



Assessment of the Implementation of GNSS into Gliding

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Abstract

Global navigation satellite systems are increasingly part of our lives and many industries including aviation. Glider flying is no exception in this trend. Global navigation satellite systems were part of gliding since the early 1990s. First as official recording devices for simple evidence of sporting performances, then as navigation systems, anti-collision systems and emergency location transmitters. Development of recording application was initiated and supported by International Gliding Commission of World Air Sports Federation in way of certifications for flight recorders. The use of navigation and other modern instruments in gliders has brought many benefits but also risks. However, the advantages outweigh the disadvantages and these systems are now integral part of gliding. With this wide usage of global navigation satellite systems devices, there is great many possibilities how and in which way one can use these systems. Pilots must orient themselves in varied selection of products, which they can use to choose one solution, that fits him. Therefore, to find out how and if pilots use these devices, we created questionnaire survey among 143 Czech glider pilots. We found out, that 84% of them are using global navigation satellite systems devices for official record of flight and for navigation as well. More than half of pilots is using free, not built-in devices. Most common devices are mobile phones up to 5 inches of screen diagonal in combination with approved flight recorder without display. If pilots use mobile device for navigation, 52% of them is using one with Windows Mobile operating system, 33% use Android. Navigational software on these mobile devices is then almost tied between SeeYou Mobile, XCSoar and LK8000. Knowledge about usage preference of global navigation systems devices should help pilots with selection and overall orientation in subject.

Keywords

Flight recorder — Gliding — GNSS — Navigation — Soaring

1. Introduction

Global navigation satellite systems (GNSS) are nowadays an integral part of many industries. Despite primary military purpose, these systems have evolved into an indispensable means of positioning for civilian sphere. GNSS

applications are used not only in transportation (road, rail, aviation and maritime), but also in telecommunication, geodesy, agriculture, mining and ecology. The market for GNSS related products is constantly growing. It is expected that around 3 billion GNSS signal

receivers will be in use by 2020 [1]. Satellite navigation is becoming part of the everyday life of many people. With continually increasing accuracy, reliability and availability of GNSS, its usage in civil aviation itself is being stepped up. This is also being supported by development of new global and regional navigation satellite systems and augmentation systems [2, 3].

In the specific conditions of gliding, the various GNSS applications nowadays has a considerable share. The World Air Sports Federation (FAI) has appointed the International Gliding Commission (IGC). The IGC saw the potential of GNSS and actively encouraged its introduction into gliding. The main benefit of GNSS that IGC saw was position record capabilities of GNSS devices. Previously, the sailplane races and tournaments needed considerable personnel to check the passage of the turning points by pilots. The effort to simplify organization and reduce organizational difficulty of the world championships was one of the first impulses for the development of GNSS recording equipment. First commercial gliding recording device was made in 1992 by RD Aviation Ltd., UK. Following the successful implementation of GNSS recording equipment, the Commission began issuing technical requirements for these devices and set up the approval process. First recording device approved for the world championship in 1995 was Cambridge Model 10. The unification of these devices has taken place. IGC approved flight recorders (FR) are used for most route flights, either as a proof of sport performance or as a record for flight evaluation. There are currently 58 IGC-approved GNSS flight recorders from 20 different manufacturers. 41 of them are currently in production [4].

GNSS record can also be obtained from commercial off-the-shelf devices like smart phones, tablets, PDAs, car navigations and others. However, these devices do not have any IGC certification, so record made by them can only be used for flight evaluation and the devices itself for in-flight navigation purposes [5]. There is a great variety of software solutions for these applications. They range from freeware community projects (for example XCSOAR navigation software for Android phones) to paid professional programs with yearly fees (like SeeYou Mobile) [6].

Other possibilities for using GNSS in gliders are reducing the risk of collision with another glider (FLARM) and emergency location transmitters (ELT) of international Cospas-Sarsat system [6].

The introduction of GNSS in gliding can be clearly evaluated positively. Benefits are here for both racing and recreational pilots. Between benefits are simple proof of flights from IGC approved FRs, the possibility to evaluate these records (and ones from non-approved recorders) to improve performance of the pilot. Simplification of navigation and related time saving, which the pilot can

devote to other activities such as observation of neighboring aircraft, planning of the weather-related strategy and piloting itself is advantage as well. Together with more precise navigation (for example in the case of out-landing – the pilot can tell the transport team his or her exact location over the phone), calculations performed by the GNSS instruments (glide ratio, glide distance, distance to nearest airport, average line speed, ground speed, etc.), flight planning and declaration (flight can be easily planned and declared from a computer with the appropriate software or, in the case of more modern and sophisticated GNSS devices, directly on the device) and increased safety (FLARM and ELT) it generally improves pilots experience.

The races, cross-country flights and their recognition to get FAI performance badges are then chapter for itself. In the past, the pilot had to carry a large barograph on board, which recorded height and time with a needle that drilled the data into soot paper (achieved by smoking the paper over mix of kerosene and naphtha). The record paper was removed after flight and immersed in a container with varnish to avoid smudging. In addition, there was a need for, at that time, heavy cameras, with which pilots photographed turning points. On some races, there was even need for judges to stand at turning point locations and mark registration marks of gliders. All these difficulties faded away with the onset of GNSS devices.

There are not many negatives in the introduction and utilization of GNSS devices to gliding. But even here we can find some complications and difficulties such as inadequate trust and reliance on GNSS by pilots. The pilot could blindly accept data from the device and not realize that they can be totally erroneous, which can lead to fatal consequences. The necessity for another battery in the aircraft and its complex fixed frame. Heavy unfixed object as a battery in the aircraft out of reach of the pilot could be dangerous (even with gel batteries with no risk of spillage) in turbulence. With this goes the necessity for cable and antenna installation. Whether it is a built-in or free GNSS device, it is always advisable to make a firm installation of cables and antennas. Installation of the built-in device itself (including its connection to air pressure sensors) and other instruments positioning could prove difficult as well. Purchase of GNSS device and all peripherals is not a cheap matter, price could range from €350 to €5050 [6].

It could be argued that a significant disadvantage of GNSS devices is the possibility of falsifying a flight record (whether for on-line contests or FAI badges and diplomas). However, it is not easy to fake files from certified IGC FR. Each IGC approved recorder has its own pressure barometer and other physical and electronic security mechanisms. To simply simulate GNSS position is just not enough to successfully forge an IGC record

file [6, 7]. GNSS devices are indisputably part of gliding. However, it is a question for what purpose and in which way are they mainly used by pilots. Therefore, we created questionnaire survey among Czech glider pilots.

2. Materials and Methods

2.1 Questionnaire survey design

The questionnaire, consisting of 6 multiple choice questions, was focused on obtaining a basic overview of the use of GNSS devices by glider pilots in Czech Republic. The survey was focused on use directly in the aircraft (navigation and IGC record). The survey has been created in electronic form (Google Forms) and was accessible from 1.12. 2015 to 26.1. 2016.

2.2 Participants

The survey has been sent to the pilots, that the author has contact with. They were also asked to distribute the survey in their aeroclub. It was also placed on Czech forum for glider pilots.

From Czech national gliding competition online contest website (see <http://www.cpska.cz/>) of the Aeroclub of the Czech Republic we can see, that 860 pilots have added at least one flight into the competition in 2015. This number can be taken as the number of pilots, who are active and actively fly cross country flights (which is a group of glider pilots, that interests us). CPS does not only serve for competition purposes, but also as a flight database and as a tool to compare performances throughout the year. Of those 860 pilots, about 200 of them have added only one flight. 143 pilots responded to survey, which is approximately 16.63% of all 860 pilots we are interested in.

2.3 Data analysis

It is appropriate to indicate to what extent the real values are likely to be correspond with this survey. The confidence interval is used for this calculation. The calculation cannot be done for the survey as a whole, but it must be done for each answer of each question separately.

Therefore, we use the two-sided confidence interval for the fraction π using equation

$$\pi \in p \pm \sqrt{\frac{p(1-p)}{n}} z_{1-\frac{\alpha}{2}}, \quad (1)$$

where p is the probability of success or the number of successes in the selection (in our case, the percentage fraction of answers in the question), n is total number of answers for that question, z is the critical value and α is the level of significance. We use the double-sided 95% confidence interval. Thus, the level of significance will be equal to 0.05.

$$z_{1-\frac{\alpha}{2}} = z_{1-\frac{0.05}{2}} = z_{0.975} \quad (2)$$

We find critical value for $z_{0.975}$ in the statistical tables for normal distribution equal to 1.96. Now it is possible use values from individual survey questions and fill them into the equation (1).

3. Results

Figure 1 shows that 42% of the participants answered that they fly on their own aircraft and 58% on aeroclub aircraft.

In figure 2 we can see that 84% of the participants answered that they use GNSS devices for IGC record and navigation purposes, 6% then only for navigation, 7% just for IGC record and 3% stated that they do not use GNSS devices at all.

Figure 3 shows that 57% of participants answered that they use free device, 29% stated that they use built-in and free device together and 14% only built-in device.

Figure 4 displays that 30% of participants replied that they use mobile phone, tablet or PDA up to 5 inches of screen diagonal, 11% with screen over 5 inches. 24% stated that they use IGC approved FR with display and map support, 18% IGC approved FR with display, but without map support and 17% stated that they use IGC approved FR without display. For better clarity, table 1 states the combination of answers.

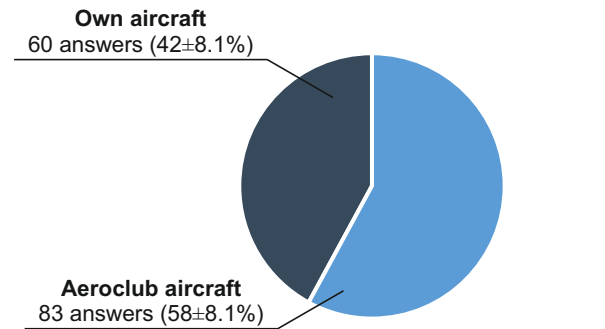


Figure 1. Questionnaire results for question 1 (Do you fly on your own aircraft or on an aeroclub aircraft?)

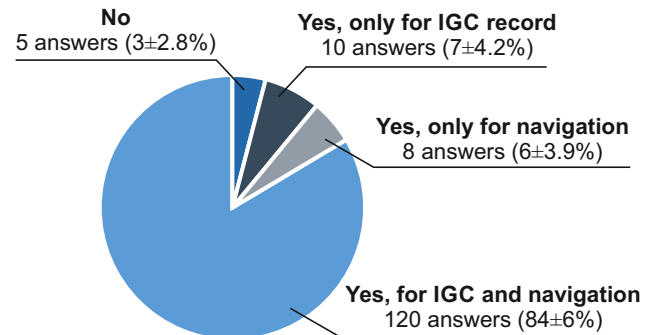


Figure 2. Questionnaire results for question 2 (Do you use GNSS devices?)

Table 1. Combination of answers to question 4 (What type of GNSS device do you use?)

Combination of device types used by pilots	Answers
Without display (IGC approved FR)	8
Without display (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	16
Without display (IGC approved FR), Mobile phone, tablet or PDA over 5 inches	4
Without display (IGC approved FR), With display and map support (IGC approved FR)	2
Without display (IGC approved FR), With display and map support (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	2
Without display (IGC approved FR), With display, but without map support (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	3
Mobile phone, tablet or PDA up to 5 inches	16
Mobile phone, tablet or PDA over 5 inches	8
With display and map support (IGC approved FR)	26
With display and map support (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	9
With display and map support (IGC approved FR), Mobile phone, tablet or PDA over 5 inches	7
With display, but without map support (IGC approved FR)	10
With display, but without map support (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	17
With display, but without map support (IGC approved FR), Mobile phone, tablet or PDA over 5 inches	3
With display, but without map support (IGC approved FR), With display and map support (IGC approved FR)	3
With display, but without map support (IGC approved FR), With display and map support (IGC approved FR), Mobile phone, tablet or PDA up to 5 inches	1
With display, but without map support (IGC approved FR), With display and map support (IGC approved FR), Mobile phone, tablet or PDA over 5 inches	1

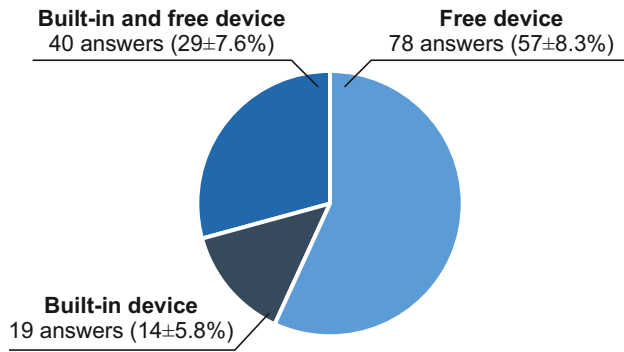


Figure 3. Questionnaire results for question 3 (Do you use a built-in GNSS device in the aircraft?)

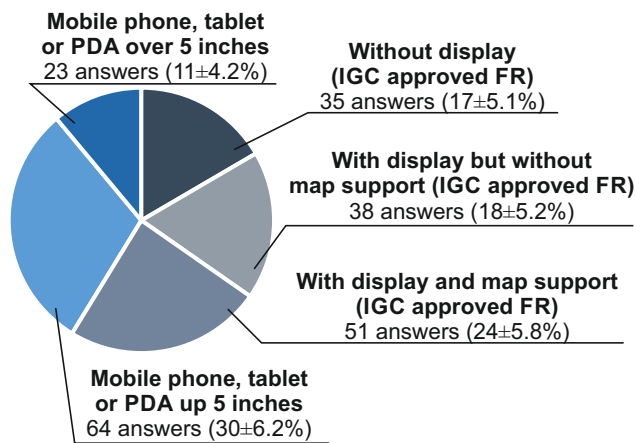


Figure 4. Questionnaire results for question 4 (What type of GNSS device do you use? - multiple choice)

It can be observed in figure 5, that if pilots use mobile device in the aircraft as a GNSS navigation, they use in 52% Windows Mobile operating system and 33% Android. 4% is then for usage of iOS, 3% Windows CE, 3% Windows Phone, 2% Linux and 3% for others.

Figure 6 shows, that 34% of participants use SeeYou Mobile software if they use mobile device in the aircraft as a GNSS navigation, 32% use XCSoar, 28% LK8000 and 6% some other software solution.

4. Discussion

In the first survey question (see Fig. 1) the pilots were asked whether they fly primarily on their own private aircraft or on aeroclubs aircraft. There may be a difference in usage of GNSS devices between these two groups. Pilots who can afford their own aircraft from the financial point of view will probably be able to afford even more sophisticated and more expensive (and built-in) devices. Aeroclubs usually buy basic devices for IGC records (FR without a map and even without display). This is due to the lower cost of these devices and unwillingness to invest

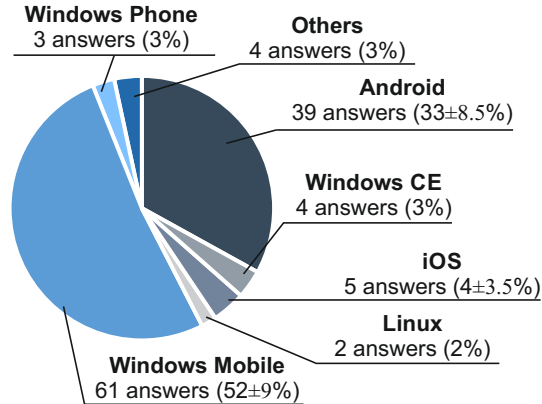


Figure 5. Questionnaire results for question 5 (If you use a mobile device in the aircraft as a GNSS navigation, what is the operating system of the device?)

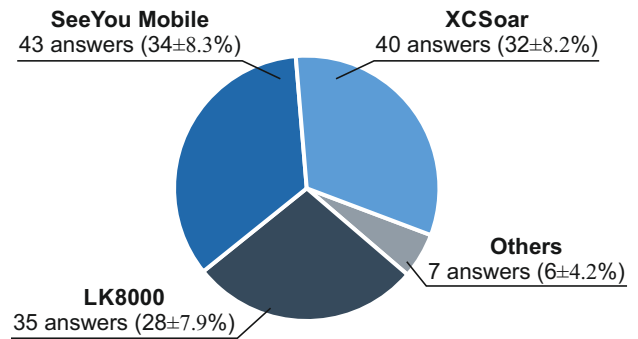


Figure 6. Questionnaire results for question 6 (If you use a mobile device in the aircraft as a GNSS navigation, what navigation software do you use?)

into device (and aircraft) in common use and ownership. Such aircrafts and their equipment are more liable to damage and accidents. Most people simply value and care for the things they own more than those they do not. From the results of survey is apparent, that we have quite balanced representation of both groups.

The second question (see Fig. 2) asked pilots if and how they used GNSS devices. It is the key question of the whole survey. 84% of the pilots answered, that they use GNSS devices for IGC record and navigation. From this answer, we can safely assume, that the pilots are indeed trying to take full advantage of GNSS devices.

The third question (see Fig. 3) asked if pilots use built-in or free device. There is significant difference in comfort of usage between these two types. And of course, in price. Built-in devices are simply made to be used comfortably in gliders, a lot of free ones is not. 57% answered free devices. It is not surprising, because they are cheaper and if one personalize his devices, they can be used to similar level of comfortability as built-in ones.

Question 4 (see Fig. 4 and Tab. 1) asked what type of GNSS devices pilots use. Pilots could choose multiple answers. 28 pilots stated, that they use IGC approved FR without display and 20 of them in combination with mobile device (either over or below 5 inches of screen diagonal). It is not surprising, because pilots want to use all advantages of GNSS devices and with FR without display, they could use only one. This combination is also the cheapest one. Next big group of 20 pilots stated, that they use IGC approved FR with display, but without map background, in combination with some mobile device. FRs with display offer basic navigation, nevertheless the map background is important for overall orientation and overview (active restricted airspaces, close alternate airfields, etc.). It is therefore reasonable to supplement these devices with some other cheap solution with map. The mobile device itself then uses a total of 24 pilots. The question is to what extent they have correctly understood the question, because the answers of some of them are inconsistent. For at least part of them we may assume, that they use IGC approved FR as well (with or without display). From all the mobile devices, ones with display up to 5 inches diagonal are dominating. It is more frequent choice probably because they are more compact (positive trait in small glider cabin) and cheaper. 51 pilots stated, that they use approved FR with display and map background in combination with anything else. It is the most expansive and the most comfortable solution. When compared to question 1, we find, that 28 of these pilots are using their own aircraft and 23 aeroclub aircraft. It is a surprisingly narrow result.

Question 5 (see Fig. 5) asked the pilots what operating system use their mobile device they use in airplane (if they use one). With 52% the Windows Mobile is the most used operating system. From this result, we can deduce, that most of these devices are PDAs or PNAs. Because windows mobile had market share on mobile phones only 3% as of 2011 already [8]. But it still is a popular solution for PDAs and PNAs. These devices are often cheaper than mobile phones. Their usage for glider flying is also better because of battery and all around wear of device when used for flying. Constant connection to power supply, direct sunlight, high differences in temperature (on the ground before take-off very high and at high altitudes under cloud they can be under 4°C) is something most of the pilots do not want their pricy mobile phone to endure. Second largest group is Android. It is the most widespread operating system for mobile phones and tablets. There are plenty of devices on the market with this operating system, including those with a good enough GNSS chip, antenna, good readability in direct sunlight and other features suitable for GNSS navigation in the glider. The price range is vast, from €50 to €1050.

The last question (see Fig. 6) of the survey asked pilots what navigational software they use if they use

mobile device. Here the results appear balanced. Each of these navigation programs has its own approach to displaying information, user environment and input. LK8000 and XCSOar are independent community projects and are free of charge, SeeYou Mobile is, on the other hand, a professional paid program. When we combine answers from question 5 and this one, we can find out, that 26 pilots use Windows Mobile and LK8000 and 27 use Windows Mobile with SeeYou Mobile. Android and XCSOar stated together 29 pilots.

Presented numbers give us a basic overview about how glider pilots use GNSS devices on board.

5. Conclusion

Presented paper shown brief introduction to possible applications of GNSS in gliding. The most notable ones are IGC records and navigation. Others are records for flight evaluation, FLARM and ELT. It also summarizes advantages and disadvantages of implementation of GNSS into gliding. This study has been focused to questionnaire survey of usage of GNSS instruments among glider pilots. We analyzed how, in which way and why pilots use stated solutions.

This article could be used by glider pilots who are not sure if they should use GNSS devices or do not know what are their possibilities. We found out, that many pilots use multiple GNSS devices at a time. Our results could be used by manufacturers to identify shortcomings of their products.

The study is limited by rather small number of participants. The survey is not the most accurate as we can see from the results, but it is sufficient enough. To achieve these results one would need more precise study with more participants.

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