High Resolution Multi-spectral Imagery

Jim Baily, AirAgronomics

AIRAGRONOMICS

Having been involved in broadacre agriculture until 2000 I perceived a need for a high resolution remote sensing service to be readily available to broadacre agriculture by providing data on an as need basis. This led me to forming AirAgronomics and subsequently becoming involved with SpecTerra services, who fortunately were based in Perth and being leaders in the field enabled me to proceed with the concept. Since 2000 AirAgronomics has supplied data on an as need basis to agronomists, farmers, farmer research groups, DAFWA, and WANTFA. AirAgronomics is now contracted by SpecTerra Services to carry out all their aerial acquisition in Western Australia and on occasions assist in other states.

SPECTERRA SERVICES PTY LTD

SpecTerra Services is a Western Australian based company offering a niche airborne remote sensing technology service. The company was incorporated in July 2000, following 10 years of research and development led by Dr Frank Honey. The company's primary focus is providing high quality, high resolution Digital Multi-Spectral Imagery (DMSI) for vegetation mapping and monitoring projects.
DMSI is a low cost, high value decision making tool utilised by agricultural, mining, forestry and other land use management industries.
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TECHNOLOGY OVERVIEW

Digital Multi-Spectral Imagery (DMSI)

DMSI is a digital aerial imaging product tuned specifically to provide high detail and sensitive information for mapping and monitoring vegetation types, growth stage, health, density and distribution. DMSI is image data of the same scene recorded simultaneously through 4 narrow spectral bands. The Digital Multi-Spectral Camera system integrates 4 individual digital imaging devices (CCDs) capable of measuring ground reflectances at high resolution (0.5 metre – 2 metre) and high sensitivity within visible and near-infrared wavelengths.

Each of the 4 bands of information collected contain important and unique data. Wavelengths of incident electromagnetic energy are either absorbed, transmitted or reflected in varying proportions by ground features according to their chemical physical properties. By measuring ground reflectances at selected wavelength positions, features displaying similar characteristics maybe automatically grouped and mapped for GIS integration and further ground based investigation.

The camera system is flown in light aircraft at varying altitudes according to the required pixel resolution (or sample point size), and "frames" of imagery are acquired along GPS controlled flight lines. The acquired frames are corrected for geometric and radiometric distortions then ortho-rectified and mosaicked to form a seamless image map of the area of interest.

The system is capable of covering over 50,000 hectares in a single flight day at 1m resolution.

Advantages of DMSI

High pixel resolution for sensitive spatial and spectral characterization of individual ground features

High spectral resolution provides sensitive information for:

- discriminating and mapping variations in vegetation type, density, distribution and health,
- and monitoring for changes in vegetation status and condition between successive survey flights.
- Natural Colour and False Colour Infrared images acquired simultaneously.
- no further digitising required.
- GIS ready.

Allows consistent and rapid interpretation (spectral and textural analysis) across multiple broadscale areas of interest using automated image classification techniques.

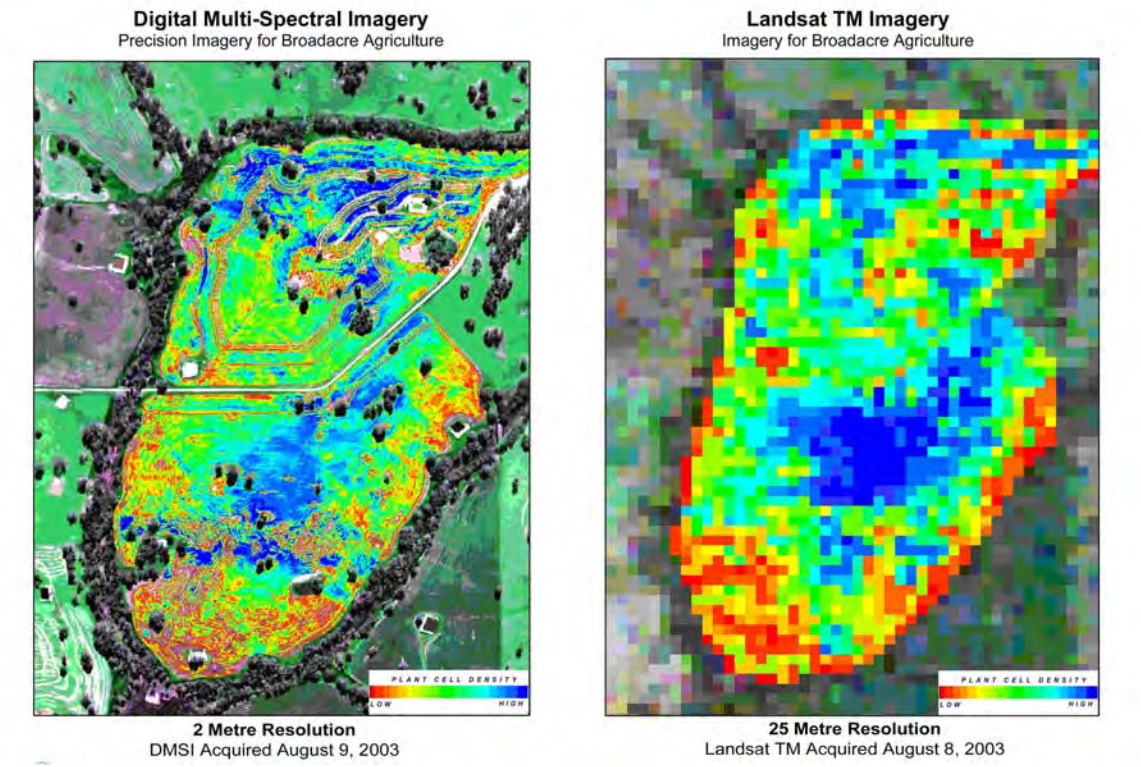


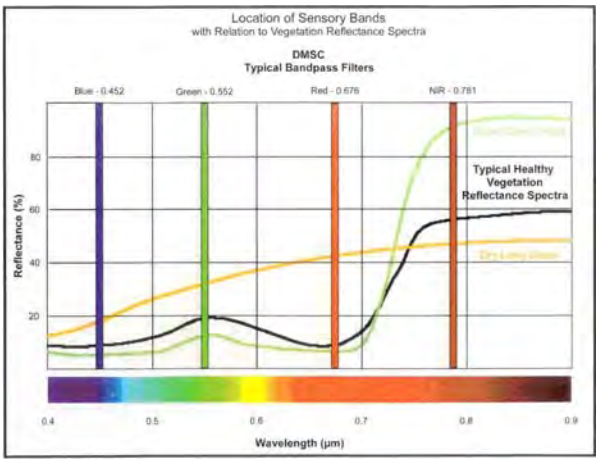
Figure 1: The advantage of high resolution Digital Multi-Spectral Imagery (DMSI) over satellite systems

As can be seen from the above example the difference is in the detail, the other main differences are:

DMSI	Satellite
Typically 0.5 to 2metre pixel resolution;	25metre pixel resolution;
Highly sensitive to leaf density, plant stress and other physiological attributes;	Moderately sensitive to plant stand density. Low sensitivity to plant stress and other physiological attributes;
Flexible airborne system for gathering data at optimum time under optimum conditions;	Infrequent passes at optimum time (16 day interval) and no data when there is cloud cover;
Data available within days of the overflight;	Data historical due to distribution lag time;

Standard bandpass filters for vegetation mapping

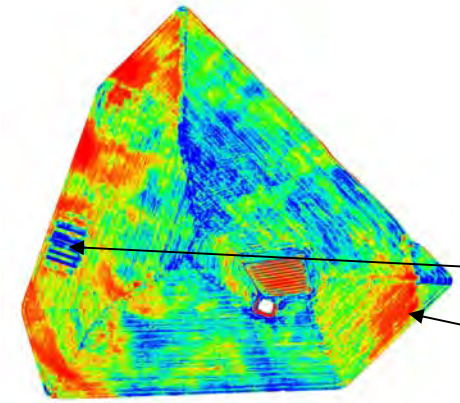
The DMSI narrow band-pass filters are easily interchanged for specific applications, however the 4 spectral bands utilised for vegetation mapping and monitoring are 20 nanometres wide and centered about the principal reflectance spectra features of vegetation.



DMSI Spectral Band and Vegetation Reflectance feature
1. Blue – 450nm (leaf pigment absorption)
2. Green – 550nm (relatively higher reflectance and transmission)
3. Red – 675nm (strong chlorophyll absorption)
4. Near Infrared – 780nm (high infrared reflectance "plateau")

Change detection

Where multi-temporal DMSI data sets exist, comparisons can be made to identify the location and extent of changes in foliage density, composition and health. Quantification and statistical analyses across broad scale areas can be made with the incorporation of localized ground based data and GIS interrogation techniques.
The example below shows the changes over a 10 week period of damage that occurred to a paddock due to severe frosting, this technique presents a meaningful representation of sensitive changes that may be occurring and not necessarily visible to the naked eye. A recent example has been research done in the phytopthera prone areas of the Gnangara groundwater mound, north of Perth DMSI detected changes over a 12 month period, that ground observers were not even aware of.

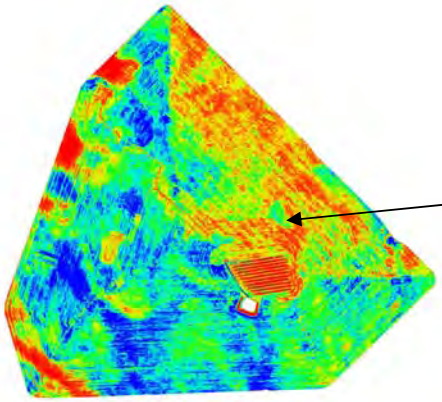


Example from a wheat crop at Borden WA

PCD 1 Taken 31 July 05
This is a typical Plant Cell Density (PCD) showing all the normal variations across the paddock Ideally the data could be used to indicate areas for strategic nutrient sampling allowing informed decisions how to manage the crop further into the season

Frost trial area, note areas of high input (blue)

This area was suffering from water logging



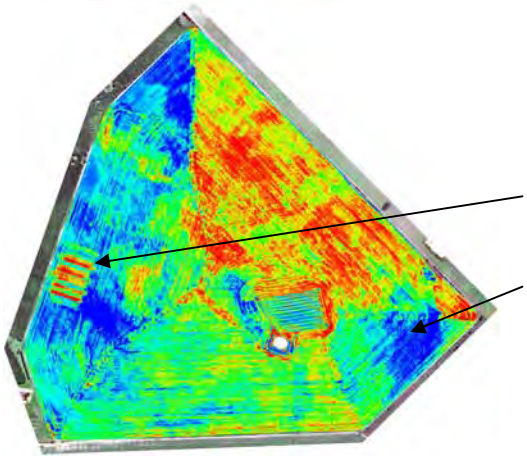
PCD 2 Taken 30 October 05

Note there are a number of changes in this PCD

Boomspray tracks, glyposphate sprayed to control weeds several days before image taken

Change Detection
(The difference between the two images above)

On discussion with the farmer and his son the areas with the most change were the areas most affected by frost



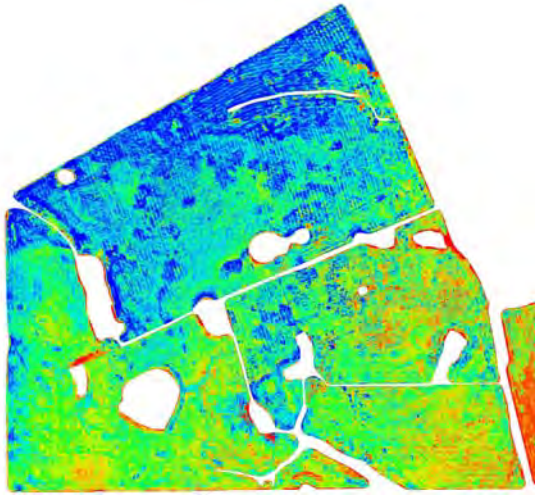
Note changes in the trial area, areas showing up red were the blue high input areas in PCD1

The wet waterlogged area actually picked up due to thinning out of plants and was not frost affected.

A fully geo-referenced image allows the user to be guided to areas of interest and perform accurate informed analysis in areas of interest

Plant Pigment Index (PPI)

The varying pigments associated with plant leaf structure absorb blue solar wavelength (420 to 470 nanometres) the more heavily pigmented the plant leaves the deeper the absorption of blue wavelengths. Different species have varying levels of pigmentation and therefore varying absorbtion/reflectance of blue wave lengths. While green wavelengths (540 to 560 nanometres) are mostly transmitted through the leaf regardless of species. Therefore by examining the ratio blue band (DMSI Band 1) and the green band (DMSI Band 2) it is possible to differentiate between plant species.

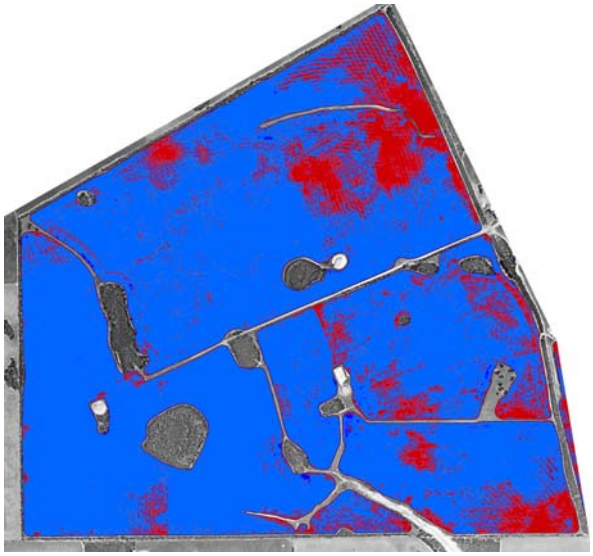


Example from a wheat crop at Esperance WA

PCD taken the 25 Sept 06

Typically shows the normal spatial variation across the paddock, the intention was to map areas of ryegrass in the paddocks to enable management decisions prior to harvest.
Using the PCD map gave no indication whatsoever of where these areas of ryegrass infestations were.

Of interest these paddocks are controlled traffic which eliminates the headland effect seen in the change detection example



Plant Pigment Index (PPI)

PPI has been derived from the original data collected which is embedded in the PCD data easy process to look at the ratio between the blue and green bands.

The red area known areas of ryegrass, it is worthwhile noting the concentrations in header trail lines that may have been carried from the main infestation

As with all Remote Sensing it is essential to ground truth to confirm that the data is correct.

CONCLUSION AND OPERATIONAL LOGISTICS APPLICABLE TO BROADACRE

The DMSI system is a proven tool for mapping and monitoring vegetation across a range of land use industries including viticulture, environmental monitoring and plantation forestry. This knowledge is directly transferable for practical and valuable applications of the technology in large scale broadacre cropping operations. DMSI is fast becoming an affordable and key knowledge tool in the Precision

Agricultural process. With camera systems located regionally the data is now readily available to growers looking to take advantage of within field variability inherent in all farming systems.

Contact: Jim Baily, Ph 0898 531 038, Mob 0428531038, Email Jim@airagronomics.com.au

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