The AGI Foresight Study - The UK Geospatial Industry in 2015

An Expert Paper

Space Observation

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Introduction

We are living through radical times in the geospatial domain, characterised by strong and far reaching advances in technology and scientific knowledge, as well as sweeping impacts on everyday life and human behaviour. I want to explore three major themes: new and improved constellations of GNSS (Global Navigation Satellite System) spacecraft; new concepts and opportunities in datums and reference systems and, finally, market forces and innovation shaping both the technologies and society in general.

Theme one: Satellite Positioning Proliferates

Satellite positioning systems proliferate and become increasingly sophisticated. Whilst GPS recently underwent something of a hiccough with the technical problems of SVN49 (the first satellite to broadcast signals on three carrier frequencies) and the press storm around the predicted system degradation, less broadly reported was the successful transition to the new US Air Force ground segment in 2007. Previously the system was supported by five ground tracking stations, now it has sixteen.

The US Air Force is ramping up to its next generation of space vehicles, GPSIII, and there are now open access civilian signals on two frequencies allowing for elimination of the troublesome ionospheric delay errors.

Europe has struggled over several hurdles in the funding model for Galileo (Europe's equivalent of GPS), but with two experimental satellites on orbit, and the four IOV (in orbit validation) spacecraft currently being integrated in the clean room at Astrium in Portsmouth, Galileo is looking like an emerging system as opposed to a vast number of desktop studies.

GLONASS, the Russian system, has steadily launched new satellites and currently has 18 healthy satellites broadcasting. The Russians are also planning new ground tracking stations for the first time beyond the Eurasian plate (in Australia, Cuba and South America), and are developing an SBAS (space-based augmentation system) capability.

The Chinese have launched their first MEO (medium earth orbit) navigation satellite and plan to have FOC (full operational capability) by 2020, with a regional staging plan to be completed by 2012 consisting of 5 geostationary, 3 geosynchronous and 4 MEO satellites. SBAS, delivering improved positioning and system integrity via geostationary satellites is operational for the US and Europe, with the Japanese and Indians also planning systems (MSAS and GAGAN respectively).

The trend is clear: more satellites, more signals, and more services: more everything. Many of the newer developments are still experimental but by 2015 they will be standard fare in the arsenal of satellites and signals available to the geospatial data community.

Given this plethora of choices do we need then to decide which system we design our devices to use? New receiver technologies can now track between 100 and 200 signals simultaneously, across the spectrum of available satellites. Receivers are configured to track new signals with only a firmware upgrade. We can envisage a future where the positioning app on your phone is upgraded to exploit new signals and satellites via iTunes.

By 2015 GNSS modernisation will have had a significant effect on all classes of positioning – from the high end, geodetic quality applications such as orbit determination of low earth orbiting satellites and warning systems for earthquakes and tsunamis down to consumer grade devices in phones and PDAs. Positioning will be more accurate, with lower latency and greater integrity. Integration with other sensor sets (typically low cost MEMS devices and compasses) will also have developed significantly. Positioning devices will work reliably in far more places than they currently do, and because of this the applications enabled by the technology will spiral upwards in terms of volume and sophistication. The development of the technology has something of the Moore's law about it: innovation, investment, accuracy and services all just keep growing.

Theme two: A Single, Global Datum

The wide gamut of positioning applications enabled and supported by GNSS/inertial technology all require underlying reference systems. We can turn to trends in the marine and aviation industries to consider where we might be in 2015, and into that mix we can pour some significant developments in space-based instrumentation and mission concepts. The pattern in the marine and aviation sectors is one of moving from local and regional spatial information systems to that of a global, integrated system. To coin a hackneyed phrase: joined up geography.

Whilst legacy spatial information systems have been retained by the national mapping agencies to satisfy certain stakeholder communities, increasingly the underlying data is captured and stored primarily in either a continental (e.g. ETRS89, the European Terrestrial Reference System 1989) or global (e.g. ITRF2005, International Terrestrial Reference Frame 2005) system. The building blocks of this shift came through revolutions in space geodesy that put geodetic class GPS receivers within the budgets of commercial companies, science organisations and national authorities, combined with concerted efforts (primarily in the scientific community) to push the envelope in terms of the accuracy and availability of ancillary data products: models of earth orientation in space, precise orbits and clock behaviours, available online and free of charge to all users. In addition new space mission concepts in

the determination of the gravity field – in particular the GRACE (gravity recovery and climate experiment) and GOCE (gravity and ocean circulation explorer) missions offer the chance to provide a consistent global definition of height in much the same way that the terrestrial reference frames enable consistent definitions of latitude and longitude.

The aviation industry now recognises these developments in the ICAO (international civil aviation organisation) annexes and Europe is drafting legislation to force airport operators to provide precise aerodrome position data of navigation aids and runways in these 'modern' coordinate systems.

Marine charting authorities are experimenting with spatial transformation models mapping legacy charts and data into the global datum. The trend is clear: a single, accessible, global datum used to store and model all spatial data.

Theme three: The Market

Len Jacobson in his book 'GNSS Markets and Applications' stated that the GNSS industry turned over $20B in 2007, and that the market was set to grow as high as $330B by 2020. Crazy numbers, right? Len's track record alone says we should take this seriously. Add to that the evident explosion of mobile applications in the iPhone and Google Android and the numbers start looking credible. The race is on between chipset system developers to be the supplier of choice, and many groups and institutes are working frenetically to integrate sensors, to exploit new signals and mapping data sources.

Another intriguing aspect of the market place is the role of innovation in building new services, both at the grassroots level in the open source iPhone and Google Android apps markets and from high end service providers. An example will put this in context. A very famous and large scale US car manufacturer decided to equip all its cars with GPS chips. The company intended to get their customers to sign up to a service agreement for the positioning a few months after purchase, once free access ran out. The response from the customer base was lukewarm, and there was little uptake, leaving the manufacturer with redundant hardware in their cars. Now, in the US many cars also have telemetry streams linked up to sensors in the cars that monitor the state of critical components, so that when a component is near to failure the company can warn the owner that they need to get the vehicle serviced. This particular company decided to start using its knowledge of both the state of the vehicle *and* its location to distribute parts out to service centres in anticipation of demand. More impressively they were then able to e-mail their customers along the lines of: "your vehicle's clutch is due to fail in two weeks time, if you take it the garage at Lincoln Avenue (1.2 miles from your usual route to work) we can carry out the repair in two hours and have you back on the road". In one fell swoop they had optimised their distribution costs and were able to offer an innovative service to their customers that clearly differentiated them from the competition. I cite this merely as an example of how ingenuity and innovation combined with burgeoning technological advances present opportunities to us which, whilst they can be exploited clearly for tremendous gains in science, can equally provide services and

efficiencies that stimulate our troubled economies. The trend is clear: only our imaginations can limit what we might achieve in the next generation.