THE ROLE OF TECHNOLOGY IN INCREASING AGRICULTURAL PRODUCTIVITY IN AUSTRALIA

SUBMISSION TO PARLIMENTARY INQUIRY FROM VANDERFIELD PTY LTD

VANDERFIELD

CONTENTS

1.0 Submission Summary

This submission outlines some of the current and emerging applications for technology in cropping farming systems. This includes automation of machinery using GPS systems, farm management decision support using spatial data and remote support tools using cellular connectivity.

This submission also highlights some of the issues clientele of Vanderfield are exposed to in regional areas, which may limit the uptake and therefore deliverable benefits of these new technologies.

Existing & Emerging Technology

Spatial Control Of Farm Equipment

- GPS Guidance used to accurately position and automate farm machinery.
- Automation delivers significant cost savings and efficiency gains.
- Accurate positioning also allow machinery to collect a wide range of spatial data used as farm management decision support.

Spatial Agronomy & Management

- Collection of spatial data using accurate GPS positioning allows farmers and their advisors to make more informed management decisions. This results in farming systems efficiency and productivity gains, as well as reduced risk from environmental factors.
- Examples of these decision support data sets are Yield Maps, Satellite Maps, Soil Maps, etc.

Machine Telemetry & Connectivity For Remote Support

- Combining telematics with on-board modems allows remote support, monitoring and control of farm machinery. This delivers efficiency and productivity gains to agribusinesses.
- Machines can have controller software updates performed, be sent commands and work orders remotely, when in a mobile network.
- An increasing volume of data is being both uploaded to and downloaded from farm machinery, requiring robust mobile network and internet speed.

Barriers To Adoption Of Technology In Agriculture

Cellular Connectivity

- Lack of adequate mobile phone coverage in regional areas

Internet Speed

- Internet speed is a limitation to efficiency of agricultural practices uploading and downloading increasingly large data files from/to farm machinery.
- Upload speed is as important as download speed for agricultural applications.

Accurate Positioning Signal

- Access to accurate 2-5cm positioning signal is limited in regional areas. Accurate positioning signal allows automation of farm equipment that delivers a range of financial and environmental benefits.
- Government interest in satellite based communications infrastructure to deliver more accurate correction signals to farm equipment would help improve agricultural efficiency.

2.0 Existing & Emerging Technology In Cropping Farming Systems In Australia

2.1 Spatial Control Of Farm Equipment

The use of accurate position data from Global Navigation Satellite Systems (GNSS) has allowed advances in accuracy and efficiency of farm machinery operations. Combining corrections from U.S. GPS and Russian GLONASS constellations with corrections from local Real Time Kinematic (RTK) Base Stations allows positioning of equipment to an accuracy of +/- 2cm.

2.1.1 Tractor Auto Steering

- The most common application of this level of positioning accuracy is for steering (guidance) of farm machinery such as tractors. Guidance has been adopted on the majority of grain, cotton and sugar farms in Australia, with an increase in adoption in horticulture in more recent times. Isbister (2013) claimed 70% of grain cropping systems utilised some form of guidance.

Benefits delivered to the agricultural industry include, but are not limited to;

- Reduced operator fatigue and operator experience requirements. Sourcing seasonal skilled labour in regional areas is a challenge for many primary producers. GPS guidance has allowed operators with minimal experience to still efficiently operate complex equipment. Reduced risk of equipment damage is also a benefit.
- Reduced machinery "overlap error" resulting in reduced input costs of seed, fertiliser and pesticides. For example, Robertson *et al.* (2007) reported a 10% average saving in pesticide spray applications in grain farming systems that were attributed to accurate machine guidance.
- Allowed adoption of "controlled traffic farming" practices that has delivered reduced soil compaction, nutrient loss and soil erosion and increased soil health. Tullberg *et al*. (2011) reported reduced nitrogen nutrition loss as nitrous oxide due to controlled traffic farming systems, while Masters *et al*. (2008) reported reduced soil and nutrient off farm runoff in a cane farming controlled traffic system.

Semi-autonomous solutions are also now commercially available, which not only automate the steering of the tractor but also all other operator control functions. This allows a relatively unskilled operator to simply be an operator presence (for human override) in the case of a system failure or environmental obstacle. This video link demonstrates a semi-autonomous application in a wheat seeding operation https://www.youtube.com/watch?v=ZCqcCItfZig

Possible transition in the future to fully autonomous farm equipment will only be possible with delivery of readily available accurate positioning signal.

2.1.2 Implement Guidance

GPS guidance applications have progressed from the early-mid 2000's with steering of the wheels of a tractor, to nowadays precisely controlling the position and height of machinery tooling.

Advantages of maintaining +/- 2 to 5cm positioning of seed, fertiliser and pesticide application tooling on farm machinery includes;

- Ability to accurately place fertilisers in the soil to reduce losses, increase use efficiency and increase crop yields.
- Ability to accurately place seeds away from crops residue to reduce yield losses from stubble borne diseases in wet environments. For example, Verrell *et al*. (2005) found that the ability to precision place durum wheat seeds between the rows of the previous season's wheat crop residue reduced the infection of Crown Rot fungus *Fusarium pseudograminearum*, resulting in a 9% increase in crop yield.
- Ability to accurately place seeds beside or under previous crop residue where there is more soil moisture, to increase crop yields in dry environments.
- Ability to accurately place insecticides, herbicides and fungicides in a manner that reduces rates applied to the environment, while still delivering crop protection benefits.

An example of a 27 metre wide planter in Central Qld equipped with +/- 5cm implement steering control for inter-row sow seed placement is shown via this link; https://www.youtube.com/watch?v=iMNpBrRqDRw

An example of using GPS automation to accurately place seed between rows of crop residue to reduce seedling disease infection.

2.1.3 Implement Height Control

Accurate RTK GPS positioning has also allowed collection of farm elevation data while machinery is carrying out other field operations. This has enabled growers to increase return on capital investment on guidance hardware to not only auto steer tractors, but also control the height of farm implements and earthmoving equipment.

Advantages of maintaining accurate height control on ground engaged farm equipment includes;

- Optimising field drainage to minimise waterlogging. Achieved through multi plane drainage levelling designs or implementation of raised bed systems.
- Reducing field waterlogging increases crop yields and reduces nitrogen losses from factors such as leaching and denitrification.
- The ability to control machinery tooling height has allowed implementation of soil conservation designs (eg. Contour banks) to reduce soil erosion losses. This is particularly the case in the northern cropping regions of Qld, which are characterised by high intensity summer rainfall events.
- Using elevation data from GPS systems to extract Topographical Derivatives allows drainage modelling. By comparing with other spatial data layers producers can quantify return on investment of field drainage solutions (this is discussed in more detail below in section 2.2.1)

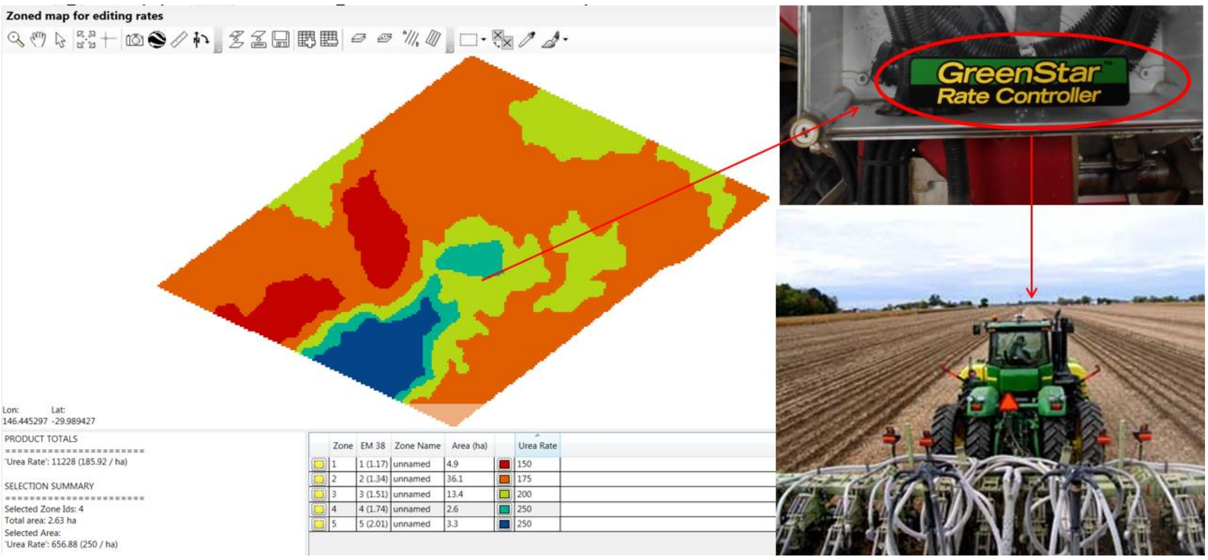
An example of using GPS automation for implement height control to accurately drain fields to reduce crop waterlogging losses.

An example of using GPS automation for implement height control to create raised bed drainage systems in horticulture.

2.1.4 Crop Input Automation, Record Keeping & Traceability

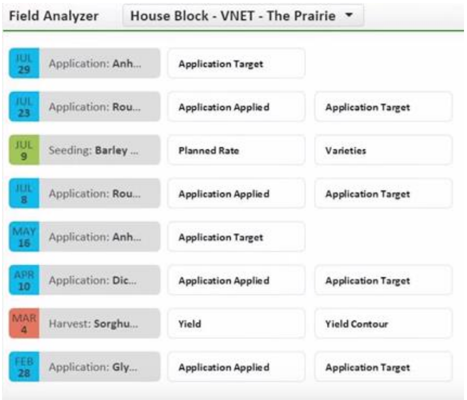
Accurate GPS “Rate Control” systems allow automation of the delivery rate of crop inputs such as seed, fertiliser, ameliorants and pesticides. By combining accurate position data with electric or hydraulic drive systems, the amount of product applied is maintained regardless of changing ground speeds.

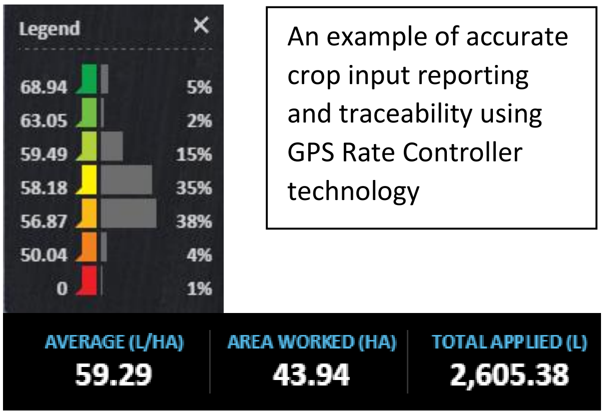
An extension of Rate Controller use is “Prescription Rate” application, whereby field management zones pre-defined by GPS coordinates will automatically trigger higher or lower rates of crop inputs. Fine tuning seed population and fertiliser inputs to the yield potential of different soil zones within a field increases profitability by either increasing yield output &/or saving on variable cost inputs.



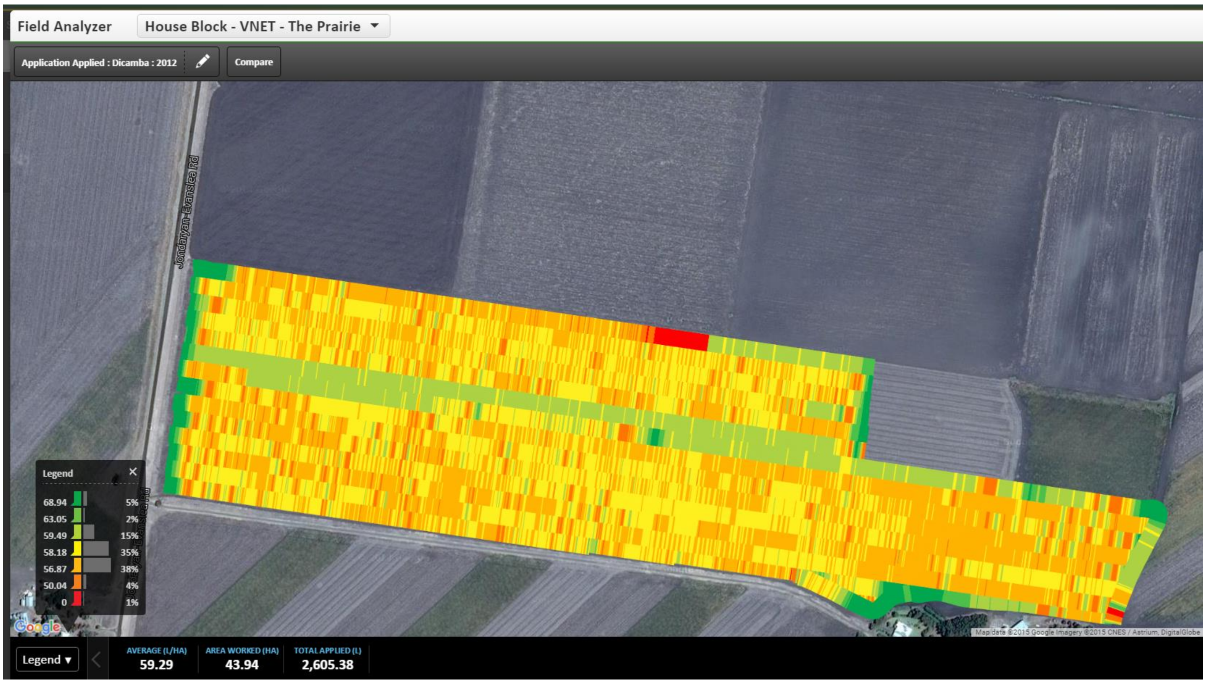
Example of a Prescription Rate (Rx) file used to control crop inputs

In addition, Rate Controllers allow accurate record keeping (Documentation) of the timing and amount of seed, fertiliser and pesticide applied to a production unit. Supply chain requirements and consumer interest in food origin has seen an increase in adoption of GPS enabled documentation within the horticultural industry. Also, industry Best Management Practice (BMP) programmes such as Qld's Smart Cane BMP and the global Better Cotton Initiative, has seen application of GPS documentation in the Sugar and Cotton industries also.





An example of accurate crop input reporting and traceability using GPS Rate Controller technology



2.0 Existing & Emerging Technology In Cropping Farming Systems In Australia (cont'd)

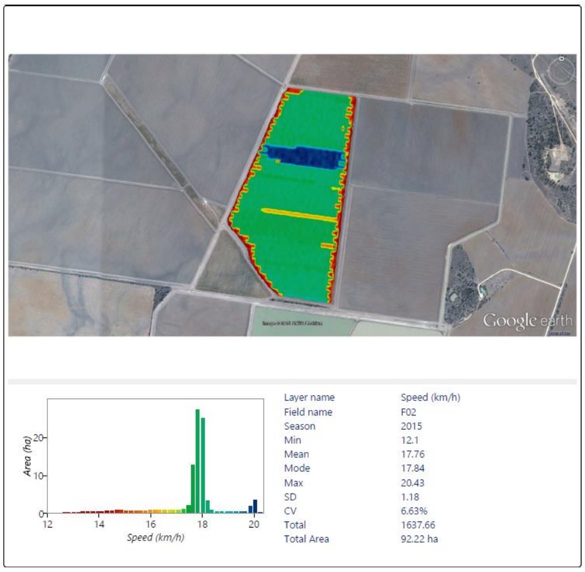
2.2 Spatial Agronomy and Management

Spatial data is information stored as geographical coordinates to identify its location on earth and is data that can be mapped. Increasingly, agricultural machinery platforms are able to collect data that is spatial. These layers of information are then used as decision support tools to produce crops more profitably.

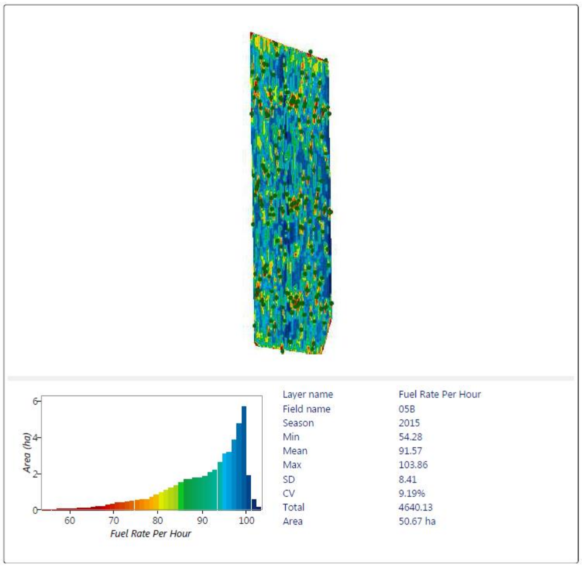
Spatial data such as Satellite Biomass Imagery and Soil Electromagnetic Induction are common layers sourced for comparison with other data that can be collected by agricultural machinery.

Examples of spatial data that can be collected by machinery platforms include;

- Elevation Maps
- Crop Yield Maps
- Product Application Maps (refer to Section 2.1.4 above)
- Temperature, Humidity & Wind Maps (from on board weather stations)
- Machine Speed Maps
- Machine Fuel Usage Maps



Example of a machine speed map



Example of a machine fuel map

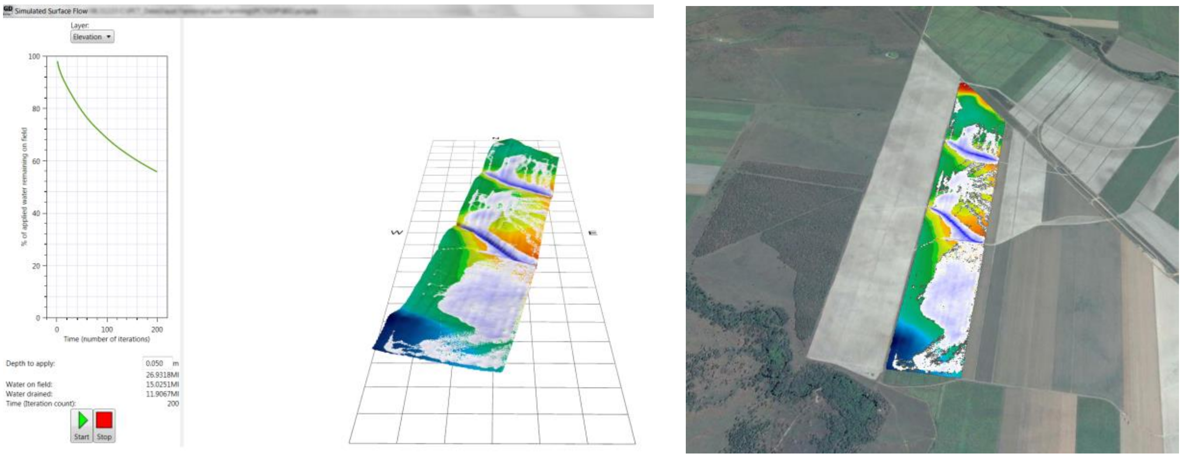
Multi-season spatial data layers are analysed for consistent trends that may help identify the causes of variation in crop performance. Utilising these data layers as decision support tools forms the basis of Precision Agronomy.

Future machinery platform developments will see many more layers of spatial data being collected. The four most common spatial data layers currently used for decision support in agriculture are Elevation, Soil, Crop Yield & Crop Health.

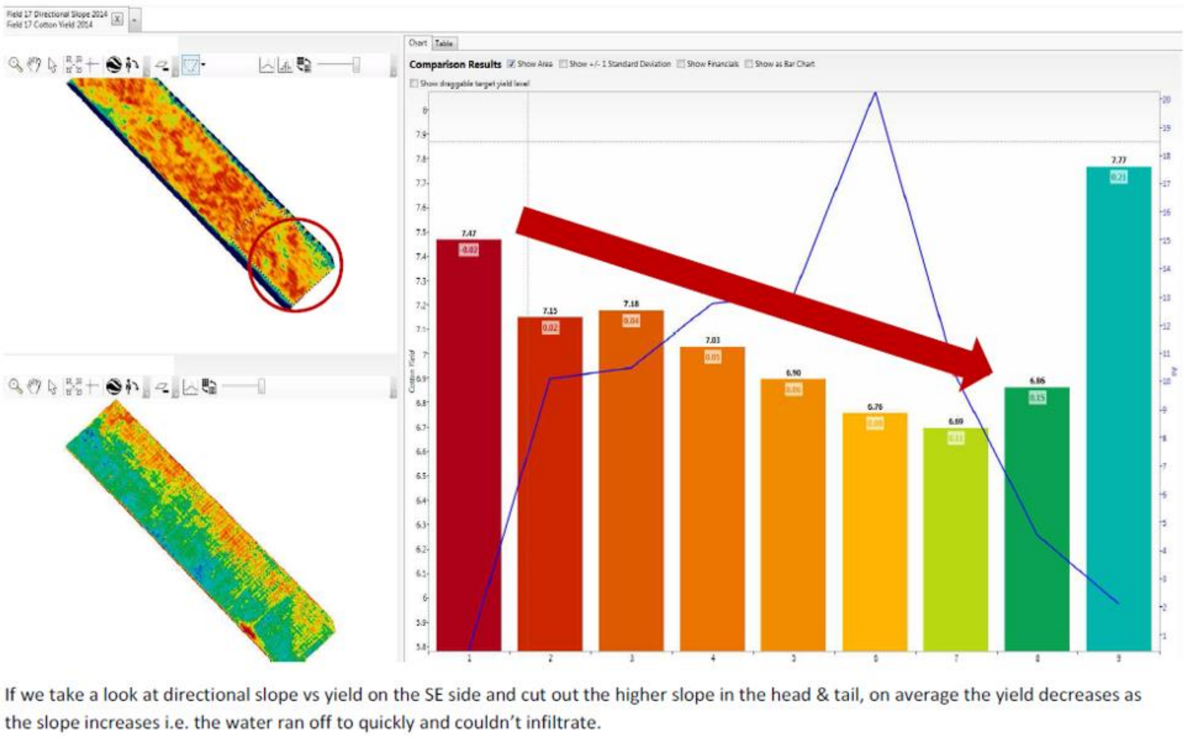
2.2.1 Elevation Data

Elevation data (& the Topographical Derivatives that can be extracted from it), are all about analysing the effect of "water on, water off" on crop performance & farm profitability.

Accurate RTK GPS guidance systems allow collection of elevation data for water flow modelling. Comparison of Topographical Derivatives with crop yield data quantifies the effect of water flow on profitability. This forms the basis of economic justification for implementation of field drainage and soil conservation designs. GPS automation of machinery height control allows delivery of these drainage or soil conservation designs.



Surface water flow simulations using elevation data collected by RTK GPS systems



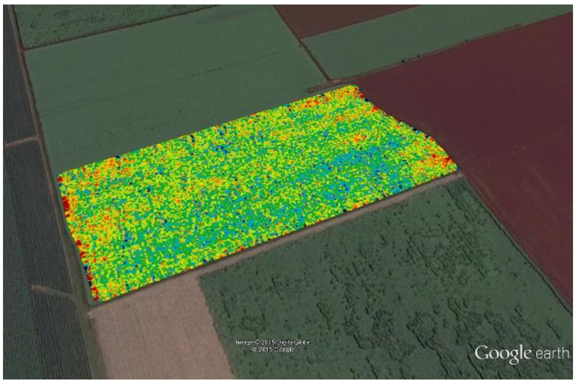
Example of analysis of relationship between irrigation directional slope & crop yield data

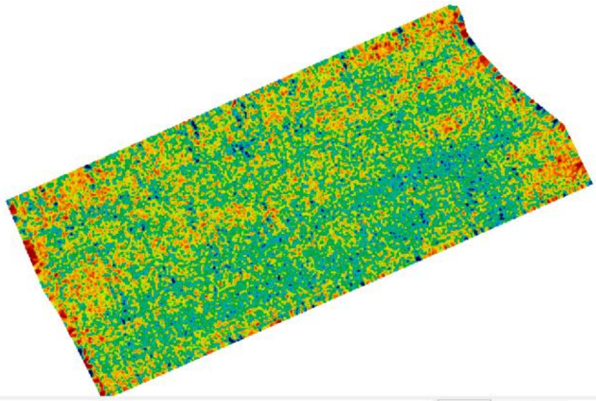
2.2.2 Crop Yield Data

By using sensors to detect changes in harvested marketable crop material with accurate position data, variability in field profitability can be measured as Yield Maps.

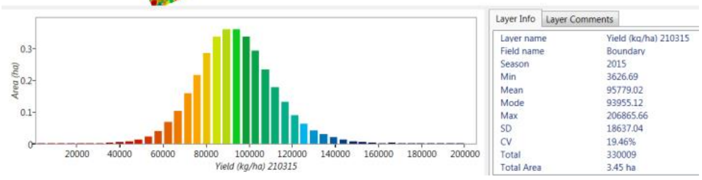
Manufacturers of grain and cotton harvesting equipment offer OEM Yield Mapping capabilities. Industry research is currently underway to deliver yield mapping in sugar cane systems, while some machine harvested horticultural crops can utilise load cell based mapping systems.

Yield Maps identify the degree of variability in a crop and quantify the cost of that variability as lost income. This allows primary producers to analyse the return on capital investment needed to rectify the variability. Comparison of Yield Maps with other spatial data layers helps understand the likely cause of the variability to rectify and improve profitability.





Example Yield Map spatial data layer from a Sweet Potato field



2.2.3 Remote Sensing (Crop Health) Data

Remote sensing is used in agriculture to measure changes in crop health. Sensors detect the amount of light absorbed or reflected by the plants as an indicator of the crop health and biomass. This information can be collected as Satellite Imagery, from Aircraft and Drones, or from sensors mounted to farm machinery.

Imagery from remote sensing is used in combination with yield maps to identify variability in crops.

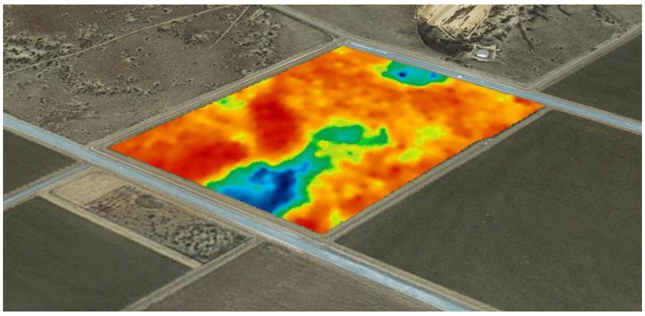
2.2.4 Soil Spatial Data

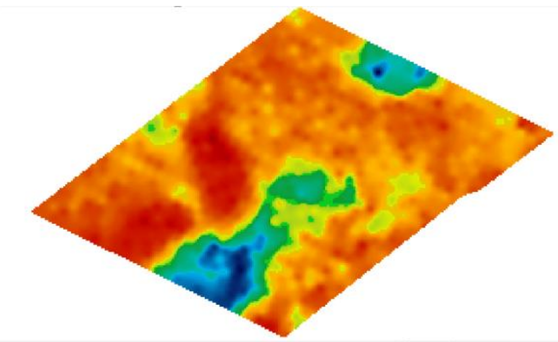
Variability in soil physical and chemical properties can also be a cause of variability in crop performance & profitability. For example the ability to identify changing soil nutrition or water holding capacity within a field, allows zonal management of the crop to increase yields &/or reduce input costs, therefore increasing farm profitability. Robertson *et al* (2012) identified that the regions shown to be most commonly associated with the use of variable rate technologies tended to be those where substantial, readily identifiable soil differences exist.

Identifying changes in soil types within a farm or field can be achieved either through detailed grid soil sampling or the use of proximal soil sensors such as Electromagnetic Induction (EMI).

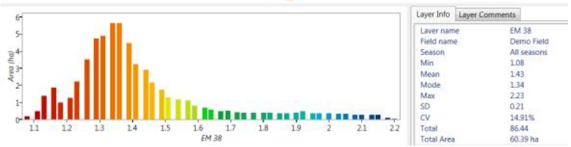
Grid soil sampling delivers very accurate and detailed analysis of changes in soils by taking many soil samples with a reference to the GPS co-ordinate. Although very accurate, the costs and labour requirements see it typically used only in intensive farming systems such as horticulture.

EMI is often used in more extensive farming systems such as broad acre grains, to identify possible changes in soil types. EMI sensors measure changing soil bulk conductivity though the profile and when combined with site specific soil sampling, can create a soil zone map of a field.

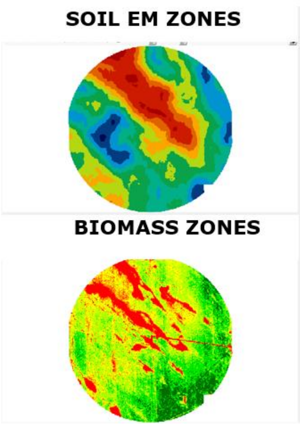


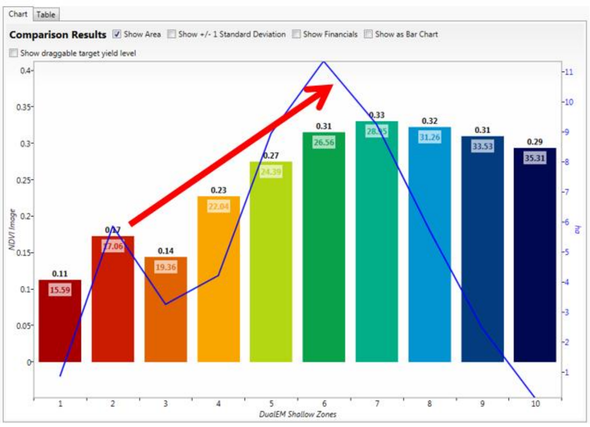


An example of an EMI conductivity map used to generate a Soil Spatial Data layer.



Identifying soil zones within a field and analysing the effect of these on changing crop performance (eg. Using Yield Maps or Remote Sensing) is the basis for adoption of variable rate technology to apply “prescription rates” of crop inputs across a field to increase profitability.





An example of relationship identified between Soil Spatial Data & Crop Health, as agronomic decision support.

2.0 Existing & Emerging Technology In Cropping Farming Systems In Australia (cont'd)

2.3 Machine Telemetry and Connectivity For Remote Support

Modern farm machinery platforms are commonly fitted with Controller Area Network (CAN bus) systems that allow multiple micro controllers and devices on the machine to communicate with each other.

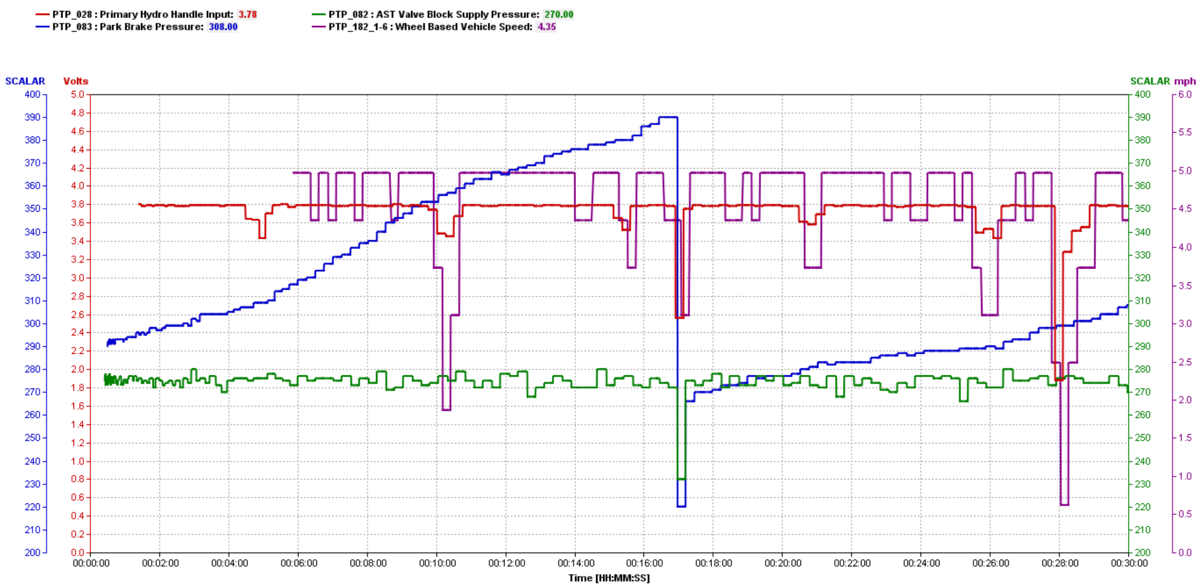
Combining CAN bus capabilities with cellular connectivity has allowed remote access to the data being collected by controllers on agricultural machinery and has also allowed delivery of remote commands to controllers. The ability to remotely access machine data and provide remote commands to these machines is a recent development in the Australian agricultural sector.

These remote connection capabilities enable delivery of timely and lower cost equipment support to primary producers in those regional areas that have adequate cellular connectivity.

2.3.1 Remote Diagnostics and Machine Support

Modern CAN bus farm equipment operating in areas with adequate cellular communications signals are able to have faults diagnosed remotely. Rather than a Field Service Technician physically driving to the farm where the machine is operating, faults can often be diagnosed off site. This allows efficiency, labour and travel savings to primary producers by being able to deliver the correct tooling and spare parts on the first field visit to a machine.

In addition, many of the micro controllers (eg. Engine management computers, hydraulics controllers, etc) on a CAN bus equipped machine can be remotely re-programmed. Updates to software and firmware can be a cause of significant machine down time, which can be costly due to the seasonality of farming systems in regional Australia. The ability to re-program machine controllers without having a specialist technician travel to site is a major time and cost saving for primary producers.



An example of a remote recording of equipment controller data via cellular link to the machine.

2.3.2 Data Downloads From Farm Machinery

The ability for farmers to remotely download Machine & Production Data being collected by their equipment is also a recent technology advancement in Australian agriculture. These downloads might be for agronomic decision support from production spatial data, for record keeping of products applied to fields, or for monitoring correct use of machinery to minimise operational costs.

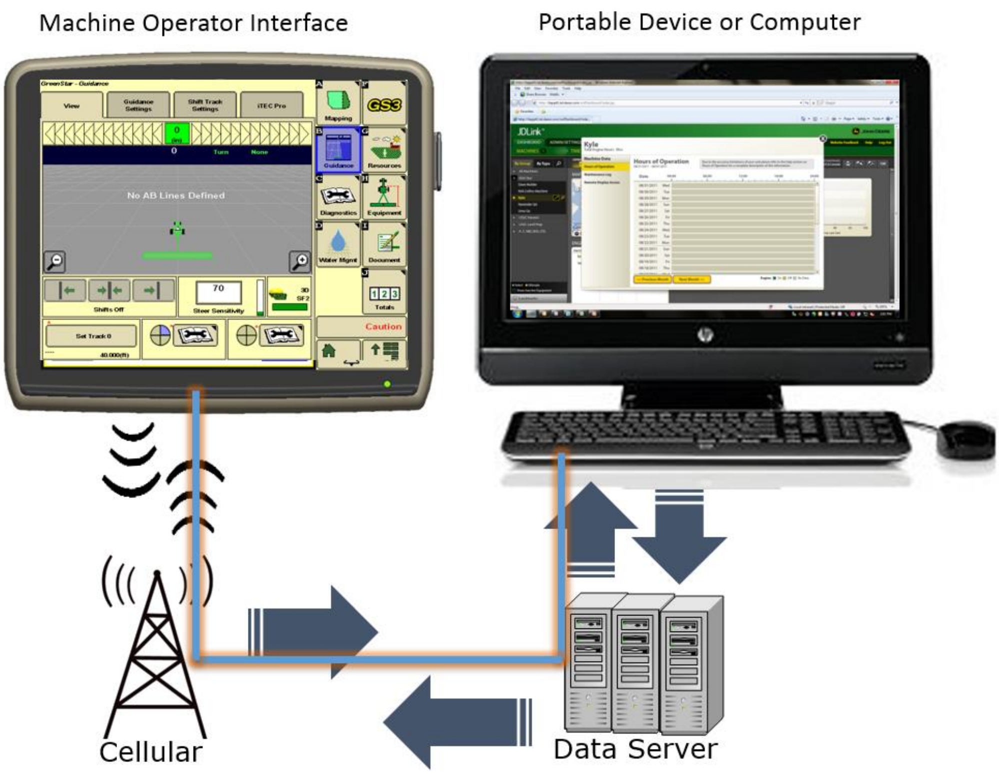
Example of Machine Data includes;

- Operating speeds (eg. Operating at too high speed)
- Geographic location (eg. Operating in the wrong field)
- Fuel consumption information (eg. High fuel use due to manner of operation)
- Mechanical warnings / alerts (eg. Shut down before damage occurs)

Examples of Production Data includes;

- Rates of seed, fertiliser & pesticides applied (refer to section 2.1.4)
- Crop yields and volumes being harvested
- Weather conditions during operations (eg correct wind/temperature when spraying)

With the continuing trend of fewer, but larger farm businesses in Australian agriculture, farmers are operating equipment over an increasingly wide geographic area. The ability for farm managers and equipment owners to remotely monitor their fleet and the tasks they are performing delivers substantial efficiency and profitability gains.



Using Cellular Connectivity To Remotely Access Machine Operator Interface

2.3.3 Data Uploads To Farm Machinery

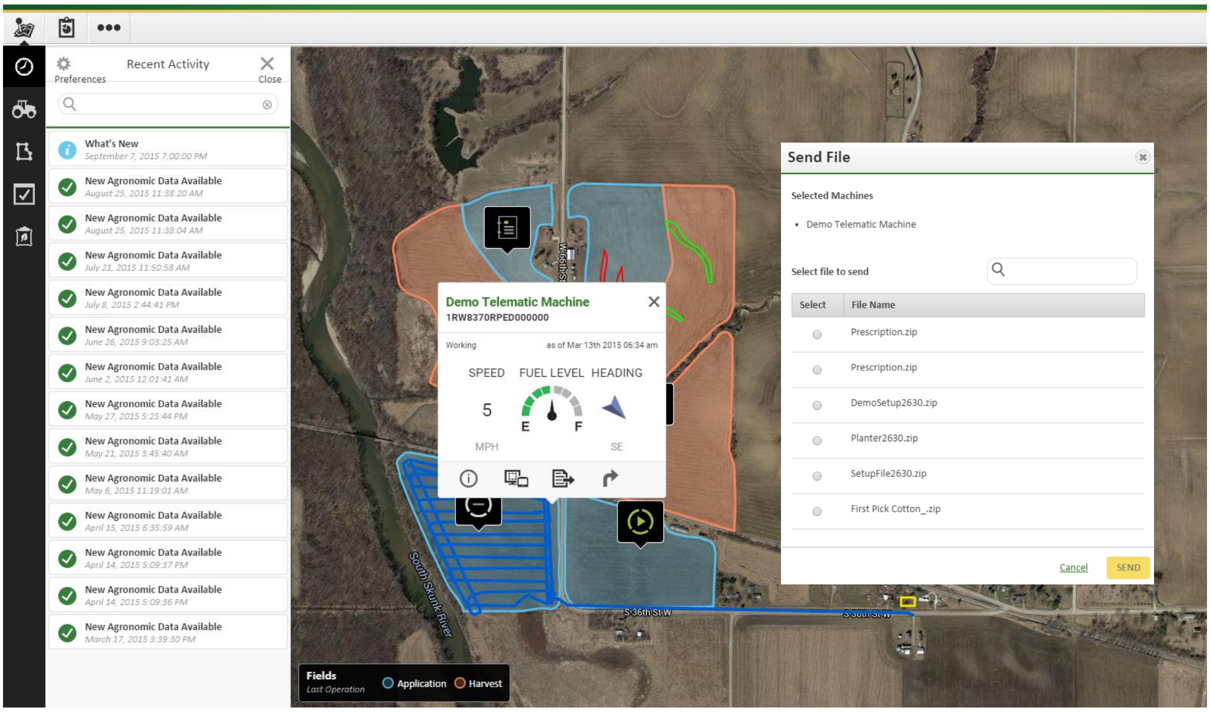
Remotely providing commands to farm machinery is a recent and developing capability. Farmers and their agronomists are able to send "Setup Files" to the GPS automation systems on equipment via cellular link.

These Setup Files effectively act as electronic work orders and reduce the risk of crop damage that may occur due to operator error from in-cab manual data entry.

Examples of Setup Files that can currently be uploaded include;

- Field names and boundaries - to ensure operation and product application in the correct farm management zone (eg. Machine is seeding or harvesting the correct field)
- GPS Guidance files – to ensure machine is being operated on the correct controlled traffic path and correct swath width (ie. Limit crop input wastage and unnecessary soil compaction)
- Planter Setup files – to ensure that the correct crop varieties and seeding rates are being applied in each farm management zone. Removes possible errors in data collected for more accurate post season comparison of profitability between different crop genotypes and agronomic management.
- Fertiliser and Pesticide Setup files – to ensure the correct product and rate is being applied in each farm management zone. Also allows paddock to plate traceability.

As agriculture becomes more exposed to "Big Data" the number and size of files being uploaded and downloaded from farm machinery platforms will increase dramatically.



3.0 Barriers To Adoption of Technology In Agriculture

This submission outlines only the technical barriers to adoption of emerging technology experienced by clientele of Vanderfield. There are also many other factors such as grower awareness and education, financial restrictions to investment in technology on farm, government policy, etc that may also be the cause of varied adoption.

3.1 Cellular Connectivity

One of the main barriers to adoption of many of the emerging technologies summarised in this submission, is lack of adequate mobile phone coverage in regional areas. The benefits of being able to offer support to farm businesses without being on site is obviously the greatest in geographically remote regions. However, the irony is that these are often the regions that do not have adequate network coverage to deliver technology enabled benefits, such as those discussed in Section 2.3

3.2 Internet Speed

With increasing amounts of data being both downloaded from and uploaded to farm machinery and other platforms, internet speed will also be a limitation to efficiency of agricultural practices.

Many innovative primary producers that are adopting the solutions discussed in Section 2.3 are limited by internet line speed capabilities, even though their farms may have good network coverage. A key point for agricultural users of internet, is that Upload speed is as important, or more important than Download speed. Timeliness in Upload of large Setup Files to machinery, or transferring high volumes of farm spatial data to supply chain partners is often more critical than data download.

3.3 Accurate Positioning Signals

As discussed in Section 2.1, the ability to receive accurate GNSS signal allows automation of farm equipment that delivers a range of financial and environmental benefits.

Achieving repeatable 2-5cm position signal normally requires a local reference point, or “Base Station” to deliver RTK corrections. Many farm businesses and agricultural service providers invest in their own local RTK base station network which delivers position corrections to farm machinery normally via radio link. This means farm equipment needs to be within 20km of a RTK base station and be able to maintain a constant radio link to it to deliver 2cm position accuracy.

Although some regional areas have access to a larger network of CORS base stations these CORS networks have a reliance on user access to high speed mobile internet, as stated by Lamb & Collier (2015). Government interest in satellite based communications infrastructure to deliver more accurate correction signals to farm equipment, may allow more primary producers to gain benefits from precise (2-5cm) GNSS automation.

4.0 Conclusion

The technology discussed in this submission is being used by Australian farmers to improve their production system efficiency to help maintain profitability of their businesses. In addition, some of this technology helps deliver reporting and traceability requirements for government and purchasers of agricultural commodities.

The adoption of the technology discussed is varied. The majority of farmers utilise some form of guidance using GNSS position signals. In comparison, adoption of variable rate applications and zonal management using spatial data has only been adopted by the most innovative producers. However, many farmers not yet using all of these tools are expressing their desire to begin doing so.

Any government policy that will encourage wider spread adoption of these new and emerging technologies will help lift productivity of the Australian agricultural sector.

GLOSSARY:

CAN bus: A controller area network vehicle standard used to allow multiple devices to communicate with each other.

Controlled Traffic Farming (CTF): a management tool which is used to reduce the damage to soils caused by heavy or repeated agricultural machinery passes on the land by confining all machinery loads to the least possible area of permanent traffic lanes.

Continuously Operating Reference Stations (CORS): A network of RTK reference stations that broadcast corrections, normally over an internet connection.

Electromagnetic Induction (EMI): Proximal sensing the measures bulk electrical conductivity of soil.

Global Navigation Satellite Systems (GNSS): Any satellite navigation system with global coverage.

Global Positioning System (GPS): A United States government satellite navigation system.

GLONASS: A Russian government satellite navigation system.

Prescription Rates or Variable Rate: Using observations of inter and intra-field variability from spatial data to define management zones that will receive site specific crop management as varying crop inputs.

Real Time Kinematic (RTK): A satellite navigation technique that provides accurate position data from satellite systems and a local reference station to provide real time corrections.

Remote Sensing: Gathering data such as infrared photography of an area from a distance, often from a satellite or airplane.

Topographical Derivatives: Data layers extracted from elevation of a field surface that relate to water flow characteristics, such as Slope and Depressions.

Yield Maps: provide data that can be used to estimate variability in gross margin of a crop.

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