The use of GNSS is a major innovation in modern agriculture, now experiencing a major shift since the introduction of machine guidance systems. The interest of farmers did not keep pace as the new technology was developed, because the variety of systems offered different solutions for different problems and (most importantly) require different rates of investment. It was unclear if the cheaper systems offered what they needed, or if the expensive systems would ever provide an acceptable return on investment. Now, however, GNSS is no longer an add-on or post-sales refit, but is installed in new tractors and machines just like cabin air conditioning. It is recognised as a useful tool to make life easier (see Figure 1).

For example, the ‘Fieldfact’ project (www.fieldfact.com) investigated European farmers’ motivations to invest in GNSS, finding three classes, in order of priority. The first related to increases in productivity. The second was the ability to develop a whole-farm information management system where field data are integrated with planning and administration, where location serves as a primary key to link data. The third was the need to comply with legislation, as GNSS helps farmers to prove and improve their compliance to environmental protection laws.

“Precision Pays” is the Farmers’ Credo
Looking at how GNSS is improving productivity, the most visible
reason is to prepare and cultivate land in parallel lines, where no parts are forgotten or treated twice, providing a substantial reduction in fuel and total traffic operations time. GNSS allows farmers to work in the dark, which is particularly important in peak periods such as planting/sowing and when harvesting. As one farmer said, “Even my son is able now to plough fields in straight lines”.

“Precision Pays” is the credo and, for many farmers, the starting point for GNSS equipment investment. On-board computers maintain all relevant information needed when revisiting the field, like the baselines of operation (so-called AB-line). The accuracy needs for field traffic guidance depend very much on farm type, cultivation type and type of farmer. In Europe, the general tendency is that more accuracy is desired.

Farmers’ desire to manage and optimize all farm activities is the second set of reasons to invest in GNSS. Time spent cultivating a difficult corner on one field might be penny wise, but this same time might be better spent on another field, increasing total financial farm margins. Monitoring all activities and operations per field, per cultivation, per machine etc., give modern farmers an incredible insight into how money is earned and where money is potentially wasted.

Farmers tend to invest in GNSS to guide and track their equipment and build up evidence for next year, next crop or the next investment planning. The whole-farm information management system connects field operations to weather conditions, soil sensors and other sources of information to create the big picture. GNSS no longer just is a machine characteristic, but now is part of the information system of the so-called ‘open air enterprise’ to be managed and optimised.

The third set of motives to move to GNSS is the wish of farmers to prove and improve their compliance to all kinds of regulations. Within European agriculture, the themes rural development, landscape and environment are hugely intertwined, confronting European farmer with complex regulations requiring new and better information tools.

GNSS offers solutions and has been used already, e.g. in the Netherlands, where manure transports carry an obliged GNSS tracking system to follow the nutrients from animal farms to arable farms. GNSS can also help in following phyto-sanitary regulations, e.g. in growing potatoes. GNSS equipped sprayers can automatically maintain the obliged distance from open water.

Today’s equipment makes it feasible for farmers to benefit from the principle of ‘prescription farming’, i.e. varying application of fertiliser, herbicides and irrigation based on the within field variability, looking at typical management units of 10-30 m². The main benefit is a substantial reduction of inputs compared to uniform applications based on the most needed spot – or even the average – in the field. For herbicides during potato haulm killing, reductions of 60% have been reported. This requires precise sensing and precise application. Other farmers even vary their planting or sowing density based on soil type in order to get a more homogeneous product.

European Governments Stimulate the Uptake of GNSS

European regional and national governments discovered the opportunities that prescription farming and guidance can bring to achieve policy goals. Concerning landscape management and environmental stewardship, the new techniques create opportunities to increase the economic viability of farms and hence the rural economy, while at the same time reducing the side effects of agriculture on the environment.

With these benefits in mind, governments stimulate the uptake of GNSS, with concerted actions to remove barriers. Initiatives are taken to provide networked solutions for RTK and to organise the necessary sensing data from satellites for prescription farming. Governments also look for opportunities to share the data collected for administrative and control purposes, considering farmers as data providers as well.

The diversity of solution providers for GNSS augmentation signals allows farmers to optimise use to their needs. Global commercial GNSS augmentation providers like OmniSTAR and StarFire cover a very large share of the market, offering a stable quality for a large group of users. On the very high accuracy side, they are complemented by RTK solutions.

In the Netherlands, several national commercial RTK networks are available that provide higher accuracies. Also, the completely free of charge Open Signal of EGNOS (the European WAAS equivalent) is providing sub-meter accuracy useful in many agricultural applications. But accuracy is addictive, and high accuracy signals are also useful for activities requiring lower accuracies, as illustrated in Figure 2 overleaf.

Chances for Surveyors

Since 1992 the area measurement of fields became compulsory for European income support to farmers. The introduction of GNSS increased both the efficiency and quality of area measurements, and research proved the use of unaugmented single frequency receivers for area measurement at the required 1:10000 scale. However, these systems were not sufficient for field boundary mapping where many farmers now use GNSS systems with augmentation systems giving them 10 cm accuracies or better.

Farmers have become suppliers of spatial data, but all kinds of systematic aspects prevent efficient sharing of data. For instance, the use of GNSS measured field boundaries in national parcel registers is not straightforward, as these parcel registers use photogrammetric interpretation on aerial imagery. The type of equipment and the measuring procedure are not standardised, jeopardising internal consistency and quality of the parcel register. When farmers choose to outsource part of their fieldwork to contractors, sharing the basic information between different types of GNSS equipment is not as simple as it may seem. The consequences of an offset of a few centimeters for mechanical weeding will remove the crop instead of weeds!

The certifier company NavCert now provides basic standards for equipment.
and is now working on extending this to standard operating procedures. With certified equipment and certified staff ahead, we may be able to create the largest voluntary geographic information (VGI) system for the rural area. However, as long as surveying skills are not taught in vocational farming schools, this seems far away. Accurate measurement of field boundaries useful for a national parcel register, and for the farmer at the same time, is an underdeveloped but needed service.

Case: Large Scale Farming in a Small Scale Landscape
The benefits of high accuracy guidance are well demonstrated in the following case. In the Netherlands, farmers have a large number of small fields (< 10 ha) separated by ditches or tree lines. The shapes and sizes of fields are not optimal for modern equipment, i.e. the fields are not a logical multiple of a single working path for a machine. Often, when starting on one edge of the field, the last working path involves a lot of inefficient machine manoeuvring, sometimes even with varying width along the edges of the field. In addition, other rural stakeholders, like Water Boards, nature conservation organisations and tourist boards, encourage farmers to create flowering field margins with an extensive management regime. These flowering edges of the field are well appreciated by biologists, but also by citizens choosing to spend their leisure time by touring through the rural landscape. The flower strips are adequate buffers around open water, preventing unwanted side effects of agricultural practices, like herbicide leakage.

Farmers and scientists in this case worked together to create a set of tools to optimise the cultivation on the centred area of a field, creating a set of flowering margins around the sides. Farmers had their fields accurately measured by a surveyor using a quad mounted RTK system. Based on the exact measured boundaries of a field and the widths of machines, the toolset optimised the agricultural parcel framed in a more natural habitat. The result was an internet based system where farmers were able to enter their cm-accurate field boundaries, based on their operating requirements, achieving an optimal solution for their cultivated area and field margins.

The agricultural land in this case does not produce as much as before, since parts of it are now sowed with flowers, but measured in man- or machine-hours, production increases and the time gained is better spent on other fields. To conclude, as this solution minimises the amount of inefficient machine manoeuvring, the efficiency of agricultural production increases, while the side effect is that the flower strips improve the touristic value of the region and improve bio-diversity within an agricultural area, and are adequate buffers around open water.

Concluding Remarks
It is still a long road ahead before all farmers will use GNSS to optimise their fieldwork, but it is developing at an increasing rate. Thanks to research, we now know European farmers’ motivations to invest in GNSS, giving the geo-information industry information to act upon, and governments material to think about. It is clear that, besides farmers, other stakeholders share benefits in realising precision or prescription agriculture. The increased use of geomatics in agriculture is adding to a greener agriculture and greater environmental stewardship while maintaining the economic vitality of farms.

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Figure 2. Different activities and the corresponding required accuracies.
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