

POSITION REPORT

GNSS Market Research and Analysis

GPS Technology Convergence

It's impact on mobile GPS applications

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1.0 Introduction

From the earliest applications of GPS it has been integrated with other technologies. Indeed it can be argued that without such integration the value of GPS and subsequently GNSS would be severely diminished.

The purpose of this paper is to examine the impact on **mobile GPS and GNSS applications** of the continued convergence of three technologies: Position, Navigation and Timing (PNT); Geographic Information Systems (GIS) and Communications Technology (CT). The paper will describe a market model for convergence and will go on to discuss some of the constraints which must be overcome for the convergence to continue.

2.0 Understanding the Market

It is important from the outset to recognize that the market for mobile applications which incorporate these technologies is wide and varied. Consumer, Professional and Industrial applications are growing rapidly, each with their distinctive requirements for precision, availability, cost and features.

The diagram below illustrates how these different user domains view technology. Some will place more emphasis on precision or availability of the PNT service for example, whereas other will be more interested in blue tooth connectivity or similar technology factors.

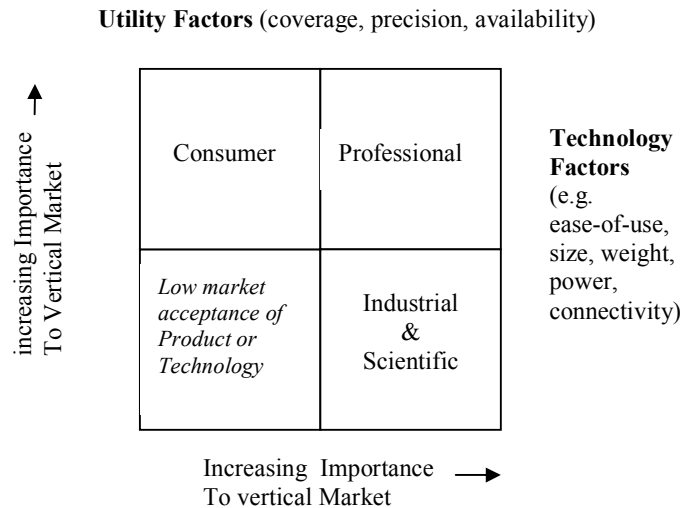


Figure 1. User Domains. Position One Consulting, GPS World May 2005.

It is no accident that convergence has occurred most quickly in the consumer domain as these are the users who place the highest weight on factors such as size, weight, power, ease of use and other factors common to consumer electronic products.

3.0 Convergence Model

The second figure (below) is a simple model to illustrate the convergence of the technology domains under discussion. Geospatial Information and Communication Technology (**GeoICT**) is a term coined by Dr Tao, Director of the GeoICT Lab at York University in Toronto, Canada. GeoICT neatly encapsulates the concept of the convergence of PNT, GIS and CT (Indeed the concept envisions the eventual incorporation of geospatial technologies into the mainstream of ICT).

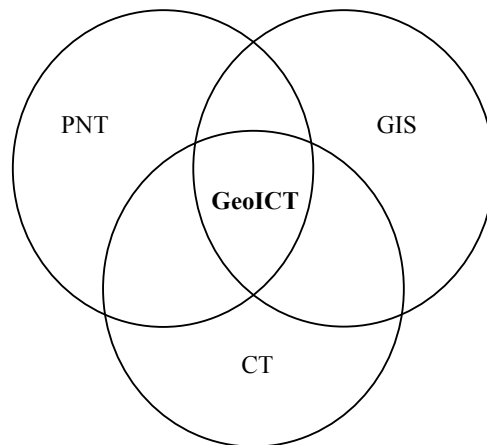


Figure 2. Technology Convergence. Derived from Ackroyd and Lorimer, 1990-94.

Using this simple model we can place mobile applications into the various spaces. For example, a personal GPS which only shows position coordinates would fall solely into the PNT space with no overlap with other technologies. A personal GPS with electronic maps would fit into the overlap between PNT and GIS. A PDA which downloads a map over a wireless connection would be in the shared domain between GIS and CT. A mobile phone with assisted GPS (A-GPS) for 911 can be described as in the CT-PNT overlap.

A brief review of GPS applications over the last decade also demonstrates that applications migrate through the domains with time. The example of the personal GPS used above will serve to illustrate the point.

The first hand-held personal GPS receivers launched in the market in the early 1990's produced coordinates readings on a simple screen (PNT Only). Within a few years these personal GPS were capable of loading colour maps and displaying navigation information graphically on the screen (PNT-GIS). Today a sophisticated personal navigator can upload maps and send location to third parties (GeoICT).

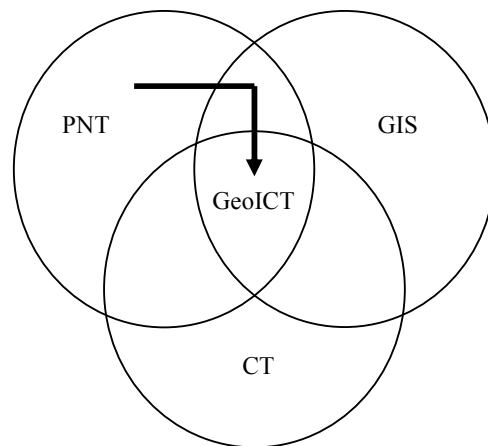


Figure 3: Migration of Applications with Time. Personal GPS.

It is probably true to say that consumer applications have migrated more quickly than professional and industrial applications. This is a function of consumer GeoICT products using more common components but also a function of some of the constraints on convergence which we shall discuss later.

4.0 Implications for future Products and Services

Given the historic trend for mobile applications to migrate to the center of convergence and the prediction that GeoICT will eventually become part of ICT the implications for future products and services are clear. Products and Services will increasingly incorporate elements of PNT, GIS and CT.

As was mentioned earlier in the paper, whereas examples of this occurring in the consumer applications are increasingly common, examples in the professional and industrial spheres (e.g. Survey, Agriculture, Aeronautics) are less frequent. In order for this trend to eventuate in these domains the constraints on convergence must be removed more completely. A subject we shall now examine in more detail.

5.0 Constraints on Convergence

Integration at the electronic component level is a key constraining factor to convergence. Component volumes (and hence cost) are driven by large consumer markets such as mobile phones and PDA's. For example to build positioning functionality into a wireless-mapping consumer product requires that the additional component cost is kept to a minimum. This has been the thrust of several GPS companies such as SiRF and u-Blox and it is interesting to note the rapid growth of CPS whose matrix technology is a software only solution on a mobile phone.

Professional and Industrial products have a tendency to use custom ASIC's and "hardened" components to achieve the performance they require. Where these components are not driven by consumer volumes, costs are significantly higher which is reflected in the retail price. When products use proprietary architecture this can also lead to higher integration costs as "standard" components may need to be customized to fit into the architecture. Engineering philosophy for professional and industrial products is moving to using as many off-the-shelf components as possible but this is still in process and is a clear constraint to technology convergence in professional and industrial applications insofar as cost is limiting factor to end user uptake.

Within the PNT domain there is also integration of different positioning and navigation sensors for example GPS with INS. Often the driver is increased availability during times that GPS is blocked. This type of integration is directly driven by the availability issues we shall discuss later in the paper.

An issue familiar to anyone involved in Geospatial industries is **Interoperability**. In an ICT context Interoperability is defined as "the ability of hardware and software on different machines from different vendors to share data". The Open Geospatial Consortium (OGC) is a non-profit organisation creating international, voluntary consensus standards organization for geospatial and location based services and the European Telecommunications Standards Institute (ETSI) is a good example of an organisation creating CT standards. Both RTCM and NMEA are open standards familiar to those involved in GNSS however much work remains in defining Interoperability between GNSS systems such as GPS, Glonass and Galileo. This is in stark contrast to the work which has occurred within CT and GIS domains.

In the consumer domain interoperability is well recognized and accepted as pre-requisite for product success. In the professional and industrial domains however interoperability is less established. Whereas many suppliers of products in these domains will advertise interoperability this does vary considerably depending on vertical market. For example in the Survey vertical market interoperability is well-known by comparison in Agriculture proprietary systems predominate.

The adoption of Interoperability (open standards) appears as much to do with corporate marketing strategy as product development roadmaps. It is interesting to note that large manufactures in some industrial markets still pursue "closed" product strategies despite the evidence from the wider ICT industry that open standards predominate over time. History would indicate that technology convergence in those vertical markets which do not embrace interoperability will be slower than those that do.

A GeolCT application without the **availability** of position, mapping and communications is of limited use. It is the most obvious constraint to convergence and one which receives a lot of attention by governments, corporations and users. Ultimately the user wants a ubiquitous product, one that works everywhere, every time and to the users required level of precision. However what defines ubiquity varies considerably between Consumer, Professional and Industrial vertical markets

For example, Assisted GPS (A-GPS) increases availability of GPS in buildings and other restricted GPS environments however the accuracy level is not acceptable to a professional user such as a surveyor. The technology improves availability for one user but not another. Conversely, a mining company would probably consider their GeolCT product to be ubiquitous if the position, mapping and wireless availability for their property is 100% regardless of availability in the town 10Km away.

In many respects the Consumer domain, leading in Integration and Interoperability, is the most difficult in terms of availability due to the wide variety of geographies and environments it expects products to operate in. The good news for consumers is that billions of dollars are being spent on GNSS augmentation, wireless roll-out and map data availability to push convergence forward.

Just as corporate marketing strategies are important to interoperability, political focus is important to the constraint of availability. Insofar as governments invest in wireless infrastructure, GNSS and make geospatial information freely accessible, the convergence of technologies will continue apace.

Many of the current and potential GeolCT applications are Real-Time. This introduces the constraint of **Data Freshness**. In a real-time application the transaction (e.g. retrieval of a traffic report based on location) needs to occur within a deadline, in this example before the vehicle has moved beyond an acceptable distance or the traffic conditions have changed. In other words there is a temporal constraint to data. Even when other constraining factors have been overcome (e.g. a fully integrated PDA with GNSS coverage and wireless connectivity) a lack of Data Freshness can render the product useless and indeed in safety critical applications could even pose a danger.

Many existing (non-real time) databases are poor at handling the timing constraints and temporal consistency of data and new providers have emerged to service real-time applications for example Telcontar for map data. Data Freshness issues exist in every aspect of the converging technologies. Map Data we have already mentioned but Data Freshness is equally important to GNSS augmentation and Wireless communication data rates. Only when the constraint is removed in all three convergent technologies can we say this particular issue is resolved for real-time GeolCT applications.

6.0 Conclusions

The Convergence model described in this paper supports the GeolCT concept and its presumption that eventually such mobile applications will become part of the wider ICT world. A brief historical overview of products shows that they have a tendency to migrate towards convergence of PNT, GIS and CT functionality.

The trend towards convergence varies considerably depending whether the application is for consumer, professional or industrial vertical markets. The consumer vertical markets are showing a convergence of technologies at a much faster rate than most professional and industrial vertical markets.

The variation in convergence can be largely explained by the respective domains ability to overcome constraining factors such as integration, interoperability, availability and data freshness.

The consumer domain is most advanced in solving issues regarding integration, interoperability and data freshness. The largest constraint would appear to be availability which is receiving attention at governmental, corporate and user levels.

In the professional and industrial domains availability is most achievable if the application is occurring in defined geographic areas such as a farm, mine site or construction site. In these domains corporate engineering and marketing strategies have a heavy influence in determining how quickly integration and interoperability issues are overcome. There is a tendency in some quarters to favour proprietary engineering and closed system architecture which history shows will slow convergence. As GeolCT applications develop in these domains we will learn more about potential data freshness constraints.

In conclusion, GeolCT convergence is visible and we can expect to see further evidence of this trend in the coming months and years in all domains and vertical markets for mobile applications. The consumer domain will continue to lead the way however the professional and industrial domains can expect to see similar demands in the future.

Sources

ICT Interoperability	www.etsi.org
Geospatial Interoperability	www.opengeospatial.org
GeolCT	www.geoict.net
Data Freshness	www.computer.org/publications/dlib

7.0 Author Biography and Credentials

Rob Lorimer is the founder and Managing Director of Position One Consulting. He has successfully completed reports into GNSS markets for a diverse range of clients including Navcom Technology (a John Deere Company), the Galileo Supervisory Authority (ProGENY Market Studies), the Queensland Government, Australia (The Global Navigation Smart State) and the Cooperative Research Centre for Spatial Information (Precise Positioning - User Needs).

From 1991-2003 he held several senior executive roles in the GNSS industry including CEO of Beeline Technology (acquired by Hemisphere GPS), Managing Director of Trimble Asia Pacific and OEM Business Unit Manager for Trimble Europe, Middle East and Africa.

His GNSS industry involvement continues today as a member of the advisory committee of the International GNSS Society (IGNSS) chair of the IGNSS special interest group Location Australia and as a regional judge for the European Satellite Navigation Competition (formally Galileo Masters competition).

The author graduated with a BSc 1st Class (Hons) from the University of Cardiff (a leading UK earth sciences institute) and undertook his post-graduate business studies at the University of Queensland, Australia. Publications include numerous papers and articles on GNSS and authorship of Global Navigation – A GPS Users Guide (1991,1994) one of the earliest books to analyse the end user applications of GPS.