FEDERATION AERONAUTIQUE INTERNATIONAL

COMMISSION D'AEROSTATION DE LA FAI

FAI BALLOONING COMMISSION

CIA

GUIDELINES FOR THE USE OF GPS
IN BALLOONING COMPETITIONS

Version 2004

Effective date April 2004

For some years now, a number of ballooning competitions have been run with GPS-Loggers. The use of these tracking devices has been different for each event. The following guidelines should help organisers of competitions in running their event with success, without having to make their own experiences and growing slowly into this new format of competition.

Gathering reports of experienced event organisers and officials, the following paragraphs will explain the main issues in GPS-Logger competitions and give advice to avoid the mistakes and problems of the past events.

This guide is written for medium events (30-60 competitors). Changes for bigger/smaller events are mainly to be made in numbers of staff, time and equipment.

1 Introduction and glossary

The use of GPS as a navigational aid in ballooning started about 1990, in the late 1990 it became a commodity for nearly every balloon pilot. A variety of GPS devices gaining more and more capabilities, at still falling prices, made the success and wide usage of handheld GPS units possible. Also inspired from GPS use in the glider community the ballooning world started to investigate in further use of GPS in competitions: as tracking devices.

During the year 2000 several early and partly successful attempts were made to use GPS units as tracking devices – as live tracking was the only focus or goal at the beginning.
Over the years the application focus shifted from live tracking to track logging to allow analysis after the flight, although live tracking remained in certain applications.

Glossary

GPS logging: The concept of *GPS Logging* means recording, storing and analysing the flight track of a balloon. The *GPS Logger* is used as a black box flight data recorder. The track or flight data can be transferred from the GPS to a PC where it can be displayed and analysed, in more recent applications even used as a base for scoring.

GPS live tracking: For *GPS live tracking* the flight data is transmitted to a base station where the received position reports are stored and displayed on a digital map. This applications allows following the balloons virtually from the competition headquarter. Live tracking can support several long distance gas balloon races, also for safety concerns. This was helpful in some Coupe de Gordon Bennett events.
It should be used to gain more public awareness for this sport. Plotted tracks of participating teams are made available on the internet.

GPS Logger device: A hand-held receiving unit of the Global Positioning System is named GPS device. It is capable to calculate its position and altitude by receiving signals from the GPS satellites. A GPS-Tracking device is the same device but used for tracking purpose.

GPS track or GPS log: It represents the data recorded with the GPS device during the flight. Still in the GPS device's memory, it will be called GPS log, after transfer from the GPS to the computer, it has become a GPS track.
A GPS track can also be recorded from GPS "Live" tracking transmissions.

Track point: One single position report of the GPS track is called a track point. It has the position and the time of the recording as fields.

GPS scoring: The scoring based on GPS is something different from traditional scoring. It is based on the stored tracks and will not be the object of this guide.

2 Equipment and staff

2.1 GPS-Logger devices

A lot of different loggers can be found on the market today, at various prices of course. To keep competitions affordable to organize, the logger's price should be low, to have the best performance (which has to be determined), the price is high. The best compromise will tell which device to choose.

A GPS-Logger device for balloon competition (also simply called device in the following) should have the following features:

2.1.1 The device should record flight data every set time interval. Intervals of 5 or 10 seconds are used commonly. Less than 5 seconds is not recommended as the precision is not high enough to give good "flown track" distance results. A minimum capacity of 5000 recordable track points is recommended. This minimum number depends on the total recording time required, 3 hours for standard hot air balloon competitions. In long distance competitions (gas balloon race) 100 hours can be recorded by setting a longer time interval.

2.1.2 The following data should be recorded for each track point:
  ▪ Logger(Competitor) ID
  ▪ Date/Time
  ▪ Position (2D) in a standard format (e.g. WGS84, lat/lon)
  ▪ Altitude (pressure and/or GPS)
  ▪ Horizontal/vertical speed are optional

2.1.3 The device must be tamper proof and manipulation of the stored data must be impossible. Some devices are already approved by FAI-IGC regarding this matter.

2.1.4 Real-Time data transmission should be possible through connectable radio-transmitter, cell-phone (GSM) or other devices. Some radio frequency transmission systems use a network of transceivers thus greatly enhancing the reach of a transmission. The Amateur Radio, GSM network and the satellite phone system are based on receivers that forward the message to the next antenna in the network. For the use of GPS tracking devices these communication technologies proved to be the most reliable.
  This will give the organizer the opportunity to show the tracks "live" to the public and media.
  (Real-time scoring is the feature we should aim for in the future.)

2.1.5 A standard interface (usually a PC-serial communication port) must be available to transfer the data to a PC. The data format should be also following a standard, for example NMEA for real-time transmission or Garmin protocol for track downloading.

2.1.6 Handling must be easy and not subject to misunderstandings. The pilot will handle the device before, during and shortly after the flight. Therefore there should be only one button, to switch it on or off.

2.1.7 A robust construction of the device is absolutely necessary. Especially during take-off and landing in rough weather conditions, the device must be shock resistant.

2.1.8 Temperature should not have an influence on the electronics.

- When attached to the envelope, the sun may shine on the device during the whole flight. Depending on the covers/boxes used, temperature may easily rise above maximum operating temperature. Normally GPS's will then switch off automatically and stop recording any further track points.
- Cold temperatures may affect battery life during the flight.

2.1.9 Power supply must be guaranteed during the whole flight, including inflation, and other preparations. Depending on the competition, this may be up to several hours. A minimum of 4 hours is necessary for standard balloon competition. A battery life of more than 100 hours may be needed for long range competitions. An external power plug is then of a big help.

The logger is put in a bag or box. This bag/box must be equipped with rings or straps, so that it can be fixed to the balloon or basket. Again, the bag/box with its fixing must stand rough treatment.

Examples of used GPS Loggers:

- ***standard GPS devices (very common)***

  advantages:
  - low interference → antenna outside the basket
  - logger sold in every GPS-shop
  - available at low price (less than EUR 200)
  - low weight
  - small and handy for most devices

  disadvantages:
  - manipulation of data is technically possible
  - handling procedures becoming complicated
  - sensible to temperature (sun heating)

Garmin devices used by german, french, american and spanish NAC's

new Garmin Geko in smaller box

- **GPS devices with input features (less common)**
  advantages:
    - manipulation of data is impossible (FAI approved)
    - event button allows input(mark) during flight
    - low interference with mobile antenna on envelope
    - big data memory
    - long life power supply
  disadvantages:
    - heavy
    - interference if antenna fixed in the basket
    - higher price (approx. EUR 1.000)

modified Volkslogger
used in Luxembourg

Newer devices may already have the possibility to send position reports to the competition center. This gives "live" tracking or even "live" scoring options.

Handheld devices (palmtops) mounted with a GPS-receiver may also be used in the future. In this case appropriate software makes marker drops electronic. The pilot chooses the moment of his virtual marker drop by pressing a colored or numbered button on the devices screen. The handheld device logs the whole track and the marker positions.

In general 10% spare devices should be available to replace malfunctioning or broken ones.

2.2 IT and other electronic equipment

For logger setup and handling and data evaluation, good IT equipment is absolutely necessary.

The following equipment is recommended:

2.2.1 **data and application server.** This is mainly a file sharing system and gives all competition officials access to the competition data. Access rights must be set with care to avoid unintended publication or even manipulation. Therefore a network environment should be setup and configured by IT-professionals. The director or scorer will decide on access rights.
It is difficult to recommend a server system to be installed but a Microsoft Windows-system is certainly known by most officials and might be the best solution. A shared printer is absolutely necessary. More than one printer may be installed and shared separately for directors, scorers and technical support officers.

2.2.2 **workstations for the scorers, the technical support officers and the competition directors.** Depending on the competition format and scoring software used, each scoring official (including flight debriefers and analysts) should have a computer available. Again, a MSWindows-system would be best. All should have the same software installed, depending on the need of the competition:

- the scoring software
- GPS-Logger setup, handling and downloading software
- flight track analyzing software like "COMPE" or "OziExplorer"
- maybe an office-suite for general needs.

Good and large screens are especially important for flight analysis. 17"-19" flat-screen monitors are recommended.
Internet access is recommended, at least for the scorer and competition directors. The number of needed officials will be discussed later.

Network and computer security is becoming a very important issue, as more and more people are working with computers in a competition. Very often a wireless LAN is available, and possibilities are given to anybody to intrude the competition IT system. A firewall may be needed in bigger events. These events may even have sub-networks configured for scoring, officials, met-officers, pilots, media or public.

A data and video projector is very useful if tasks or weather-reports are explained to the competitors. In the scoring room, a projector can help discussing and analysing flights.

The logger power is supplied by batteries. Depending on the devices, rechargeable batteries may be used, if they guarantee sufficient power for the whole flight. Standard alkaline batteries may also be used. These normally last longer than the rechargeable ones, but the costs and the environmental issue are to be considered.
Sufficient chargers must be available to recharge the batteries between 2 competition flights. This time may be very short. It is recommended to have a second set of spare batteries fully charged, or being charged during a competition flight.

A supplementary workstation should be installed for the jury. As a great part of the scoring is now electronic, they will also need access.

2.3 Staff requirements

The competition officials in GPS-Logger events have very new duties and a new profile of the officials needs to be established.

The staff may be divided into 4 groups:

2.3.1 **Competition directors.** The directors should be familiar with the new competition and scoring format. Mainly, they should understand the new scoring procedures to avoid a task setting that will be difficult or long to score. The scorer should give permanent feedback about the amount of work still to do, so that the director may set more "logger"-scored tasks.

2.3.2 **Scoring officials.** They should have very good knowledge in ballooning competition and of course ease of use with computers.
The chief scorer should also be comfortable with the GPS-Logger format and its scoring specialties As the GPS-Loggers give new possibilities for task setting, the chief scorer should work closely together with the directors to determine what tasks are possible to score in reasonable time and effort.
Depending on the scoring software used, analyzing the flight tracks

manually with the computer (COMPEGPS or OziExplorer) takes as many scoring officials as debriefers were needed in a traditional competition. This means approx. one scoring official per 7 competitors. If the scoring software is also analyzing the flight track automatically, the scoring officials may be reduced to one per 10 competitors.

2.3.3 ***Technical support officers.*** Due to the new equipment to be handled by the competition officials, technical support officers are needed to set up and handle the GPS-Loggers. They don't have to be IT-specialists but comfortable with technical equipment and computers. After the flight, they also download the track data and make it available for scoring. If the downloading software is well designed and highly automated, only 2 people are necessary to organize and handle up to 100 devices. To accelerate the downloading procedure and make data available faster, the scoring officials may help in times where a lot of competitors are coming for debriefing.

2.3.4 ***Measuring officials.*** The skills and people needed for this job have not changed. The number of measuring teams is an organizers' and directors' decision as it depends on the task setting and organizers budget. 5 teams of 2 to 3 people would be perfect.

This official's team composition is of course only valid for events without observers.

2.4 Jury

The jury will also have to be given access to the data to be able to check scoring. The scorer will explain the used scoring procedures at the beginning of the competition. He will then be available for further questions and may grant access to the tracks and other data through the network/server administrator.

3 Handling procedures

The following guidelines cover the general procedures concerning the technical equipment, mainly the GPS-Loggers.

3.1 Preparations

Prior to an event, several steps should be undertaken to prepare the technical part of the competition.

3.1.1 A technical coordinator will have to be named. He will organize the devices and all other technical equipment for the competition. He will make a detail list of what's needed and keep track of all equipment, starting from transport, setup to packing up after the event. He should also be available to solve problems in case of damage and failures.

3.1.2 The devices should be available at least several days before the event starts. For a good preparation and possible testing, this may be extended to 2 weeks. Not working devices may then still be changed or send back.

3.1.3 As a lot of different systems are being used today, the officials should be trained the days before the first flight, especially the technical support officers that may be recruited among the local volunteers or helpers. They should all be trained on how to handle, distribute, collect, operate the GPS-Loggers, download tracks and recharge the batteries. Small problems during the event may be solved by them too.

3.1.4 A training should also be given to the competitors. This may be done during or after the general briefing. The pilots need to be advised on the procedures for competition flights, how and when to switch it on/off, attach it to the balloon and where to bring it back. To avoid problems during competition, all pilots should be given the possibility to make a training flight with the logger. The track will be downloaded and shown to the pilot to make him understand the system and what he will be scored to.

3.1.5 The pilots should be told how to setup their own GPS as the data may be used for backup if the GPS-Loggers did, for what reason ever, not record track data.

3.2 Pre-Flight

Before each flight, the technical support officer will check the status of the batteries and put the fully charged ones in the GPS-Logger.

The distribution of the logger is best done while preparing the briefing room, or right after the downloading of the previous flight. The devices will be put on the competitors table together with the task sheet and markers.
If there is no defined sitting order, the distribution may also be made after the briefing on a large table. The competitors will then have to come by and pick it up. This takes less than 3 minutes for more than 50 pilots, depending on the size of the table.

During briefing flight specific advice has to be given to the pilots. Explanations about the number of marks to be made (if such devices are used), or about the moment to switch it on or off, can help eliminate confusion and later problems with the tracks. Officials should also be briefed about the flight specifics.

If the take-off is from a common launch area the technical support officer will take some spare devices with him. In case there is a problem with a pilot's GPS-Logger it can be replaced. This is very important at the first flight.
Pilots may have questions about the devices that will then also be answered immediately. Therefore is recommended to have the first flight taking off from the common launch area.

3.3 In-flight

During the competition flight the logger is completely under the pilots responsibility. The competitor must be aware of the fact that in case of any damage, he will have to repare or replace the device, or pay for the service.

Unless the devices have an real-time connection to the competition center, no action from the competition officials is needed.

3.4 Post-flight

After the flight the competitors will bring the GPS-Loggers back to a defined place. A counter is a good solution for checking in. A drive-through may be arranged. The pilots do sometimes prefer the drive-through as they do not loose time and they can deliver it before going for refueling.

It is best to have this close to the scoring so that the data can be downloaded immediately and proceed to scoring.
A rigorous and strict procedure is necessary. The in-coming devices will have to be collected and stored for the following download. After downloading the tracks from the loggers they need to be stored separately to avoid mixing them up with the incoming devices.

The batteries may then be recharged. If charged batteries (maybe a second set) are already available the GPS-loggers may be prepared for the next flight and even distributed while waiting for the last competitors to come in. Nevertheless it is very important that the logger memory is only deleted after the tracks on the server are backed up.

The technical support officer is responsible for all GPS-Logger handling before and after the flight.

4 Track evaluation

The GPS-Logger is able to collect a lot of data and stores it in the internal memory. The collected information is the main outcome of this new format of flying balloon competitions. The following lines will describe a good way to handle and evaluate the flight data.

The ownership of the recorded data shall lie with the organizer of the event. As the competition rules normally do not state this, it is important to add it to the invitation or registration that will be signed by the competitor. Each competitor will be allowed to be given his flight tracks at the end of the event. If he wants to share it then with others, he may do so. Tracking logs or data shall not be published by the event organizers without the express authorization of the concerned pilot.

4.1 Data handling

GPS-Logger settings have been described at the beginning and don't need further explanations.
The first contact after collecting the data is the download from the GPS-Logger at the competition center.
Different models of GPS-Logger have different downloading software. None of the retail software is really designed for ballooning purposes.

A software should have these basic features:

4.1.1 Automatic download. Hitting **one** single button will download the data from the GPS-Logger's memory. This is fast and safe for not mixing up data.

4.1.2 GPS-Logger ID recognition. The number of the device has to be recognized to avoid saving data under a wrong pilot's competition number.

4.1.3 File saving. The downloaded data is saved to a standard and usable format (e.g. IGC or OziExplorer format). To increase data backup security the software may save the flight tracks to 2 different formats and destinations. If the downloading software is linked to the scoring software, the GPS-Logger ID used by each competitor is available and the name of the competitor may be in the file name. This is important if the GPS-Logger ID is fixed (e.g. serial number) and a competitor's device has to be change due to problems or failure.
The final name of the flight track should have at least the date/flight number and competition number in it.
To save even more downloading information the flight track data can be saved to a SQL database. Downloading time/date and official as well as the push button mark can be saved and all information can easily be used in further analyzing software. The database file is very small and accessible by some common analyzing software (e.g. MS_Excel, MS Access, VBA). The security of this kind of database is easy to set up and control.

4.1.4 Deleting the devices memory. If the data is downloaded and saved correctly, the data may be deleted. Although it is safer to keep the tracks in the GPS-Logger until the first scoring of that flight is done, the immediate deletion of the data may save some time for the preparation of the next flight.

After the flight data has been downloaded for all competitors, the saved flight tracks should be backed up to a second computer or storage device, maybe a write-once CD. If the above described software is saving the data immediately to 2 different storage systems, this may be skipped.

The security of the data must be guaranteed at any moment. No manipulation of the data must be possible. This is mainly a network and file sharing/access problem and should therefore be dealt and configured with great care.
Every official should have a different login. This login will grant access to the data and be used to record who created and changed data throughout the competition and when he did so. If, in bigger events, more users/scorers are working with the scoring software, it must also take care of multiple user identification and access control.

4.2 Scoring

The scoring software is the first point of action for the future.

The transformation from flight track data to scoring results can be summarized to 2 main steps:

4.2.1 Flight analysis. In the future, many efforts will concentrate on the development of an automatic flight track analyzing software.
The ideal software will be able to determine the results directly once the task sheet data has been entered.
Today, some experimental software is written in Excel/VBA or Perl. This works fine, but still needs a lot of customization for each flight and task and highly skilled programmers are absolutely necessary.
Without an automatic flight analysis, the scoring officials named in the first part of this guide can do the debriefing and analyzing job. This comes very close to the traditional debriefing, except that the tool has become electronic. A mapping software as OziExplorer is suitable for this. A new software "COMPE" is being used. The track is shown on a digital (scanned) map and the detailed flight data may be analyzed using replay features with views from different angles. Additional tools and software for PZ monitoring are available and may be used.

4.2.2 Score calculation. The score calculation software should be able to use the result data directly from the analyzing software. This eliminates many mistakes while entering the results. The result processing itself can be done by the traditional/existing scoring software.
This scoring software will need further development once online scoring is possible. The GPS-Loggers will then be able to send online position data to the scoring computer and results can be calculated and published in real-time. This is comparable to other competitions like sailing. The America's Cup is a good example of what is possible today.

4.3 Flight report form

The "classic" observer sheet was a big help in debriefing and a good transcription paper for scoring. It will be replaced by a "flight report form" filled in and signed by the competitor. A template form is shown on the following page.

The grey part on the right side is left blank by the pilot and used for scoring purposes only. The scoring officials that analyze the flight tracks will write down the determined results. The chief scorer will make his remarks and checks on the same paper by using a different color (red).

Logger N°

Flight Report Form

Competitor

N°:	Name:

Flight

N°:	Date:	AM
		PM

Time logger back:
# of points in log:

Take Off

Coord.:	Time:
Remarks:	

PID:	Coord:
Elev:	
Remarks:	

Landing

Coord.:	Time:
Remarks:	

PID:	Coord:
Elev:	
Remarks:	

Task

Coord.:	Time:
Remarks:	Estimated result:

PID:	Coord:
Result:	
Penalties:	

Task

Coord.:	Time:
Remarks:	Estimated result:

PID:	Coord:
Result:	
Penalties:	

Task

Coord.:	Time:
Remarks:	Estimated result:

PID:	Coord:
Result:	
Penalties:	

for scoring room completion

Additional information annexed		Pilot's signature:		Scorer:
No	Yes:			
No	Yes:			

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4.4 Publication

The publication of the results is traditionally done by paper on the Official Notice Board. However, the web has become an effective way of reaching a lot of people, competitors, ballooning community all over the world, media and the public.
But publication of the results will not be treated here.

The track visualizations may also be published on an Internet site. Simple formats may be used to reach a maximum of people. But it is very difficult to show the huge amount of available tracks on one single image. New ways of publication are becoming more and more popular. SVG (Scalable Vector Graphics) is a very good mean to select, show and enlarge tracks in a simple browser window.

5 Links and contacts

Competitions:

Mobilux Trophy, 2nd round of the World Honda Grand Prix:
http://www.mobilux-trophy.lu/

GPS device manufacturer:

Garmin: http://www.garmin.com/

Volkslogger: http://www.volkslogger.com/

Software:

COMPE digital mapping, simulating and analyzing software
http://www.compegps.com/

OziExplorer digital mapping and analyzing software:
http://www.oziexplorer.com/

Experienced experts:

Mathijs deBruijn	mathijs@debruijn.de
Claude Weber	claude@weber.org
Gerald Stürzlinger	gerald.stuerzlinger@rzl.at
Marcus Blaha	marcus.blaha@t-online.de
Laurent Sanglard	laurent.sanglard@ecam.fr

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