Demystifying Guidance - Steering a Straight Line through the Hype

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ABSTRACT

This paper will explain the basic operating parameters of farm GPS systems and the various levels of accuracy they offer. It will identify their applicability to PA and CTF and integrating precision steering into a farming system for maximum impact. Some practical aspects of machine guidance troubleshooting will be discussed and future advances in differential signal technology and networked solutions examined.

Keywords: Sub metre, RTK, Repeatability, Pass to pass, CORS

INTRODUCTION

GPS has been around a while, Australian engineers were the first to develop the algorithms needed to steer a tractor from GPS input in 1995/6. The GPS (American DOD) network consists of 28 Satellites in orbit around the earth while the Glonass (Russian) system has approximately 24 satellites in orbit. Galileo is a European consortium currently preparing to launch another constellation. To effectively pinpoint a position on the earth the GPS receiver needs to see at least 4 satellites at the same time. This locates the position to within 5-15m since Selective Availability (US Defence Force scrambling) has been turned off. To achieve higher accuracies various additional satellite signals are analysed, this can bring the position down to around 1-3m. To improve again the receiver uses correction signals in various forms to refine and remove the errors inherent in the system. Correction signals can be broadcast as free to air; - Marine beacon, or as various proprietary signals - Omnistar, Starfire, etc. via communication satellites. This commonly known as differential GPS, and accuracies range from 0.7m. to sub 10cm.

For the highest possible accuracies, a local RTK (Real Time Kinematic) solution is needed. This can come from a farm or community base station or some form of networked RTK solution distributed via Internet or mobile phone.

Since its introduction to agriculture in the late 90s, GPS based machine guidance has been rapidly adopted by Australian farmers (45% use GRDC survey, 2004) In the ten years from 1997 to now prices have fallen 60%. There are huge variations in features, accuracy levels, capabilities and opportunities to upgrade in the product lines available in this area. Quite often there are serious discrepancies between what the salesperson claims, what the farmer expects and unit capability. To avoid frustration and wasted expenditure it is wise to invest in independent advice and support as an aid to the purchase decision.

SYSTEMS USES

The following matrix identifies the major types and usage potentials of the various systems on the market.

Accuracy level	Usage	Handheld	Lightbar	AutoSteer
Uncorrected – 5-10m	Recreational, P.Ag. applications, farm mapping	✓	✓	**X**
Differential – sub metre	Recreational, P.Ag. applications, farm mapping, random traffic systems	✓	✓	**X**
Differential – 50cm	As with sub-metre	**N/A**	✓	**X**
Differential – 30cm	As with sub-metre	**N/A**	**X**	✓
Local Base Station - 10cm or Differential – with Omnistar correction signal	Low intensity CT systems	**N/A**	**XX**	✓✓
2cm RTK with local or networked solution	High intensity CTF systems, surveying, engineering	**N/A**	**XXX**	✓✓✓

DEFINING THE USE

Failure to adequately identify current and future requirements for guidance is a certain path to disillusionment with the technology. Some growers' expectation of system capacity may be unrealistic given their budget or current equipment. Rather than be stampeded into to a hasty purchase by enthusiastic sales talk, growers should evaluate their requirements thoroughly before purchasing. For instance, buying dual frequency 2cm RTK with a light bar would be poor economics for a contractor whose sole use was spreading manure over pasture while an organic small crop producer with irrigation could easily justify the expense of a steering kit as well.

UNDERSTANDING ACCURACY MEASUREMENT

System accuracy

Understanding system accuracy is crucial to making a sound investment in guidance technology. While there are many mathematical methods for determining accuracy, marketing has distilled these to two key indicators. These are "Pass to Pass" and "Repeatability", sometimes called "Return to Path".

Most advertising and sales material quote accuracies which reflect most favourably on the product promoted, hence many sub meter systems will be promoted as "achieving 100mm (4") accuracy". This can be defined as "pass to pass within 10 min timeframe" within the document; however many times the definition is absent.

To avoid disappointment system performance should be compared using the repeatable accuracy which should be quoted over a reasonable period of time = > 24hrs and 95% confidence interval. There are now many independent tests that allow these figures to be accurately represented.

Operational accuracy

The accuracy figures discussed above are derived under lab type conditions; actual operational attainment may be considerably different. Software set-up, steering linkage wear, operator error, surface conditions, base station set-up, implement set-up, trailed or mounted equipment and side slopes all degrade steering performance in the field. Recently there have been several 2cm systems that have not performed to that level 'repeatably'.

APPLICATIONS

Benefits and uses of guidance equipment have been widely reported. (**www.grdc.com.au**) A summary for RTK 2cm systems would include the following.

Labour management
Skill level,
Availability,
Shift length.

Precise Operations
Side dressing,
Shielded Spraying,
Banding fertiliser and pesticides,
Inter-row sowing,
Relay cropping,
Targeted amelioration,
Residue manipulation,
Operational advantages,
Night spraying,
Dusty conditions,
Disc seeding,
Accurate guess rows (no misses or overlaps).

INTEGRATION TO FARMING SYSTEM

Guidance equipment should value add to the whole farm system, rather than be a means to an end. 2 cm RTK systems should operate in conjunction with matched widths and wheels, sound agronomy and natural resource management, extensive on farm research and spatial data management. We have seen many farmers purchase 2cm systems without considering the huge value adding potential by matching machinery widths and tyres. Guidance becomes a lever to achieve greater operational and management efficiencies just as much as improved workplace conditions and straighter driving.

OPERATIONAL BASICS

Base station setup

Probably the biggest reason for poor auto-steer performance is quick and nasty base station setups by companies/farmers. You need to realise that if your base moves a couple of centimetres, then your lines will also move this amount. We have even seen base stations set up on dam walls on a star picket. This is not acceptable as a permanent base station location. Even shed mounting has caused some problems due to heating/cooling of steel. Sheds also pose particular problems with 'multipathing'. This is where the base station receives a secondary 'bounced' signal from the same satellites from a reflective surface, such as a roof. Some GPS manufacturers have written 'smart' software to overcome this problem, but there are some manufacturers who cannot deal with this effect. It may also be a good idea to get you base station locations properly surveyed in, and the settings saved securely.

Tuning a machine

Properly set up auto-steer systems should never "hunt" for the line for more than a few metres at the start of a run or vary more than 1-2cm off the line. Failure to achieve this indicates component or tuning problems, extremely harsh conditions or implement effects. Steering movements should be smooth, not jerky although cold oil can cause some jerkiness early. We have witnessed several poorly set up tractors where it won't be too long before the hydraulic or steering system fails due to very aggressive steering settings. Contact your manufacturer if you are having these problems.

Data backup

Auto steer systems rely on computers and as such are prone to the same pitfalls as your desktop or laptop. Always back up your important information and carry a notebook with basic tuning settings, (gain, valve and steering values) and the co-ordinates of the A/B lines for each field. Ensure you backup your data card once you have captured all boundary files and A/B lines; once they are lost from the card, it is very difficult to get the machine in exactly the same place again. If you are steering more than 1 machine (i.e. you have more than 1 PC/rover unit) copy all the files across to each machine so that all operations occur on the same tracks. Modifying the A/B lines or adding 'nudge' factors while working in a paddock; unless absolutely necessary, merely creates headaches for every operation after that.

Operator training

We have seen guidance companies blamed for poor systems, when in fact the problem has been operator error. When purchasing you need to consider the ability to lock away important settings in the system. All too often we hear where un-trained operators have adjusted important settings in the machine or base station. This has led to disastrous consequences for all operations thereafter – especially in irrigated bed systems.

Get good training with your system, train all new operators well and make sure you pick a manufacturer with a good reputation for support – as you WILL need it. Be aware that some manufacturers charge for all support while others offer free phone support.

FUTURE TRENDS

Driverless tractors

While it can safely be assumed that there are several autonomous vehicles under development around the world, on board operators are going to be required for some years yet.

Automatic operational recording

While second party monitoring of spraying and sowing operations and equipment can be carried out remotely using existing technology and software, operational logging in real time for management is still in its infancy. Based on the adage, "You can't manage what you don't measure" there is a need for providers of guidance equipment to ensure their products can do more than just steer tractors. For the intensity of management to increase, spatial data (time and position) is required. From managing Integrated Weed Management strategies to on farm research trials, recording applications by time and

field position is mandatory. Things the pocket notebook just wasn't designed to handle. Our travels through Australia have also highlighted how poor farmers are at record keeping. With the advent of QA and other regulatory systems, the time has come to record all operations. The advantage of linking GPS to a controller/recoding device will enable automated, spatial record keeping.

Fortunately, a growing list of companies is addressing these issues although linkages between guidance companies and farm management software developers are tenuous and rare. Examples include JD Apex and AGCO's GTA range of software.

Networked solutions

The authors estimate Australian growers have purchased enough RTK base stations to provide a networked solution to an area 3.5 times the area of Australia. How? Local base stations are limited by radio output power and atmospheric conditions from providing accurate data to a rover once past a certain distance known as the baseline. Depending on terrain, manufacturer, firmware, radio type, and frequency the baseline is limited to between 10 km and 25km.

If base stations are arranged in a grid, (75km) networked, data processed by a central processor and then retransmitted as a 'correction' signal, rovers can operate without loss of accuracy anywhere within the grid, provided they can access the 'correction' signal from the network providers. Companies such as Leica and Trimble (and soon TopCon) offer full-networked RTK solutions, but their use in Australia is limited to capital cities at present. There are moves to network many cropping areas of Australia in years to come.

Community base stations are local solutions to similar problems. It is inefficient for twenty farmers in an area to buy twenty base stations when four would do. All reputable GPS providers can offer multi base capacity for their rover systems. Some GPS manufacturers are promoting themselves as having 'networked' RTK solutions, but the current networks operating are merely a smarter extension of shared base stations. The future should be in fully networked RTK solutions.

CONCLUSION

Guidance equipment is part of Australia's contribution to global agriculture. Its use offers growers a range of benefits limited only by their imagination. Many products are marketed beyond their designed applications and careful research and independent advice avoids many of the pitfalls.