POSITION REPORT

GNSS Market Research and Analysis

The Adoption of GPS in Cropping Agriculture

Market Analysis

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1.0 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.

2.0 Introduction

From the inception of GPS for commercial use, agriculture has been predicted as a large potential market. GPS can be used by growers, agronomists and agencies responsible for environmental and regulatory control. Applications cover the full gamut of GPS products from low cost handhelds to automated steering systems capable of centimeter accuracy.

The adoption of GPS has been most extensive in countries with established large scale agricultural enterprises such as the US, Canada and Australia and the adoption rate is growing quickly in emerging agricultural powerhouses like Brazil and Ukraine.

It has not all been plain sailing, some of the early GPS providers, with little experience of agriculture, took time to learn the vagaries of the market and mistakes were made in marketing, product introduction and support. However in recent years many GPS manufactures have seen considerable volume growth and the introduction of products by more established agricultural players such as John Deere and Case New Holland has certainly helped give the technology widespread credibility amongst farming communities.

Cropping agriculture is not uniform and spans a wide range of plant species, soil types and farming methods. Likewise GPS adoption has not been uniform. Some crop sectors such as irrigated cotton have adopted GPS systems rapidly, others such as sugar cane are only beginning to use the technology to its full extent. Within crop regions some growers purchase yield monitors with GPS, others buy some form of GPS guidance and others a simple hand-held. Whether spending $50,000 or $500, all have taken a decision that GPS will meet a need and can be financially justified. We shall return to this theme later in the article.

Considering the considerable economic and environmental benefits of using GPS to individual growers, communities and national economies it is important to understand some of the factors which are influencing the adoption decisions and how the growers needs are being met by the GPS supply chain.

3.0 Understanding the market.

Agriculture is a notoriously volatile and price sensitive market. Predominantly populated by family owned and operated enterprises, purchase decisions are carefully taken and often based upon word-of-mouth recommendations. The adoption of new technology in a given geographical area commonly follows the success of prominent growers who experiment with the technology first. As a consequence the adoption time frame from initial sales to innovative growers through to volume sales to mainstream growers can be many seasons, a period of time further modified by the vagaries of climate, yields and commodity prices (growers are quick to close their wallets if they feel that bad times are ahead). These factors often cause inexperienced entrants to underestimate the time for new technology to be adopted.

Another important aspect of agricultural is the diversity of enterprise performance compared to other industries. Diagram 1 below illustrates that in most industries individual enterprises perform 85% to 95% as effectively as the best of breed. In agriculture the majority of individual enterprises operate around 60% as effectively as the best in breed. The implications for the adoption of new technology are obvious, there is simply not the same performance related imperatives to keeping up with the competition (i.e. other growers) as in other industries. It also reflects the underlying individualistic nature of most growers, they like to do it their way.

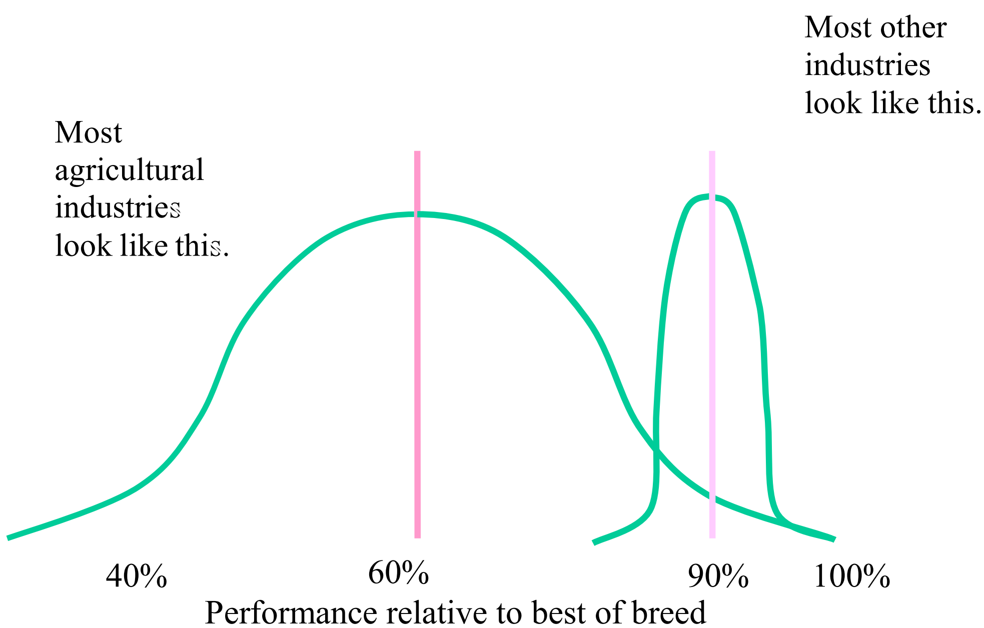

Figure 1. Relative performance of Agricultural Enterprises
Source: James Moody, WANTFA Conference, Perth, Australia, Feb 2005

Combine the volatile nature of the underlying industry with individualistic nature of the enterprises and reasons for the wide variation in adoption rates of GPS in agriculture start to become clearer. Yet the need for positioning and spatially referenced information is real and is generally used to help fulfill two primary goals (1) Increasing farm productivity by boosting crop yields and (2) improving operating efficiency by reducing the usage of chemical and fuel and decreasing the number machine hours.

An important point to note is that historically yields have been improved by *increasing* the chemical input, the change in farming practices advocated today are intended to increase yields while at the same time potentially *decreasing* chemical input.

4.0 GPS and Precision Farming

Precision Farming is a term often used to describe the use of GPS and other technologies in improving farm productivity and operating efficiency. Diagram 2 illustrates three major applications for GPS (Mapping, Input Control and Machine Control) which incorporate this concept and how they relate to the three main approaches that most growers initially take to Precision Agriculture (Improving Agronomy, Reducing Error and Changing Practice).

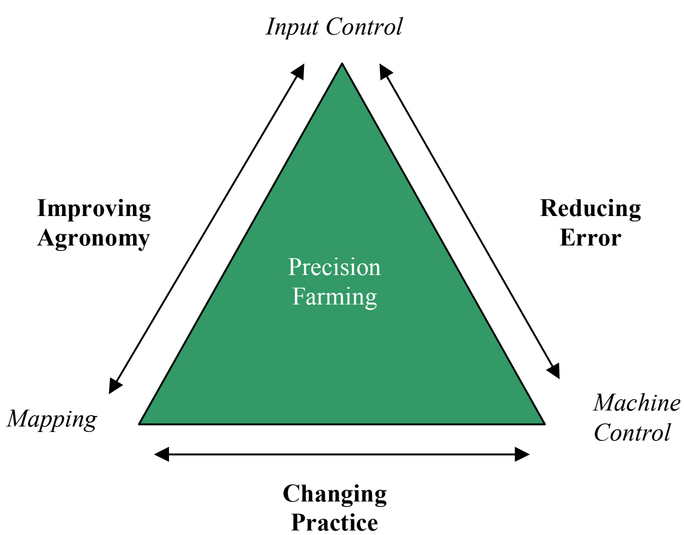

Figure 2. GPS Adoption in Cropping Agriculture ©Position One Consulting

Mapping describes using GPS as part of a data collection system which includes geographical position. The purpose is to collect geographically referenced data for subsequent analysis and decision making. *Input Control* refers to using GPS to monitor, control and precisely apply inputs such as fertilizers, pesticides and seed or seed plants. *Machine Control* is using GPS to better control the steering of agricultural machinery and implements.

As mentioned previously, growers have typically approached Precision Farming from the perspective of either: (i) Improving Agronomy, (ii) Reducing Error or (iii) Changing Practice. Many will use the term Precision Farming but most do not initially use the full array of products and techniques available to them. It is important to note that these approaches are not mutually exclusive it is simply that most growers start of with one before moving to others. Farming enterprises which are using elements of all three approaches can perhaps be said to have truly adopted Precision Farming.

Improving Agronomy is a "scientific" approach to Precision Farming. It typically involves a considerable amount of data collection (Mapping) of the farm property including soil composition, pest concentrations and yields. This information can be built up over successive seasons and the grower then uses techniques such as Variable Rate Technology (VRT) to place chemicals only where required (Input Control). The objective is to progressively improve yields while restricting chemical usage to those areas which can be proven to require it. In this approach the primary objective is farm productivity with a secondary outcome of operating efficiency.

Reducing Error can perhaps be described as the "practical" approach to Precision Farming. It most commonly involves helping the operator drive the machinery in a straighter line through the use of a visual guidance system or an automated steering system. By reducing the amount of overlap (where the ground is covered twice) and underlap (where a strip may be missed) seed, chemical and fuel input can be reduced by up to 10%. Further advantages are reduced fatigue, a decrease in the time taken to perform operations and a reduction in the need to repeat or "fill-in" jobs. Additional techniques include methods such as boom-section-control where a spray boom with multiple nozzles on each side will switch off the end nozzles if it detects it is overlapping. Generally with this approach the grower is seeking operating efficiency with a *potential* bonus of farm productivity although in practice this is often not measured.

The third approach is where the grower is **Changing Practice** often with the joint goals of both improving both farm productivity and operating efficiency. An example of this is the adoption of control traffic. With this practice the grower permanently divides his field into crop zones and driving zones. Every pass of machinery for sowing, fertilizing, spraying and harvesting is along the same wheel ruts (driving zone) significantly decreasing compaction in the crop zone which improves soil structure, water retention and root penetration. Growers moving to control traffic report steady improvements in crop yields as the effects of compaction are reduced season by season. The investment is considerable as machinery is generally fitted with sub-inch auto-steering to ensure as small a driving zone as possible. In addition implements are often standardized to "fit into" the new driving patterns. Prior to changing farm practice growers usually undertake significant mapping activity to determine the optimum layout and implementation of the farming system being adopted.

5.0 The economics of GPS adoption

It is important to understand the initial approach of growers as the economics are significantly different between the three choices. At a minimum most growers will do a simple calculation of payback as illustrated in the formulae below.

Payback (years) = Capital Cost / (Savings + Yield Improvements)

Where Payback measured in years is the capital cost of the equipment divided by the savings and yield improvements measured in dollars per annum. For example if the capital cost is $10,000 , savings in fuel, chemicals etc are estimated at $1,000/year and additional revenue from yield improvements at $3,000/year, payback would be estimated at 2 years and 6 months.

It is obvious from this simple pay back formulae that a grower who is only considering savings (which corresponds to the Reducing Error approach) will either have to accept a longer payback than growers adopting other approaches or alternatively will seek products with a lower capital cost. In reality growers choose the latter and this goes someway to explain the prevalence and popularity of relatively low cost products such as visual guidance systems amongst growers in this category.

Extending this observation further, growers who are changing farm practice often fully account for both expected yield improvements and extensive savings. This in turn justifies the higher capital costs of products such as sub-inch auto-steer and associated equipment changes.

Obviously the size of the farm, scale of operations and crop value are all factors in the economics of adoption. However the basic rule applies, if the grower is only justifying his purchase on operating efficiency and not taking into account potential improvements in farm productivity he will not be prepared to spend as much on the product.

6.0 GPS adoption in practice.

As we mentioned earlier in the article, within a given crop region the adoption of new technology is generally attempted first by a relatively small group of progressive growers. The main body of growers wait until the technology is proven to have benefit by the progressive group before adopting it themselves.

Obviously the choice of approach by the leading growers in a given area will have a significant impact on the overall adoption pattern. For example, in Australian cotton the majority of the progressive growers engaged in Changing Practice by adopting Control Traffic. The consequence for the GPS supply chain was a concentration of dual frequency GPS RTK auto-steering systems. This pattern was consistently repeated by the mainstream growers once data was produced showing both improved operating efficiency and farm productivity. Today the vast majority of cotton properties in Australia are using such technology.

In another example, progressive broad acre wheat growers in Canada tended to initially adopt an approach to reduce errors. As a consequence relatively low cost visual guidance systems are very common in that sector. By comparison, a significant number of progressive growers involved in broad acre wheat production in Western Australia have adopted a change in practice called zero till. This has led to a larger proportion of auto-steering systems being purchased as opposed to visual guidance.

To continue the examples, in some parts of the Queensland (Australia) sugar industry yield mapping and variable rate control (Improved Agronomy) are popular and 500Km further up the coast growers are buying sub-inch Auto-steer.

It does seem from these examples that the initial choice of the leading growers has a significant impact on GPS adoption in any given geographical area.

7.0 The GPS supply chain

As the different approaches to Precision Farming have evolved so the GPS Supply chain has produced products to satisfy the need. Many of the manufacturers started serving one particular approach and have subsequently increased their product lines to meet the demands of one or two other sides of the triangle.

A consequence of this great variety of products is that as the grower adopts more of the PF approaches (other sides of the triangle) he is often faced with interfacing different products from different vendors and compatibility becomes an issue.

8.0 Interoperability

Interoperability is defined as "the ability of hardware and software on different machines from different vendors to share data" and is an important concept for any grower thinking of buying GPS products.

Interoperability makes it easy to pick and choose the best products from a range of manufactures with the confidence that they will work together. The computer industry is fully interoperable, you can choose any combination of PC, printers, keyboards and mice and they will all work together. This also future proofs your purchase because you can upgrade parts of your system at different times

Let's use the example of buying an auto-steer and a GPS reference station which you want to use together to achieve 2cm accurate steering. If you buy them from the same manufacturer you would reasonably expect them to work together. However if they use a proprietary communications interface they will not work with any other manufacturers equipment and are therefore not considered interoperable.

If you buy the GPS reference station from one manufacturer and the auto-steer from a second and they use a published open standard to communicate with each other, they are interoperable. Interoperability depends on open standards such as exist in the computer industry. Such standards do exist for GPS and further standards are under development for agricultural electronics.

9.0 Open Standards

Many non-agricultural industries use interoperable GPS on a frequent basis. Indeed in some markets such as offshore oil exploration any product which is not fully interoperable is simply not acceptable and will not be purchased. The key point here is that many of the GPS manufactures supply product into both marine markets and agriculture so their products already have these standards within them.

RTCM and NMEA are two open data formats which are widely used in GPS applications and will be familiar to many people reading this paper. Although widely promoted in many industries they remain relatively unknown within agriculture.

Other industries which have defined a number of open standards are those who use Geographical Information Systems (GIS). The standards here tend to be around map data and are therefore of direct relevance to many of the products used in agriculture. Two of the most common map standards are ESRI Shape and GeoTIFF. Both these started life as manufacturers proprietary formats but were subsequently published and became “open”. These map formats are often used to get different map data sources into farm management software.

The agricultural industry is itself developing an open standard for connecting electronics. The ISO11783 standard allows electronics from different manufacturers to communicate via a Controller Area Network (CAN) usually referred to as a CAN Bus. This requires a physical connection between devices. ISO11783 will become more and more common on agricultural machinery in coming years.

All these standards can be found in many GPS Precision Farming products today. The decision to market the availability and benefits of open standards is often down to each of the vendors.

10.0 Conclusions

The use of GPS in Precision Farming has been a long and hard road for manufacturers, dealers and growers. After many years of product improvements and learning how to effectively apply the technology, real benefits in terms of both operating efficiency and farm productivity can now be demonstrated for a large number of crop sectors.

It is important for the GPS community to understand that in practice the term Precision Farming means different thing to different growers. Depending on whether the growers initial focus is on reducing error, improving agronomy or changing farm practice significantly changes the economics of their decision making and hence the product mix they are likely to purchase.

Leading growers in each crop growing region tend to heavily influence the purchasing decisions of following growers. Trying to promote “top of the range” auto-steer in an area where only the economics of reducing error have been proven is certainly an uphill task.

Experience has shown that with time and patience the farming community will experiment with and adopt more and more aspects of the complete Precision Farming mix and so continue to improve their overall competitive position.

Interoperability will become an increasingly important topic within Precision Farming as more sides of the triangle are adopted by farmers. Much education remains to be done in this area within farming communities.

Improving our knowledge of the adoption process can help ensure that the right products are available to the right growers in the right area at the right time. When the economics are proven the adoption process is quicker benefiting not only the individual growers and the GPS supply chain but as operating efficiencies and farm productivity improve the wider economy benefits as well.