Part 5: System Selection and

Practical Satellite Navigation

In the previous articles the (im)possibilities of satellite navigation systems were discussed. Some readers might have wondered why it is important to have this knowledge. In this article I will try to discuss the selection of receivers based on a number of possible applications. Global knowledge of items discussed in the previous articles is necessary to fully appreciate this article.

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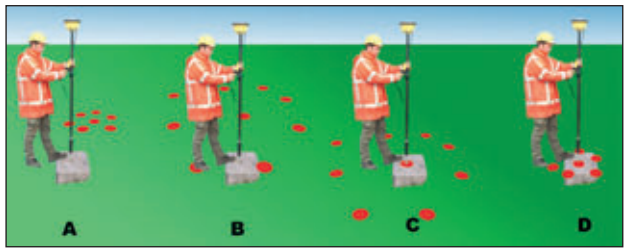


Precision and Reliability.
A. High precision; low reliability
B. Low precision; low reliability
C. Low precision; high reliability
D. High precision; high reliability

Receiver Characteristics

Before discussing the specifics of the receivers and how to select the correct one, it is wise to take a step back. Every application of course requires certain receiver characteristics. But actually there is usually a more fundamental question underlying this choice, for example a certain precision requirement for the derived position. But also whether measured positions can be stored, whether (external) power supply is available and if we need the measurement in real time.

Ultimately we are looking for the cheapest solution that will fulfil the requirements of our application. The examples in this article are chosen to be as generic as possible, but can as a result deviate from specific applications. They are therefore meant only as an indication: every user will have to determine for himself if the specifics mentioned are applicable for his application.

Table 1 gives an overview of possible GPS applications and the specifics deemed important for these applications by the author. The various columns in the table will be explained throughout the article.

Precision, Reliability and Availability

The choice for a specific type of receiver is often based upon the required precision and reliability. Precision is usually defined as the average deviation (standard deviation) in meters from our average position as found when a large number of measurements is averaged. The reliability can be defined as the difference between our averaged position and our true position. These definitions are often used in statistics when determining the 'accuracy' of our position.

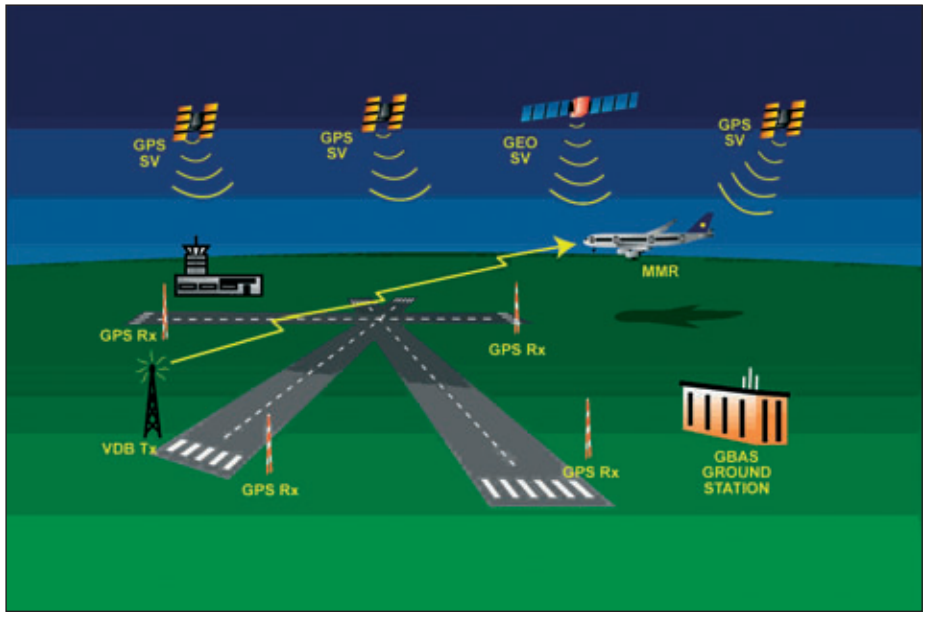
Next to accuracy another important element in our measurement is the availability of our positioning system. When, for example, we are attempting to land an aircraft it is useful to have 100 per cent availability or at least know that it is not available (integrity). Precision and reliability are thus a geometric accuracy while availability is a time-determined factor.

In reality 100 per cent availability is never achieved, but for landing an availability of over 99 per cent is usually required. For a large number of other applications a (short) outage of the signals will not pose a problem, so a lower availability is reasonable for these applications.

Channels and Frequencies

The number of channels determines the number of satellites a receiver can track simultaneously. In the past one could differentiate between so-called multi-channel, sequential and multiplexed receivers. The latter two date from the time when GPS chipsets and radio receivers were expensive. Now they are almost obsolete. All current receivers can receive up to 50 GPS (and Glonass) channels simultaneously.

The number of channels is not synonym with the number of satellites that can be tracked; this depends on the number of frequencies that need to be received. A combined L1 / L2



The use of dGPS in aviation is complicated and usually consists of a combination of WAAS / EGNOS and a local reference station (source: www.eurocontrol.fr).

Applications

When operating under these circumstances a watertight and robust receiver is essential.

receiver uses two channels per satellite. When, in the future, a third frequency is added (L5) this would require a channel of its own for each tracked satellite.
The advantage of receiving multiple frequencies, as made clear in previous articles, is the option to determine the ionospheric and tropospheric errors. These receivers will, as a rule, give better results. Furthermore almost all so-called carrier phase systems use two frequencies during initialization.

Differential Reception
In the previous article it was shown that there are two basic types of differential techniques, code phase dGPS and carrier phase dGPS. The former will deliver a precision of up to several decimeters in the horizontal, the latter a precision of centimeters in all three dimensions. This makes carrier phase dGPS extremely suitable for applications where accurate height measurements play an important role, such as surveying. When selecting a dGPS system, the method used for transmitting the corrections plays an important part. There are for instance free of charge WAAS / EGNOS (w) corrections (see also previous article and the table on page 57) that can only be received with a suitably equipped GPS receiver. A next step could be a, usually paid for, code phase dGPS service (d). But a RTK carrier phase system (r) with a reference station is amongst the options as well, especially when operating in out of place locations. The choice for a differential system will therefore usually depend on the required precision on one hand and on the other on the available budget and infrastructure.

Receiver

With the receiver we mean the box itself. This seems trivial, but weight and size play a large role in many applications. A receiver for position determination during hiking should for example be as small and lightweight as possible. Some receivers are equipped with an integrated, internal antenna (i), while some others can be connected to an external antenna (e). The latter is important for receivers that are installed in enclosed spaces such as aircraft and ships.

Under these circumstances high accuracy and reliability are highly important.

Two land surveyors using RTK backpacks and separate GPS antenna.

Furthermore the power supply is important. Do we need an internal battery (i) and if so, how long does it perform on a single charge? Can we also couple an external power supply (e) to the receiver? Finally robustness should be mentioned. Receivers that need to operate under all circumstances need to be dust- and watertight as well. But extreme temperatures can cause problems such as overheating during prolonged use and the receiver selected must be able to withstand these.

User Interface and Display

These are perhaps the most important criteria when purchasing a system. If we want to employ the receiver in the most economical way, a simple method of operation (s) is highly important so that the user will get acquainted with the system as fast as possible.

A simple way of operation however is not synonymous with a limited functionality. It is more a matter of logical placement of buttons, menu options and such. For receivers that are to be used outside, a good readability of the screen is important. These systems should perform well under circumstances with bright sunlight (and the accompanying use of sun glasses). And finally, it must be possible to operate the system with (fingerless) gloves if it is to be used in cold environments.

Experienced users will need a system that – next to a simple operation – has a wide variety of customizable settings (c) so that they can adapt the receiver to the demands of the project.

Some receivers are of the black-box type and can only be programmed using an external computer. This can cause practical problems, especially if the accompanying software uses a so-called hardware key (dongle). Most users will, for this reason, prefer a receiver that can be operated without further hard- and / or software other than required for the application. However for applications where a large number of, untrained, operators use the system a black box type receiver can be an ideal solution.

Ports and Storage

Depending on the application a number of communication ports (p) or an internal data storage can be needed. A common protocol for data transmission to other equipment is the NMEA 0183 protocol. This protocol consists of a hardware and message specification and was conceived in the maritime sector.

Furthermore most manufacturers use their own specific data messages that can usually contain more information. However not all software is capable of using these protocols. For some applications, such as a GIS, a receiver that can transfer data in a number of formats is required.

When considering data storage, a large number of solutions is found as well. Most receivers capable of storing data have an internal memory (i). Next to that, memory cards are in wide use. There are several types of memory cards, but most modern receivers employ the same types of cards as found in digital cameras and MP3 players.

Conclusion

It should be clear from the previous paragraphs that every application has its own specific receiver demands. And even though only an impression of certain specifics is given, it should be clear that there are many possibilities. Every user therefore will have to determine which characteristic is more important for his application.

Application	Horizontal precision	Vertical precision	Reliability	Availability	Number of channels	Number of frequencies	DGPS reception	Antenna	Power supply	Size	Weight	Robustness	User Interface	Display	Communication	Data Exchange
Recreation	-	-	±	-	-	1	(w)[1]	i	i	+	+	+	s	±	-	-
Car	-	-	±	±	-	1	(w)[1]	ie	ie	+	±	±	s	+	-	-
Shipping	±	-	±	+	-	1	wd	e	e	-	±	±	s	±	p	±
Aviation	±	±	+	+	±	2	wr	e	e	-	±	+	s[5]	±[5]	p	±
GIS	±	±	±	±	±	1	w	i(e)[2]	i	+	+	+	s	+	i	+
Land survey	+	+	+	±	+	2+	r	i(e)[2]	i(e)[3]	±	+	+	c	±	i	+
Hydrography	+	+[4]	+	±	+	2+	dr	e	e	-	-	±	c[5]	±[5]	p	±
Construction	+	+	+	+	+	2+	dr	e	e	+	±	+	s[5]	+[5]	p	±
Timing	-	-	-	+	±	2+	-	e	e	-	-	±	-	-	p	±

Table 1: Applications versus specifics of GPS receivers. – = less important; + = important

Notes:

1. *WAAS / Egnos is a benefit, but not required*
2. *Depending on the type, with a backpack the antenna is external, otherwise it is internal*
3. *External power supply is important for an RTK base station*
4. *Depending on the application, a dGPS system with waterlevel corrections will do. In these cases vertical precision is not important.*
5. *The system is sometimes controlled externally, in these cases no user interface (black box) and / or display is needed.*

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