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Land-based GPS keeps the roads safe

Tall buildings, tunnels and parking garages pose a major challenge for the accurate positioning of self-driving cars. Satellite navigation is inadequate for this purpose, so researchers are developing a wireless terrestrial GPS.

By Amanda Verdonk
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Somewhere in the foreseeable future, self-driving cars will fill the streets. Unfortunately, in densely built-up areas with tall buildings, tunnels or parking garages, the built-in GPS fails. Even when smart software determines the precise location of a vehicle, it remains an educated guess. To allow self-driving cars to drive around in urban areas without causing trouble, a more accurate positioning system is needed.

FAILING GPS

'GPS was developed for military purposes in the 1960s', says Christian Tiberius, Associate Professor of Geoscience and Remote Sensing at TU Delft. 'It was used to determine the position of tanks, fighter planes and ships, but now it is also used in commercial ships and smartphones. It was never intended for those applications.' GPS satellites send a signal to a receiver on earth. The receiver determines its location based on the time it takes for the signal to travel from the satellite to the receiver, multiplied by the speed of light. The location is then determined by measuring the distance between the satellites and the receiver. The problem is that there is a lot of signal reflection in built-up areas: the GPS signal bumps into all kinds of objects such as buildings before it reaches the receiver. Tiberius: 'At the Weena in Rotterdam, near the sky scraper of Nationale Nederlanden, I once did a position calculation with a simple receiver. It was hundreds of meters off.'

Tiberius and his colleagues are now working on a solution to this problem. They are developing a land-based GPS with an accuracy of one decimetre instead of metres. In contrast to satellite navigation, they use transmitters the size of a Wi-Fi modem that emit very short radio pulses on the ultra-wideband. The signal receiver of could eventually be placed in a small chip. Sending short pulses implicates that more bandwidth of the radio spectrum is required. 'But the great thing is that the bandwidth is not needed all the time, probably just a millisecond every second.' The receivers could be combined with the 5G communication network because the range should be similar.

It already works in the lab, says Tiberius. 'Now the biggest challenge is to make it work in practice.' This summer a trial in The Green Village started, an experimental village on the TU Delft campus where a real living environment is simulated with streets, houses, traffic and, of course, residents. The researchers will attach their transmitters to lampposts and build a receiver themselves. 'For now, the receiver will be put in a large storage box from IKEA, but ideally it will fit in a navigation system or smartphone.' For this test it is essential that the transmitters are all well synchronized. Therefore a fibre optic connection will be established with VSL, the Netherlands Metrology Institute, which is also in Delft. A laser pulse with the time indication is sent from the institute with picosecond accuracy.

To accurately know the time, an important role is reserved for the so-called time-frequency reference equipment, which has been developed by OPNT, a spin-off of VU Amsterdam. OPNT was also one of the initiators of the SuperGPS project.

'We are experts in time distribution', says Marco Gorter, co-founder and Chief Operations Officer at OPNT. 'And TU Delft is particularly good at wirelessly sending the signal.' The company developed a time distribution system based on the universal UTC traceable time. Gorter: 'Many vital infrastructures, like telecommunications, the financial sector and the energy sector, depend on accurate timing using GPS, but you could jam or spoof those signals. For example, financial transactions cannot take place without a UTC traceable timestamp, and spoofing power plants with a false timing reference can lead to black outs, when power plants start to drift in phase in relation to the rest of the energy grid. For these markets, we have developed a terrestrial timing service, which we operate via fibre optics.' The next step, however, is making this timing service wireless. This is where the SuperGPS project comes in. Apart from car navigation, it

'I once did a position calculation with a simple receiver near a skyscraper. It was hundreds of meters off'

could also serve as a very accurate navigation for people in buildings such as hospitals, shopping centres or supermarkets, or to locate people who have made an emergency call. If the trial at The Green Village yields good results, then as far as Tiberius is concerned, the next step is to test the equipment near a main road. 'Autonomous driving is seen as the most important application. That will probably first happen on main roads. And the Netherlands already has fibre infrastructure along all motorways.' Although the project will officially end next year, all project partners want to continue to further develop the technology. Gorter: 'I'm convinced that we will be able to distinguish ourselves with this technology worldwide and that the major car brands will show interest.'

SUPER GPS

Project name: SuperGPS: Accurate timing and positioning through an optical-wireless distributed time and frequency reference

Participating institutes: TU Delft (and VU Amsterdam in the initial phase)

Principal researchers: Christian Tiberius, PhD, Associate Professor Geoscience and Remote Sensing at TU Delft, and Gerard Jansen, PhD, Associate Professor Circuits and Systems at TU Delft

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