# Digital Farming: what does it really mean?

*And what is the vision of Europe's farm machinery industry for Digital Farming?*

*13 February 2017*

## 1 Digital Farming: what does it really mean?

### 1.1 Introduction

Digital Farming describes the evolution in agriculture and agricultural engineering from Precision Farming to connected, knowledge-based farm production systems. Digital Farming makes use of Precision Farming technology, yet – in addition – also takes recourse to intelligent networks and data management tools. The aim in Digital Farming is to use all available information and expertise to enable the automation of sustainable processes in agriculture.

Precision Farming started when GPS signals were made available to the general public. Precision Farming enables vehicle guidance and site-specific monitoring and control. Combined with telematics and data management, Precision Farming improves the accuracy of operations and allows the managing of in-field (or in-herd) variations. The objective is to give each plant (or animal) exactly what it needs to grow optimally, with the aim to improve the agronomic output while reducing the input (= producing 'more with less').

In the early 2010s, Precision Farming was boosted by the advancement of new technologies such as cheap and improved sensors, actuators and micro-processors, high bandwidth cellular communication, cloud based ICT systems and big data analytics. As a result, data is no longer sourced merely from the farm equipment used, but new services are being offered with new algorithms to transform data into actionable intelligence.

Digital Farming is structurally similar to the concept of 'Industry 4.0'. However, the parameters in agricultural production processes are somewhat different from industrial processes, as agriculture is heavily determined by natural and biological factors. Therefore, we use the term 'Digital Farming' in this document.[1]

### 1.2 Scope

Digital Farming covers all aspects of agriculture. However, the main focus of this document is on primary production in arable and livestock farming. Primary production is mostly realized by farmers and agricultural contractors (hereafter referred to as 'end customers').

---

[1] More information on the definition and history of the terms Digital Farming and Agriculture 4.0 can be found in the Annex at the end of this document.

## 1.3 Connecting smart machines

Due to the inherent complexity of agricultural production processes, the multitude of business partners involved, and the different sources of information, extensive and differentiated communication structures arise in Digital Farming. **Figure 1** illustrates the Digital Farming landscape at farm level.

In order to make Digital Farming possible, two central preconditions must be fulfilled:

**Smart machines**:
machines must be able to receive, send, generate (via sensors) & process data

**Connected machines**:
communication and inter-face standards must permit seamless data exchange between machines, with business partners, and among data portals.

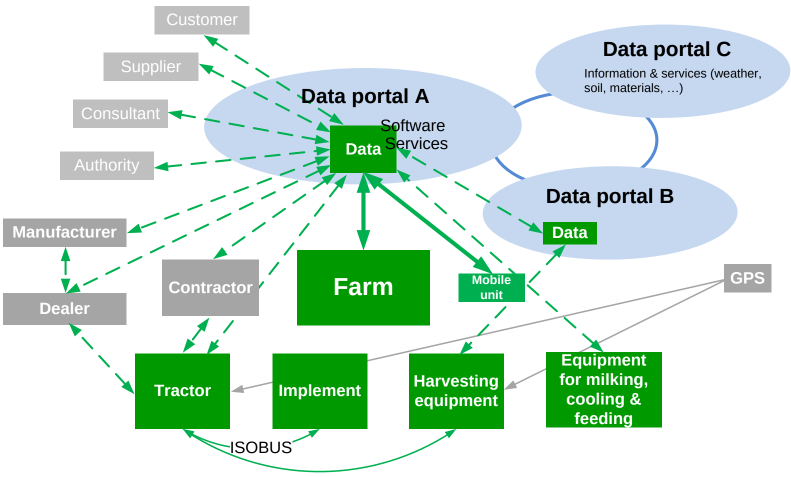


**Figure 1: Example of a network for a farm**

## 1.4 Data management & ownership

In the context of Digital Farming, data management is of fundamental importance: data volumes must remain manageable and, above all, controllable. Transferring data management to a data portal makes it easier to control the processing and flow of information. The farmer decides on the allocation of access rights and on the question which partner(s) receive(s) which kind of data. In this way, the farmer can retain "ownership" of the data.

# 2 Digital Farming: adding value through *data*

Even when using sensors and optimised control algorithms, individual devices have reached a technological maturity level at which further improvements are limited when compared to the much greater optimisation potential offered by data algorithms. This point can best be understood when thinking of, for instance, a car which has primarily been designed for speed: at a certain point of technology maturity, the car will not arrive faster at its final destination if it always takes the same route, whereas real-time optimised GPS routing based on the actual traffic situation could optimise the process and shorten actual travel time.

Data is the key ingredient for the European farming sector to become more productive and sustainable and remain competitive in a global environment. Looking at the food production chain as a whole, data is a key tool to demonstrate compliance with legal obligations and risen societal expectations as regards food safety and production methods. With enhanced transparency and traceability, it will be possible to produce more and better food for a growing population while reducing the environmental footprint.

Huge amounts of data are already available. However, going beyond the mere presence and availability of data, Digital Farming means to create considerable added value from such data:

- **Data as a technology enabler:** Digital Farming makes other Precision Farming tools work better. For instance, Variable Rate Technology (VRT) based on soil sampling was initially limited to a handful of soil samples, but was improved with the yield monitoring input. The next step is to improve the variable rate maps with algorithms based on data from multiple fields, and taking into account parameters not directly related to the field itself, like seed characteristics and environmental conditions.
- **Improved production processes:** For the end customer, connected production processes, together with the (partially) automated collection and targeted analysis of data, permits an entirely new level of transparency and evaluation of the current operating situation, providing new opportunities for operational control.
- **Decision support:** For data processing, and in particular data analysis, expert systems are available to the end customer, which would be difficult or impossible for individual farms to attain by in-house data processing. In other words, farmers can now leverage a hitherto unknown level of knowledge from external partners.
- **Data exchange / benchmarking:** Networking with external partners, and in particular the automated integration of information and data, leads to a considerably broader knowledge base and hence to well-founded, fast decision-making. Value (algorithms) is created based on data captured in other areas of the production chain.
- **Farm operations, inputs and outputs are optimised:** seeds are optimised for the field and environmental conditions, equipment is optimised for the job. Data is used to enhance the performance of these input products with additional services.

Digital Farming already is a reality in some areas: for instance, GPS guidance systems for controlled traffic farming, site-specific fertilisation or plant protection measures as part of a complete production/input cycle using proprietary cloud-based connectivity. This being said, automated data processing and completely integrated, harmonised networks still present a not-so-distant future for agriculture and agricultural machinery. Dedicated efforts by all concerned actors are needed to realize this future vision.

# 3 The farm machinery industry's vision for Digital Farming

As an industry servicing farmers and agricultural contractors, the farm machinery industry is fully committed to realize the concept of Digital Farming and continuously improve and develop it further.

**Manufacturers of agricultural machines focus, first of all, on the development of highly efficient machines that are suited for Digital Farming**. In other words, the industry focuses on the development of machines which are compatible with the digital infrastructure of the farm and can make the required contribution to the optimisation of production processes.

Digitally smart farm machines must:

- be able to send and receive information via appropriate sensors and communication hardware,
- facilitate automated operations,
- enable the optimal utilisation of machinery, and
- assist the driver.

Whereas, in the past, the industry's primary focus was on the optimisation of the farm machine itself, this focus has now gradually shifted towards the optimal integration of the farm machine into the production system (process optimisation).

**Secondly, manufacturers of agricultural machines are shifting from a hardware- to a service-oriented approach**. Data not only allows additional services for processes on the farm, but also enables services to enhance the performance of the vehicle. Data allows to make the equipment more suitable for the job, with enhanced maintenance to increase machine uptime and reduce unplanned downtime, thus lowering operational costs for the farmer.

For the manufacturers of agriculture machines to advance on this path of development, it is important to obtain – provided the end customer agrees – access to farm machinery-related data in order to:

- support the utilisation of machinery, e.g. by providing data for **optimised machinery settings**;
- derive machinery **design optimisations** from utilisation data;
- **facilitate** machine-to-machine (**M2M**) **communication**, to allow machines to communicate with one another via data portals, and to enhance them with additional intelligence (process knowledge) in order to increase efficiency;
- **recognise** additional needs e.g. in relation to functionality or driver training;
- **collect data** from the data management systems, e.g. to optimise the preparation of application maps for the sowing of seeds and the application of fertilisers and plant protection products;
- use the data obtained to document the work done and the resources used, e.g. via yield maps and current status maps of applications;
- develop additional offers, e.g. in the consultation or service areas.

To achieve these goals, manufacturers of agricultural machinery will network with data portals, so as to provide the possibility of data exchange. If necessary, portals can also be offered by manufacturers themselves. For sustainable utilisation on the part of farmers, it is essential that:

- the different data systems are networked with one another.
- end customers, as owners of the data, determine the amount of data, data type (e.g. soil, yield, machinery…) the time period, and the partners with whom they wish to exchange data via the portals.
- data handling happens in a transparent way.
- data exchange and handling happens in a safe and secure way.
- data elements should be well-defined (a broadly accepted common data model).

## 4 The added value for customers & manufacturers

**For end customers,** the main advantage of Digital Farming is the significantly larger information- and knowledge-base obtained (brand-independently) from sensors, machines and other sources. Specific benefits can be provided by the utilisation of data portals, for example:

- the integrated design of farm data processing solutions means that data (e.g. master data) must be entered and maintained only once;
- data gathering can be automated without the end-customer having to insert the data manually;
- the quality of decision-making is enhanced by consistent data;
- there is a reduction of support complexity (and costs) for in-house data processing;
- there is more rapid exploitation of high-performance technology – without investment by the farm;

- professional portal providers have high security standards in relation to data protection and security;
- data mobility is greatly increased, e.g. information concerning production is available directly in the field.
- farmers can leverage knowledge (based on algorithms) from external parties.

**For manufacturers** of agricultural machinery, networking with a data portal can also provide additional advantages, such as:

- better & closer relationships with end customers;
- using data from the vehicles and value chain players to optimise products and internal processes;
- higher machine efficiency in terms of both production costs and environmental protection, through intelligent networking;
- the utilisation of information made available by other data portal partners;
- process optimisation for support and dealer activities;
- expansion of product offerings in non-physical services related to the equipment or agronomic processes, e.g. in the areas of machine servicing, consultation services, etc.

In return for data, farmers will obtain agricultural equipment that:

- is better suited for the job
- is more productive
- has increased up-time and less unplanned downtime
- comes with enhanced automation features to reduce input costs such as agro-chemicals
- provides data to optimise the agronomic and logistics processes further

## 5 Ingredients of a successful data portal

When using data portals, it is important for end customers that they are not restricted in their scope of decision-making and have all the necessary tools at hand to create value from their data. When selecting a data portal, they should therefore examine the following criteria:

- **Security & ownership of control**
  - Protection of personal and operational data from physical and logical errors as well as from unauthorised access
  - Transparency in the data handling and access permission control
- **Design possibilities** e.g.
  - Openness of the data portal to partners (e.g. via cross-manufacturer standards) and the possibility of adding or rejecting partners
  - The players connected to the over-arching eco-system (platform)
  - Modular concept permitting a phased implementation
  - Simple, multi-media operation
- **Availability & performance**
  - Assurance of permanent availability and performance capacity of the data portal;
  - Automation of data transmission;
  - On-site support by service partners;
- **Data portability**
  - Technical and economic opportunities to move data from the portal back to in-house data processing or transfer to another portal;

    - Utilisation of standards
- **Integration capacity**
    - Preconditions for the networking of in-house data processing with the data portal.

**Portals are for visiting, platforms are for building on!** Through portals the user will have access to operate the app (interface-functionality) developed on the platform. There is much to do about "open platforms". In computing, an open platform describes a software system which is based on open standards, such as published and fully documented external application programming interfaces (API) that allow using the software to function in other ways than the original programmer intended, without requiring modification of the source code. Using these interfaces, a third party could integrate with the platform to add functionality. **However, an open platform does not mean it is open source**, and most open platforms have multiple implementations of APIs.

**For CEMA, APIs, the right platform safety and security protocols, and cross-platform standardised interfaces for communication are the key elements for a successful deployment of data portals.**

## 6 Framework conditions for Digital Farming

For the agricultural machinery industry, it has been – and remains – of vital importance that the end customer, the 'farmer', can decide freely among individual products, and can combine machinery of different manufacturers. This has been achieved via uniform interface standards (e.g. the three-point hitch or the ISOBUS connection between tractor and implement).

This freedom of choice in terms of:
- selection of the data portal;
- determination of partners with whom to collaborate (on the portal);
- the consequent necessity of being able to exchange data between portals; and
- free choice in the purchase of machinery and the use of software applications relevant to the orientation of the farm must also be maintained for end customers within the framework of Digital Farming.

In order for Agriculture 4.0 to become a reality and to deliver its full benefits in the sense of fair competition at all levels (manufacturers, dealers and farmers), and the stimulation of innovation and competitiveness, among other things, the following preconditions are required:
- **Availability of smart, connected machines;**
- **Interoperability** – standardised interfaces for communication (of device, machine, FMIS, cloud-platform…).

AEF and AgGateway are considered the key players to promote interoperability in the primary agricultural production chain.

Since decades ISO-11783 (ISOBUS) is the de-facto standard between tractors and implements of different brands. The Agricultural Industry Electronics Foundation (AEF), an independent international organization, has been founded for the implementation and further enhancement of ISOBUS. But over time its work is expanded to include other important areas such as Electric Drives, Camera Systems, Farm Management Information Systems, High speed ISOBUS and Wireless In-field Communication, developing guidelines and transferring the gained knowledge to ISO level. Currently over 190 members support and actively collaborate within the AEF.

Besides the exchange of agricultural specific data concerning field and crop operations, there also is a need for standardizing more transaction related data exchange with other actors in the supply chain. AgGateway is the recognized international organisation for enabling the use of information and communication technologies for Agriculture. AgGateway aims to expand the use of e-Business standards and guidelines globally through the concept of collaboration. AgGateway collects and shares "what has worked" in various regions of the world, through the use of AgGateway's intellectual property, to promote global e-businesses, and to collaborate on necessary standards where specific needs exist.

AEF and AgGateway have joined forces to make the data exchange standard future proof for Digital Farming. The added value of the cooperation between AEF and AgGateway lies in the joining of different areas of expertise and knowledge. It allows to cover the complete landscape of Digital Farming. Figure 2 illustrates the respective areas of expertise. In the overlapping area (highlighted in grey) both organizations work together to align the development and acceptance of these data exchanges standards.

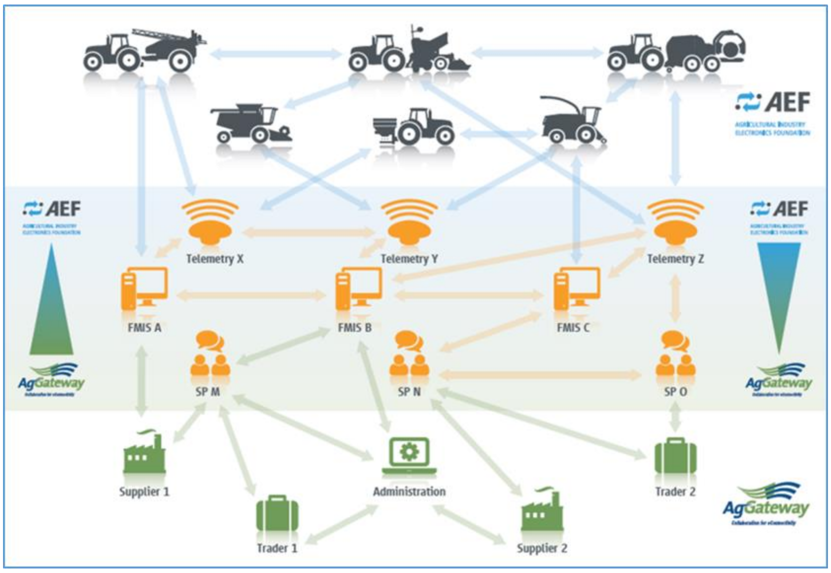


**Figure 2: Respective areas of expertise of AEF and AgGateway. Areas of cooperation are highlighted in grey.**

- **Data rights** – Assurance of data ownership by farmers (through pubic law regulations and contract law);
- **Connectivity –** Appropriate digital infrastructure (such as network coverage and transmission rates);
- **Accessibility** – Opportunities to access existing databases (for climate/weather, soil, etc.).
- **Digital skills** – training, tools, networking of customers, service technicians, advisors
- **Align policies** for adoption of agriculture 4.0 technologies

## Annex: Defining the terms ‘Agriculture 4.0’ & ‘Digital Farming’

### Agriculture 1.0

Situation in the early 20th century. A labour-intensive system of agriculture with low productivity. It was able to feed the population but required a vast number of small farms and a third of the population to be active in the primary agricultural production process.

### Agriculture 2.0

Widely remembered as “The Green Revolution”, this phase of farming began in the late 1950s when agronomic management practices like supplemental nitrogen and new tools like synthetic pesticides, fertilisers and more efficient specialised machines allowed to take advantage of relatively cheap inputs, thus dramatically increasing yield potential and growing returns to scale (consolidation) at all levels.

### Agriculture 3.0

“Precision Farming” started once military GPS-signals were made available for public use.

Precision Farming entails solutions for:

- **Guidance:** early adopters in the mid-1990s were using GPS-signals for manual guidance. They built further on technology used in aerial spraying. The first automatic steering solutions appeared in the late 90s. During the 2000s, guidance accuracy was improved to 1 cm.
- **Sensing & control:** during the 1990s, combine harvesters were equipped with yield monitors based on GPS location. The first automatic Variable Rate Application (VRA) started at the same time. Low fertiliser prices and high technology costs initially limited adoption of variable rate technology. In the early days, VRA was based on soil sampling input, but performance improved drastically based on data gathered by yield monitors.
- **Telematics:** Telematics is a technology used to monitor vehicle fleets. It appeared in the early 2000s, and was inspired by the transportation industry. It is based on cellular technology and allows the optimisation of the logistics processes on the farm.
- **Data management:** Farming software has become widely available since the birth of the PC in the early 80s.

Precision Farming improves the accuracy of the operations, managing in-field variations rather than treating fields as a whole, managing animals rather than herds. The intention is to give each plant exactly what it needs to grow optimally, with the goal to optimise the agronomic output while reducing the input (‘more with less’).

Agriculture 3.0 can be seen as the gradual introduction of more and more advanced and mature Precision Farming technologies. The focus is moved from pure efficiency in terms of cutting costs to profitability which can be seen as objectively and creatively seeking ways to lower costs and enhance quality or develop differentiated products. The introduction of intelligence is key.

### Agriculture 4.0

A new boost in Precision Agriculture can be observed around the early 2010s based on the evolution of several technologies:

- Cheap and improved sensors and actuators
- Low cost micro-processors
- High bandwidth cellular communication
- Cloud based ICT systems

- Big data analytics

As of the 2010s, smart technologies are also increasingly fitted as standard features on tractors, combine harvesters and other equipment, like:

- Smart control devices (on-board computers)
- Many sensors for the operation of the machine and the agronomic process
- Advanced automation capabilities (guidance, seed placement, spraying, …)
- Communication technology (telematics) embedded in the vehicle

In addition, the following phenomena were introduced:

- Physical products are enhanced with additional **non-physical services** with new algorithms being developed to transform data into value adding information, to optimise the products and the agronomic process, reduce risk and limit vulnerability from external influences like machinery breakdown, weather and diseases.
- Emergence of agricultural **eco-systems**, with platforms combining data from several sources, be they sensors or equipment, in the field/farm or external sources. The farmer monitors his operations from a dashboard with real-time or near real-time information, and makes decisions based on quantified hypotheses to increase the financial result.
- **Cooperation** across different players in the agricultural and food value chain. Digital data is the glue that unites the eco-system participants to provide value to the food supply chain. Based on the same data, service providers offer different services to different stakeholders.

As a result, agricultural equipment has become one out of many elements in the complete production system, although an eminently important one. It is not only the biggest data generator, but also the executioner of the plans and maps generated by data platforms and agronomic models.

This evolution happens in parallel with similar evolutions in the industrial world, where it is marked as "Industry 4.0", based on a vision for future manufacturing from Domnhall Carrol. Accordingly, the term "Agriculture 4.0" is often used in farming.

In terms of definitions, Agriculture 4.0, in analogy to Industry 4.0, stands for the integrated internal and external networking of farming operations. This means that information in digital form exists for all farm sectors and processes; communication with external partners such as suppliers and end customers is likewise carried out electronically; and data transmission, processing and analysis are (largely) automated. The use of Internet-based portals can facilitate the handling of large volumes of data, as well as networking within the farm and with external partners.

Other terms frequently used are "**Smart Agriculture**" and "**Digital Farming**". It is based on the emergence of smart technology in agriculture. Smart devices consist of sensors, actuators, a **digital** brain and communication technology.

**In order not to confuse the existing terms, the term Digital Farming has been used throughout this document, referring to the more recent evolution in Precision Farming based on digital data & data management.**

Agriculture 4.0 paves the way for the next evolution of farming consisting of unmanned operations and autonomous decision systems. Agriculture 5.0 will be based around robotics and (some form of) artificial intelligence.

*****