Integrating Multi-constellation GNSS and Terrestrial Positioning Technologies for Autonomous Machine Control (MC) Applications

Mrs Qizhi Shi (isxqs@nottingham.ac.uk), University of Nottingham
Dr Xiaolin Meng, Dr Yiqun Zhu & Professor Alan Dodson, University of Nottingham
Mr Karl Soar, Leica Geosystems Ltd

Recently the GPS system has been integrated into designs of cars, bulldozers, drills, excavators, pavers, farming equipment, and graders that are produced by most of the major manufacturers for autonomous or assisted driving, mining, construction, agricultural and environmental applications. For today's contractors, machine control technology is vital and the benefits that machine control could bring are apparent, in terms of precise, timely and efficient work delivery, automated job and data management and effective and accurate billing. When GPS is used for machine control, its main roles include both positioning and navigating the machinery and determining the attitude of their blades and buckets. On many sites, such as an open-cut pit, where the depth can often range from two hundred to six hundred metres with wall slopes exceeding 55 degrees, tracking a sufficient number of well distributed GPS satellites can prove to be extremely difficult and the signal degradation caused by diffraction or deflection sometimes makes positioning impossible due to multipath. Augmentation adoption of new signals and system modernisation are necessities to overcome the difficulties that are faced by GNSS only positioning, for the provision of accurate, reliable and continuous position and navigation solutions of these moving platforms in real time. However, such an integrated system is not necessarily a simple, robust, ready to use and profitable solution.

By around 2014, Galileo will hopefully approach its initial operational capability, China's Compass will start the deployment of its MEO satellites, and L2C and L5 signals of GPS will probably be available for positioning. These multi-constellations and new signals will certainly improve the overall performance of GNSS positioning and navigation but the same problems for positioning under dense canopy or in deep pits will still exist and multipath will still be one of the constraints on the provision of precise and real-time position solutions.

Figure 1. A bulldozer with a Leica MC system

This project will focus on a thorough review to the current machine control practice and then will proceed to research and develop advanced algorithms for the real-time data fusion of available ranging measurements from multi-constellation GNSS and terrestrial sensor systems. It is anticipated that by the end of this project a prototype platform based on reconfigurable software GNSS receiver concept will be devised and a series of performance tests will have been carried out, leaving a clear path for commercial exploitation. Figure 1 shows a grader that is integrated with a Leica machine control system. Figure 2 shows the electrically powered (battery) locomotive and 120m test track that is located on the roof of Nottingham Geospatial Building. It can be utilized for various dynamic tests.

Figure 2. The locomotive and the test track