# The Flymaster Tracker
## Report for CIMA on the trial at WPC 2018 Thailand, May 2017
### Richard Meredith-Hardy

*This document and all accompanying files can be found at **http://wiki.fai.org/x/CQAgAg***

## Overview

In CIMA championships we have been almost exclusively using AMOD flight recorders since 2009.  They have proven simple, reliable, cheap and accurate, but are no longer available; nobody seems to have found any suitable alternative, and there is a desire to implement some kind of real-time tracking in our championships.

The HG & PG fraternity have been using Flymaster products for some time.  Some of these devices transmit data in near real time, and there is one model, the Flymaster Tracker 360, which shows no nav information, cannot be connected to a display and therefore meets the basic CIMA requirement.

The Flymaster Tracker 360 is a small (93 gr) 72 channel GPS/GLONASS logger with c. 20 hour battery life, and memory capacity of some 83 hours @ 1 sec fixes.

It transmits real time data @ 1 sec fixes by 2G or 3G (depending on the device variant) and Flymaster provide a website at **https://lt.flymaster.net** which displays tracker position in near-real-time (c. 4 min delay) and provides a method of downloading the saved data in .igc file format.  .igc data can also be downloaded directly from the device if necessary.

Compared to flight recorders we are used to using, the Flymaster Tracker is quite expensive to buy (c. 250€) and there are on-going costs associated with sim cards, however, the UK company **flyevent.org** has a stock of >600 to rent at a cost of c. 15€ - 20€ each for a competition, and will deliver them ready to go with a suitable sim and pre-configured for the event.

On the basis that this device:

- Seemed physically almost perfect for use in any Microlight and Paramotor event which requires flight recorders.
- The real time data feature really does increase safety (the SOS button)
- They have the potential to move our sport forwards with real time displays for spectators,  a score the moment a pilot lands, or even in real-time.

Richard Meredith-Hardy (RMH) made a written presentation to the 2017 CIMA Plenary proposing a full-scale test of the Flymaster Tracker at the next FAI World Paramotor Championships in Thailand 28 April – 6 May 2018.

 The plenary decided to fund this test in the form of renting enough trackers for all competitors, and appointed RMH as a steward to the event and to oversee and report on the test.

This is that report.

# Advance planning

## Hardware

Prior to the Plenary meeting in November 2017 RMH had already been leant one tracker by flyEvent.org to test. Once the go-ahead from CIMA for the WPC trial was received, emails were sent to flyEvent.org reserving up to 150 trackers to rent for the WPC. Responses were disappointingly slow, usually several weeks, but could partly be excused by the fact that Brett Janaway of flyEvent was in the process of moving from UK to Slovenia.

Due to the nature of mobile comms in Thailand it was decided that the slightly more expensive 3g trackers would be required for WPC but for the purposes of this trial a special price was successfully negotiated.

As the championship approached, updates from WPC organizers indicated that 120 trackers would be enough so the order with flyEvent.org was changed without problem. 120 trackers and hardware to charge 50 simultaneously arrived in UK a week before RMH departure for Thailand.

## Software

The HG & PG people have been using flymasters for years but they do things differently to us. There is a variety of integrated softwares out there eg Airtribune: https://airtribune.com or http://fastretrieve.com but these are all paid services and mostly seem quite unsuitable for us.

The flymaster system itself is quite powerful and has an API of sorts, but there is absolutely no documentation for any of it.

CIMA has traditionally taken the view that if we are to use any special software then ideally it should be open source, and if not, then at least it should be properly documented so any competition organizer can use it without necessarily having to hire in expert help. The Flymaster system is neither.

The only solution for this trial, agreed with the CIMA Bureau, was to hire someone who knows how the Flymaster system works, can demonstrate all its capabilities, and RMH should document it as much as possible for potential future use in CIMA sanctioned events.

Chris Trow was recommended by flyEvent.org as a suitable expert. He is a microlight instructor in UK but spends a lot of time travelling the World to work with the Paragliding World Cup and other paragliding competitions that use Flymaster instruments with the speciality of live tracking displays and retrieve management. RMH went to talk to him; there would be a cost in both travel and time because he does this sort of stuff professionally, but given the lack of system documentation, a relatively short conversation made it rather clear that our trial would not be very successful without him.

He was briefed that at the very least we needed .igc files out of the flymaster system with file names according to the CIMA specification and to demonstrate as much other capability of the system as possible.


# Travelling with 120 flymaster trackers

## Value

⚠ It must be appreciated that this quantity is worth about 30,000 € so it is important they do not get lost in transit!

## Weight

The whole lot weighed about 28 Kg before it was put in two large suitcases. The total weight exceeded the 30kg baggage limit before any personal clothing Etc. was added. When it was weighed at the airport the overweight charge was quoted at US$50 / Kg so travelling with quantities of Trackers is potentially a very expensive exercise unless arrangements for heavier baggage are made in advance. At 95g each, 120 trackers by themselves weigh 11.5 Kg and 50 charging leads 1 kg. This represents a lighter way of doing it, but a large quantity of USB power supplies would need to be supplied locally.

## Dangerous cargo

Reading the ICAO rules about carriage in aircraft of Lithium batteries contained inside equipment there seems to be two possible interpretations; a) only four such devices may be carried, or, b) passenger aircraft may not carry more than 5kg of lithium batteries. With 120 you obviously fail on a) but the total weight of all their batteries is only about 2.4 Kg, well under the limit, so it appears b) is OK.

## Shipping

flyEvent.org is based in Slovenia. They are happy to ship trackers within the EU but prefer they are transported to events elsewhere as personal baggage by someone travelling to (and back) the event from the EU.

For WPC Thailand FlyEvent got the trackers to UK as someone's luggage so it was just a 5 hour return drive for RMH to collect them and he took 120 trackers to WPC 2018 in Thailand contained in 5x charging boxes (20 each) and one other box, plus 55 charging cables.

⚠ To return them to Slovenia by international courier even within the EU can be VERY expensive, so it is important to agree with flyEvent the exact method and timing of return before the rental contract is agreed.

120 flymasters plus their cases Etc carefully packed and sealed in a strong cardboard box 55cm x 50cm x 36cm x 28Kg cost c.100€ to send UK – Slovenia on a 4 day delivery by TNT. Insurance (as recommended by FlyEvent) can add several

hundred € to this so it is important for an organizer to include receive & return shipping of rented flymasters in their budget, or consider delivering them personally via Ryanair, Easyjet Etc.

# Tracker setup

✔ Rented trackers are configured ready to go at the competition site.  Flymaster have a deal with Vodaphone to supply suitable SIM cards, and to save comms cost they have the ability to activate and de-activate them upon command.  In our case they were activated from midnight UTC 29 Apr – 5 May [1]

Trackers can be configured in two firmware modes: 'Normal' and 'Competition'.  Trackers can only be changed between these two modes via the server with commands of a type which is not available to a competition organizer.

⚠ If trackers are rented then the mode will be set by the rental company.

⚠ In Competition mode the tracker can only be turned off when the tracker is being charged.

All the trackers at WPC 2018 were initially configured in normal mode which changed later to competition mode.

## Advantages of Competition mode

✔ Flymaster trackers have a unique type of charging connection which most pilots will not have so this is a useful feature when the trackers are rented because the person who rented them has some time to find missing ones before the battery runs out.

## Disadvantages of Competition mode

⚠ Because the user cannot turn the tracker off, the comp organizer must be equipped and ready to collect every tracker after nav tasks, turn them off, charge them overnight, turn them on and distribute them the next day.  This is more work and responsibility for the organizer than we are used to with the AMOD which the organizer only sees briefly for downloading at the end of a task and everything else (switching on & off, battery state Etc) is the responsibility of the pilot.

To turn on a tracker you press the left button 1 and then confirm this by pressing right button 2 within five seconds.  To turn off a tracker in normal mode you do the same thing.  In competition mode, this turn off action does not turn off the tracker, instead it puts the tracker into 'retrieve mode' which sends a signal to the server that the pilot needs help, but not the kind of critical help the pilot might need had they pressed the SOS button.  As with SOS, admin can acknowledge a retrieve signal and the indicator lights will show this.

⚠ At WPC 2018 we had many inadvertent activations of retrieve mode, and this is bad because in retrieve mode the tracker only sends one fix per minute (enough for a retrieve) rather than 60.  These inadvertent activations occurred because our users, especially before takeoff, often wished to see battery level, and this is done by a single press of right button 2, however, in practice they seemed as likely to press left button 1 as right button 2 to achieve this, but when their press of left button 1 didn't display what they expected, they immediately pressed right button 2 which instead of displaying battery level, simply confirmed the command to go into retrieve mode….

⚠ And unlike SOS, there is no simple way to get out of retrieve mode; it requires a general reset (simultaneously press SOS and button 2 for ~2 seconds and the tracker reboots).  At WPC 2018 our hired expert had the ability to change a tracker from retrieve mode to normal via the server, he did this often, so we never lost any data, but this is not a function which would normally be available to a comp organizer.

## Loss of rented trackers

The rental deal from flyEvent.org states: *Any rental equipment lost or damaged whilst the items are in your care, including in transport or with courier services, must be paid for by you at the end of the rental term.*  And it puts a value of 250 € on each Flymaster Tracker 360 3g

Of course it is possible they could be lost in transit, but this can be insured for, but what about competitors losing them?  They are quite robust, and waterproof, so if switched on and transmitting then it is easy to see where they are online.

There is not much point in stealing one because they are inextricably linked to the Flymaster server and its location will show up as soon as it next transmits.

flyEvent.org say it is very rare for them to go missing though they have had one or two which didn't survive being dropped from a great height.

✔ None went missing at WPC 2018.

## Usage conclusion

⚠ Retrieve mode may be useful in HG & PG where landing out is usual, but for Microlight & Paramotor competitions where landing out is rare but inadvertent activations seem common, then it is better NOT to have this functionality at all and just rely on the SOS button to alert help.  Without a special firmware change the only way to do this is to operate them in normal mode.

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[1] We were not told this in advance, but only found out after they did not work when we first arrived and asked why?

⚠ The risk of operating them in normal mode is that the user can turn his tracker off and then the tracker cannot be found.

**Solution 1:** Make it clear in the local regs that trackers are mandatory; if teams or pilots do not own them then they must either buy them or rent them from a provider like flyEvent.org.

⚠ In the HG & PG world it is the organizer who does the renting so it is entirely possible flyEvent.org would not like to do it this way, or charge a premium to send out small lots of trackers to different teams.

**Solution 2:** The organizer rents sufficient trackers for all pilots from a rental provider like flyEvent.org and 'sub-rents' trackers and charging cables to teams for the duration of the event.  The safe keeping and charging of trackers becomes the responsibility of the pilot or team (similar to AMOD) and a deposit is repaid upon safe return of the tracker and cable at the end of the event.

⚠ This requires significant pre-planning and financial investment on the part of the organizer; some may not do it in time.

✔ If flymaster trackers become mandatory in CIMA sanctioned events then in practice it seems likely that a combination of the above two solutions may be the answer.

⚠ The only remaining difficulty is associated with the way some teams fail to get themselves organized before the last minute:   Tracker rental must be arranged well in advance of the event, if the event is planned for the European summer then it would be wise to book them a year in advance.   An organizer does not want to pay to rent trackers which are not used, but it could be disastrous if he did not have enough of them to sub-rent on the first day of the event.

# Setting up lt.flymaster.net for a competition

Quite easy.   If you don't already have one, **Create a login** at https://lt.flymaster.net/

A 'group' in competition mode is synonymous with a competition name, it has a from and to date, and all trackers in a group are displayed on the same page.   **Go to my groups and Add Group**, you are the owner of this group.

You can **add group users** if they already have their own login to lt.flymaster.net.  Group users have less permissions than the owner, but can download .igc zip files (which is useful, eg for a scorer)

In your group, **add group instruments**
Trackers are registered to your group by their flymaster serial No.  This can be done manually but it emits an invitation to the tracker owner to confirm their tracker can be added to the group.  This could be a very painful exercise to do manually.

✔ Much better, **load all group instruments by uploading a .fsdb file** .fsdb is a CIVL designed xml format [2] and loading them this way doesn't require an invitation for a tracker to join a group, it is just joined [3].

The fsdb file will also set some comp parameters like dates but not all items, so you need to review comp setup online. [4]

❓ . fsdb files can also load task and results, though this might be limited to displaying the sort of simple things hg & pg people do. [5]

⚠ Retrieve events and SOS events are by default OFF for every instrument.  Fsdb file does not set then ON so you need to manually edit every instrument. [6]

Once some tracks have been recorded by the system you can download a whole day's worth of igc files in a .zip file. [7]

⚠ Downloads are by UTC day, so in the Far East you may need to download the day before too if some tracks started before midnight UTC. [8]

⚠ Downloaded files are split by when the tracker was switched on and off; there is no task window time filtering to separate recording out of window, which can make very big files full of useless data, or worse, if more than one nav task in a day, there is no way to split files into each task.  (both of these features are intrinsic to FRDL and the AMOD)

⚠ The resulting igc files must be renamed to the CIMA specification and they are missing some of the CIMA required header info. [9] (all features intrinsic to FRDL and the AMOD)

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[2] See example .fsdb file in CIMA Flymaster Tracker user manual;   Note that xml is case sensitive and very fussy about syntax, when loading a good file to flymaster it does say success, but it says nothing if the file is malformed.
[3] To do: create a simple fsdb file generator which will work for CIMA.
[4] To do: get a better example xml file or ideally a proper fsdb.xsd file for full spec of .fsdb file format
[5] To do: investigate capabilities of .fsdb capability to display task & results – need example xml file or ideally a fsdb.xsd file
[6] Should be possible; need proper FsCustomAttribute codes to do this – need better example xml file or ideally a fsdb.xsd file
[7] To do:  Find out what happens if you download .igc files before the end of a task – do you get incomplete files of those still flying or just files from trackers which have already been switched off.
[8] Would be much better if 'download days' was aligned with local time for the event, but still won't solve the day change from 23:59:59 to 00:00:00 which some analysis programs struggle with.  The only solution is to timeshift the files from UTC to local.
[9] For a basic renamer, see CIMA flymaster utilities.xlsm

❓ It may be possible to implement a comprehensive solution to get track points almost live through the api interface via a CIMA stand-alone software which talks to the flymaster server at regular intervals and solves all these problems by building its own .igc files to exactly the CIMA specification. [10]

# lt.flymaster.net performance

It is believed the trackers transmit every 60 seconds with data in reverse order, most recent first, the idea being that if comms are poor or intermittent then at least the current position is most likely to be known for safety purposes. If comms have been out for a while and then recover, then the online database is 'backfilled' from the current position.

It is apparently not unknown to have very long delays between successful transmissions, for example flights over deep valleys where all the mobile phone antennas are looking down into the valley. In these cases all the missing track will still be transmitted once comms are re-established, eg when the pilot comes into land.

✓ If comms fail entirely, then all track data can still be extracted from a tracker fairly easily [11] after it is returned to the scoring centre via gpsDump [12] or similar compatible software.

✓ The 'real time' view of trackers is delayed by something between 4 and 4 1/2 minutes. This is for presentational purposes; even in conditions of good comms shorter delays can cause the icons to jump about simply because not all data has been received yet. It is believed that when these are used in CIVL events they require a 15 min delay for tactical reasons.

✓ It is also possible to replay single tracks or whole 'groups'. A fun example is the triangle-eco task in WPC 2018 at **https://lt.flymaster.net/?grp=2234&d=578815200** [13] (for best effect put playback --> speed to 5x)

# Tracker performance

As an relatively expensive piece of modern tech it would be nice to say the Flymaster trackers used at WPC 2018 in Thailand performed flawlessly, but in fact we were really surprised to find they did not, and in some cases pilots would have lost some score had they not also being using one or more of our proven, but old tech, AMODs as backup. Below is a number of cases identified either during flight analysis or by national teams and brought to the attention of the Director via complaint.

*All tracks noted below are available in WPC2018_flymaster_error_tracks.zip at http://wiki.fai.org/x/CQAgAg*

### Case 1; mysterious parallel track
Comp no 113, Task 4, 2 May 2018

This aircraft had one flymaster and two AMODs on board.

113T04V1R1 is the original flymaster track downloaded from server.
113T04V1R2 is the track from the pilot's secondary logger (amod)
113T04V1R3 is the track from the pilot's third logger (amod)
113T04V1R4 is a replication of R2 but loaded synthetically via memory stick through FRDL to confirm FRDL did the right thing.
113T04V1R5 is a gpsbabel conversion of the original NMEA data used to generate R2 to also confirm FRDL did the right thing.
113T04V1R6 is a gpsDump direct from the flymaster tracker

### Of note
1) R2 & R3 (green & blue in Figs 1 – 3) are very similar as you would expect from 2 different trackers on board
2) R5 is identical to R2 suggesting FRDL, our AMOD downloader, is doing the right thing.

3) R1 (red in figs 1 – 3) is equally similar EXCEPT between about 02:29:10 & 02:38:04 where the whole leg is weirdly displaced very neatly some hundreds of metres to the west. Fig 4 shows R1 relative to the task at the SW corner, Fig 5 shows R2 relative to the task in the same place. R1 misses all the gates in the whole leg whereas R2 & R3 hits them all.
⚠ Having analysed 1000's of tracks over the years we have never seen anything like this error without there being some obvious jump indicating start and finish of the error.


Fig 1


Fig. 2


Fig. 3

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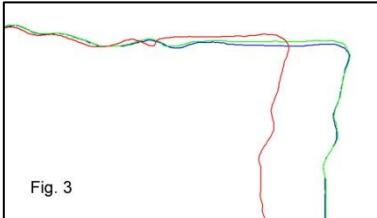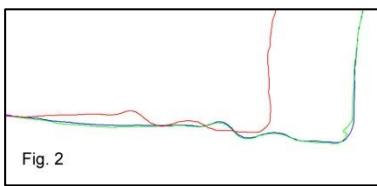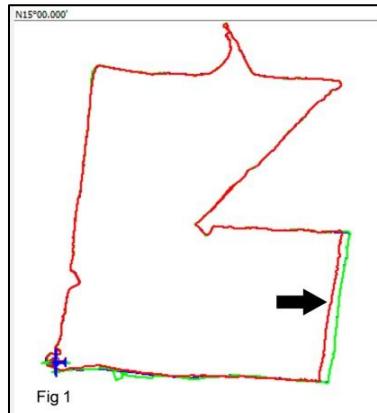
[10] To do: Discuss with Flymaster the possibility of direct access to track data via API
[11] Unfortunately gpsDump .igc output includes one line intolerable to microFlap: The date must be changed from `HFDTEDATE:300418,01` to `HFDTE300418` (where date is ddmmyy format)
[12] Get gpsDump for Windows or Mac, and usage instructions via the Flymaster downloads page https://www.flymaster.net/downloads
[13] See CIMA_Flymaster_usage_instructions for details on how to compose this url.

4) There is a misplaced track point in R1 at 03:09:47 (Fig 6) which doesn't seem to be a simple random drop-out but is very close to being on the track flown 0:4:25 before
B0305221452024N10106228EA0002200026
B0309471452024N10106229EA0002200027
This does NOT occur in R6 (Fig 7) which is the same track downloaded directly from the tracker via gpsDump;
⚠ This perhaps suggests some sort of comms or db error?
See also case 4 below

## Case 2: Split tracks
Comp No 001, Task 4, 2 May 2018

Two igc files in the same flight. The last point in the first file 001T04V2R1 is
B0119191452251N10107548EA0037400388
and the first in the second, 001T04V1R1 is
B0119221452277N10107546EA4433000392
The pilot was flying at the time.

In 001T04V1R1, the atmospheric alt is a constant 44330 which is unlikely!

001T04V1R2 and 001T04V1R3 are the same files as downloaded via gpsDump, the atmospheric alt in R3 is now a constant 44308 so the split tracks fault would seem to lie in the instrument rather than the database.

⚠ We encountered quite a few other examples of split tracks, it makes the flight difficult to analyse without stitching them together which is often a time consuming manual exercise prone to error and best avoided.

## Case 3: Lazy track
Comp No 096, Task 4, 2 May 2018

V1R1 is the original downloaded flymaster track; V2R1 is the same thing downloaded directly with gpsDump

V1R2 is the pilot's amod backup. This is incomplete, probably ran out of batteries which is a pilot responsibility. (Fig 8)

Betwee n about 02:24:21 and 02:28:16 the amod track goes further south (Fig 10) to fly straight through the first turnpoint, the flymaster tracks take a bit of a shortcut (Fig 9) avoiding the turnpoint.

After about 02:28:16 the tracks match exactly (where they exist).

## Case 4; Another spurious point
Comp No 012, Task 7, 4 May 2018

V1R1 spurious point at 05:34:39 not present in V2R1 which is the same thing downloaded with gpsDump

Although this one did not compromise analysis there is one I've seen in this event through a gate (both ways) which is the sort of thing which requires a sharp operator to spot or very good auto analysis.

See case 1 above, which demonstrates it wasn't just a problem on 2 may.

## Tracker performance conclusion
The one big unknown is where the tracker was located on the aircraft during the flight. No gps will give reliable fixes if the antenna does not have a decent view of the sky.

On the other hand, if there was poor reception then we would expect to see some indication of this in the track data in the form of:
- No data, ie a gap in the track.
- Erratic data, the fixes are in a line which obviously wasn't flown.
- Some indication in the fix validity element of each B record in the .igc file [14].
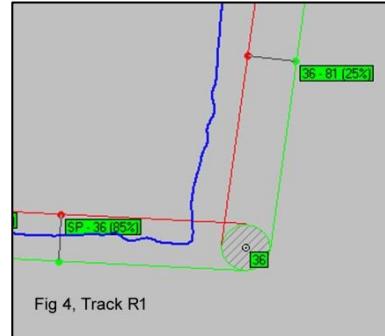


Fig 4, Track R1
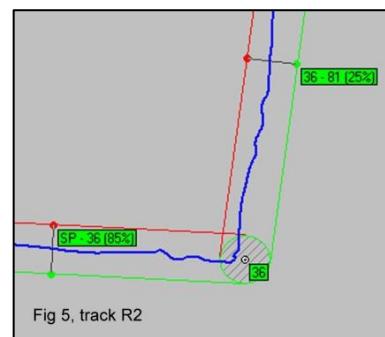


Fig 5, track R2
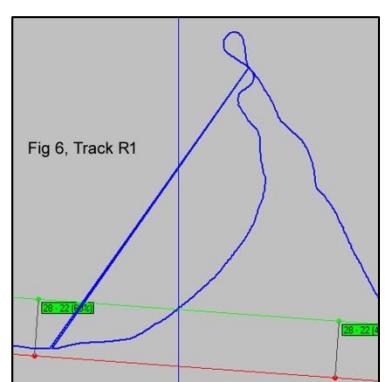


Fig 6, Track R1
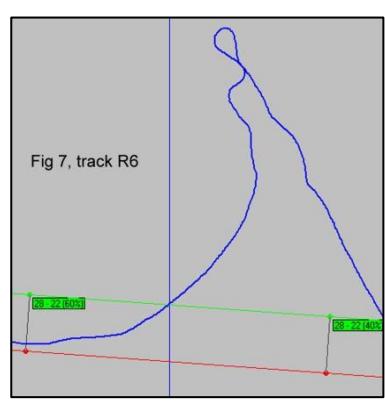


Fig 7, track R6
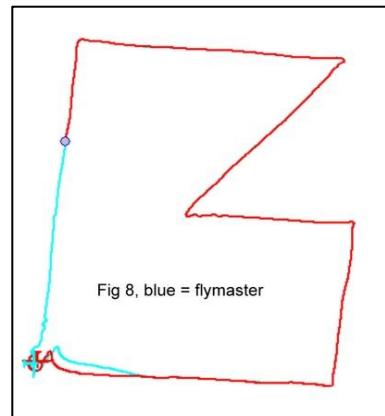


Fig 8, blue = flymaster

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[14] It is always A. The specification says: *Use A to denote a 3-D fix, V for a 2-D fix and X to denote unknown. Where data in NMEA format is used within the FR, in the GSA sentence (DOP and active satellites), put A in the IGC file for GSA mode 3, and V for GSA mode 2.*

We don't see any of these in the cases quoted above which should mean there is always a good signal, in which case the mis-placed tracks are like that for some other reason.

With the AMOD we can delve much deeper into what the device had been doing because it saves all the NMEA output by the GPS engine to the extent of several sentences per second which includes a mass of data like which satellites it is using


Fig 9; V1R1 Flymaster


Fig 10; V1R2 AMOD

at that moment and allows for a much more forensic analysis, but so far as we know this is not possible with the Flymaster tracker so one can only guess the reasons for these positional inaccuracies.

One thing that could be happening is track prediction. This is a very sophisticated feature of some gps engines designed to still create a track synthetically in poor or no reception conditions. Classically, it is how your gps still seems to know where it is even in an 'urban canyon' of a city where a view of the sky is very restricted, or how your gps still works as you drive through a short tunnel.


Fig 11, track from db

⚠ This was identified by IGC many years ago as a prohibited feature in any of their approved flight recorders because it not only gives a false record, it can also be exploited as a method of cheating. CIMA has similar wording in S10 Annex 6.4.1

It is difficult to say if case 1 is caused by track prediction, in fact it is difficult to imagine what case 1 could be caused by, but in case 3 it seems rather likely.


Fig 12, track from instrument

⚠ To be able to score any kind of competition reliably then in poor reception conditions we must have no track or an erratic track rather than a nice smooth fake one. The former serves as a lesson learnt by the pilot to make sure his tracker is positioned properly in the aircraft, the latter only serves to undermine confidence in the whole system.

In case 2, split tracks, it is possible to imagine that because the GPS alt was being recorded consistently at something over 44,000 metres there was very poor reception, but this doesn't explain why the first track seems reasonable, or that it almost exactly joins up with the first fix of the second track only a few seconds later.

The spurious points in cases 1 and 4 are clearly a db data error of some kind because they are not evident in a direct download but they could compromise auto-analysis in the case where they pass through a scoring point.
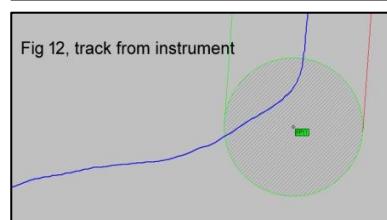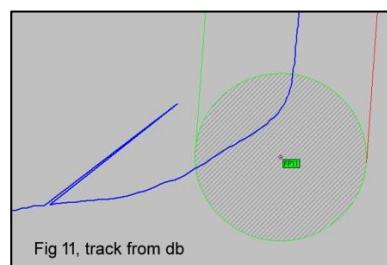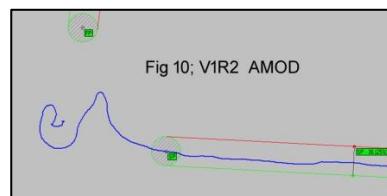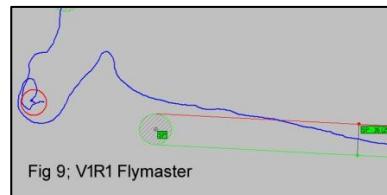
# Overall conclusion

✔ The idea of transmitting live data is highly attractive; of course you have the live displays and all that stuff but it's still only half useful unless the viewer can also see who's winning at any given moment. But imagine a kind of pump pushing this data in near real time from the flymaster servers, through the online version of microFlap, and then into Nayot's new google sheets scoring system – suddenly you have the possibility of a really compelling solution to those hours of waiting for a task result.

Whilst there are financial and logistical implications in using these trackers, especially to the already hard-pressed competition organizer, if the system was good enough then I am sure these would be surmountable, but if we get errors of the type described above, things could actually be worse; ultimately garbage in = garbage out; and in some cases we did get garbage out compared to what we have been using for years.

⚠ I hope Flymaster will be able to solve all these problems but in the meantime I must say I find it difficult to recommend this system as a mandatory requirement for future microlight & paramotor championships.

They could be used – at their own risk – by pilots in CIMA sanctioned championships, but first, someone would have to put together a system which will reliably and easily deliver tracks for each task to a competition director in a form which meets the CIMA specification as laid out in S10 Annex 6.