Transport applications of precise positioning

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Acknowledgement of Country

We proudly acknowledge the First Peoples of Victoria and their ongoing strength in practising the world's oldest living and continuous culture. We acknowledge the Traditional Owners' lands, waters and skies on which we live and work and pay respects to their Elders past and present.

Description of artwork

Aaron Duggan 'Movements Between
the Five Clans' 2019, acrylic on canvas.

'The tracks are going between the five clans
of the Gunaikurnai and the hands are the symbols
of my spirit travelling around the campsites.'

This artwork was created through programs
provided by the Torch. The Torch provides art,
cultural and arts industry support to Indigenous
offenders and ex-offenders in Victoria. The
Torch aims to reduce the rate of re-offending
by encouraging the exploration of identity and
culture through art programs to define new
pathways upon release.

Contents

Introduction

Global Navigation Satellite System (GNSS) positioning technology, such as GPS, has changed the way we live and travel, and has brought enormous economic, productivity, social and environmental benefits.

Gone are the days of juggling a street directory while trying to navigate roads and traffic. Today we can simply enter an address into our vehicle or mapping app and be guided along the optimal route to our destination.

The standard form of GNSS positioning technology supports free and instant positioning accuracy of 5-10m. This is suitable for general navigation applications and has been integrated into a diverse range of transport applications, providing significant benefits to business and the community.

There are a wide range of other transport applications that have benefited from more advanced precise positioning technology, capable of 2-5cm positioning accuracy. These applications use higher quality GNSS equipment and GNSS correction services that can meet more accurate positioning requirements.

Ongoing advancements in GNSS technology are reducing costs and increasing accessibility to precise positioning, which will deliver further benefits across the transport sector, including mass-market transport applications. This will further enable innovation, enhance productivity, and improve safety for business and the community.

The Department of Transport and Planning (DTP) is actively working to ensure accurate, reliable and accessible precise positioning across Victoria.

DTP is supporting and promoting precise positioning for transport applications to enhance productivity and efficiency, enable innovation and automation, and improve safety and environmental outcomes. This will ensure business and the community benefit from ongoing advances in precise positioning as we build thriving places and connected communities.

This report will highlight available precise positioning technologies, and the transport applications that are benefiting from precise positioning.

Source: Aptella, Tiny Mobile Robots

Precise positioning technology and GNSS correction services

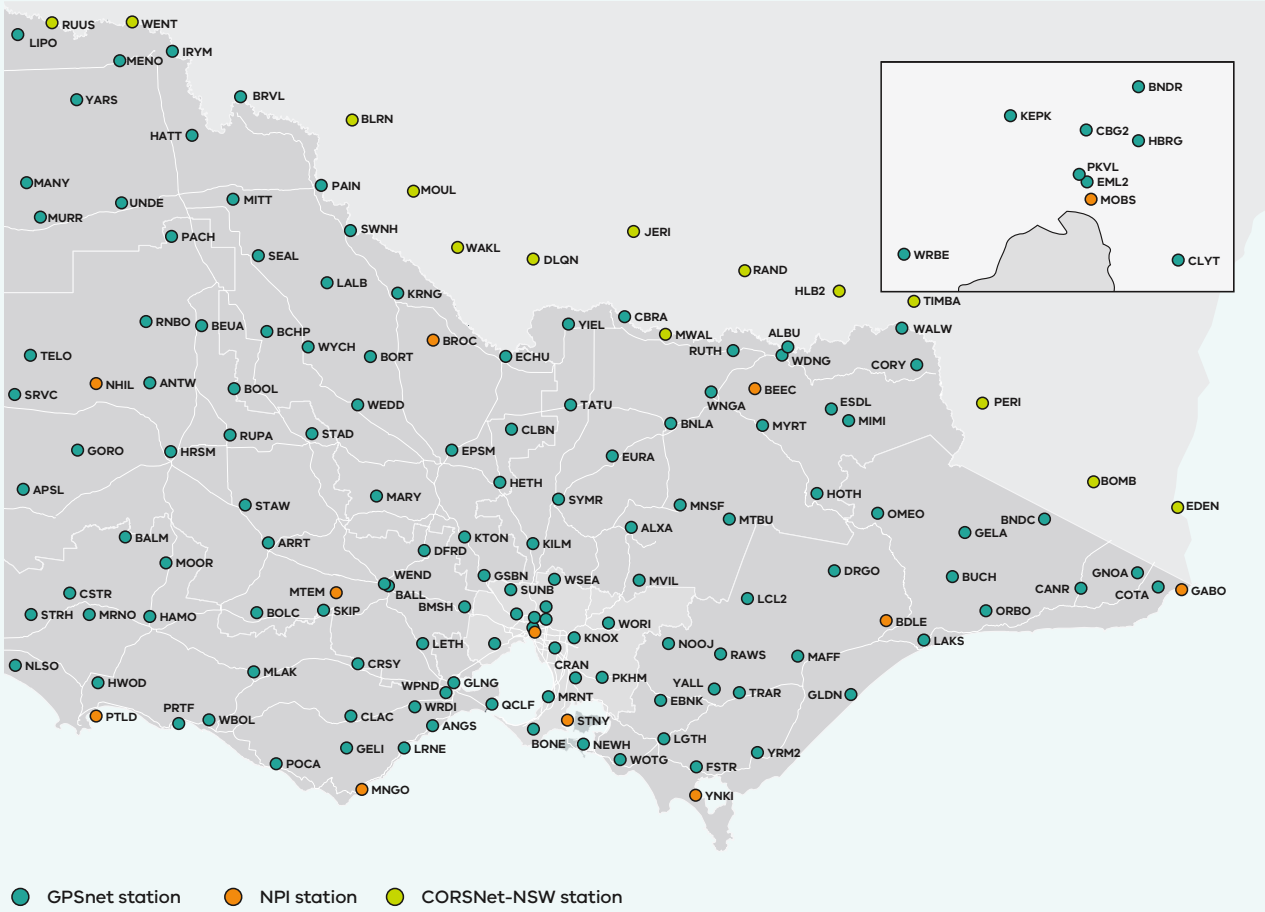
The department's Geodesy team is responsible for the ongoing maintenance and enhancement of Victoria's primary positioning infrastructure and information services that enable precise positioning capability in Victoria.

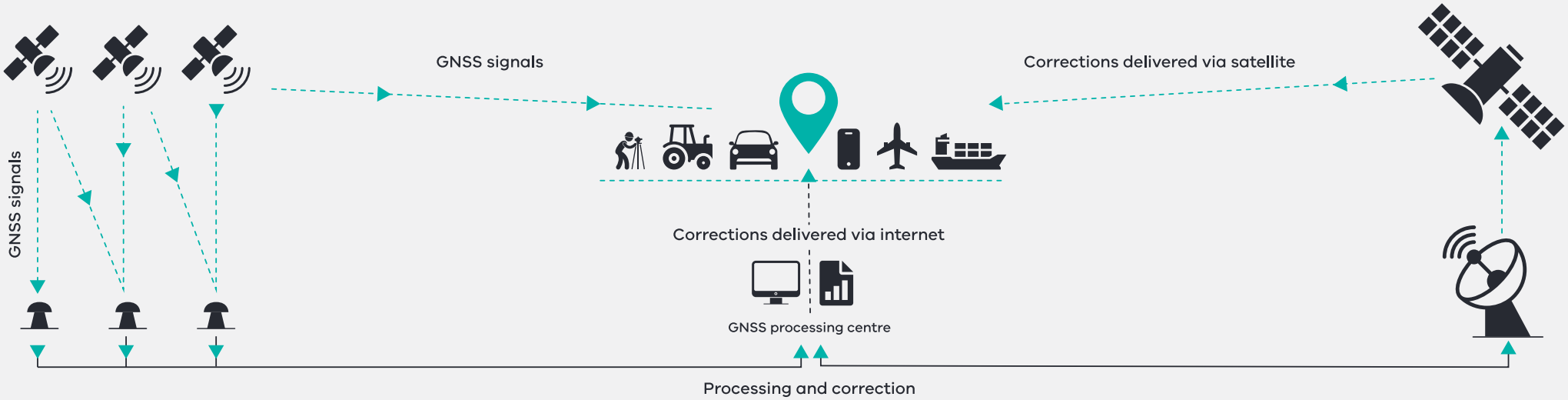
GNSS reference station network

Precise positioning is achieved through the application of GNSS corrections that can improve GNSS positioning accuracy from several metres to centimetres. GNSS correction services rely on a network of GNSS reference stations that continuously track the GNSS satellite signals and stream data to a processing centre. The data streams are compared with the known positions of the GNSS reference stations to instantly derive and distribute GNSS corrections. These corrections are used by GNSS devices to improve positioning accuracy.

The DTP Geodesy team manages the state-wide network of 150 continuous GNSS reference stations known as GPSnet. This high-quality positioning infrastructure and information services contribute to the National Positioning Infrastructure Capability (NPIC) and enables centimetre-level precise positioning services in Victoria.

Victoria's Continuously Operating Reference Station Network





GNSS correction services

There are a wide range of precise positioning technologies and GNSS correction services available. The different services support varying levels of positioning accuracy, reliability and availability, and can be delivered through different communication channels and fee structures.

Network Real-Time Kinematic (NRTK)

Network Real-Time Kinematic (NRTK) GNSS correction services in Victoria are delivered by commercial providers through paid subscription services. These precise positioning services have been in operation for over two decades and reliably support high-accuracy positioning requirements. They also provide productivity and efficiency benefits to a wide range of industries including precision agriculture, construction and surveying.

Precise Point Positioning (PPP)

Commercial providers offer alternative GNSS correction services including Precise Point Positioning (PPP) and PPP-RTK. These services also draw on a continuous data stream from a GNSS reference station network to model GNSS corrections over an entire region. There are international initiatives exploring the potential to use 5G to distribute GNSS corrections.

Satellite Based Augmentation Service (SBAS)

The Southern Positioning Augmentation Network (SouthPAN) is a Satellite Based Augmentation Service available over Australia, New Zealand and maritime regions. SouthPAN is a free GNSS correction service delivered by satellite and automatically applied in compatible GNSS devices to improve positioning accuracy to 1 metre or less.

SouthPAN is designed to support the high integrity requirements of aviation applications. It will also provide increased GNSS positioning accuracy and integrity benefits for many other applications, including across the transport sector.

The table below highlights the capability of the primary GNSS correction services against a range of parameters. Various transport applications make use of the different GNSS correction services depending on precise positioning requirements.

GNSS Correction services	• NRTK GPSnet	• PPP-RTK, PPP	• SBAS (SouthPAN)
Positioning accuracy	• 2 – 10cm	• 10cm – 0.5m	• 0.5m – 1.5m
Initialisation time	• Fast - seconds	• Fast < 1 min to slow > 30 min	• Fast < 1 min
Performance	• High accuracy and reliable	• Accuracy and reliability	• High integrity
Coverage	• Local and statewide	• Regional and global	• Regional
Communications	• Internet - two way	• Satellite – one way (Internet available and 5G emerging)	• Satellite – one way (Internet available)
Costs	• Paid subscription	• Paid subscription	• Free
GNSS equipment	• Specialist/high grade	• Medium grade	• All to be capable
Example transport applications	• Surveying • Construction • Machine guidance	• Asset monitoring • Road vehicle guidance	• Marine navigation • Air navigation

Source: GPSnet GNSS reference station in Heidelberg to support North East Link

Source: Freight Victoria, DTP

Applications of precise positioning in transport

There are a wide range of existing and emerging transport applications benefiting from use of precise positioning technology.

Existing applications have tended to use higher quality GNSS equipment and correction services to meet higher accuracy positioning requirements. This is particularly the case in the surveying and construction of major transport infrastructure as well as ongoing infrastructure monitoring and maintenance activities. Maritime and Aviation sectors have also relied on various forms of precise positioning technology for many decades.

Ongoing advancements in GNSS technology are reducing costs and increasing accessibility to precise positioning that will deliver further benefits across the transport sector, including mass-market transport applications, such as:

- Transport infrastructure
- Maritime
- Aviation
- Rail
- Road
- Micromobility

Transport infrastructure

Precise positioning technology is currently used in the surveying and construction of all forms of transport infrastructure. Surveying and construction activities routinely utilise NRTK GNSS correction services to ensure tasks are performed efficiently and achieve high-accuracy requirements.

This can include airborne surveys for initial planning and design, boundary surveys, construction setout surveys and as-built surveys. Earthmoving machinery can also integrate precise positioning technology to support machine guidance and construction.

Precise positioning technology currently also supports ongoing transport infrastructure monitoring and maintenance activities. Mobile laser scanning surveys are conducted to monitor roads, railways, assets and vegetation, and to support maintenance activities.

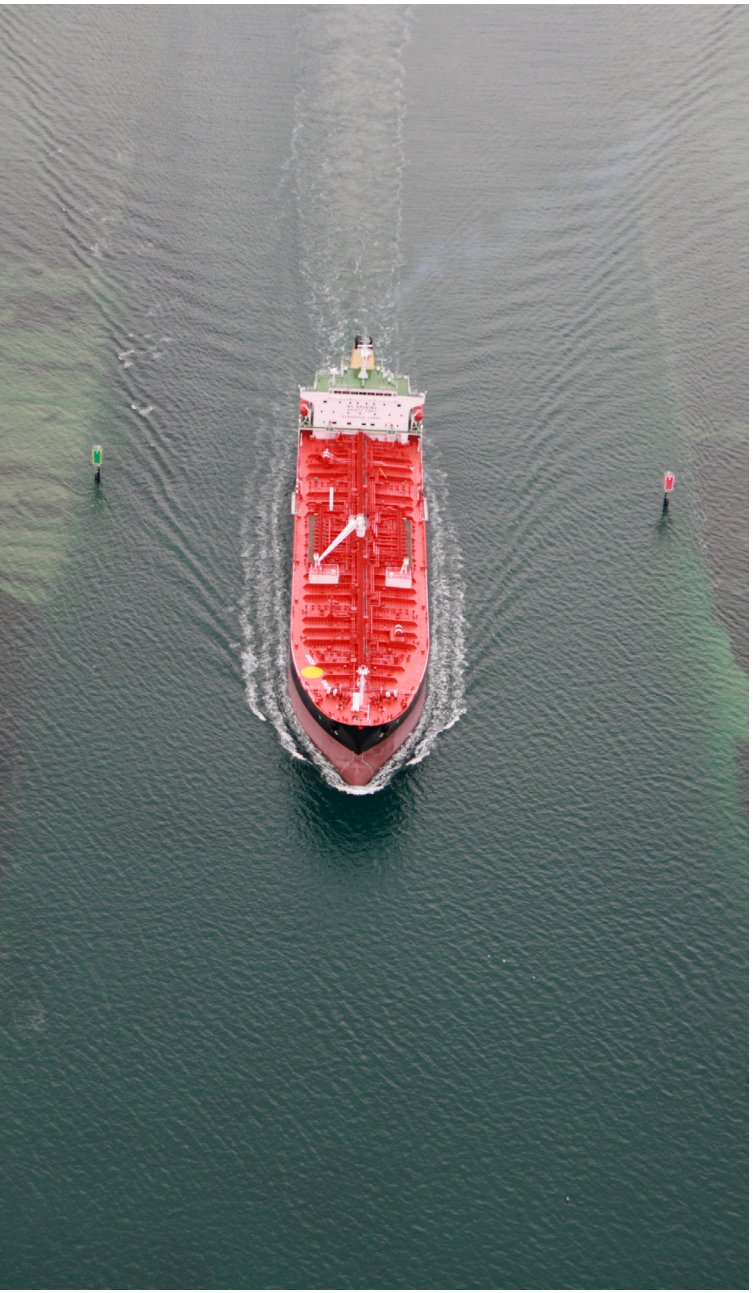
Scanners, including precise positioning systems, are mounted to vehicles or trains to conduct the survey safely and efficiently without the need to impede normal transport operations.

When conducting physical maintenance of transport infrastructure, precise positioning systems are being used to indicate work zones and protect worker safety.

Source: Surveyor-General Victoria, DTP

Surveying and mapping	• Surveying for all phases of the project cycle (planning, design, construction, as-constructed, QA verification), • Creation of spatial information used throughout the project and ongoing (e.g. digital engineering)
Civil construction	• Machine control guidance performing earthworks (e.g. dozers, motor graders, excavators and pavers) • Lane marking operations • Line and rumble strip installation • Augmented reality – visualising 3D assets
Construction worker safety	• Smart construction site zoning and alerting (geo-fencing)
Infrastructure monitoring	• Infrastructure scanning with LiDAR and imagery (e.g. rail design tamping, vegetation mapping, asset mapping and defect/hazard identification)

Source: Aptella



Source: Freight Victoria, DTP

Maritime

Precise positioning improves our understanding of the position and dynamics of vessels and is increasingly being used to enhance traditional systems of maritime navigation.

Hydrographic surveying vessels currently use precise positioning NRTK GNSS correction services to accurately locate the vessel and scanning sensors used to map the sea floor. Improved sea floor mapping can enhance navigation and support environmental monitoring and dredging activities.

Precise positioning supports vessels to manage under-keel clearance more effectively when navigating through port environments and shallow channels, and enables the efficient and safe carriage of additional cargo. Port pilots currently use NRTK GNSS correction services within Portable Pilot Units (PPU) to safely navigate and dock large vessels. PPUs provide accurate position, heading, pitch and roll.

Emerging

Looking to the future, the use of reliable precise positioning with high integrity may provide opportunities to establish autonomous maritime systems that can safely and seamlessly operate at reduced cost.

Maritime applications are well suited to utilise the new SouthPAN GNSS correction services which can support sub-metre and even 10 centimetre-level high integrity positioning around the entire Australia and New Zealand maritime regions.

Machinery operating at container ports could utilise precise positioning to support safe and efficient loading and unloading.

Maritime	• Enhanced navigation and pilotage • Avoid collisions with ships, fixed structures and hazards in water • Cable protection and exclusion zone alerting • Compliance with fisheries/reserves • More effective under keel clearance (UKC) management
Port operations	• Enhanced container management • Exclusion zone alerting • Automation of cargo loading – container pickup, transfer and placement

Rail

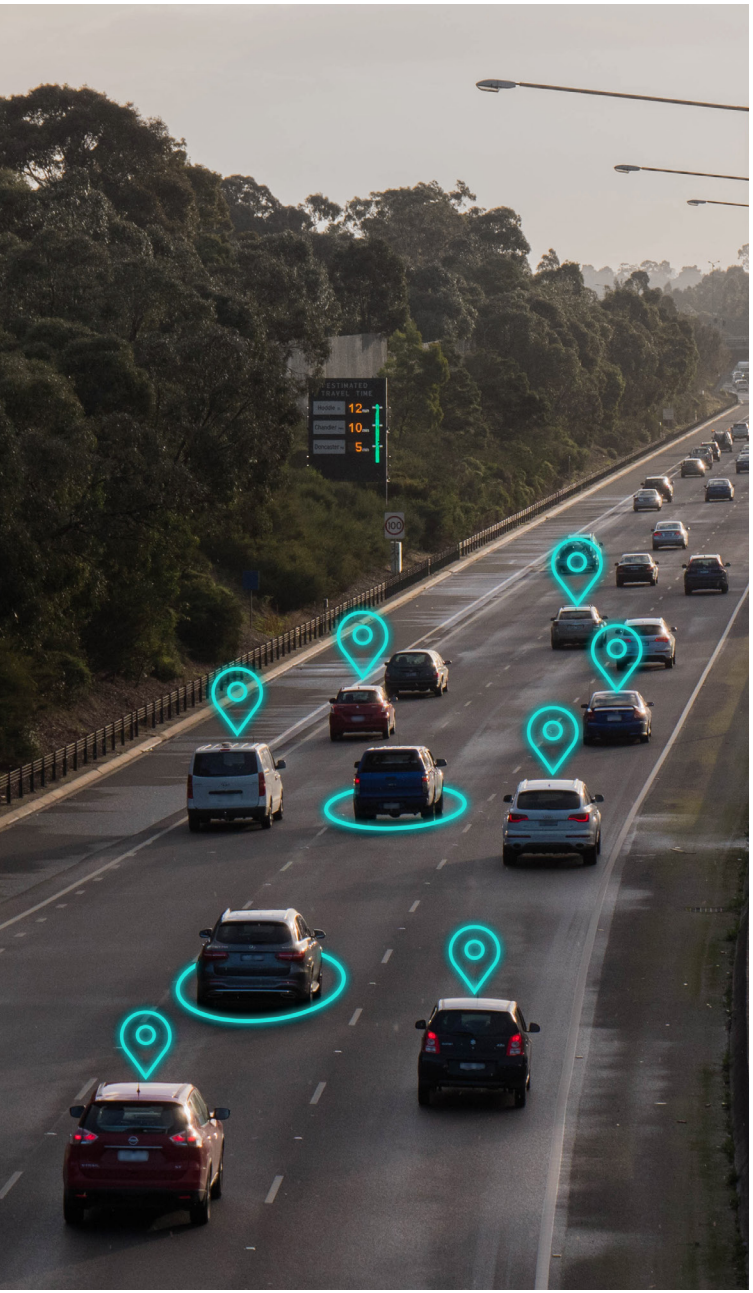
Precise positioning can bring efficiency improvements to rail operations, reducing costs and increasing safety. Precise positioning technology to an accuracy of less than 1 metre can be integrated into trains to support general positioning, network monitoring and the shunting of locomotives and rolling stock between yards and platforms.

Emerging

High accuracy, high integrity precise positioning can support the transition to modern rail control systems from 'fixed block' signalling systems to real-time 'moving block' signalling systems. Precise positioning technology can confirm the track a train is on and continuously communicate a safe distance between trains. This can improve the network capacity and train frequency, without requiring fundamental changes to the existing tracks or the trains.

Rail

- Improved track-determination and traffic management
- Enhanced GNSS-based signaling systems (reduced headways)
- Enforcement of speed restrictions and temporary slow orders
- Increase efficiency of rail yards and precise moving of rail stock
- Enable automation and Intelligent Railway Systems



Source: Shutterstock

Road

In road transport applications, sub-metre to decimetre accuracy positioning may be sufficient to support lane-level vehicle positioning and guidance on roads. In these applications, GNSS technology is only one component in a collection of sensors used to support vehicle operations. On roads, there is an increased requirement for high positioning integrity and reliable delivery of GNSS corrections.

Precise positioning and integration of GNSS correction services in road vehicles can support vehicle navigation systems, vehicle fleet management, traffic management systems and intelligent transport systems.

Emerging

Advanced Driver Assistance Systems (ADAS) and Autonomous Driving Systems (ADS) are already being developed and tested for use on Australian roads. These systems require a range of integrated sensor technologies to operate safely, including GNSS technology to provide sub-metre, lane-level precise positioning of vehicles in real-time.

Precise positioning services based on Victoria's GPSNet infrastructure will be able to support authoritative validation and verification of vehicle positioning systems. This will ensure Autonomous Driving Systems operate within legal and regulatory frameworks and verify the accuracy and reliability of services.

Vehicle navigation systems	• Lane-level positioning – turn-by-turn instruction • Congestion and traffic speed mapping
Vehicle fleet management	• Route optimisation, fleet efficiency and monitoring • Truck platooning and fleet tracking • Monitor driver/vehicle behaviour (e.g. traffic violations, identify preventative maintenance)
Traffic management systems	• Monitor and control lane-level congestion • Locate incidents and construction disruptions • Support distance-based and real-time tolling – electronic RUC (eRUC), reducing admin costs
Intelligent transport systems	• Advanced Driver Assistance Systems (ADAS) • Autonomous Driving Systems (ADS) • Support enhanced co-operative intelligent transport systems (C-ITS) – signal priority

Source: Shutterstock

Contact us

To find out more about the potential of precise positioning technology and services for your applications, please contact the Geodesy team for advice and support.

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