Self steering machinery comes of age

by Mark Casey
Kondinin Group
Toowoomba, Queensland

Tractors and harvesters that steer themselves would have sounded like science fiction 10 years ago, yet today there are several systems which can effectively guide machinery.
Tractors and more recently cotton pickers can now steer themselves along a row with remarkable accuracy.
Automatic guidance is provided by either video, global positioning or mechanical means with costs ranging from $7100 to $80,000.
Most current systems are geared up for row crop situations, as much of the development work was funded by the Australian Cotton Research and Development Corporation.
But one of the leading Global Positioning-based systems has been used in broadacre farming for four years and it is expected that more of the technology will be adapted for cereal and pulse production in the not too distant future.
In all cases the current systems are designed to improve efficiency while reducing operator fatigue. When the machinery is guided automatically, the operator can more easily concentrate on the implement.
These systems can also help set up properties for controlled traffic farming while significantly reducing spray, seed and fertiliser overlap.
Another claimed benefit for some systems is the elimination of guess row problems in cotton. This is caused when the end rows do not match up with each pass of tillage machinery leaving furrows too wide or narrow.
Anecdotal evidence from owners indicates that the small number of systems in use are working well.
Australia has been to the forefront internationally in the development of this technology, mainly through the National Centre for Engineering in Agriculture (NCEA) which is a joint venture between the Queensland Department of Primary Industries and the University of Southern Queensland.
A GPS based system has also been developed by Agsystems in Brisbane. Several companies including Queensland Surveying Instrument Services and Precision Farming Australia provide GPS based system which provide guidance information on screen without the automatic steering. If there is an error or divergence in a row using a mechanical method, this would be repeated across a paddock. The GPS systems are based on mathematical equations which means a mistake in one row will not be repeated across the paddock.
On the international front New Holland and the United States space agency NASA developed a prototype mower conditioner that could steer itself a couple of years ago and more recently John Deere has introduced its Row Trak guidance system for cotton pickers.
The National Agriculture Research Centre in Tsukuba, Japan has developed a 'driverless' tractor which uses satellite navigation to manoeuvre accurately and carry out basic farm chores.
The Japanese tractor which was developed as a solution to a chronic labour shortage and Japan's ageing farmers, can carry out spraying, planting, tillage and fertiliser spreading.
According to the Farmers Weekly in Britain, the 56 kiloWatts (75hp) tractor is equipped with a fibre optic gyroscope and a GPS navigation system. The researchers claim it can travel at 5.4km/h without straying more than 100mm off its course.
The tractor which cost about $250,000 to develop receives relevant data from an on board computer and then follows its defined route, changing direction using longitude and latitude readings from the differential global positioning system (DGPS).

According to the research team the machine has proven successful in trials with the only question now revolving about how to ensure safe operation.
There have already been some stories here in Australia of automatic guidance cotton pickers ending up in drains after the operator fell asleep near the end of a long shift. In light of this the new NCEA picker guidance system which is expected to be ready for commercialisation in the next 18 months will have end of row detection to warn the operator to take over. The system which will also have multi - sensing heads is expected to cost about $7000.

Auto-trak
The Auto-trak automatic steering system is a lower cost system which uses a furrow following skid to supply a steering signal. The system was developed at the NCEA with funding from the Australian Cotton research and Development Corporation and commercialised by Agridry Rimik in Toowoomba, Queensland. It costs about $7100 and is currently available for Case Magnum and John Deere 8000 and 7000 series tractors.
According to Agridry Rimik the device can be used for automatic steering at speeds of up to 15km/h and with well maintained furrows it will keep the tractor to within plus or minus 25mm of the centreline of the furrow. Because it keeps tractor tyres from intruding on furrow walls the Auto-trak is said to reduce compaction of the furrow walls, to allow better water infiltration while at the same time reducing damage to the root zones.
The system is installed at the front of the tractor usually at the front differential casing with the follower hanging down between the front wheels.
It uses a follower mechanism that senses the steering angle of the front wheels and controls two hydraulic valves installed in the power steering circuit. A remote control unit and display in the cab houses the controls for the Auto-trak. The display shows the position of the follower relative to the tractor.
When the operator wants to take over, simply turning the steering wheel will disengage the Auto-trak. Likewise lifting the follower disengages the system.
It is usually connected to a lift switch which automatically lifts and lowers the follower at the end of each row when the linkage is raised.
As it uses the furrow to guide it, the system cannot operate where there are no furrows or beds.
Simplicity is the biggest attraction for this system.
Advantages
Price
Reduced driver fatigue
Simplicity
Less compaction
Accuracy (as claimed)
Reduces guess row variance
Disadvantages
Only works where there are furrows
Limited numbers in use for reliability data

Vision Guidance System
The vision guidance system (VGS) was developed with funding from the Australian Cotton Research and Development Corporation at the NCEA in Toowoomba by a research team including John Billingsley and Murray Schoenfisch. It has been a long road to the commercialisation of the VGS which has led to some frustrations for people involved in the project as well as growers. One of the factors that delayed the commercialisation of the VGS was the legal implications of a 'rogue' tractor steering itself into trouble with the operator asleep in the cabin.
The search for a commercial VGS partner took five years before Case Australia took up the technology.

After going through the lengthy Case Corporation proving regime, the system is now available commercially for Magnum 8900, 7100 and 7200 series tractors. To the best of our knowledge this is the first commercially available tractor guidance system in the world. The system is generating considerable interest in the United States amongst Case dealers and the US Department of Agriculture.
The VGS has two video cameras mounted on the cab which can be adjusted to suit the type of work being done. The two cameras are used to cater for differing light and crop conditions. If the sun is shining straight into the camera the system will not work and to overcome this problem, which usually occurs in the evening, the operator can simply switch to the other camera which is set up at a different angle to the sun. A cab mounted computer processes the image and plots a line of best fit, by placing a series of dots over the image of the crop on the screen. The computer then sends a message to the steering sensor and hydraulics to make the necessary corrections. The computer also stores settings and operation time.
An audible alarm sounds at the end of each row to alert the operator to take over and turn the machine around for the next row.
Once in the next row the driver can activate the system to take over the steering task.
The VGS relies on images from a crop to process signals for steering. It can work from the time the crop has emerged to a sufficient height until the time a canopy has formed. It cannot be used to plant a crop. Case claims the system can keep the tractor within 20mm-50mm of the desired track while travelling through crop at 20km/h. The company sees an advantage in guiding the tractor rather than the implement, as it can be used for several tasks. Also if the implement is correctly matched to the tractor then it will be largely controlled by the tractor.
Case says the VGS can increase operating speed by up to 50 per cent which can give labour savings.
The cost of the VGS system is about $10,000 fitted.

Advantages

Price
Reduced driver fatigue
Relative simplicity
Less compaction
Accuracy (as claimed)

Disadvantages

Only works where there are plants
Limited numbers in use for reliability data

Row-Trak

The Row-Trak is a recent development from John Deere which allows 'hands off' cotton picker operation.
It uses a probe assembly that mounts onto one of the row units. The probe assembly runs on both sides of the row. A centre pivot allows side to side movement of the probe as it follows the row activating an electronic sensor that sends a signal to the controller in the cab.
The feedback sensor mounts to the steering arm on the guide axle and sends a signal to the system controller so it is aware of how far the steering wheels are turned and in what direction.
The system controller monitors the inputs from the probe and feedback sensor and sends a signal to the hydraulic manifold. The main function of the controller is to monitor the input signal from the probe sensor and the feedback sensor and send output signals to the hydraulic manifold to adjust the steering system.
The hydraulic manifold assembly receives signals from the systems controller which disengages the steering wheel. It also signals the controller immediately the operator turns the steering wheel to regain manual control. The manifold assembly mounts under the cab. The Row-Trak costs about $10,000.

Advantages
Reduces operator fatigue
Can improve picking accuracy
Disadvantages
Cost
Lack of end of row sensor
Limited number in use for reliability data

Beeline Navigator
The Beeline system was developed by Agsystems and the Mailler family in Boggabilla and uses DGPS signals relayed through a base station for tractor guidance. Like other systems, savings are claimed on input costs such as diesel, seed, fertiliser and sprays.
The system has been in use on the Mailler's broadacre dryland farm since 1994 and the claimed accuracy is under 100mm with the maximum range of operations from the base station put at 25 kilometres. The system was initially set up on a Spray - Coupe self propelled sprayer to reduce overlap, it was later used to guide and steer a Caterpillar Challenger tractor. The technology can be fitted on a harvester or cotton picker and the control monitor can be moved between machines according to Agsystems.
The Maillers credit the Beeline with substantial chemical savings and they used it to convert their farm to controlled traffic operations.
Before using the Beeline system the operator needs to set 'way points' to get a fix or reference line.
The operator sets the first way point which takes about five minutes to lock in the longitude and latitude, it is then a matter of driving to the other end of the paddock to set the second way point. All further work in the paddocks runs in reference and parallel to the initial two way points. Way points need to be set up for each paddock and the system can store an indefinite number of these references according to Agsystems.
But this means the system is suited to end to end farming rather than 'round and round' working as used on most broadacre farms. Agsystems is currently developing a system for 'round and round' working.
As with all DGPS based systems that rely on a base station, trees and hills can cause some problems in obtaining a clear signal.
The Beeline which is marketed by Agsystems is currently undergoing trials in cotton operations at Mungindi mounted on a John Deere 8400 and at Moree using a JD 8300.
The Beeline automatic guidance system starts at US$36,490 including US$3495 for the annual cost of renting the base station.
Advantages
Reduced driver fatigue
Reduced chemical overlap
Less compaction
Allows night operation
Broadacre or row cropping applications
Accuracy (as claimed)
Can link into mapping and yield hardware or software
Reduces guess row variance
Disadvantages
Cost
Limited number of units in use for reliability data
Requires base station

Orthman

Orthman produce a range of guidance systems which are marketed by Vanderfield machinery in Toowoomba. Orthman systems have been in use for several years in the cotton industry for guiding tillage implements and more recently the company has introduced a guidance system for cotton pickers and strippers. The system operates the same way as the John Deere Row-Trak.

Beware of big claims

In summing up there are some very interesting systems currently in use which offer benefits such as a reduction in chemical overlap and reduced operator fatigue. Farmers need to carefully examine the benefits of each system and see if the economic arguments stack up.

A healthy scepticism is considered useful in assessing claimed accuracy figures with other guidance systems.

The next generation of tractors and harvesters will have 'fly by wire' systems similar to aircraft with electronics running all functions of the machine. Devices such as the VGS will simply be plugged in and there will be no need to break into hydraulic plumbing lines.

More systems are also expected to be adapted for broadacre use with possibilities already apparent for the VGS for example in sorghum harvesting where the distinctive red colour of the crop can be used for video based guidance.

It can be expected that in 10 years most row crop and broadacre tractors and harvesters will have a automatic guidance system on board.

The Japanese researchers on machinery guidance are looking forward to great things from the guidance technology. National Agriculture Research Centre spokesperson Inoue Keiich said " we hope the tractor will help decrease heavy labour work on the farm, improve the accuracy of farm operations and perhaps even put some joy back into agriculture".

Acknowledgments: Murray Schoenfisch, NCEA, Kim Bremner and Greg McVeigh, Dalby and Andrew Green, Kondinin Group.

System	Guidance	Claimed accuracy	Approximate Cost	Contact details
Auto-trak	**mechanical**	**+/-25mm of furrow centreline at 15km/h**	**$7000**	Agridry-Rimik 331 Taylor St Toowoomba Queensland 4350 ph: (07) 4633 2299
VGS	**video**	**2-5cm at 20km/h**	**$10,000**	Case 31-67 Kurrajong Ave. St Mary's NSW 2760 ph: (02) 9673 7777
Row-Trak	**mechanical**	**N/A**	**$10,000**	John Deere 166-170 Magnesium Drv Creastmead Queensland 4132 ph: (07) 3802 3222
Beeline Navigator Pro 20 Navigator Pro 2	 **GPS** **GPS**	 **10-20cm** **2cm**	 **US$39,995 plus US$6,995 base station hire.** **US$49,995 plus US$9,995 base station hire**	Agsystems 101 Riverside Drv West End Queensland 4101 ph: (07) 3255 2799
Orthman Tracker MP3 Tracer hitch Cotton picker	 **mechanical** **mechanical** **mechanical**		 **$15,470** **$10,900** **$12,800**	**Vanderfield** **Carrington Road** **Toowoomba** **Queensland 4350** **ph: (07) 46334822**