LOCATION ACCURACY

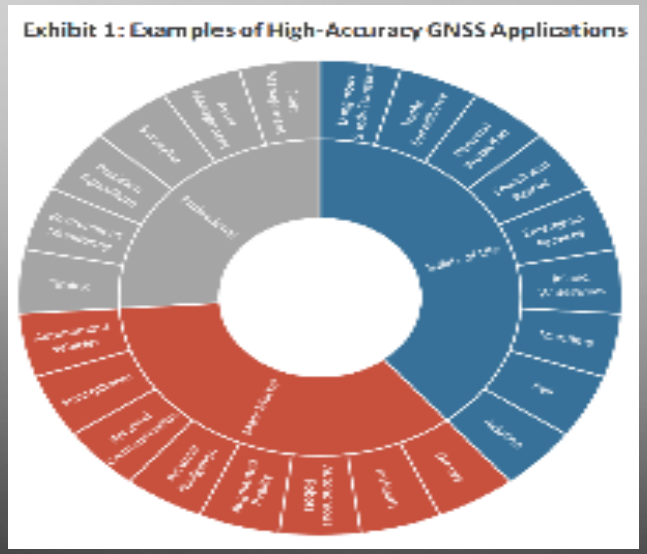
USING PPE-RTK TECHNOLOGY

OVERVIEW

- Whilst GNSS offers fantastic benefits to the modern world and has enabled many applications across multiple industries, often the standalone accuracy provided is not sufficient for professional applications such as Precision Agriculture and Surveying.
- Errors must be eliminated from the location data to achieve high accuracy positioning; multiple technologies such as PPP (Precise Point Positioning), RTK (Real Time Kinematic) and more recently the hybridisation of the two, PPP-RTK, have been developed to achieve this.

PP-RTK

- RTK is held back by its requirement for bi-directional communication, limiting the number of users the network could support.
- PPP has long convergence times which typically don't align with mass-market user requirements
- PPP-RTK eliminates both issues and looks to be a promising technology for the mass-market. Multiple innovative concepts have already been developed for PPP-RTK, highlighting its potential.



INTRODUCTION

- The main goal of this study is to assess the innovative concepts around Real-Time Kinematic (RTK) and Precise Point Positioning (PPP), with focus on their hybrid variations (e.g. PPP-RTK), relevant ongoing standardisation activities, new players in the market, opportunities and limitations, as well as to perform an analysis on the PPP-RTK actual functioning, and associated pros and cons for this concept to be used in mass market applications, including automotive platforms.
- PPP-RTK techniques utilise State Space Representation (SSR), which was established by Wübbena G. (Geo++) [RD.11]. SSR broadcasts a single stream of correction data (one - way communication) to all rovers within a serviced area, providing a significant benefit over OSR techniques.

PRECISE POINT POSITIONING – REAL-TIME KINEMATIC (PPP-RTK)

- Researchers and service providers are hybridising PPP and RTK in an attempt to obtain the benefits of both technologies. The concept of PPP-RTK is to augment PPP estimations with precise undifferenced atmospheric corrections and satellite clock corrections from a network of CORS, so that instantaneous ambiguity fixing is achievable for users within the network these resolved integer ambiguities lead

Exhibit 7: High level view of main benefits and drawbacks of PPP-RTK compared to PPP and RTK only

Solution	Benefits	Drawbacks
PPP	Has no local ground infrastructure requirements Global	Long convergence times Lower accuracy
RTK	High accuracy (2cm) Near-instant convergence times	Highly reliant upon local ground infrastructure Short range of transmissions
PPP-RTK	Fast convergence times High accuracy Lower density CORS network than NRTK Degrades to standard PPP	Reliant upon local ground infrastructure

DRAWBACKS OF PPP-RTK

- PPP-RTK requires the same localised infrastructure as NRTK, limiting very high-accuracy positioning to areas within range of base stations. As the technology is still relatively new it has not yet been widely adopted by signal augmentation service providers, leading to a less competitively priced market. This market situation is exacerbated by the current lack of standardised data formats, highlighting the early development stage of the technology.
- Despite these challenges, there are several PPP-RTK services already available in the market and multiple innovative concepts remain under development,showcasing the potential of the technology . These innovative concepts utilise different methodologies for removing errors from the received signals, but are all based on the same principle technology and the equations for resolving ambiguities remain the same.

OPINIONS OF EXPERTS

- Many are not ready to reveal about the technology they have used.
- Fugro have announced that they are using the uncalibrated phase delay technique for their commercial PPP-RTK service.
- Before PPP-RTK can be deployed to the mass-market, there is still significant development required to understand the technicalities of its deployment. Most of the available literature focuses the methodologies of the technologies, and so there is little understanding on how this can be implemented. Experts did state that the operating environment for mass-market application of augmented signals will be much harder than for professional applications.

POTENTIAL PPP-RTK BASED APPLICATIONS

- Mass-market applications (such as drones, smartphones, etc.) demand careful consideration of the bandwidth, latency and data transfer cost for correction data transmission in the development of a real-time precise positioning system.
- Autonomous vehicles are one of the most highly anticipated mass-market applications and most localisation experts agree that for fully autonomous navigation, the vehicle needs to position itself within 20-30cm horizontally.

APPLICATIONS IN AGRICULTURAL FIELD

- Agriculture is a well-established application for GNSS data, with many tractor manufacturers incorporating GNSS receivers within their models to enable tracking and in some cases automated control.
- Applications enabled through improved accuracy GNSS:
  - Automated ploughing, seeding and crop dusting etc.
  - Marking of crop locations within farms
  - Potential to track herds + flocks
  - Use of UAVs to monitor and work on crops

Surveying

- Surveying was one of the earliest adopters of high accuracy GNSS services and has been fundamental in defining the user requirements for developing technologies

Common 3D Digital Map Concept

- ld improve autonomous vehicles. It is anticipated that an accuracy of 10 – 30 cm would be sufficient for the Common 3D Digital Map Concept.

Navigation maps

Mass-market navigation tools such as Google maps have become widely adopted around the world; however, often these have issues with providing an accurate initial user location. Multiple methodologies are being developed to resolve this issue, with Google focusing on the use of machine learning and scene recognition. This solution faces many issues such as the visual environments changing throughout the year. Instead it is envisaged that PPP-RTK could be implemented to provide the high-accuracy initial location, enhancing the user experience

FLAMINGO H2020

- Fulfilling enhanced Location Accuracy in the Mass-market through Initial Galileo services Horizon 2020 (FLAMINGO H2020) is an EU Funded project which has developed an enhanced location accuracy solution for the mass-market.
- It is implemented via a service which itself is enabled through a programmers Application Programming Interface (API). Styled on Google's Geolocation API, the FLAMINGO API provides a familiar interface and conceals the complexities of GNSS positioning to the end users.

HOW IT WORKS ??

- Behind the scenes, FLAMINGO is utilising multi-constellation and multi-frequency (when available) GNSS from Smartphone and IoT devices along with different GNSS and positioning services dependent on the location and densification of the ground network providing the required RTCM data services.
- FLAMINGO H2020 addresses mass-market devices such as smartphones and IoT devices, to facilitate and demonstrate reliable positioning and navigation in consumer applications. FLAMINGO is using the European Global Navigation Satellite System (E-GNSS) to build the enabling infrastructure and services for high-accuracy positioning