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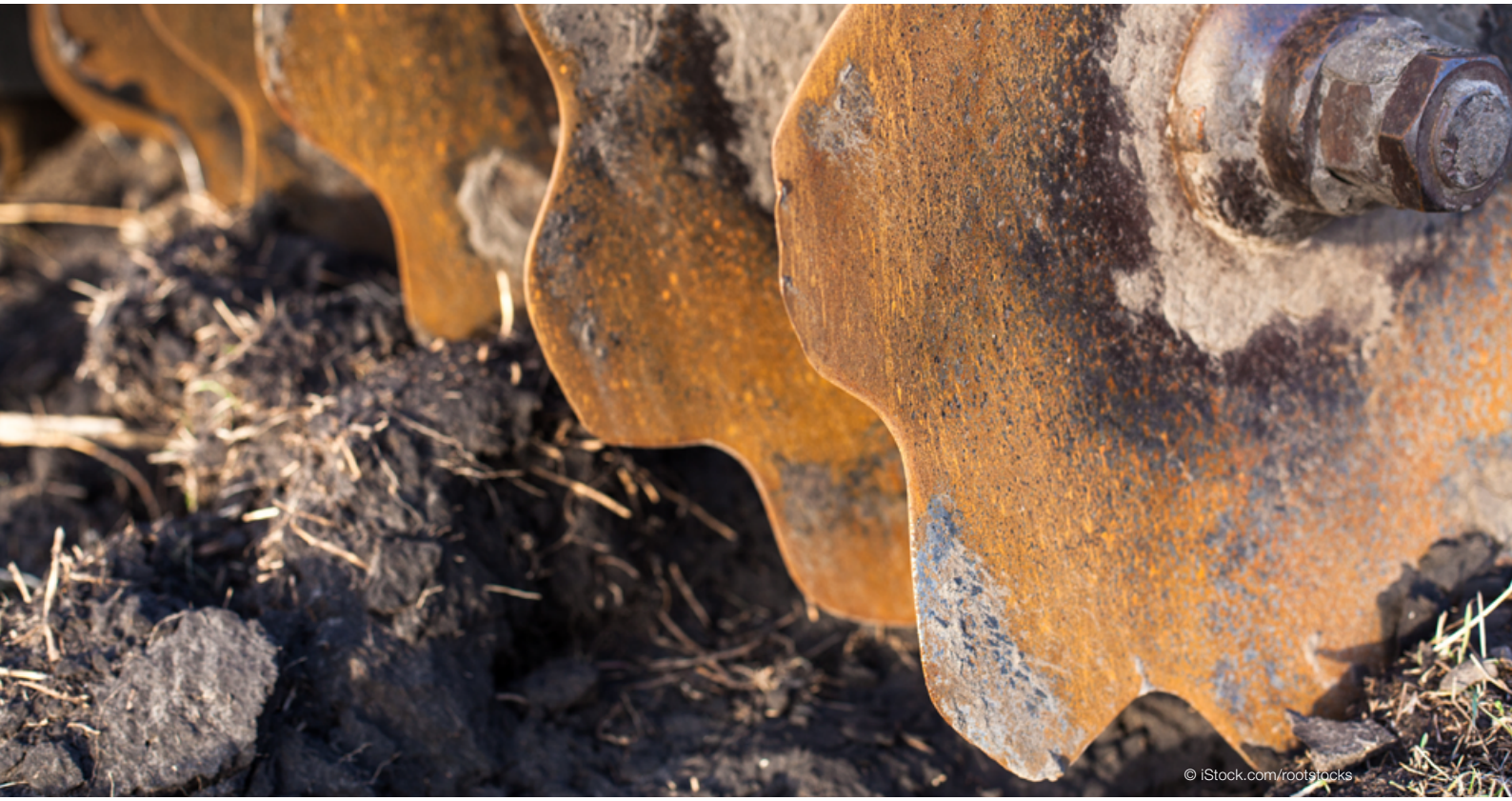

Agriculture 4.0 – ensuring connectivity of agricultural equipment

Challenges and technical solutions for the digital landscape in established farms with mixed or analogue equipment

This white paper proposes solutions aimed at bringing old but functioning agricultural equipment into the digital age. It sets out the benefits of collecting data and networking on the farm. It also analyses the key challenges facing farmers when digitising non-networked agricultural equipment.

Three reasons to read this white paper

Learn more about

- the main challenges in digitising agriculture,
- the benefits of collecting data and networking on the farm,
- technical solutions for digitising analogue agricultural equipment.

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Executive Summary

Global demand for agricultural products is rising. At the same time, consumers, retailers and participants in the value chains are steadily tightening up their requirements on product quality and transparency of production.

Today, digital technologies can help farmers to meet these requirements and optimise their processes at the same time. But there are a number of obstacles to overcome before these opportunities can be exploited.

Key challenges facing farmers wanting to digitise their processes:

- Because of its age, the overwhelming majority of agricultural equipment currently in use is analogue, i.e. not equipped with digital technology and not networked.
- Farmers wanting to use new technologies need to extend their media competence.
- Telecommunications infrastructures are inadequate in rural areas.
- Data protection and data sovereignty must be ensured.
- Once collected, data has to be organised and analysed as “big data”.
- Standalone solutions should be avoided.

Technological solutions to overcome these challenges already exist.

Bluetooth “beacons”, GPS and RFID systems combined with software, standardisation and interoperability mean legacy machinery can now be digitised. Known as partial digitisation, this is a realistic route into Agriculture 4.0 for many farmers.

This white paper deals with the challenges facing farmers wanting to bring their businesses into the digital era. It suggests how almost any agribusiness can adopt a partial digitisation solution as a way of introducing digitisation rationally using existing, non-networked agricultural equipment.

Content

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Welcome note

The Common Agricultural Policy, working in synergy with other EU policies and funds, is prioritising innovation and digitisation in agriculture as never before. This is essential not only to keep our farmers competitive and profitable, but also to protect our precious environment and contribute to EU climate targets and sustainable development goals. For example, there is a **new wave of ICT innovation in and for agriculture**, incorporating the **Internet of Things, Cloud Computing, and Big Data**. And the EU is actively investing in harnessing these innovations and new technologies to modernise and improve the agricultural sector.

In 2016 and 2017 alone, the EU's Research and Innovation Programme Horizon 2020 is supporting Large Scale Pilots in Smart Agriculture. We believe that technology and Precision farming technologies have the potential to help meet increasing global demand for food while ensuring the sustainability of primary production, based on a more precise and resource efficient approach to production management. These ideas are also reflected in our Rural Development Policies. In September 2016, the Commission hosted a 2-day conference in Cork, Ireland, where over 350 experts and rural stakeholders elaborated a Declaration on the Future of EU Rural Development.

This document, entitled „*A Better Life for Rural Areas*," contains a 10 point plan for developing and investing in the potential of rural communities and agriculture, and it argues that „ the rural economy and rural businesses will depend increasingly on digitisation as well as knowledge workers who make the most of the digital transformation and enhance rural production in a sustainable manner".

I am heartened by the fact that CEMA and other important agri-food stakeholders share these principles, and I am confident that your White Paper will play a part to ensure our farmers and agri-food businesses can take full advantage of these exciting changes in the sector.

Phil Hogan
EU Commissioner for Agriculture and Rural Development

Foreword

Farmers have the key task of producing sufficient quantities of high-quality food and primary raw materials. A key prerequisite for this is environmentally friendly and resource-efficient production. But there are many factors that make it difficult for farmers to carry out this task, including structural changes and global trends.

To overcome the challenges and increase the competitiveness and sustainability of European agriculture, get young people interested in agriculture and act in more environmentally friendly way, we need to grasp the opportunities offered by digitisation. Commitment is needed, as well as capital investment.

Policy makers need to create incentives as well as a suitable operating environment to ensure that farming remains an attractive profession for new generations and that agriculture can be transformed over the long term. The private sector also needs to bring user-friendly solutions to market. If everyone is to share in the opportunities offered by Agriculture 4.0, we also need feasible, affordable solutions for bringing analogue machinery into the digital age. Although not everyone has the financial capacity to use the very latest agricultural equipment, every farmer should be able to start out on the journey to Agriculture 4.0.

I am firmly convinced, both personally and as Secretary General of the CEMA, that digitisation is the key to overcoming many challenges in agriculture. I hope you enjoy reading this paper.

Dr. Ulrich Adam
Secretary General, CEMA –
European Agricultural Machinery

Introduction
Digitisation in agriculture

Global population is increasing, and with it global demand for agricultural products. Farmers are facing rising pressure to increase productivity per hectare in Germany, Europe and around the world. This is compounded by climate change as well as tighter regulation of, for example, pesticides and fertilisers.[1] In this context digital technologies can support farmers and make their work easier. They can do this by optimising operating procedures and resource utilisation, or by meeting the requirements for greater transparency in the agricultural value chain.

Developments in digital technology mean, for example, that agribusinesses can improve the precision with which they monitor and feed livestock, or manage arable land and record production. This is made possible by innovations in, for example, sensor technology, digital positioning, visual detection systems or data visualisation.[2] The structural transformation in agriculture also makes introducing digital innovations more attractive, as potential savings or productivity increases are greater for large businesses.

This is confirmed in a study by the Federal Association for Information Technology, Telecommunications and New Media (Bundesverband Informationswirtschaft, Telecommunications und neue Medien e.V., BITKOM) and the Fraunhofer Institute for Industrial Engineering (IAO). It states that the potential for added value will increase by 1.2 per cent annually up to 2025. This represents an increase of three billion euros.[3]

> Whilst there were still 472,000 agricultural operations in 1999/2000 managing an average of 36.3 hectares of land, there were just 285,000 operations in 2013 managing 58.6 hectares each. This is a continuing trend.[4]

But before this potential can be exploited a number of different challenges need to be overcome. This white paper deals with the challenges facing farmers in particular and proposes partial digitisation as a simple initial solution almost every agribusiness can adopt.

1. Challenges facing farmers – ensuring connectivity of agricultural equipment

Agriculture is highly dependent on the agricultural equipment used, the infrastructure and the workforce. Agricultural equipment comprises all mobile and stationary machinery and equipment used for indoor and outdoor agricultural operations. Modern agricultural equipment provides a range of different options for collecting and analysing process data. But not everyone has digital agricultural equipment, is aware of its benefits, or trusts it sufficiently to use it. Nevertheless, the potentials of digitisation and using data for agriculture are generally recognised – after all, farmers were in the vanguard of electronic data capture for arable and livestock farming. What are the obstacles that need to be overcome for the future if the revolution known as Agriculture 4.0 is to achieve its full potential?

1.1 Analogue agricultural equipment

Tractors will always be part of farming, whether out on the field or in the cattle shed. So many farms use large numbers of tractors. In 2012 there were more than 1.2 million licences issued for agricultural tractors in Germany. [5]

The slogan Agriculture 4.0 draws on the term "Industry 4.0" and refers to increased integration of IT and communications technology with agricultural production. Using smart, networked systems combining various different types of data from multiple sources promises to increase productivity and efficiency. Another feature is the increase in transparency along the value chain. It is not just agriculture that benefits, but also the environment and downstream economic activities right down to the end consumer. The model for the future is a fully automated and autonomous agriculture.

The average age of these machines was 27.5 years. Compared to other classes of vehicle such as cars, they are many times older.[6]

"For the German market my estimate would be that 60 to 70 per cent of existing machinery in use is still analogue, with 30 to 40 per cent fitted with digital technology. But that is based entirely on the date of purchase – the age of the machines."

Prof Dr Wolfgang Büscher –
University of Bonn, Institute of Agricultural Engineering

The average age of tractors has increased steadily over the last 30 years. The main reasons for this are the longevity of the machines but also high purchasing costs. New tractors cost from 50,000 to 150,000 euros. Specialised machinery such as combine harvesters can be two or three times as high. Large agricultural equipment, particularly tractors, represent long-term investment assets for farms. Due to the high average age a large number of tractors used are currently not state of the art and are not network-enabled.

1.2 Lack of media skills

Digital media and modern technologies have been part of farmers' daily lives for years.[7] They were networked from an early stage and were in the vanguard of electronic business management. But we also know that there has been some resistance to some digital products by farmers in the past. This is partly because the services offered did not match the expectations and needs of the target group or the state of their knowledge.[8]

"Training staff in new technology is often very difficult and costs farmers time and money."

Prof Dr habil. Eberhard Hartung –
Christian Albrecht University at Kiel,
Institute of Agricultural Process Engineering

Digital applications increasingly need to become part of farmers' everyday routines, whatever their prior knowledge or age. This means that further training is needed as well as formal education and training. Although many digital applications are intuitive to use there will be some specialised applications for which new expertise and new competences are required. The crucial point here is that digital solutions need to be seen as a source of practical assistance, a relief rather than a burden. It is important that the time and investment involved in introducing digital solutions is commensurate with the added value that results from using them, particularly in the peak growing season.

1.3 Deficiencies in telecommunications infrastructure in rural areas

Digital technology is networked technology. An Internet connection is essential for many applications to work. Modern agriculture, like all other sectors of the economy, relies on modern telecommunications infrastructures. But in rural areas there is often only a limited mobile signal or landline Internet connection. This often makes it impossible to make optimum use of digital applications to achieve costs savings and increase efficient utilisation of resources, which are relevant not only in business terms but also in terms of natural, environmental and climate protection.[9]

1.4 Uncertainties over farm data protection

Digital applications in agriculture process large amounts of data, link them and automate processes, helping farmers with decision-making and production processes. It is very important for users that they retain data sovereignty at every point, that their data are secure and cannot be used or leaked by unauthorised persons. Personal data are relatively well protected under the German Federal Data Protection Act[10] but as yet there is no generally valid legal basis for guaranteeing data protection for operational data. This creates general uncertainty and distrust of digital solutions in agriculture and holds back the development of an Agriculture 4.0.[11]

"Legislation simply cannot keep up with the rate at which digitisation is developing, for example on data protection. So there is a great deal in the digital sector that is not yet covered by this legislation. Many farmers are worried that data are leaving their businesses that they would really prefer to keep to themselves."

Dr Martin Kunisch – Chief Executive, Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V. (KTBL)

1.5 Handling big data in agriculture

The potential for Agriculture 4.0 is due to the large pool of data that farmers collect from their operations. Of course this is also a challenge. After all, data are worthless until they are systematically combined, analysed and interpreted. For raw data to be transformed into knowledge and used as a basis for clear recommendations, they need to be collected, combined and organised in a systematic way and made available in a way that the owner has authorised. Standalone digital solutions should be avoided.

1.6 Standalone solutions

Many digital products for the agricultural sector are neither compatible across different manufacturers (interoperable) nor networkable. They are standalone solutions that are very difficult to integrate into an overall design concept. Standardisation and creating interfaces allows data collected to be used in many different forms to optimise various farm management processes. A central challenge in digitising the industry is around enabling the exchange of data across applications and the agricultural sector. Without this, information and, along with it, some of the potential added value of digitisation will be lost.

"The greatest challenge for digitisation in agriculture is incompatibility of products from different manufacturers."

Prof Dr-Ing. Stefan Böttinger, University Of Hohenheim

Key challenges facing farmers – ensuring connectivity of agricultural equipment

1. Analogue agricultural equipment
2. Lack of media skills
3. Deficiencies in telecommunications infrastructure in rural areas
4. Uncertainties over farm data protection
5. Handling big data in agriculture
6. Standalone solutions

2. Agriculture 4.0 – What's the point of collecting data and networking on the farm?

Production of agricultural goods is increasingly associated with the generation of data. But only a small part is currently used. So there are good reasons for improving data utilisation in agriculture.

2.1 It pays to utilise data

As well as sound expert knowledge, stringent accounting is key to increasing the efficiency of a business. New possibilities offered by modern technologies on automated collection, analysis and interpretation of operating data have been implemented in many other industries. In agriculture, proper accounting is the basis on which a company is taxed.[12] To apply for direct payments from the EU under "greening" programmes, or payments from national subsidy programmes at national and local level, farmers have to declare areas under cultivation along with the location and periods involved. Direct payments now make up a considerable proportion of a farm's income and should be documented in line with cross-compliance regulations to ensure they can be traced in the event of an audit.[13]

"Farmers – or farming businesses – will have to deal with an increasing amount of data. There's no doubt about that. So documentation will become increasingly important."

Dr Bernd Scherer – Managing Director, VDMA Landtechnik, VDMA Verband Deutscher Maschinen- und Anlagebau e.V.

2.2 Exploiting data makes work easier

Farmers are required to collect certain data, and to provide seamless records. For example, they must ensure the traceability of foods and feedstuffs for every link in the value chain from primary agricultural production to retail. Records of fertiliser and pesticide measures also need to be documented down to the very last detail.[14]

Modern farm management software that allows collected data to be organised rationally make it far easier to meet documentation requirements such as these. Farmers can also save time with digital support applications.[15] Almost 50 per cent of mandatory documentation was digitised or at least partially digitised by 2008, though not through automated processes.[16] Manual data entry is still necessary for many software solutions since the lack of interfaces and standards as well as redundant data often prevent fully automated solutions.[17]

"One of the blessings of digitisation for agriculture is that automation means production managers no longer have to perform routine admin tasks such as entering non-sensitive data by hand."

Dr Martin Kunisch – Chief Executive, Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V. (KTBL)

2.3 Utilising data creates transparency

The current trend is towards greater transparency. On top of their mandatory obligations on documentation, many farmers are also signing up to voluntary certification agreements. "Global GAP", "QS", animal welfare or eco labels are attempts to create greater transparency and credibility. They help farmers to differentiate themselves and improve their market presence.[18] Industry-wide agreements such as those within the sugar industry commit farmers to the transparent documentation of all processes within the value chain to guarantee permanently high product quality.[19] Civil society and political actors are increasingly campaigning for the highest levels of transparency in the value chain. For example, a more responsible use of pesticides and fertiliser, or species-appropriate animal management. Transparency is being driven across all sectors by all actors in the agricultural value chain and by consumers. Digital solutions provide ways of meeting this order of the day, building up trust within the industry and in the public, and being able to report on your own production to interested parties in a traceable way without having to spend too much labour and time resources on it.

3. Technological solutions for analogue agricultural equipment

Due to the relatively high average age of agricultural equipment there is an increasing demand for solutions that retrofit machinery and ensure its connectivity in order to integrate it into the digital world. Solutions created to do this need to be standardised, robust, universal and interoperable, as well as being capable of being installed and used with no special extra training. They also need to take into account the inadequate telecommunications infrastructure in rural areas and develop solutions that work even where there is no mobile phone signal across parts of the areas under cultivation.

3.1 Bluetooth "beacons" in agriculture

Once collected, data have to be transmitted to be used. "Beacons" have been set up as transmitters that send their signals using an energy-saving Bluetooth protocol. These beacons transmit their signals over a radius of just under 30 metres. These are detected and decoded by a compatible app on a smartphone, tablet or computer. When a Bluetooth-compatible device comes within range of the transmitter the data are collected and processed. If installed on equipment, tractors, combine harvesters, lorries or in the cattle shed, they allow a vehicle, device or a person to be clearly identified. The crop's route from the field to the barn is documented seamlessly. Every vehicle, whatever its age, manufacturer or purpose, can be fitted with one of these beacons. Mixed machinery inventories can be retrofitted without any difficulty.20 Due to their low electricity consumption, batteries only need to be replaced every four years or so.

Task: Identification of machinery and other points of interest

Applications: ARecording working hours, identifying workforce

3.2 GPS in agriculture

Pinpointing positions to the nearest centimetre is a key prerequisite for the partial automation of workflows in agriculture. For example for processing, maintaining or harvesting areas under cultivation. Everyday positioning systems such as GPS have been used in agricultural equipment for a long time now, both as fixed units or hand-held devices. The "Global Positioning System" (GPS) is a global satellite navigation system used for positioning and navigation. Originally developed for military purposes, it has now established itself as the world's most important positioning system for aircraft, cars, mobile phones or even sports watches.

Task: Recording positions and movements, autonomous or assisted driving

Applications: Monitoring and support on parallel journeys, autonomous driving

One example of a practical application of a Bluetooth "beacon" is the **365ActiveBox** from 365FarmNet. The box can be installed on any machine but also on buildings, for example in the cattle shed or barn. The device then continuously transmits its ID from that position. When an employee's Bluetooth-enabled device comes within range, the transmitter and receiver pair with each other using the 365ActiveApp. Both the position of the user (via the mobile device) and the duration of "shared" activity are collected and saved in encrypted form in the Cloud, a backup data server. Registered users can view and process the data collected. For example, farm management software can be used to track working hours. The work of the farmer and the machinery are captured by an automated system.

1. The beacon is activated and permanently paired with the smartphone, then installed on the analogue agricultural equipment.

2. If the Bluetooth-enabled device with the associated app comes within range, they pair. Now both the position of the user and the duration of shared activity are collected and saved in the Cloud.

3. The information is available from the Cloud to all users registered in the farm management software.

4. All registered users can track work in the farm management software.

3.3 RFID in agriculture

Another well-established technology for detecting animals at automated feeding machines is RFID (radio-frequency identification). This refers to transceiver systems for automatic, contactless identification and localising of objects and animals. An RFID system consists of a transponder that is located at or in the object or animal and contains an identification code as well as a "reader" and a "writer" to read out and describe the transponder. The readers have interfaces with other IT devices. Depending on the frequency used, the range varies from a few centimetres to 10 metres. The range can be increased by fitting transponders with a power supply. Developed at the end of the Second World War, RFID technology has proven highly useful in agriculture, for example in livestock management.21 RFID is now even being trialled for tracking batches of cereal crops.22 Minute transponders are already inserted into batches of cereals during harvesting so that batches can be clearly identified at later process stages, for example at the flour mill and their processing documented.23 Objects can also be located to distances of up to 300 metres using radio tags.

Task: Identification, positioning

Applications: Identification and localisation of livestock, batches of cereal, equipment.

"What we need is better network coverage. There's no point in having perfect digitisation if there's no radio signal over large areas."

Thomas Böck – CTO, CLAAS KGaA mbH

CHECKLIST for digitisation of analogue agricultural equipment

Key criteria to be considered when selecting solutions for use on analogue agricultural equipment

Users should start by defining the requirements they want to meet using digital solutions and how much they need or want partial digitisation. The criteria used will differ depending on the issue. System-integrating solutions with smart-linked analyses embedded in a total management solution (for example using farm management software) are generally most beneficial. They can provide rational recommendations and this also helps to avoid standalone solutions.

System requirements for integration into a total farm management system:

- ✔ Independent of manufacturers and age of machinery
- ✔ Rational linking with operating data and work specifications
- ✔ Smart analyses and interpretation within an individual farm management system
- ✔ Capable of networking with other parts of the farm, compatibility with other applications
- ✔ Targeted capture of relevant data (machine/POI, location, persons, times) on a platform/program compatible with other farm applications
- ✔ Data protection und data security ensured
- ✔ Support/services for users
- ✔ International usability

Hardware requirements:

- ✔ Software integration
- ✔ Costs/economic viability
- ✔ Ease of use
- ✔ Internet connection: online/offline use possible
- ✔ Robustness and weather resistance
- ✔ Secure power supply

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Conclusions – Partial digitisation of analogue units as an important step towards Agriculture 4.0

New technologies and software programs alone cannot solve all the challenges of digitisation. Infrastructure, training and further training, the structural and legislative operating environment and willingness to implement new technologies are also involved. For Agriculture 4.0 to work, a modern telecommunications infrastructure in rural areas is essential. However modern and digitisation-ready the machinery is, a stable, fully available and high-performance Internet form the backbone of digitisation.

On data protection and data security, companies are responsible for ensuring farmers trust their products and services over the long term, removing grey areas and supporting a system of competition that is fair and fit for purpose. On the other hand, professional and further training, as well as training courses, need to be adjusted to take account of the digital landscape. As well as the basic theoretical principles, this is about communicating practical knowledge and 'hands-on' experiences – items to test and try out, in order to familiarise both the new generation and established farmers with the technology. If practitioners can be convinced of the benefits of digital solutions and be trained in how to deal with them, this will open up new areas and broaden the base for the Agriculture 4.0 concept. Companies, training establishments and the public sector can and should collaborate on this.

"Partial digitisation is a sensible step for a farmer on the way to a digitised farm."

Dr Bernd Scherer – VDMA Verband Deutscher Maschinen- und Anlagebau e.V.

Technological solutions provide an important contribution towards transforming the challenges of digitisation into opportunities. Apparently simple technologies such as Bluetooth, GPS or RFID enable partial digitisation of farms with agricultural equipment that is analogue or mixed but still fit for purpose. If they are embedded in a total modern farm management system, for example using farm management software, these technologies can be developed over the long term to form part of the digital landscape.

In 2015 one fifth of all farms (19 per cent) used Industry 4.0 applications. In agribusinesses with 100 or more employees the figure was one third of the total (33 per cent). The trend towards Agriculture 4.0 is clear.[24]

A cost/benefit analysis must underpin every deployment of any technology. A technology will only achieve widespread adoption if the expected benefits outweigh the costs. If investment costs in the digital agricultural equipment are too high for the farm, purchasing will be postponed. If the farmer first has to familiarise himself with complex installations and control mechanisms he will probably not deploy them. If data protection is not guaranteed, so that farmer has to fear losing control over important operating data, this also means he will stick to what he knows.

If investments in new technologies are proportionate to the outcome from the start, the first step towards a digitised landscape has been taken. So partial digitisation operates as a turnkey for Agriculture 4.0. It can be used to digitise analogue and mixed machinery incrementally. Partial digitisation is a simple, cost-effective, robust and secure technological solution. Through universal applicability and low investment costs manufacturers are increasingly creating solutions that are open to all agribusinesses, the family farm and agricultural cooperative alike.

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