis. Use the small plastic triangle to ensure that 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 above.

Appendix 9

INTERESTING THINGS TO KNOW

1.1 Map errors

Distance accuracy is limited by the errors inherent in determining a position on a map. The principle position errors are:

- *Map distortion*   Due to the projection of the earth onto flat paper, map distortion is variable over the surface of a map, but is small when compared to the following two errors.

- *Reproduction error*   Any feature on a map can have a position error of as much as 0.5 millimetres. On a 1:500,000 map this error can result in a distance uncertainty between two points of about 350 metres (a statistical average).

- *Reading error*   A pair of position coordinates can be estimated to a precision similar to the reproduction error at best. This will give an average distance error of ±500 metres when using a 1:500,000 map.

1.2 Round-off error example

A pilot has completed a "300 km" triangle flight. The distance on the three legs are (to 2 decimal places): 80.06, 120.06, and 99.86 km for a total of 299.98 km, and a Diamond Goal flight has not occurred. However, if the leg lengths are rounded prior to summing then the total of 80.1, 120.1 and 99.9 is 300.1 km. This is a false success – premature rounding has created distance that does not exist.

1.3 Geodetic Datum (GD) selection for flight data

Lat/long data is only definitive (and therefore accurate) if it is coupled with the GD from which it is derived. For instance, for the same geographical point in southeast England there is an apparent difference of about 140 metres between lat/longs to the local UK datum of OSGB36 and lat/longs to WGS84. This increases to about 800 metres if the Tokyo datum is set. None of these lat/long figures are wrong, although the usefulness of the Tokyo datum in southern England could be questioned.

This illustrates the importance of knowing the GD that applies to any lat/long figures that are quoted, and the errors that can apply if lat/longs to the wrong datum are used inadvertently when another datum is expected. It also shows why the IGC has decided to standardise on the world Geodetic Datum WGS84 as it is accepted as a good overall model for shape of the earth, and averages out local irregularities. After the IGC decision, WGS84 also became the required ICAO Geodetic Datum for aviation navigation use.

FLIGHT DECLARATION

Use a dark felt tip pen and write LARGE. Hold declaration about 1.5m from camera when photographing.

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

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

.... **Signature(s)**

Glider ....

   Type & Registration

FR / Baro ....

   Type & Serial no. (main)   **(backup)**

Start PT ....

   The tow release point, a remote start point, or the crossing of a start line

TP 1 ....

   Describe turn points with a concise narrative, or with geographical coordinates

TP 2 ....

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

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

.... **Signature**

   The above declaration was made and photographed in my presence.

This form is designed to be used at 2X size. Photocopy at 140%.

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