2014 CIVL PLENARY – ANNEX 24A
SOFTWARE WORKING GROUP PROPOSALS

1. GPS distance measurements

1.1 Proposal

1. Change Section 7 in its entirety, including all annexes and referenced rule documents, to the effect that the only earth model used for distance measurements within CIVL is the FAI sphere.
2. Include the following text in "CIVL GAP", the scoring documentation for centralized cross country competitions:
   "As of January 1st, 2015, all distance measurements and airspace validations are based on the FAI sphere. From then on, it is each pilot's responsibility to use an instrument that indicates distances to relevant features (such as turn points or airspace boundaries) based on the FAI sphere, or to adjust their flying to compensate for the differences in distance calculations between different earth models."
3. In "CIVL GAP", reduce the tolerance for turnpoint cylinders to 0.01% of the cylinder radius, with a minimum of 1m.

1.2 Background

Calculating the distance between two points from their respective coordinates depends on the assumed shape of planet Earth. Two options are commonly used: A sphere, or an ellipsoid. Depending on which model one uses, calculated distances may differ quite a bit.

After a period of confusion caused by CASI (FAI Air Sport General Commission), it is now once again up to each Airsports Commission (like CIVL) to decide which model is best suited for their sport.

Within Section 7, only S7D - Records and Badges defines this:
S7D 5.2.1 Measurement of distance: For all records and for badge flights, distances shall be measured by GPS or approved flight data recorder. In this case, the GPS datum used shall be WGS84 and the earth model shall be the WGS84 Ellipsoid. See General Section 7.3.1.1.

No indication is given in S7A or S7B as to which model should be used.

Common practice within CIVL so far has been to allow both models, for practicality's sake, given that both are used by different instruments in use by pilots. The potential difference between the two models was noticed early on when GPS was introduced, and dealt with by the 0.5% tolerance found in Section 7A and 7B, 15.3.2.

FS, our official scoring software, implements the FAI sphere and applies the 0.5% tolerance to all measurements, PG and HG.

Of the instrument and/or software manufacturers known, all except one implement the FAI sphere: Flytec/Bräuniger, Aircotec, DigiFly, Compass (C-Pilot), LK8000, XCSoar…
The exception is Flymaster: they implement the WGS84 ellipsoid, but changed their implementation as a result of our discussion; their newest firmware can now use either the ellipsoid or the FAI sphere.

On the other hand, all general purpose GPS receivers, most prominently Garmin products, use the WGS84 ellipsoid.

1.3 Problem

Allowing both WGS84- and FAI-sphere-based instruments in our competitions, and giving the necessary tolerance for turnpoints to accommodate for this was no big problem as long as cylinder radii used in competitions were only a couple hundred meters long. But with the big cylinders used nowadays, differences between those two earth models add up to several hundreds of meters, providing a potentially unfair advantage to pilots with the “right” instruments and a deeper understanding of how FS distance calculations work.

Because the FAI sphere is the model specifically created for us, and supported by all the relevant instruments, this is what we should use exclusively, to be able to increase the precision of our task evaluation and along with it increase fairness for our competition pilots.

Pilots still wishing to compete with GPS receivers that were not built for flying can continue to do so if they take into account the fact that they may have to adjust their flying, and that the distance shown by their device may indicate having reached a turnpoint, or being clear of airspace, when in fact, according to the FAI sphere, they are not.

If we mandate the FAI sphere for competitions, it is only logical to also use that model for all record and badge flights as well. This way distances achieved during record or badge attempts become directly comparable with those achieved in competition flights, and airspace boundaries are identical for all flights.

2. GPS altitude measurements

2.1 Proposal

Include the following text in section 4.3 of “CIVL GAP”, the scoring documentation for centralized cross country competitions:
“As of January 1st, 2015, all GPS altitude calculations must be based on the Geoid. From then on, only instruments and software releases which base their altitude calculations on the Geoid (‘MSL’) are permitted in FAI Category 1 competitions.”

2.2 Background

Similar to distance, there are also two models on which GPS altitude is calculated: The WGS84 ellipsoid (again!) and a thing called the "Geoid", which is an even more accurate representation of the earth’s shape.

Regarding altitude measurement, the FAI Sporting Code General Section states:

SC GS 7.3.1.5 Altitude. Methods for the measurement and checking of altitude are determined by the FAI Air Sport Commission concerned. These may be by the use of calibrated barographs, flight recorders (including those recording GNSS fixes as well as pressure altitude), sighting frames, observation aircraft, or ranging radar.

GNSS = Global Navigation Satellite System - for example GPS.

Note that the General Section does not mention the model to be used.

Right now, in CIVL we use whatever the instruments give us. As Mark Graham determined a few years ago, instruments are split nearly 50/50 between ellipsoid- and geoid-based altitude calculations (see http://www.xcmag.com/wp-content/uploads/2011/07/GPS-Altitude-Table.jpg).

Depending on where you are on the globe, differences between those two can be up to 100m. In most parts of Europe, for instance, it's about 60 or more meters (http://www.esri.com/news/arcuser/0703/graphics/geoid3_lg.jpg). So two pilots flying at exactly the same altitude may be evaluated as 100m apart in altitude based on what instrument they use (not even thinking about GPS accuracy!).

This can be troublesome if we use GPS altitude to determine whether a pilot was or was not in violation of airspace rules. This is now becoming even more troublesome since we will be relying much more on GPS altitude for the Final Glide Decelerators introduced in Paragliding competitions.

According to Flytec, all GPS modules in use worldwide always return the altitude based on the geoid, along with the correction necessary to achieve the ellipsoid value. So changing the implementation to a unified standard across all instruments should be relatively straight forward. Still, for some older instruments, manufacturers may choose not to do it, and we will have to exclude those instruments going forward.

2.3 Implementation

Once the rule is in place, CIVL informs the major instrument manufacturers of this change, and asks them to provide a firmware release number from which onwards the altitude calculation is based on the Geoid. This information is made public on CIVL's web site and should be referred to by the local regulations of all CIVL cross-country competitions in the following 2 years.

As an additional measure, a check can be built into FS, to verify that a submitted tracklog comes from a valid instrument or software.

3. Altitude correction with "True Altitude"

3.1 Proposal

For paragliding, modify section 4.3 (Altitude) in "CIVL GAP", the scoring documentation for centralized cross country competitions, from

"Altitude evaluation is based on GPS altitude, as given in GPS tracklogs."

to

"Altitude evaluation for ESS validation and altitude bonus calculation in stopped tasks is based on a combination of barometric altitude information and GPS altitude, both as given in GPS tracklogs. The algorithm by which the two altitude data streams are combined to a calculated "true altitude" is given in [Dimov 2013][1]. To score tasks taking into account the calculated true altitude values, a score keeper must either pre-process the raw tracklog files with the software published by Daniel Dimov, or, if supported by the scoring software, use the built-in functionality of the scoring software to the same effect."

3.2 Background

In his paper as well as in his presentation to the 2013 Plenary, Daniel Dimov demonstrated how the accuracy of altitude measurement can be significantly improved by combining barometric with GPS altitude information. He developed an algorithm that calculates a "true altitude", using the best characteristics of both altitude data streams available in modern instruments' tracklog files.

[1] [Dimov 2013]: Dimov, Danie: „True Altitude calculations"; 2013

In paragliding competitions, having accurate altitude information with little spread between different instruments or pilots is becoming increasingly crucial. The altitude bonus in stopped tasks, introduced in 2011, was the first time where altitude values from track logs became relevant to the distribution of points. This is now even more pronounced with the proposed introduction of Final Glide Decelerators, where altitude plays a major role in awarding points to pilots. Therefore, we must use the best technology available to ensure that pilots get awarded points for their flying achievement, and are not punished by uncontrollable technical inaccuracies.

For airspace validation, we must continue to use the currently standard GPS altitude: This is the value a pilot sees on the screen while in flight, the value he adjusts his flying to. He must be able to rely on this figure, and not suddenly find himself punished for airspace infringements based on a calculated value he had no way to evaluate himself while in the air.

3.3 Implementation

Once this rule is in place, the Software Working Group will incorporate Daniel's algorithm in FS and make its use a configuration option for competitions. Until this is the case, his own reference implementation can be used to pre-process all downloaded tracklog files before processing them with FS for the actual flight evaluation and scoring.