WHITE PAPER

How UDR technology is going to enable new business models and change existing ones for automotive applications

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Executive Summary

Satellite navigation systems have been around for over 35 years and they have made all aspects of navigation much easier. Until now there have been only minor revisions to automotive satellite navigation and we have learned to deal with the limitations the technology has suffered from in the past. However, new advances in a number of technologies have contributed to significantly improving the navigation accuracy and reliability. This white paper will review the current state of satellite navigation, highlight recent technology advances, and explore possible new business opportunities these innovations enable. Depending on the application, businesses adopting UDR technology in their products and services will be able to significantly differentiate their offerings from competitors. For example, in the case of navigation units the benefits will include providing an enhanced customer experience especially in marginal signal areas. For road tolling organizations the infrastructure required, such as gantries, will be much simpler and consequently much cheaper to install. Fleet management organizations will be able to improve the efficiency of fuel management solutions to their customers and offer the potential to differentiate themselves from competitors with the accuracy of route and traffic planning for example.

Introduction

There are over 120 satellites orbiting the earth arranged in constellations of global navigation satellite systems (GNSS) that transmit extremely accurate time information. By comparing the signals received from four or more satellites, receivers can calculate their position on the earth in terms of latitude, longitude and altitude.

Navigation inconveniences

However, as most of us have noticed when using a GNSS device, they all suffer from a number of limitations. Firstly, they need to receive the extremely weak satellite signals in order to determine their location.

Because signals are a hundred times smaller than your home Wi-Fi signal, anything that interferes with the reception, such as walls of concrete, results in the unit being unable to provide an accurate location "fix". For example, when driving into a multi-level or underground parking garage, signals will be blocked completely, losing all chances of reporting the vehicle's location. Another common situation is the "urban canyon" – an open road lined with tall buildings, typically in a densely built-up city area. In this scenario, the clear line-of-sight to the satellites is blocked and reflections of the signals occur, which subsequently interfere with the signals coming directly from the satellite.

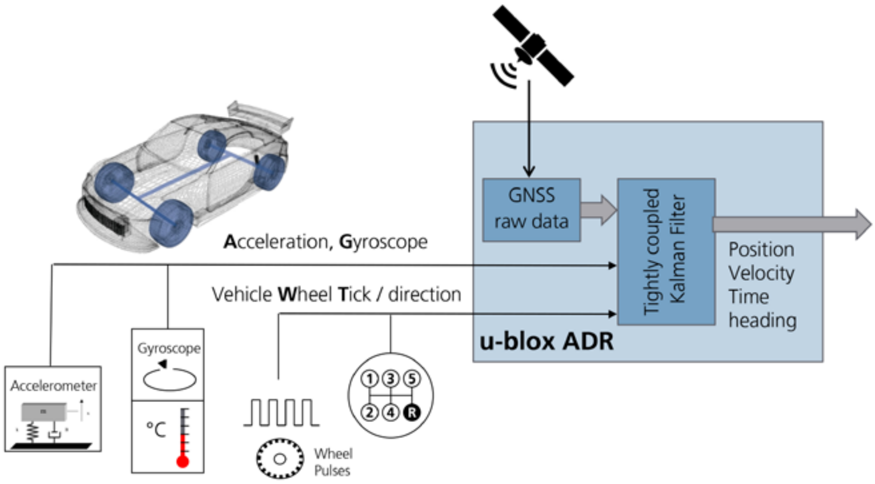
Underground parking garages block GNSS signals, leaving no chance to report the vehicle position.

Thankfully, new advances in GNSS systems, combined with the availability of reliable and accurate inertial sensors, have led to significant improvements in the navigation experience so that the limitations caused by urban canyons', multi-path signal reception, and poor satellite signal quality can be overcome. Already available in the factory-fitted navigation systems in top-end vehicle models, it won't be long before units based on this new approach will be available to add to any vehicle.

Dead reckoning combined with GNSS data

Today, there are factory-fitted units that combine the GNSS positional data with the vehicle's speed, direction and acceleration forces so that should the GNSS data momentarily fail, for example when driving into a tunnel, the unit can continue to calculate, by dead reckoning, the vehicle's current position.

This approach is called 3D automotive dead reckoning (ADR) and uses sensors in the vehicle such as to the wheels or an odometer, a gyroscope and accelerometer motion sensors.



Automotive Dead Reckoning (ADR) at a glance.

For ADR, access to this information is achieved over the vehicle's own computer network, which is possible when the module is installed at the time of manufacturing. This limits the technology to first mount applications.

Technology innovations

Recent advances in miniature inertial sensor technology, primarily driven by the smart phone industry, have meant that gyroscope and accelerometers can now be used in miniature modules, such as the u-blox ADR module NEO-M8L. While NEO-M8L works extremely well, the module does rely on having access to vehicle distance data provided through the odometer or wheel sensors.

NEO-M8L, a ready-to-use module providing leading performance with 100% coverage, is optimal for applications where vehicle speed is available.

The next innovation step is to calculate distance moved without having access to wheel speed information or the odometer. Freeing the navigation system from the vehicle's own network potentially unleashes a whole new range of applications that can be used in any vehicle.

This new approach is termed Untethered Dead Reckoning (UDR), and combines all the sensor data together with that of the GNSS data. UDR facilitates the next level of vehicle tracking in situations where the GNSS signal quality is poor due to buildings and reflected multiple paths, or when it is lost completely such as in a tunnel.

UDR enables new business opportunities

While ADR and the NEO-M8L provide leading positioning performance and can be considered "top of the league" (since having access to privileged vehicle information), UDR offers a clear performance advantage to using GNSS alone. The following examples illustrate how UDR can enable a whole new realm of possible applications in situations where no direct access to vehicle movement data is the norm.

UDR simplifies urban road tolling

Consider an urban road tolling application. As our cities become increasingly grid-locked, various traffic charging initiatives are deployed and major motorway routes have privately-funded toll roads built along the side of them. Vehicle-based GNSS devices report their location and other essential information to a central billing system as the vehicle enters, transits, and exits the toll road. Using GNSS alone, especially in the urban canyon areas, the location data accuracy might exhibit extremely variable locations or none at all.

Urban canyons create signal reflections and are a challenge for GNSS receivers.

In this scenario, the impact of poor location accuracy will result in vehicles close to, but not on, the toll road being charged, and those on the toll road not being charged. As a consequence of poor location accuracy, GNSS based toll systems tend to be implemented outside of cities on motorways where the accuracy requirement is less important. Other short-range and proprietary solutions, such as Dedicated Short Range Communications (DSRC), tend to be used in urban environments. However, such systems require significant infrastructure and gantry installations.

In a road test performed in downtown Singapore, GNSS combined with UDR shows a two to three times improvement in accuracy than without UDR.

UDR | GNSS only

UDR vs. GNSS only in downtown Singapore.

This gain in accuracy is changing the game in road pricing. As it might be too early to claim that GNSS systems will completely replace all short-range road tolling installations, there are situations where it is considered highly viable for new projects. And there are instances, such as in Singapore, where the Land Transport Authority is currently considering implementing a GNSS based solution for its next generation of electronic road pricing in order to minimize the costly and visually distasteful gantry infrastructure. A technology such as UDR can help them achieve their goal.

Using UDR to improve the accuracy of pay as you drive insurance systems

Another application that will benefit from UDR is the telematics-based pay-as-you-drive (PAYD) systems. Quickly gaining popularity, insurance companies have been adept at using real-time telematics systems to monitor a driver's driving behavior when defining premiums based on variables such as the distance travelled. For both insurer and insured this is a fair way to charge for insurance. However, the challenge is for the insurance company to be sure that the mileage data is accurate and verified.

Auditing the odometer reading would be one way of achieving this as well as asking the driver to report odometer readings on a regular basis combined with spot checks. Auditing odometer readings would be the ideal solution, but this would be a costly exercise. A telematics based approach solves this challenge but in many cases the distance travelled is not received from the odometer but by a GNSS system. This is because the majority of such devices are designed for installation by the insured.

A professional installation that incorporates connection to the vehicle's own communication system would represent a significant cost that would negate any potential savings. Additionally, there are potential software compatibility issues connected with this approach.

A GNSS-based PAYD solution without dead reckoning can introduce errors in the order of up to +/- 10% (due to signal outages, signal reflections, and other problems mentioned previously), which would be reflected in the bill to the vehicle's owner.

Implementing UDR could greatly reduce the potential errors to a few percentage points, helping to maintain accurate billing and customer satisfaction.

Using UDR for long term vehicle leasing

Another example for a UDR approach is for vehicles on long term rental contracts. The rental company or car dealer can use a telematics unit to issue maintenance and routine service reminders to the vehicle renter based on the distance travelled. Again, UDR will greatly improve the accuracy of reporting, which will help to maintain customer loyalty and avoid the issuing of unnecessary reminders.

UDR improves performance and reduces size of OBD dongle-based applications

Another application for vehicle-based telematics is the reporting of on-board diagnostics (OBD). Increasingly being used for managing and tracking fleets of trucks and other commercial vehicles, OBD can provide vital engine management data that can warn the driver of likely failure. OBD can also be used to highlight poor driving styles such as over-revving and speeding. Other features that OBD can provide are tracking long idling times, fuel efficiency, and a vehicle's position. Such devices are now also becoming popular for use in private vehicles. Together with a connected smart phone app, a private vehicle owner can find out more about the vehicle's performance and other vital service data. For many of the parameters above, the need to accurately know the vehicle's position, direction, and speed are crucial. For OBD to be commercially successful, particularly for consumer-based installation and usage, attention to the unit's size and style will be key. In most private vehicles the OBD port is located in a hard to reach location with very limited space. It might be that the OBD port faces down from underneath the steering column or is located behind a hinged cover. Either way, if the OBD dongle is not small enough, then the driver's knee might hit it or the protective cover would not close and be constantly in the way.

Small dongle inserted in an OBD port in a vehicle.

For the OBD manufacturer and system integrator, a key requirement is to keep the dongle size as small as possible, such that it will fit into any vehicle. Naturally, if the OBD dongle is kept as small as possible, then the antenna inside the dongle enclosure must also be quite small. It is vital that the GNSS reception functions properly despite the reduced signal strength from the compromised antenna size. Another complication is due to the OBD port location, which is often located behind or underneath the dashboard. This means that anything plugged into the port will not have line-of-sight communication to GNSS satellites. While UDR still requires a minimum signal level to operate, it has been proven in a scenario run with a compromised antenna that UDR was able to improve position accuracy by several times compared to a non-UDR product. A GNSS-only solution would barely map to the streets while UDR is able to provide the location accurately on the road.

UDR GNSS only

UDR vs. GNSS only using a compromised antenna (weak signals).

In this context, the use of UDR will significantly assist in reducing the impact of poor signal strength and quality due to the OBD dongle location and antenna size. It will enable Telematics Solution Providers to release small OBD dongles including all important position based features such as accurate mileage, accurate street level tracking, parking location and much more.

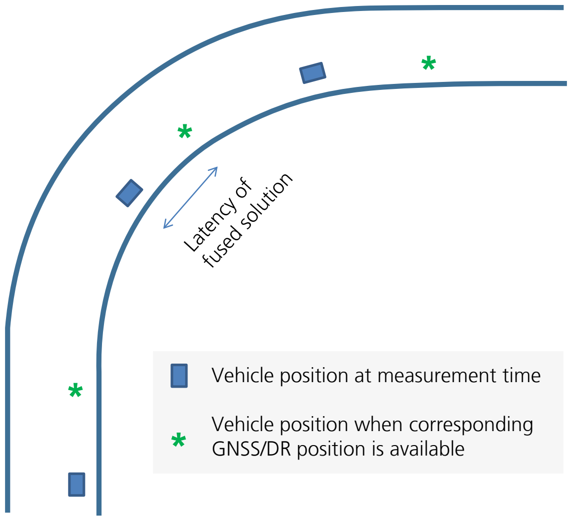
UDR enabling crash detection for insurance companies

Providing a reliable and accurate record of actions leading up to a road traffic accident has always been difficult for insurance companies faced with processing claims from several parties. In some cases it has become important to have proof that an accident actually took place at the time and place stated. Fraudulent insurance claims cost the industry significant amounts of money, and increases in insurance premiums impact honest policyholders. For these situations there is the potential for a new insurance model that uses a vehicle-based unit to accurately record the events, location, and timing of an accident event, immediately prior to and shortly after the incident.

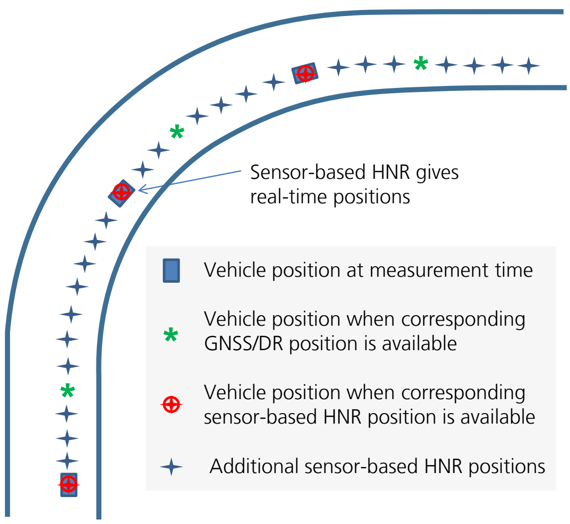
The use of an accelerometer that has a very high data collection rate can determine whether an accident happened or not, and the nature of the accident. This might be a collision in the front, sides or rear, or a combination of several over an extremely short period, typically shorter than 20 milliseconds.

Determining the position of the accident requires the tracking of the vehicle positioning in order to identify the position of accident within a few meters. Typically GNSS applications have some latency (up to several hundred milliseconds) in calculating the actual position, which for a vehicle travelling at a high speed, for example on a highway or interstate, would equate to up to 50 meters. Using UDR technology with a real-time positioning update every 50 ms (20Hz update rate) would ensure that the reported position of the accident is far more precise and within the required few meters. As mentioned before, a precise location is important for emergency services and insurers when giving a complete picture of the accident.

Latency of fused solutions



Solution: Sensor-Based High Navigation Rate (HNR)



In addition to the accident and insurance applications, real-time positioning with UDR can also be used to provide a smooth and responsive navigation stream for interactive applications such as navigation and live tracking.

Conclusion

Untethered Dead Reckoning (UDR) technology blends GNSS location information with motion sensor data to deliver positional information accuracy that was previously unheard of for GNSS-only applications. The technology provides better navigation and positioning in cases of weak or reflected signals or short signal loss, as well as delivers an immediate position fix from the moment the device is switched on. UDR offers not only a better user experience but provides the foundation for enabling a whole new range of business services. Incorporating UDR into your application will also aid the reduction of the overall system cost where installation represents a significant cost of the deployment, such as for road tolling and for vehicle insurance/telematics.

More information on u-blox and the range of UDR solutions can be found here: https://www.u-blox.com/en/udr-untethered-dead-reckoning

About the Author

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Florian Bousquet has been part of the Product Strategy team in the Product Center Positioning at u-blox AG since 2014. His main objectives are developing consumer and industrial markets, with a specific focus on wearables and telematics solutions. In 2011, he started working for u-blox AG as a field application engineer, part of the EMEA Sales team. Prior to u-blox, he worked as a mixed signal development engineer in NXP and ST-Ericsson, specializing in audio circuitry for mobile phones. He currently lives in Zurich, Switzerland.

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About u-blox

Swiss u-blox (SIX:UBXN) is a global leader in wireless and positioning semiconductors and modules for the automotive, industrial and consumer markets. u-blox solutions enable people, vehicles and machines to locate their exact position and communicate wirelessly over cellular and short range networks.

With a broad portfolio of chips, modules and software solutions, u-blox is uniquely positioned to empower OEMs to develop innovative solutions for the Internet of Things, quickly and cost-effectively. With headquarters in Thalwil, Switzerland, u-blox is globally present with offices in Europe, Asia and the USA.

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