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Avoiding the Pitfalls of GNSS

Working with the strengths and weaknesses of satellite navigation systems

A project manager working on a positioning and navigation system sits hunched at his desk. His mood is not good. Months of work seem to have been for nothing. The GPS system he has been working on is not working, as it should. Actually, it's worse than that. The system gives every appearance of working perfectly – getting a position, reporting it to the user, providing the relevant information – but the information is inaccurate and hence leading to bad conclusions. Users have lost confidence in the technology and management is unhappy, to say the least.

Sounds familiar? If you are lucky, then no. But in my experience there are many cases where these types of problem have been reality for unlucky project teams.

But why is this? And what steps can be taken to put things right? Is the system the project team has designed fundamentally flawed, or will a bit of tinkering solve the issues?

GPS specifically, and GNSS more generally, works fantastically well in its native mode of operation with an open view of the sky. High vehicle speeds, even in an aircraft manoeuvring at several times the speed of sound, are well within the capabilities of the GPS system. To use more specific language, the accuracy and continuity of positioning information is very high in open sky conditions.

Back down to earth, a person walking with their GPS on the edge of the street in a typical town or city could well have a very different experience.

First the continuity of service could be affected by the receiver losing its lock on the visible GPS satellites. This could be due to the satellites being blocked behind buildings. Or the receiver may be located inside a building or shopping centre where the received satellite power is too low. Or the user could unwittingly point the antenna at the ground rather than the sky. In fact, these and a whole range of related effects can cause major difficulties for GPS receivers.

Secondly, even if the user is experiencing good continuity, the accuracy of the solution can be affected by multipath signals being seen and interpreted as 'good' by the GPS receiver. This will 'trick' the receiver, which will read the effective distance from the satellite to the user as being the bounced signal length, rather than the direct signal length. Errors from a few metres to several hundred metres are quite common from multipath effects.

As well as continuity and accuracy, the ability to trust the position being given, deserves careful consideration. There are multiple factors that affect integrity. Some are common, such as local interference from TV or microwave stations and, particularly near the equator, sun spot activity. Others are relatively rare such as satellite clock or transmission errors. When these do occur, however, they can cause major position errors, up to several kilometres in extreme cases.

The importance of these effects to our imaginary project team leader depends on what the positioning information is being used for.

In a vehicle navigation system the ultimate responsibility for safety lies with the driver, who should ignore incorrect instructions that might compromise safety. In this case, the priority of the design team may be low cost of manufacture above performance.

At the other extreme, safety critical systems such as aircraft landing or rail signalling require high and guaranteed integrity, accuracy and continuity. Often GPS alone is not sufficient and needs to be complemented, or augmented, by additional sensors or systems.

In the middle are, generically, systems that rely on GPS for commercial purposes. Examples are road tolling, congestion charging, tracking and logistics. In these cases, GPS alone may well be sufficient for positioning, but safeguards need to be designed to ensure proper use and system accuracy.

Whatever the application, the system design team should be very clear, up front, what the accuracy, continuity and integrity requirements of the system are. Equally important are trade-off decisions between time, cost and quality at the project level, system level and user terminal level. Only with these defined and agreed can a proper test plan be developed.

Often, such a test plan will require a mix of 'live' and 'laboratory' testing. Linking to the theme in this issue, real time data capture, a common test approach is to capture real data from the field and then recreate elements of that field data in a controlled laboratory environment. At its simplest, a navigation system developer can drive a route in the real world and capture 'NMEA' data from the receiver being used. This data can then be used to create a trajectory in the lab test system, also to vary factors such as satellite power levels and satellite visibility.

By using progressive test cases and approaches, the designer can design-in the performance they require. Equally important, the design team can understand the limitations of their system and ensure that processes and operational use cases take account of these to provide the appropriate level of service.

In summary, everyone working with GNSS technology development or using GNSS systems in a professional capacity should be aware of the inherent strengths and weaknesses of the GPS and other GNSS systems. At the receiver and system design level, many of the problems can be overcome by a logical and progressive test approach linked to the design objectives. The team that ignores inherent weaknesses and does not strive to take account of them is in for a miserable time indeed.