

REPORT of the

CIA Special TRACKING Working Group 2004

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1. Abstract

GPS Logging, in other words the recording, storing, and analysing the flight track of a balloon is feasible and common nowadays at balloon competitions. Different technical and organisational aspects of GPS Logging in ballooning events are discussed in this report. It summarises the recent experiences using this technology.

A separate document provides operational guidelines of how to apply GPS Logging successfully to a balloon competition (called the guidelines).

A specialised variant of GPS use is the *live tracking* of balloons with live transmissions of GPS-position reports to a base station for competition or media and public information purposes.

This report shows the history and current state of GPS logging and live tracking in the ballooning community.

The Tracking Working Group, set up by the CIA plenary to investigate into the technology and operational procedures reports with this document to the CIA Plenary.

2. Nomenclature / Definitions / Glossary

For the following we need to distinguish the understandings and the different use of words; to clarify the language definitions in the field of “GPS logging & tracking”

GPS DEVICE: a hand-held receiving unit of the Global Positioning System, capable to calculate its position and altitude by receiving signals from the GPS satellites.

In this context GPS units with the listed capabilities (see chapter Technical Requirements, features of GPS devices) are named “Loggers” or “Trackers”.

A GPS TRACKING device or (GPS) Tracker for short, as well as a GPS LOGGER device, or logger for short is a standard GPS unit with the required features.

How do we call the people doing the logging now? I thought loggers work with wood?

GPS LOGGING or LOGGING: refers to the recording of a sequence of 3d-positions captured with a GPS device, in this context logged during a balloon (competition) flight. Also named TRACK LOGGING, in other words recording a flight track of a balloon.

GPS TRACKING or better GPS *LIVE* TRACKING: GPS positions are transmitted in real time (live) to the base station e.g. competitions headquarters. A remark about language use: In the United States the European "loggers" are also called "trackers", please don't confuse.

GPS TRACK or GPS LOG: the data recorded with the GPS device during the flight.

GPS-SCORING: a general expression that is used when the achieving of results is based on GPS tracks (and not marker measurements). For that purpose other standards to the procedures and requirements may be applied. GPS scoring is not the primary focus of the CIA Special Tracking Working Group, but we may advise other bodies in overlapping issues.

3. Acknowledgements

For this long lasting investigation and this report to be valuable, a lot of dedicated people contributed their thoughts and efforts. Over the past years several event organisers and competition officials were eager to try these "new" GPS logging thing, in the beginning as a complementary, an additional observing device. Our special thank goes to all the supporting people at these events, including the directors, debriefers, observers and also the competition pilots that got accustomed to the idea of carrying a "black box" flight data recorder.

The main investigators and contributors of the GPS LOGGING/TRACKING idea, the people that made a lot of basic ground work, preparations and proofs of different ideas, concepts, and uses of this technology as well as writing their findings in documents include (in alphabetical order):

Alex Nagorski (CAN), Claude Weber (LUX), Gerald Stürzlinger (AUT), Hans Åkerstedt (SWE), Jean Claude Weber (LUX), Janne Balkedal (SWE) and his group, especially Göran Blumental, Laurent Sanglard (FRA), Marc Rosenfeld (LUX), Markus Blaha (GER), Markus Haggenev (GER), Mathijs de Bruijn (NET), Uwe Schneider (GER), and a few other unnamed contributors.

Special thanks to Uwe Schneider for the ongoing creative interchange about GPS, radios and software for this field. Thanks also to Mathijs de Bruijn for his constant investigations, development, and applications of GPS logging and tracking.

The GPS TRACKING WORKING GROUP was put into place by the CIA Plenary at the CIA meeting in 2001. Its purpose is to investigate about GPS tracking and logging for balloon competitions. It reports directly to the Plenary.

4. Introduction

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, stirred by the famous FlyTrack demo (of Intelis, Italy) at the CIA conference in the year 2000 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 early primary focus.

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.

The concept of *GPS Logging* means the 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.

For *GPS live tracking* the flight data is transmitted to a base station where the received position reports are stored and displayed overlaying a map. This applications allows virtually following the balloons from the competition headquarter. Live tracking supported several long distance gas balloon races, also for safety concerns this was helpful in some Coupe de Gordon Bennett events.

It was successfully used to gain more public awareness for this sport - plotted tracks of participating teams were made available on the internet.

This report reflects the goals of GPS logging & live tracking. It also highlights the technical aspects of the used GPS devices and the software used for analysis. Based on a lot of experience this report gives guidance for setting up *GPS logging* at balloon competitions.

At the end there is a list of related addresses like that of GPS logger-rental Organisations and links to further information. In the appendices you also will find some links to other historical documents of early GPS tracking.

This report can not be a final statement on GPS logging & tracking, as this technology evolves at a high pace. It tries to reflect the current state (as of early 2004), the knowledge, and understanding of the systems and procedures with GPS logging & tracking in the ballooning community.

5. Goals of GPS logging & tracking

For GPS "usage" in ballooning competition we distinguish two fields of applications:

GPS logging
GPS live tracking

The Goals depend on these two different GPS device applications:

For *GPS logging* the main goals are the technical flight recording, to provide a proof, an evidence of the actual flight. The recorded data could be used for technical flight analysis; it could be used to check for infringements of flight and competition rules.

The flight tracks, especially with advanced displaying software are also used for comparison of performances of competing pilots and could be placed on the internet for public interest or used to broadcast via television to reach a wider audience. To its full extent, the recorded track logs provide a basis for scoring.

For the second field of application, *GPS live tracking*, the goals could include the above purposes, the focus widens here also to safety and publicity for media purposes. Currently mainly applied in long distance (and long time) typed events, usually with gas balloons. The GPS Trackers are being used for scoring purposes in gas ballooning already.

6. Experiences & Applications of GPS logging / tracking / scoring

Experimental GPS live tracking was early demonstrated at:

Luxembourg Nationals 2000 with the FlyTrack Software from Intelis, Italy with live display.
Pre-WAG 2000 Sevilla, Spain – small experimental tests

GPS live tracking was successfully installed at:

Mobilux Trophy in Luxembourg since 2001 (with virtual marking, live internet display)
Gordon Bennett gas balloon race since 2001
Americas Challenge gas balloon race since 2001 (with internet live display)

GPS logging was used with success at:

Gordon Bennett gas balloon race since 2000 (St. Hubert, Belgium)
Italian Nationals 2001
Brazilian Championship 2002
2002 Hot Air Balloon World Championship, Chatellerault, France.
German Championship since 2001
Motegi, part of the Honda Grand Prix 2003, Japan
MOL Cup 2003 at Debrecen, Hungary

GPS logging with GPS-based scoring was used with success at:

Luxembourg Nationals since 2001
French Nationals 2002
Spanish Nationals 2003
Coupe d`Europe, France 2003
VMAX cup in Somogybabod, Hungary 2003

(The list is not complete! Further detail is available at the Working Group)

7. Technical Requirements

- a) Minimal capabilities for the Logging / Tracking devices
- b) Required and optional features for the analysis software

Further details on that requirements see the 'Guidelines for GPS Loggers in ballooning competition' (mentioned in the next chapter)

a) Minimal capabilities for the Logging / Tracking devices

The basis for a Logger or Tracker is an industry standard GPS device capable of providing a 3-d position in real time. It could be a consumer product or even a bare bone GPS kit when combined with other devices to fulfil the requirements mentioned here.

For the features and capabilities there are two different set of numbers for the two different purposes: one applies to short-range flights (typically hot air balloon) and the other is meant for the second application: long range gas balloon flights that last up to 100 hours.

To be usable as a GPS Logger in our context, the GPS unit would need additionally:

Recording capability: The unit needs to be able to store the track log at set time intervals, preferably at 10 seconds up to 10 minutes. The total recording capacity should be not less then 3 hours with the 10 second sample rate and not less then 100 hours with a 6 minutes sample rate.

Recorded Data: The stored data (a track point) must include the time of recording, the 2-d position (based on WGS84) as well as the altitude of the device at the recording. This altitude may be based on GPS calculations or better measured with an ambient pressure sensor.

Run time / battery life: Depending on the application a GPS Logger should have a power supply to run 4 hours minimum for a short-range hot air event. For long-range gas balloon events, a run time of 100 hours is to be supported.

Handling: A GPS Logger has to be robust in ballooning sport; it has to be shock resistant. The GPS Logger can be attached to the basket or envelope, depending again on the type of device (weight!) and purpose.

Data transfer capability: A standard interface (usually a PC-serial communication port) must be available to transfer the data to a PC.

A GPS Tracker (to be used as live tracking devices) would need a GPS and:

Transmission device: A handheld radio or a (GSM) telephone is needed to transmit the actual position (provided by the GPS unit) to the base station. Some radio frequency transmission systems use a network of transceivers thus greatly enhancing the reach of a transmission. The Amateur Radio network is an example also the 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.

Live Data output: for live tracking the GPS needs a constant data output to enable the transmission device to transmit the actual position data. Usually this output is based on the NMEA protocol, the NMEA-sentences are sent over a serial connection.

Transmitted Data: must include the Identifier of the unit (and therefore of the balloon), the 2-d position (based on WGS84) as well as the altitude of the device at the recording.

Run time / battery life: The higher power consumption of a transmitting device leads usually to higher power requirements, especially for the long-range applications like the 100 hours of a gas balloon flight.

Sample Rate / transmission rate: for a live tracking application, the rate of the position reports should ideally be programmable, ranging from 5 seconds to 6 hours.

b) Required and optional features for the analysis software

To get the recorded track out of the GPS logger you need a program that is capable of the download. With that flight data, the track available in the computer you can do more:

We separate three different aspects of TRACK Analysis:

- Graphical Analysis (visualisation of tracks)

- Technical Analysis (infringements of rules based on GPS track)

- Scoring purpose (measurements based on GPS track)

For graphical/visual analysis of the tracks:

- Mapping capabilities

- Display of Tracks over Map

- barographic / altitude trace of flight

- 3d-track display over 3d-map

- flight replay features with various views

- Software should be manageable by non-experts or have an easy learning curve.

- Provide a feature to avoid human error (fail proof?) [e.g. the number of downloaded track points was such a double-checking feature]

- To fulfil the media purpose of GPS logging & tracking: provide a format media can use: internet or broadcast

Examples of Visual Analysis Software & experiences:

- WINAPRS for live tracking, only 2dimensions, simpler maps

- OziExplorer for downloading & visual logging analysis

- COMPE by gliders from Spain, downloading & visualisation

For technical analysis:

Examples of Technical Analysis Software & experiences:

- eKLIPS by Garry Lockyer for downloading and analysing, provides also scoring

- PERL-Scripts to check for PZ infringements or for reached altitudes (Markus Blaha).

- EXCEL-Macros for the same purpose, mainly developed by Mathijs de Bruijn, some co-developments with Laurent Sanglard (FRA)

- Take off time and time of final landing could be deduced from the raw track data.

Some of the analysis software also blends into the scoring purpose. ('The box' and other new tasks where invented based on the new possibility of technical analysis of flight tracks)

For scoring purpose:

Task data input (so that the program would know what and where to measure to)

Data interface to scoring program or inclusion of a scoring program.

Examples of Scoring Software (based on GPS tracks) & experiences:

EXCEL-Macros for scoring purpose, mainly developed by Mathijs de Bruijn, some co-developments with Laurent Sanglard (FRA)

EXCEL-Macros home-made for the Volkslogger Luxembourg (deducts take off time and landing time, uses specially marked track points - triggered by the pilot - for scoring)

eKLIPS by Garry Lockyer

8. Guidelines / Operational Procedures

"You will need skilled people, but one attitude you can't do without is *dedication*." [Gerald Stürzlinger]

Again, separate the two different types of applications: GPS Logging, GPS Live Tracking

The operational Guide is available as a separate document called '**Guidelines for GPS Loggers in ballooning competition**' from the Tracking Working Group and it should get a status of an advisory document with the CIA.

Further information like existing reports on GPS logger and tracker use, historical experiences in that field can be obtained from the CIA Special Tracking Working Group.

9. Future of GPS logging & tracking

As the technology is still evolving in this field, further study is clearly necessary.

Some options were not taken in the past because of the costs. Further technical improvements are possible now. We see the best opportunities in the field of live transmissions and on the software side.

There are new programs available that improve on the existing ideas of presentation, so this would please the media and publicity needs of GPS live tracking applications.

The other software improvements should help to make the data & download handling of the GPS Logger devices easier.

Another main opportunity in the software field lies in the automated scoring process that really could help running events easier, with a quicker process to get to the results. This development could also fuel the media response, as a near time (close to real time) visualisation, analysis, and also scoring of competitors performances would certainly help the sport of ballooning to gain more awareness in the public.