SOLVING PRECISION FARMING CHALLENGES

PRECISION FARMING INVOLVES THE USE OF MODERN TECHNOLOGIES SUCH AS GLOBAL POSITIONING (GPS) – VIA SENSORS, SATELLITE AND AERIAL IMAGES – TOGETHER WITH COMPUTERISED TOOLS SUCH AS GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN ORDER TO ANALYSE VARIATIONS IN CROP GROWTH OR HEALTH AND HOW THESE DIFFER SPATIALLY OVER A FIELD.

Originating in the 1980s, the development of modern information system and communications technologies coincided with the availability of satellite navigation systems. Today, the accessibility of ever more powerful computers and the introduction of new approaches to satellite imaging have led to an explosion in precision agriculture applications and capability.

These new farming techniques are essential tools for monitoring and managing crops, and as such contribute to 'agronomy' – the discipline that combines agriculture and economics. Driven by rising fertiliser costs and volatile crop prices, agronomy service providers are experiencing growing demand. This in turn is being fuelled by increased awareness among growers that investment in such services can result in significant cost efficiencies and improved yields.

There are many ways in which precision farming can help farmers make more informed and therefore accurate choices. In the past a complete field would receive the same treatment, whereas precision farming makes it possible to split up the crop into sub-field management areas. Today it even possible to conduct spatial analysis of the crop in blocks as small as 20m by 20m. This allows local soil or climate conditions to be taken into consideration and encourages more efficient fertiliser application.

There are many different types of precision farming system, but all have one factor in common: by acquiring and interpreting information that is useful to farmers geographically, they improve knowledge of the agricultural environment. Add to this the fact that GPS costs have fallen dramatically over the last decade and it is not hard to explain the current boom in such systems.

Most precision farming systems are based on the same principle:

using various sensors or imagers, data is collected about soil type, plant growth, weather and irrigation and then referenced to the physical location in a field using GPS coordinates. A GIS then processes and analyses information, creating maps by superimposing this geo-referenced data as a layer on top of a geographical 'base map'.

Such maps show a clear snapshot of a farm that can be easily understood and related to activities on it. For example, specialist companies supply farmers with specially-created maps that show crop growth during a previous year - or even just the previous week - to identify areas where the crops have not grown. These areas are identified using a different shade of colour, giving an at-a-glance insight that allows farmers to target resources such as water and fertiliser to the crops most in need. Used effectively, this improves crop yields, reduces fertiliser costs and minimises the harmful effects that over-fertilisation can have on the environment.

Early adopters

Over the past three decades, precision agriculture has become standard practice in the American Midwest where it is used to save money by targeting fertiliser application. Satellites are used to acquire images of vast farms which are difficult to manage effectively any other way. Farmers use these maps to optimise the application of fertiliser, a process which can be fully-automated by the use of very large GPS-enabled agricultural vehicles.

Getting over the 'dark art' of precision farming

The UK, however, has been much slower to adopt satellite-based precision farming. This is a surprise as the UK is already intensively farmed and achieves four times the yield of the American Midwest. So what is the problem?

Put simply, some farmers have had their fingers burnt. There are several reasons for this, including a lack of technology integration and the absence of holistic services to help farmers process and convert the raw data into useful information.

As time goes on, however, there are generational shifts in the way technology is adopted and applied on farms. Where more educated and informed agricultural decision-making is called for, specialist agronomy partners are there to help.

Farmers in the past may have had some grounds for scepticism, but satellite and GIS technology has moved forward to a point where it is not only more accessible, but also much better suited to the demanding requirements of UK agriculture.

Taking the risk out of precision agriculture

Precision farming service provider SOYL and satellite image provider DMCii are working together to fulfil the specific needs of UK agriculture. It's a convincing partnership: DMCii's unique imaging capabilities guarantee regular, up-to-date UK imaging, while SOYL understands the farmer's agronomy requirements.

SOYL works with all sizes of farm. Its experienced agronomists provide information in a format that is both familiar and optimised for a farmer's own specific set of requirements. Note that this is a consultative process designed to overcome the traditional barriers of trust and understanding that are associated with a new technology, while also lowering the risk to farmers themselves.

However, it's not just about helping farmers with new technology, but also about choosing the right tool for the job. SOYL offers a broad range of agronomy services which farmers know they can rely upon. As a domain expert, the company can recommend new satellite-based precision farming services where it sees that customers can gain valuable information about their crops.

Explaining precision agriculture's role in farming today, SOYL Technical Manager Simon Griffin said, "Rather than taking the magic out of farming, precision agriculture is a valuable ally and intelligence source for farmers to allocate resources and more accurately predict crop yields."

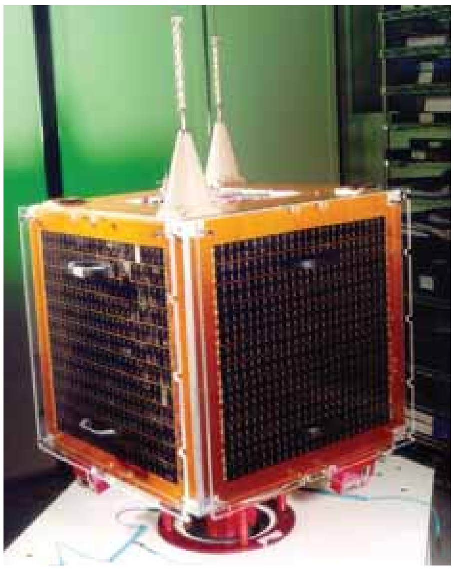
SOYL works closely with farmers and understands their practical needs, as well as the broader needs of the overall farming and business processes in UK agriculture. This allows the company to provide a more valuable data service while also taking the risk out of satellite image based precision agriculture. This applies whether SOYL provides its tools direct to the farmer, or to an agronomist.

Satellite imaging

Using the first GPS signals to divide a field into a grid, early precision agriculture in the 1980s relied purely upon land-based data acquisition. Soil samples taken within each grid reference were used to build up a picture of the differing requirements across a field.

Farmers familiar with the use of aeroplanes for drop spraying also began using aerial imaging as a way to map fields. However, aerial imaging is difficult to achieve and can be an expensive pursuit because aircraft and pilot hire are costly and flights require ideal weather conditions.

With the advent of the US Landsat



The SSTL-100 provides the core capability to carry a wide range of payloads. Active variants include SSTL-100i 32 (1st generation DMC) and SSTL-100i 22 (2nd generation DMC). Source: Surrey Satellite Technology Limited (SSTL).

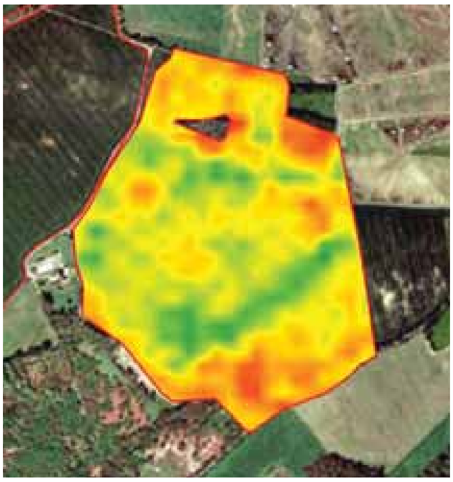
A UK mosaic comprising images from multiple DMCii satellites

programme, satellite imaging became available for the first time. This was a huge advance for precision agriculture because satellite images could be used to consistently map whole farms from space. Such data has been the mainstay of US-based farming for the past three decades. However, as these original satellites reach the end of their operational life, Landsat data provision is becoming increasingly unreliable. New commercial data services now offer a number of significant benefits, including more timely, regular imaging, and wider area mapping.

The importance of timing

DMCii coordinates multiple satellites in a group called the DMC constellation in order to acquire imagery of the Earth. This has important repercussions for agricultural crop monitoring.

The company is able to acquire regular and consecutive images of a particular field



Leaf_Area_Index_Field_Scouting.jpg [caption: Satellite images are particularly good at showing spatial variation in LAI

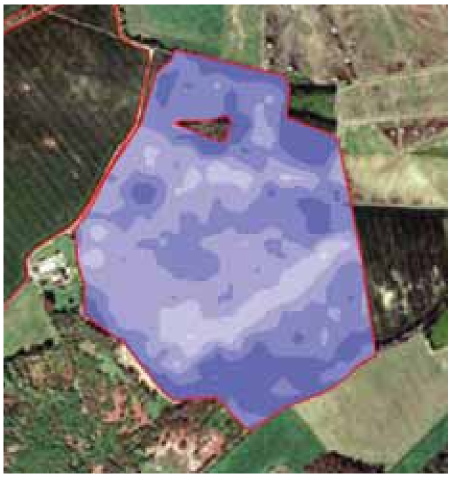
over a period of time. Such 'multi-temporal imaging' capability allows farmers to see the growth of crops over time. This is particularly important in the UK, where the growing season is short and regular updates are needed within it.

Contending with the British weather

The great British weather also places demands on this schedule because farms are frequently obscured by cloud cover. In the past, this represented a major barrier for precision farming with satellites in the UK. However, by coordinating multiple satellites there are more available slots to acquire images every month. So if the required area is obscured with cloud, another image can be acquired within a short timeframe.

The short growing season places additional demands on satellite imaging and DMCii delivers the data to SOYL very rapidly so that it can serve timely information to customers.

Satellite imaging is both an art and a science. Since the first Earth observation satellites were launched, teams on the ground have been battling the elements in order to image the planet while avoiding cloud cover. A typical observation satellite such as Landsat 7 might only pass over a particular location



A nitrogen management map for winter wheat.

on Earth once every 16 days. So if the target area is obscured by cloud, the next opportunity to acquire an image is another 16 days away.

This has two important consequences for precision agriculture. Firstly, it may be impossible to image the crop at all within the growing season because of cloud cover, which is a particular challenge in the UK. Secondly, the frequency of images may not be sufficient to monitor crop growth within the short UK growing season. In addition, for applications that are not time-critical it may not be possible to acquire a mosaic of contiguous images of an area because different images may be acquired weeks or months apart.

"During the UK's growing season, you would be lucky to get one good image a month using a single land-surveying satellite," said Owen Hawkins, Business Development Manager at DMCii.

New approaches and new technologies in satellite imaging have brought about a step change in the way satellite imaging is acquired and delivered that solves the traditional challenges of UK agriculture.

New eyes in the sky

From its headquarters in Guildford, UK, DMCii controls the DMC constellation and can image anywhere on Earth.

SOYL simply specifies the areas that need to be imaged and the timeframe within which these must be acquired and DMCii acquires the images. These are then processed and provided to SOYL geo-referenced and in a format that is ready to use in its GIS software. Crucially, this can be achieved within 48 hours to provide much more up-to-date information than previously possible.

SOYL then analyses the images and uses them in conjunction with other data to produce a fertiliser application map that specifies the recommended product and dosage of fertiliser required in a given geographical location.

DMCII SENSOR MODEL

The standard DMC Imager is a 6 channel, Surrey Linear Imager (SLIM6), built by Surrey Satellite Technology Ltd (SSTL), UK. The sensor is an evolution of previous multispectral cameras flown on various SSTL missions. The SLIM6 design provides for a nadir-viewing, ***three-band multispectral*** scanning camera capable of providing mid-resolution image information of the Earth's surface when operated from DMC spacecraft located in a near polar, sun-synchronous and circular orbit at a 686 km nominal altitude, with an orbit inclination of 98 degrees. The SLIM6 is designed to collect and detect radiation from the Earth in a swath 600 km wide as it passes overhead, utilising the spacecraft orbital motion to provide an along-track scan (push broom configuration). As a DMC image is acquired the CCD scan lines for each of the 6 channels are stored in a Solid State Data Recorder (SSDR) in a band-interlaced RAW format format. A separate SSDR is used to store data from each bank of three CCDs as it is acquired. For more information, visit **www.dmcii.com**

Farmers can access the map service online and use this as a guide, combining it with their own experience of the land in order to generate the highest possible yield and grow the best-quality crops.

Plant vision

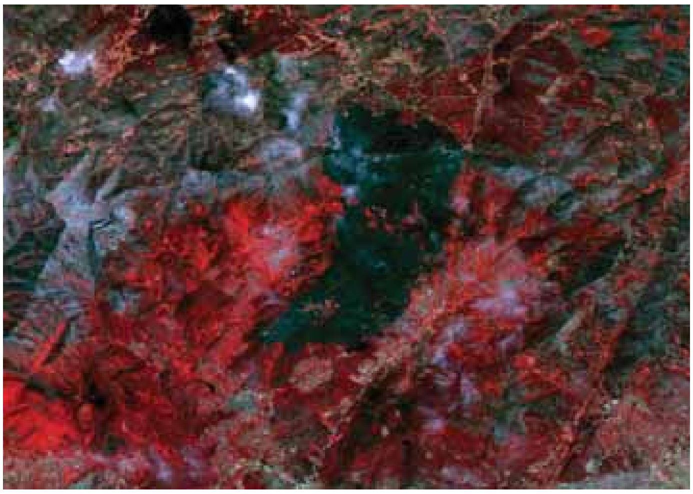
The satellite imagery supplied by DMCii is multi-spectral. These images include near infra-red data that can be used to provide a measure of vegetation growth when compared to visible red light using the Normalised Difference Vegetation Index (NDVI).

NDVI is a ratio of red and near infra-red data that is proportional to the level of chlorophyll in a plant. The two sets of data provide information about the amount of leaf structure and the plant's energy production, ie new growth and chlorophyll respectively.

Chlorophyll function depends on the presence of nitrogen, so a farmer could use this NDVI information to quantify the amount of extra nitrogen that needs to be applied at a given geographical point.

This ratio is used as a marker and is usually shown on maps as artificial red. The variation in NDVI is shown by the shade of red on a map. A deep opaque shade indicates a high NDVI and therefore significant growth of vegetation.

Leaf Area Index (LAI) is another common measurement derived from satellite imagery. This is the ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows. In areas where a crop is dense, the LAI will be higher than those where crops are not growing.



Recent forest fires in Arenas de San Pedro, Spain False color image of the aftermath of the fire, with chlorophyll activity shown in red. Source: Deimos Imaging (www.deimos-imaging.com)

Watering pivots - synthetic true colour image of a large area with irrigation system by pivot. Source: Deimos Imaging (www.deimos-imaging.com)

Putting it all together

A complete overview of a farm can be captured by using satellite imaging, allowing farmers to quickly identify areas of concern. This is an important differentiator for SOYL's service: the alternative requires the use of costly, time-consuming and disruptive tractor-mounted equipment.

By combining satellite image-based analysis with its ground-based services such as soil sampling, a very powerful data set can be collected. Using state-of-the-art GIS techniques, SOYL is able to combine the phosphorous and potassium measurements from soil samples and ground measurements of crops with satellite-based information. Correlations in this data can verify a situation and allow more confident decisions to be made.

Success

More growers than ever achieved higher yields and a more even crop through variably applying nitrogen in 2009. Initial harvest feedback from those who used SOYL's SOYLsense service suggests an average benefit of £30-40 per hectare.

Simon Beddows, farm manager for the 800ha Phillimore Farm in South Oxfordshire, is one grower who has measured the difference. He used SOYLsense to apply a variable rate of nitrogen to half of one field of his Solstice winter wheat crop, blanket-applying the rest and then carrying out a yield trial with winter wheat. A hectare block of each was cut and measured over a weighbridge. "We got an extra 0.45t/ha from using SOYLSense on one trial and almost an extra tonne per ha from the second trial – that's a yield benefit of 4% and 8% respectively," he noted. At £100 tonne that's an average benefit of over £70 per hectare.

"The service lets you apply exactly the right amount of nitrogen the crop needs, which helps you optimise yield and minimise waste," added Mr Beddows, who was a finalist in Farmers Weekly's 2009 Farm Manager of the Year award.

Future farming

Using new agricultural machinery, it is possible to insert a memory stick and load an application map so that the fertiliser application is automatically controlled as the vehicle is driven. Some farmers in the UK are already using GPS-enabled tractors and equipment, and their use is set to increase as equipment prices fall and precision agriculture data services become more accessible.

While terrestrial equipment continues to advance, so has satellite imaging. Two new satellites joined the DMC constellation in July 2009. The UK-DMC2 and Deimos-1 satellites provide new capabilities and feature technological advances that will further advance precision farming throughout the world.

Using these new satellites, it is now possible to acquire agricultural areas as one huge image. Because the images are acquired rapidly as the satellites pass overhead, the weather and light conditions are consistent from the North of Scotland to the South of England. For the end-user, this means a consistent set of images that can be compared and processed in the same way. It is also possible to produce very consistent data, whereas a mosaic of smaller, separate images would each need to be calibrated by visiting a field in that location with a light meter.

The new satellites also allow DMCii to acquire and supply data with an even faster turnaround to the benefit of farms with fast growing crops. In fact there are now up to 21 imaging windows every month, providing many more opportunities to acquire cloud-free images.

Sharper images from the new satellites also contain more information per hectare, enabling clearer, more detailed application maps.

soylsense
variable rate nitrogen