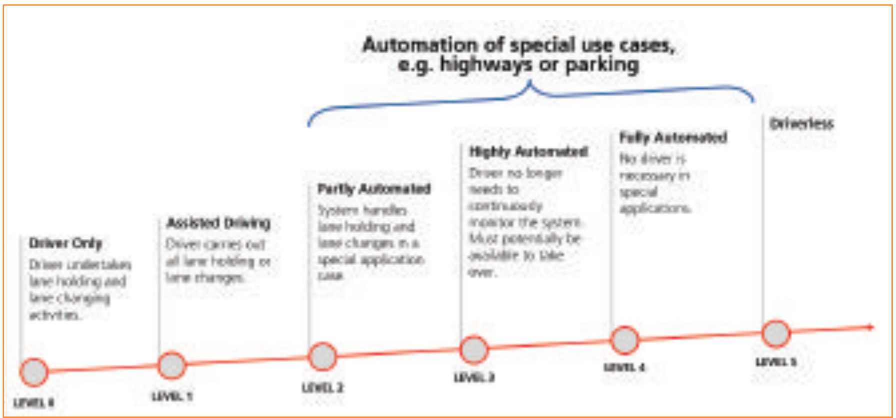

Figure 3. Roadmap to autonomous driving

band, today's modern navigation satellite systems send out their signals in up to three separate bands. The American GPS system, for instance, transmits in the L1, L2, and L5 bands, centred on 1575 MHz, 1227 MHz and 1176 MHz respectively. Russia's GLONASS transmits only in the L1 and L2 bands, as does China's BeiDou. High-precision GNSS receivers can take advantage of multiple frequency bands from a single constellation, massively reducing the time it takes to achieve high precision. The result is markedly more robust positioning performance and, ultimately, a more reliable service for the user.

Future high-precision GNSS systems will be composed of multiple elements (of which, the GNSS constellations currently in orbit are the most obvious). On the ground, GNSS reference stations will monitor signal errors in real time. Adopting the SSR approach, correction services will then broadcast the error components over the internet, as well as via geostationary satellites. In addition to being fitted with dual-band GNSS receivers, rovers will be equipped with cellular modems to receive the correction stream broadcast over the internet, and L-band receivers to pick up the satellite correction stream.

High-precision positioning for autonomous driving

While today's vehicle fleet continues to be dominated by vehicles that are entirely controlled by their driver, increasing numbers of them offer at least some assisted driving capabilities. Moving toward fully autonomous driving will require an incremental increase in the level of automation in special use cases, such as on highways or for parking. Whereas today, drivers may benefit from assisted driving (Level 1 in Figure 3), they are still required to carry out all lane holding and lane-change manoeuvres. Some cars on the roads today are already in Level 2, with partly automated systems that carry out these actions autonomously in special application cases.

A combination of technologies will be needed to meet safety requirements for autonomous driving. Combining camera images, LiDAR and radar data with high-definition maps already allows vehicles to position themselves on the map with high (roughly 10-centimetre) accuracy, as well as to detect obstacles in many use conditions. However, these systems alone are not safe enough to make the driver obsolete. During the transition towards fully automated driving, a vehicle's precise position will determine whether autonomous driving mode can be engaged. Poor environmental conditions, or an absence of distinguishing landmarks, could cause optical systems to fail to correctly determine the use case – a challenging situation, particularly in Level 4 systems, in which the driver can fully relinquish control over the vehicle in certain situations.

It is in these scenarios that high-precision GNSS, combined with automotive dead reckoning (which blends satellite navigation data with individual wheel speed, gyroscope and accelerometer information to deliver accurate positioning in the absence of GNSS) can step in as a fully independent source of position. The precise position that it delivers would not only help identify the correct segment of high-definition maps and geo-fence critical areas (for example, to reduce speed), it could also be used to calibrate the vehicle's sensors. Only with such systems in place would it become possible to meet the safety requirements for autonomous vehicles laid out in ISO 26262. These include functional safety and the capacity of the vehicle to safely respond to errors, at both the firmware and hardware level – ensuring the consistent safety of its passengers.

Sensing technologies such as LiDAR and radar are not safe enough on their own to make the driver obsolete. During the transition towards fully automated driving, a vehicle's precise position will determine whether autonomous driving mode can be safely engaged.

Functional safety is a prerequisite for safe autonomous vehicles. It is, however, by no means sufficient. Functional safety is vehicle-centric, in that it deals with errors that might occur on the vehicle. For positioning, the main error sources – satellite clock and position, multipath effects or potential glitches in the correction stream – are external to the vehicle. A functionally safe vehicle would therefore see no reason to reject flawed data. Accounting for such external errors requires a more holistic approach, which could be called "integrity". As opposed to functional safety, integrity would deal with the entire technology chain from a holistic perspective, encompassing the various sensors, the V2X infrastructure, and security systems at all levels. It requires that all technologies, including GNSS, provide a measure of confidence in their output – in order to warn when an alternative technology should be used in its place.

The path to high GNSS accuracy is crucial to enabling increased road safety in advanced driver assistance systems (ADAS) and fully autonomous driving. As an independent source of positioning information, high-precision GNSS – enabled using multiband receivers and SSR correction data – will reliably deliver a guaranteed position of the vehicle, regardless of the circumstances. Ultimately, it will have to be accurate to decimetre level on open highways, and to sub-metre level on more challenging urban highways – ensuring that the reported position is not only accurate, but accurate to an extremely high probability. And for it to be adopted in volume by the market, it will have to be both qualitatively irreproachable and affordable.

u-blox embarked on the path to high-precision GNSS in 2016, with the launch of NEO-M8P: by far the smallest and lowest power RTK receiver on the market. In 2017, it announced Sapcorda, a joint venture with Bosch, Mitsubishi Electric and Geo++, to bring a global and affordable GNSS correction service that is compatible with mass-market applications. Going forward, u-blox is committed to filling the gaps that stand in the way of enabling highly and fully autonomous systems – in particular, automated driving.