Space Enabled Innovation in Cities: Advances in Earth Observation

The Earth Observation (EO) industry is going through a time of radical and exciting transformation. No longer exclusively the realm of government and big industry, space is becoming increasingly accessible to the mass market. Exponential evolution of technology, coupled with reduced cost of manufacture and launch, has triggered a renaissance, which is capturing the imagination of the markets.

Sensor technology can deliver extremely high-resolution imagery, Synthetic Aperture Radar (SAR), and video on a satellite that is as small as 400kg. New operating concepts and business models are also removing barriers to entry. This has led to an influx of private companies into the sector, demonstrating widespread disruption. Entrepreneurship in response to data needs of the community is stimulating the market through a new wave of space-based applications. For cities, space enabled services are key to realising industrial revolution, where the notion of digital twin and real-time data analytics is driving market growth.

Trends in Earth Observation

The most significant trends in the space sector may be characterised by advancements in upstream technology or improvements in downstream service provision. Upstream innovations are being driven by miniaturisation of electronics, improved optics systems, power capture/storage, and improved communications systems. Advances in EO capability are being observed in spatial resolution, temporal resolution, radiometric resolution, real-time data access and greater storage capacity. These developments will enable greater ability to carry out situational awareness and deliver advanced analytics capability.

Increased availability of this technology at significantly reduced cost has enabled a movement towards the deployment of distributed small satellite systems. The traditional model of satellite manufacture has been broken by leveraging a rapid iterative development approach, which allows delivery at a fraction of the cost and time of legacy satellite systems. High temporal resolution satellite imagery provided by these constellations will reveal patterns in, and allow monitoring of, highly changeable environments, moving closer to a reality of persistent surveillance. Furthermore, greater demand for near real-time applications has led to the development of geostationary data relay satellites, enabling EO platforms in low Earth orbits to have almost continual communication with a control ground station. With satellites producing increasing amounts of data, more work is also being done to enable on-board processing. These advances will facilitate near real-time transfer of data, empowering users to make smarter and quicker decisions. One of the most exciting recent developments is the offer of video from space. This type of technology will continue to become more prolific allowing true situational awareness over an area of interest.

A significant development in terms of realising the value of EO data for economic development is European investment into the Copernicus programme. The programme will deliver 25 petabytes of open EO data over the next five years, leading to generation of an estimated US$35bn market, and tens of thousands of new jobs by 2030, from services and applications that exploit the data in new value chains. The Copernicus satellites, termed Sentinels, carry a range of technologies such as radar...
and multi-spectral imaging instruments for land, ocean and atmospheric monitoring.

Downstream innovations refer to developments in the latter stages of the industrial process, notably delivery of value added services. Currently, one of the most significant disrupting technologies is Artificial Intelligence. With dense time series of high resolution satellite imagery now available on the cloud, we have arrived at a juncture in the space industry where it is possible to exploit computer vision technology. This type of technology will facilitate the recognition of important dynamic features in a fully automated manner. To realise such techniques and manage the unprecedented volumes of data required to undertake them it is necessary to exploit new IT infrastructures, such as high performance computing and graphic processing units.

Traditionally one of the soft blockers to enabling downstream exploitation of satellite data has been the commercial models surrounding data provision. Current commercial data provider business models are inflexible and tend to be based on “pay-per-image”, irrespective of how much of the image is of use to the customer. This, together with the relatively inflated cost of imagery, has led to a scenario where market needs are not being met and there is an underutilisation of available EO data. Diversification of these business models is becoming increasingly common, allowing a more customer oriented experience, with a decrease in emphasis on minimum area orders and the development of “pay-per-pixel” type models. This allows flow through of similar terms from the service provider to the customer where Software as a Service (SaaS) models are increasingly becoming the norm.

**Big Data in Cities**

A thirst to understand and manage our environment through the application of knowledge is causing a paradigm shift to occur in our cities, where the adoption and use of Big Data is being harnessed to improve quality of life. Critical resources will need to be monitored and optimised to reduce costs, and decisions will need to be made to accommodate city inhabitants. According to a recent study, the expected global value of products and services for this market will be US$1.5 trillion by 2020. Cities are experiencing unprecedented access to information, new emerging technologies and the convergence of information and infrastructure networks. EO provides an unparalleled opportunity for providing non-invasive, high resolution, wide area surveillance across a city. Advancements in EO technology alongside wider transformation in the space sector converge perfectly with this new revolution occurring in cities.

**Case Study 1 – Local Council Planning Management**

The challenge of supporting sustainable growth without exceeding infrastructure capacity in Milton Keynes, whilst meeting key carbon reduction targets, is a major one. Historically, the planning management was done manually and involved issuing planning permits. To ensure adherence to the permit, planning officers were sent to physically inspect the properties listed in the database and verify that changes were in accordance with those approved within the planning permit. The entire process was inefficient and costly. The Satellite Applications Catapult has collaborated with Milton Keynes Council to leverage space technology in support of conducting change detection to the built environment over time.

By utilising very high resolution multispectral satellite imagery (8 spectral bands, 30cm spatial resolution) it is possible to track change and easily identify where any illegal activity may be occurring. This is done by characterising the land use according to several parameters such as geometry, colour, height and texture. These characteristics are extracted from the imagery and classified. Images captured at different dates are then compared to highlight and characterise discrepancy. Updates are provided quarterly through an intuitive dashboard that allows users to interrogate the data and make informed decisions, conducting analysis in accordance with the approved planning permits. Planning officers can simply view change information at their desks with substantial time and cost saving to the council. This represents the type of change that will be required to address the growing challenge facing UK cities around economic development and sustainability.

**Case Study 2 – Asset Monitoring**

Engineers are not able to constantly monitor bridges and other structures in person, so the ability to remotely monitor assets and detect unexpected movements or sinking at a millimetre level could potentially highlight problems before they become disasters. The Satellite Applications Catapult, in collaboration with University of Cambridge, University of Leeds, and InSpace Missions, are working to demonstrate how the use of Interferometric Synthetic Aperture Radar (InSAR) (X-band, 3m spatial resolution) and IoT technology can provide a reliable and sustainable solution for improving and lowering asset management costs. When features on the ground move, the distance between the sensor on the satellite and the Earth’s surface changes, thereby producing a corresponding change in measured signal phase. The changes in measured phase that occur between repeat passes of the satellite are used to quantify millimetre scale ground movements. In the future, the Building Information Modelling (BIM) community will be able to make use of bridge monitoring services that exploit this technology and use BIM software to help improve visualisation techniques and develop new asset management solutions.

**Case Study 3 – Community Action Platform for Energy (CAPE)**

CAPE works with communities and businesses to provide a new way to manage energy. CAPE members are invited to give their ideas for schemes such as solar panels, insulation, or electric cars, and the best suppliers bid to deliver the schemes. By buying as a community group, prices are reduced and quality of service improved. The platform gives local companies the opportunity to become suppliers which also creates jobs in the local area. This project is a collaboration between SmartKlub, Community Action MK, Open University, Tech Mahindra, Satellite Applications Catapult and Milton Keynes Council.

The platform leverages analysis of satellite imagery (4 spectral bands, 1.5m spatial resolution) to derive information products, identifying the potential for new solar energy projects (thermal emissivity and roof pitch/orientation) in and around the city, and model the cost and potential for any such new renewable energy capacity to link to the electricity grid. The results of this analysis,
enriched by integration with other spatial and non-spatial data, is also used to highlight where the greatest potential exists to implement energy saving schemes, such as the installation of loft insulation or Ground Source Heat Pumps (size and accessibility of garden) at a property-by-property level across the city.

Conclusion

The EO sector is rapidly coming of age, moving away from the cottage industry it once was and becoming firmly embedded as a mainstream technology across numerous market verticals. This is largely enabled through strong collaboration with other tech sectors, which is adding significant value across a range of commercial opportunities. Space based applications have been enabled in areas such as air pollution, ground movement, renewable energy potential, heat vulnerability indexing, ecosystem services, flood management, housing, and development and infrastructure monitoring. End users at all stages across the various market areas are getting excited about EO, and the mass market has never been closer to the data, providing new sources of intelligence to give a competitive advantage.

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https://www.geomatics-world.co.uk/content/article/space-enabled-innovation-in-cities-advances-in-earth-observation