UNIVERSITÄT HOHENHEIM

Precision Farming – Technology for Highly Efficient Production Systems

Advancement in Photogrammetry, Remote Sensing and Geoinformatics
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Technology in Crop Production
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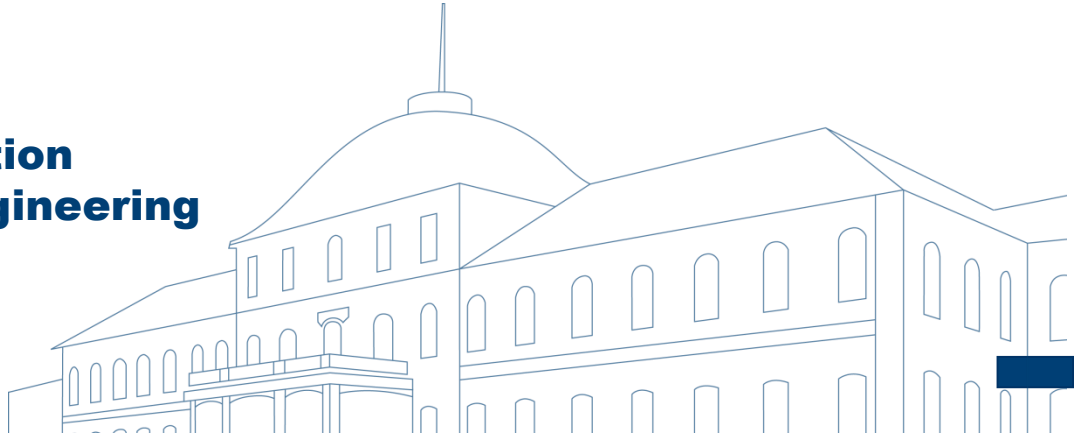
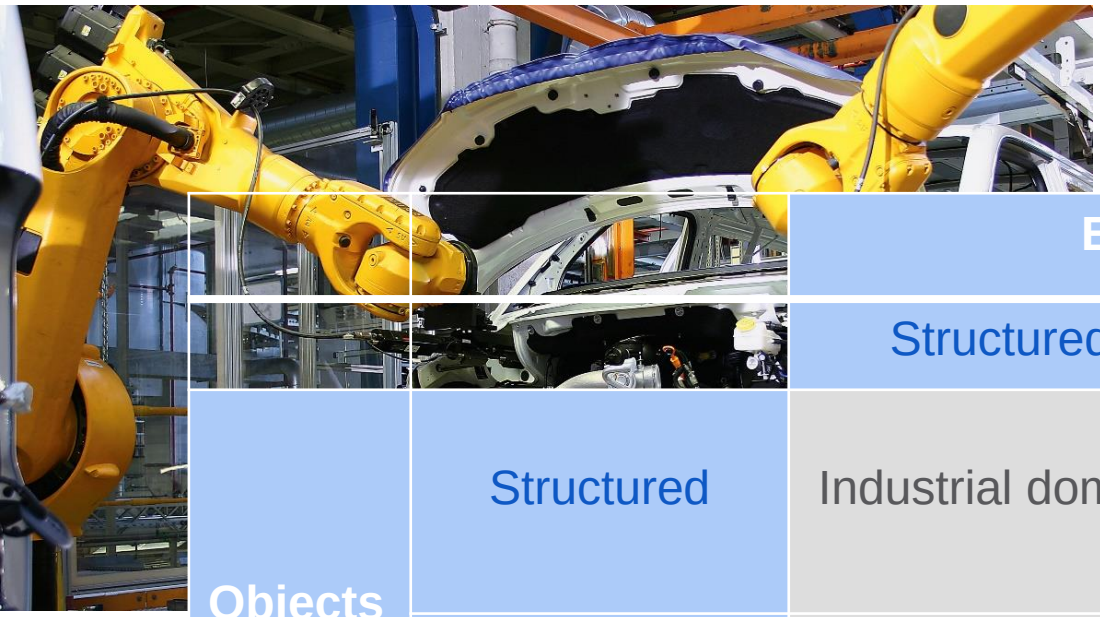
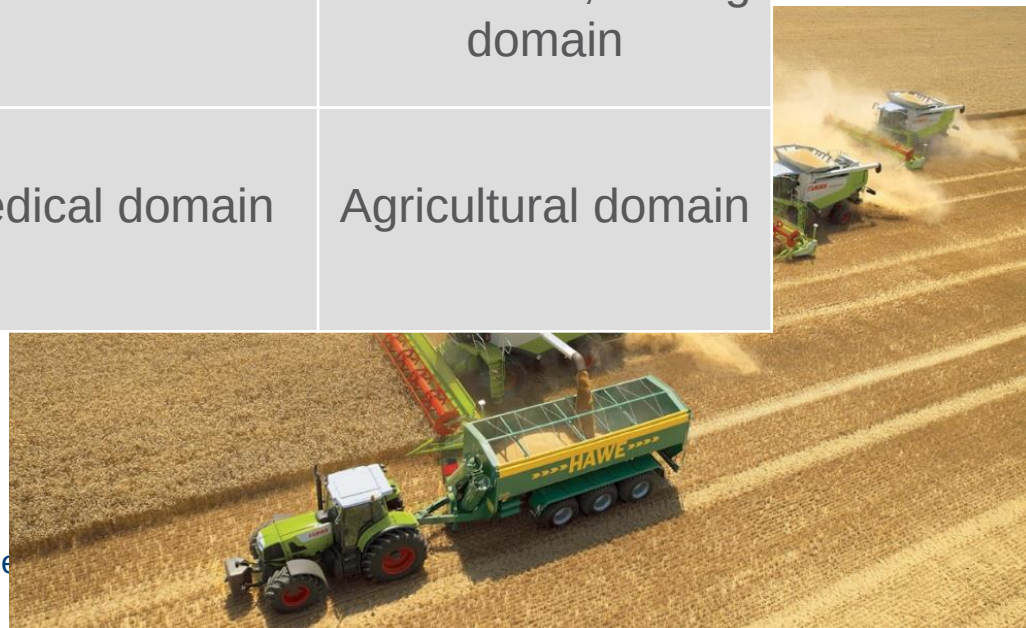


Industry & Agriculture (1)



		Environment	
		Structured	Unstructured
Objects	Structured	Industrial domain	Military, Space, Underwater, Mining domain
	Unstructured	Medical domain	Agricultural domain



Source: Bechar & Vigneault, 2016

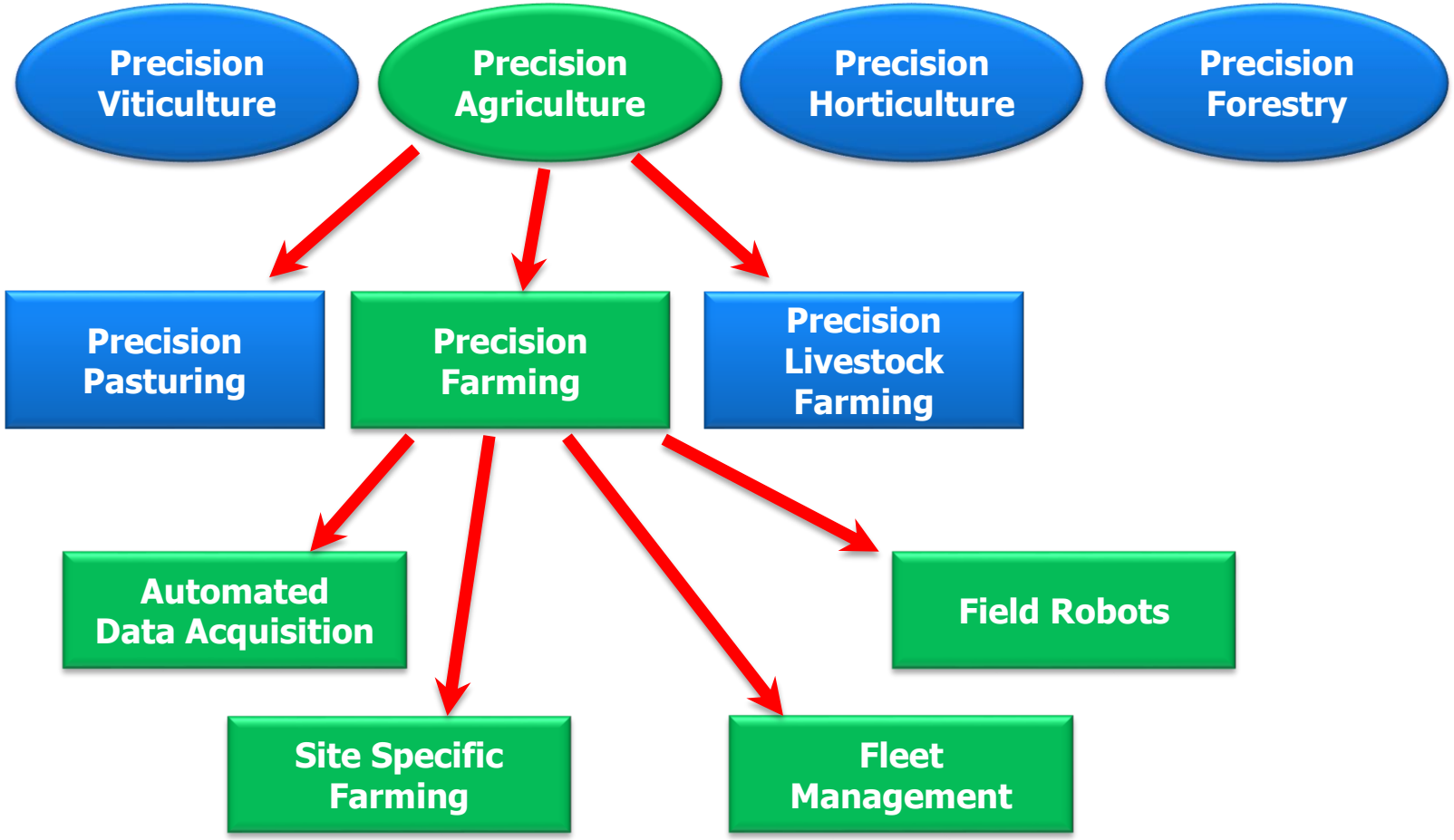
Industry & Agriculture (2)

- Industrial domain (industry 4.0)
  - Highly complex, but conditions are constant and straightforward to control (deterministic)
- Agricultural domain (digital farming)
  - Highly complex and dynamic conditions in time & space (only partly deterministic & highly stochastic)

AG TECH: 100+ TECHNOLOGY COMPANIES CHANGING THE FARM

CBINSIGHTS

IT in Agriculture



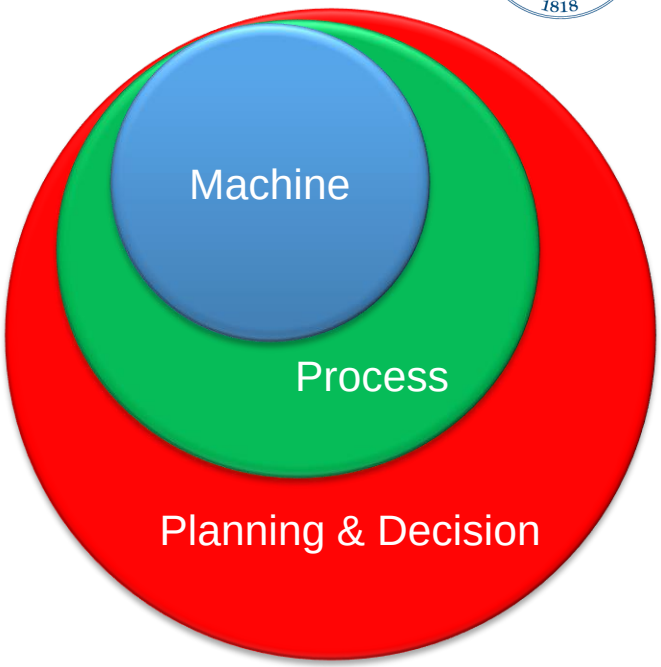
Source: Auernhammer 2004

Purposes of Mechanisation

- Increase land productivity
  - Higher yields, minimise losses, increase quality
- Increase labor productivity
  - Working hours per ha
- Decrease production costs
  - € per ha
- Preserve natural resources
  - Sustainability
- Improve working conditions

Automation + Information technology

Extended Automation in Agricultural Technology



- Automation in Machine Control
  - Automatic steering, auto headland turning, adaptive settings for complex machinery (combine) …
- Automation in Process Control
  - Data acquisition of relevant soil & crop properties, modeling & simulation, prices, crop rotation, external information sources (internet) …
- Automation in Planning & Decision Support
  - Data analysis, storage & retrieval, modeling, expert knowledge, prices, compliance to standards, certification, external information sources (internet) …

Precision Farming

Automated Data Aquisition	Site Specific Farming	Fleet Management	Autonomous Machines
• Field books and book keeping	• Tillage	• Route planning	• Implement control/ automated guidance
• Basic data for Precision Farming	• Sowing	• Location monitoring	• Master slave
• On farm research	• Fertilisation	• Location monitoring with map-matching	• Automated tractors and robots
• Administration	• Spraying	• Fleet control and navigation	
• Quality management	• Harvesting	• Teleservice	
	• Irrigation		

Crop Management

Labour Management

Farm Management

Machine Management

Traceability (Documentation)

Source: Auernhammer 2004

Definition of Precision Farming

- Site-specific agriculture has been defined as

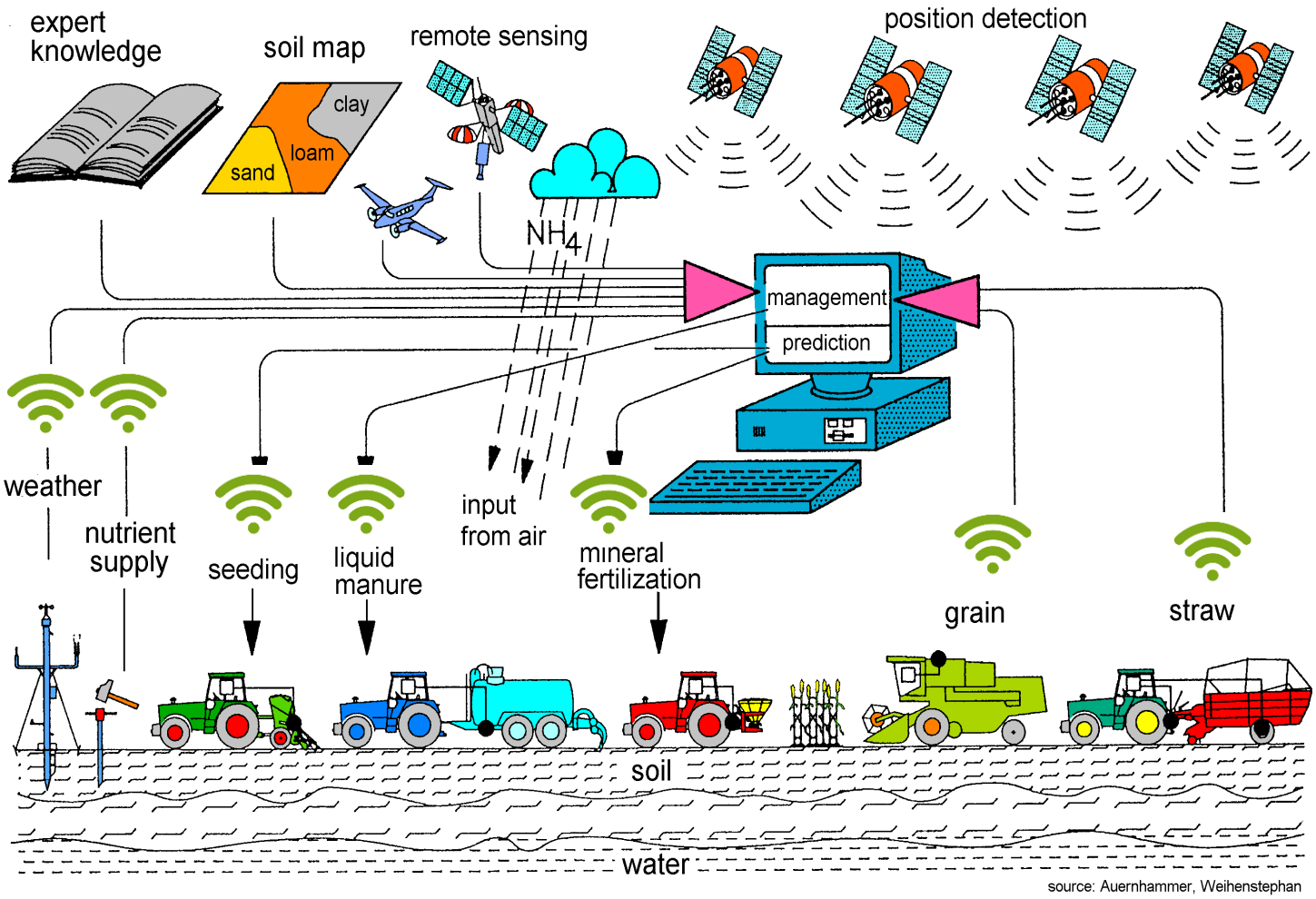
  “an information and technology based agricultural management system to identify, analyze, and manage spatial and temporal variability within fields for optimal profitability, sustainability, and protection of the environment” (G. Johnson, University of Minnesota)

- Precision Farming tries to observe and respond to spatial and temporal variability.

- Precision Farming is a concept to reduce decision uncertainty.

- To do the right thing at the right place and the right time.

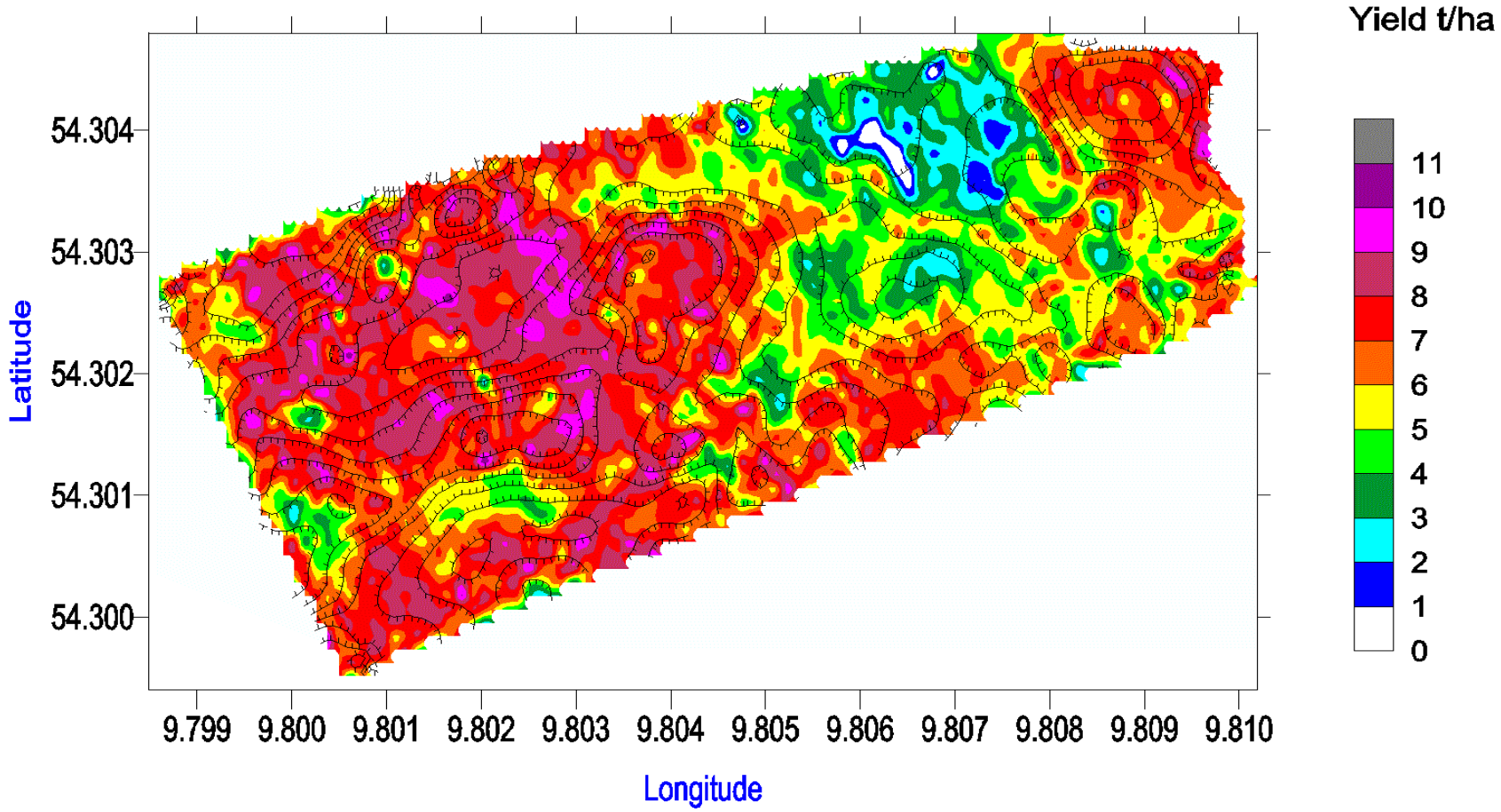
Site-specific Management



Crop Heterogeneity

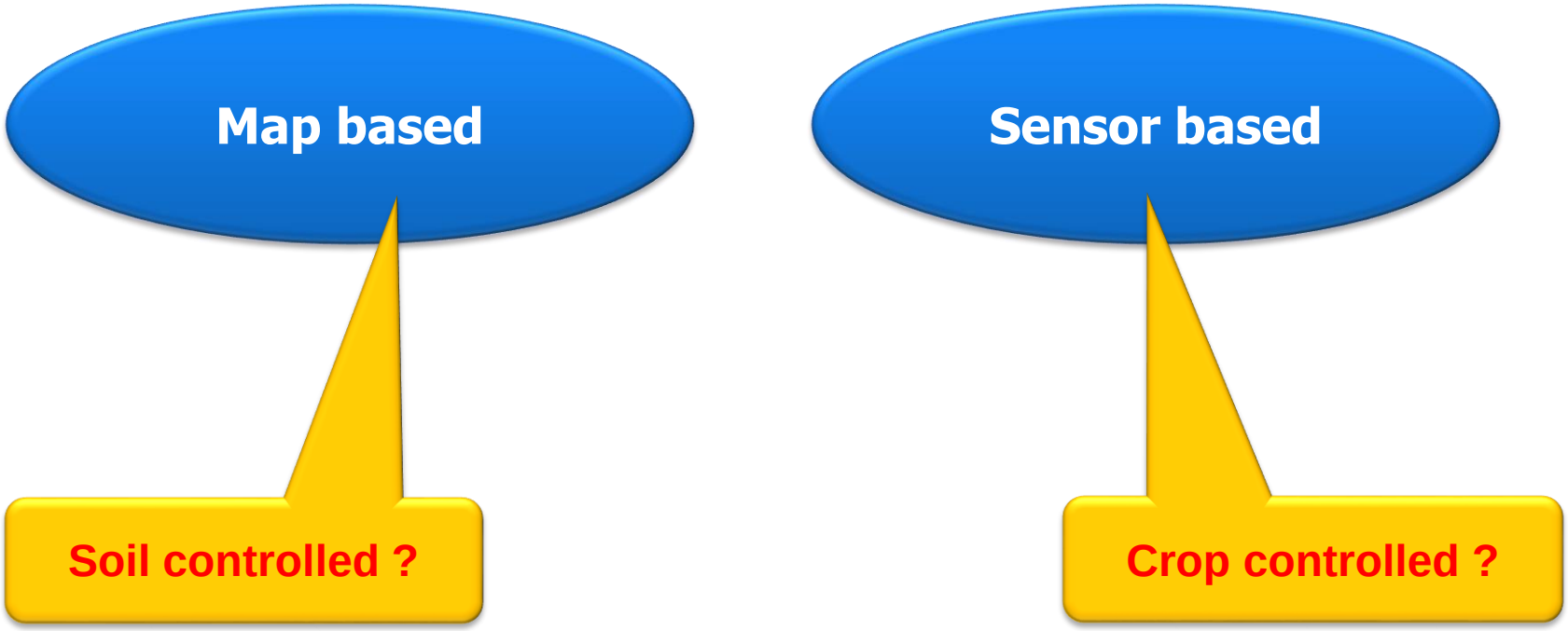
Soil Heterogeneity

Yield Map Winter Wheat (32 ha)



Site-specific Treatments – Variable Rate Application (VRA)

Main Principles

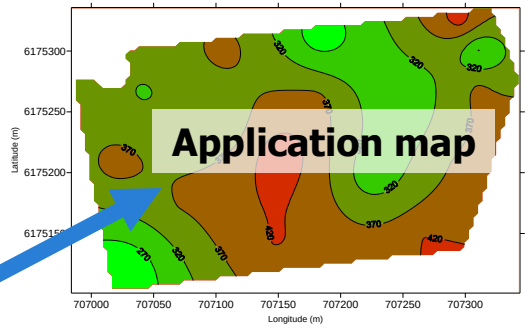


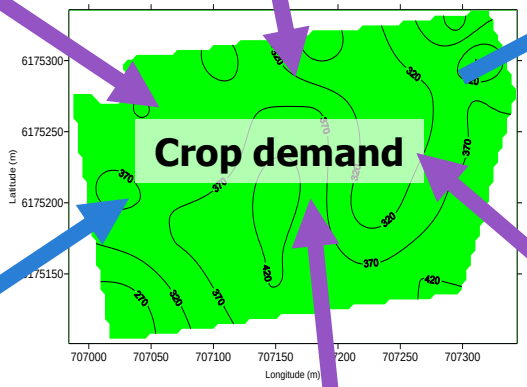
Process of Generating Application Maps

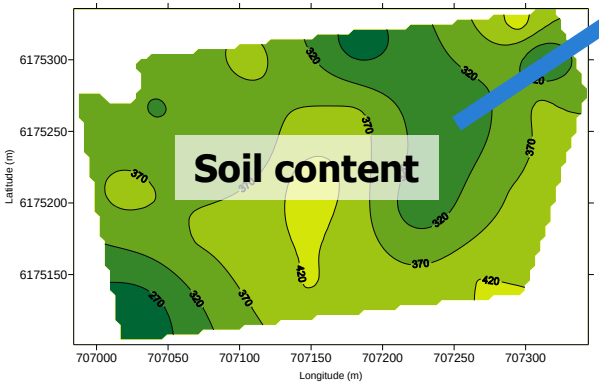
Application dose rate=
Demand minus content

Management strategy (yield expectation, economics etc.)

Crop sensing



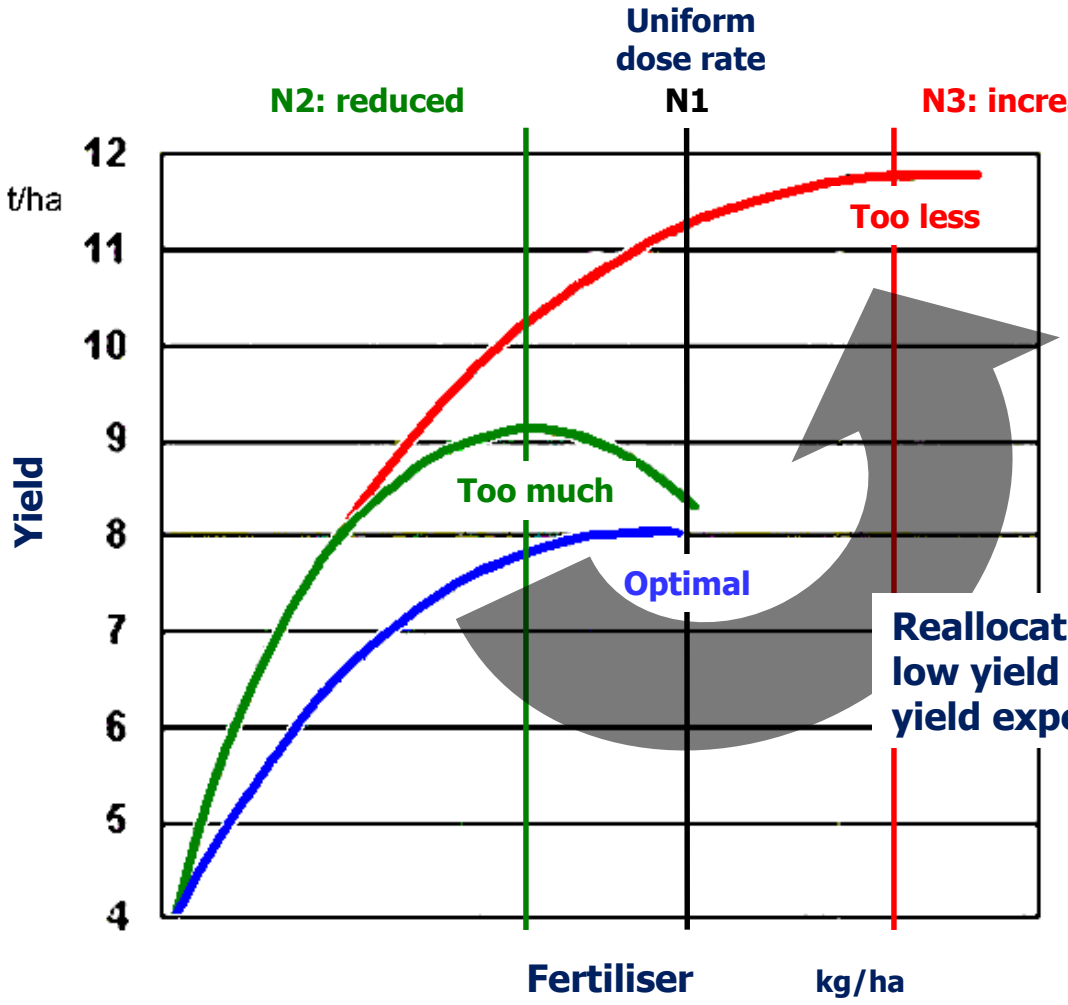




Weather

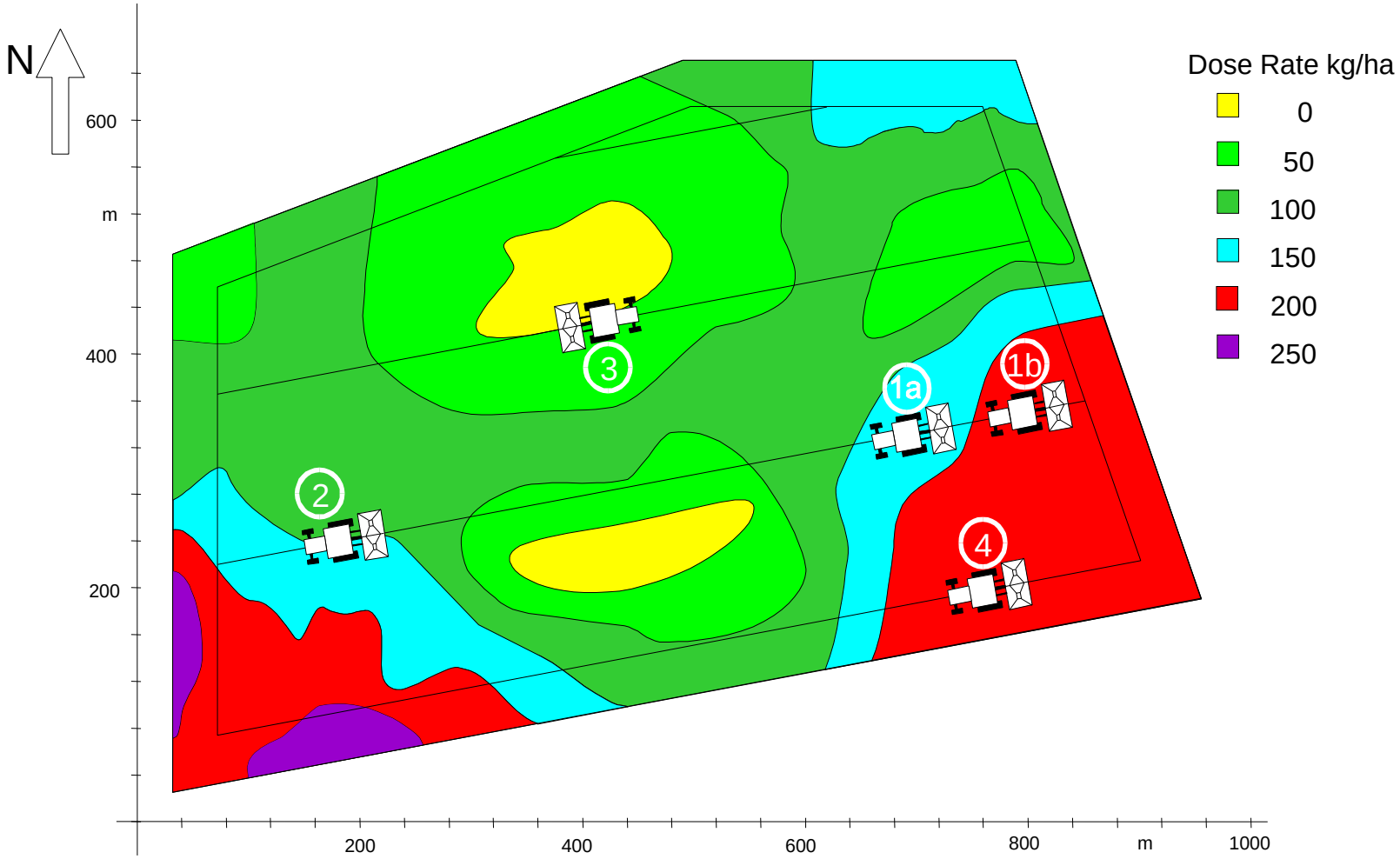
Expert knowledge: variety, crop protection, quality, SOM etc.

Fertilization



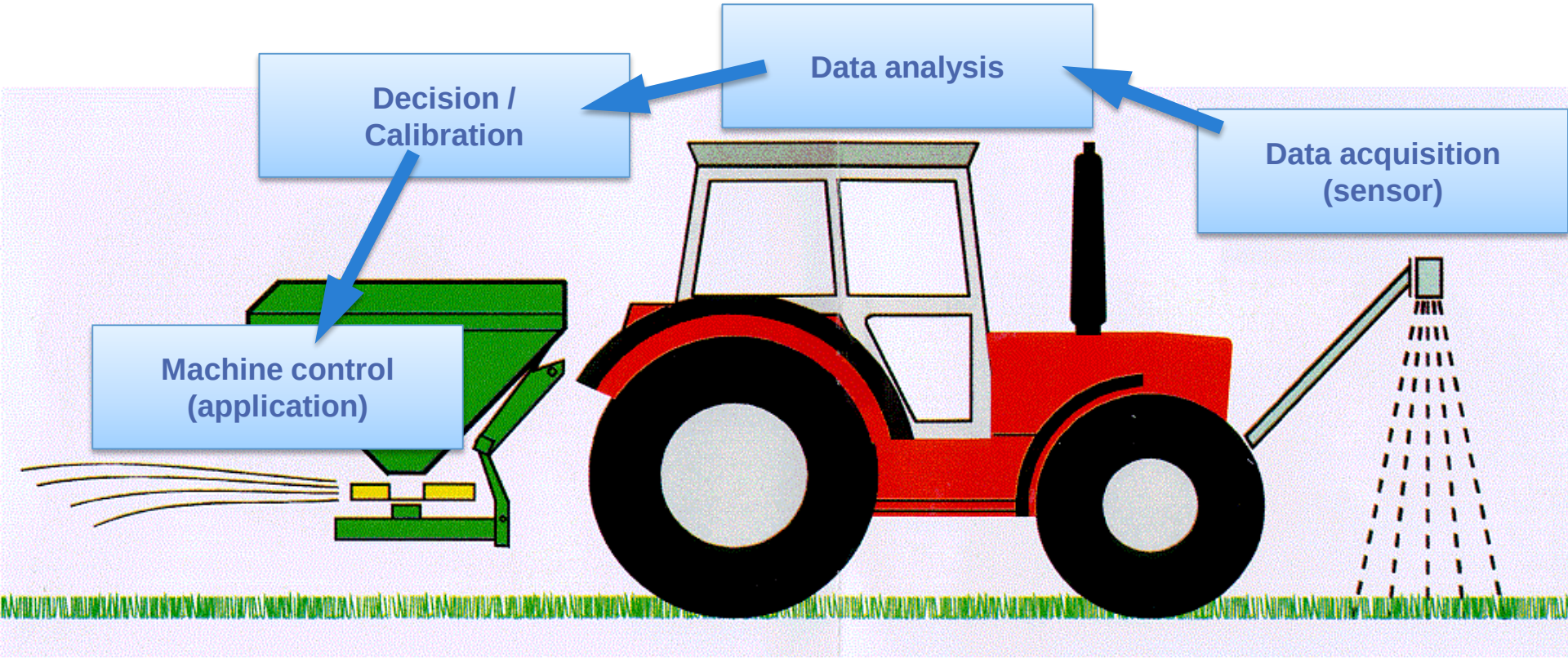
Reallocation of fertilizer from spots of low yield expectation to areas of high yield expectations.

Execution / Application / Map-based System

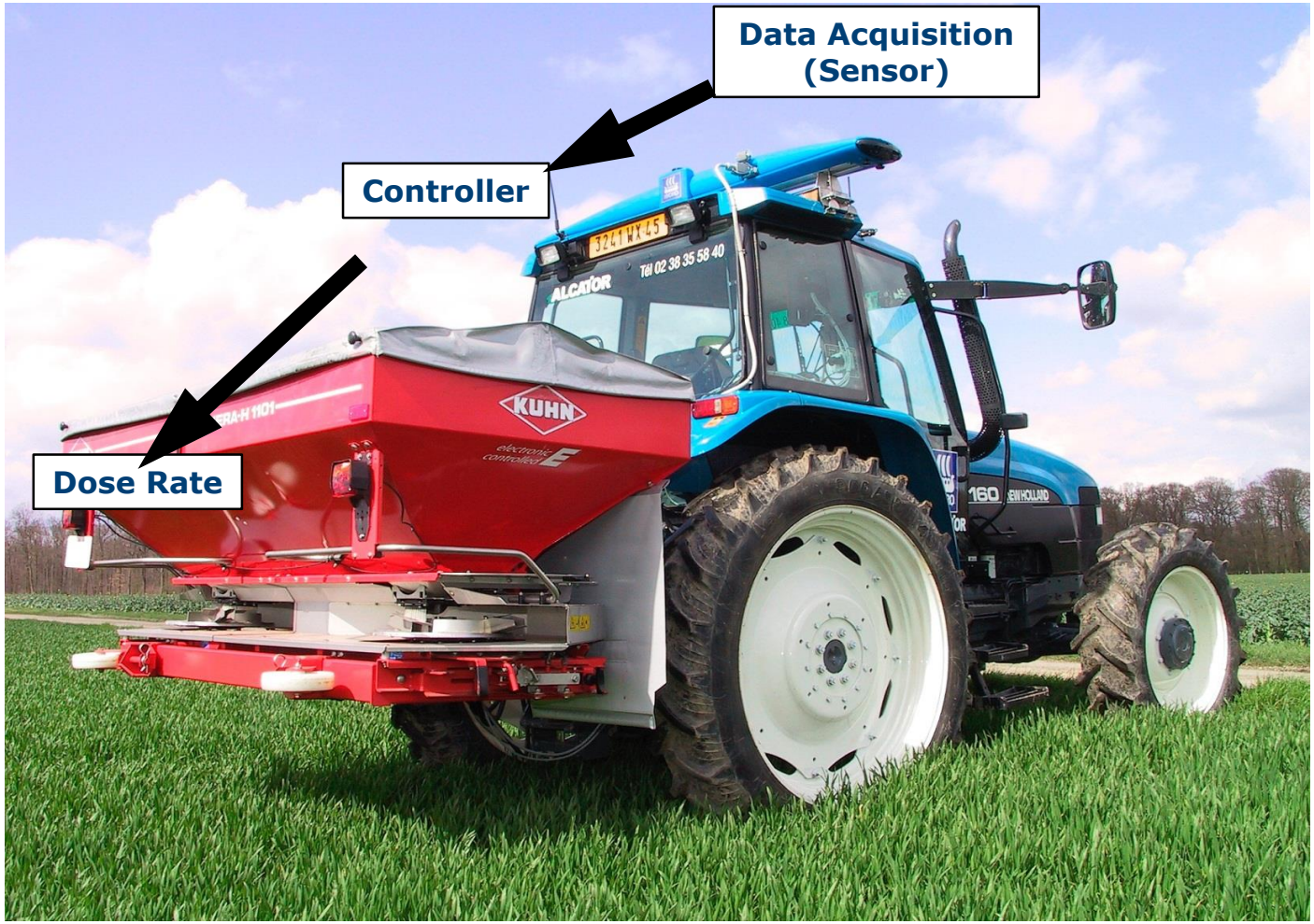


Source: Amazone / Griepentrog

Sensor-based Crop Management

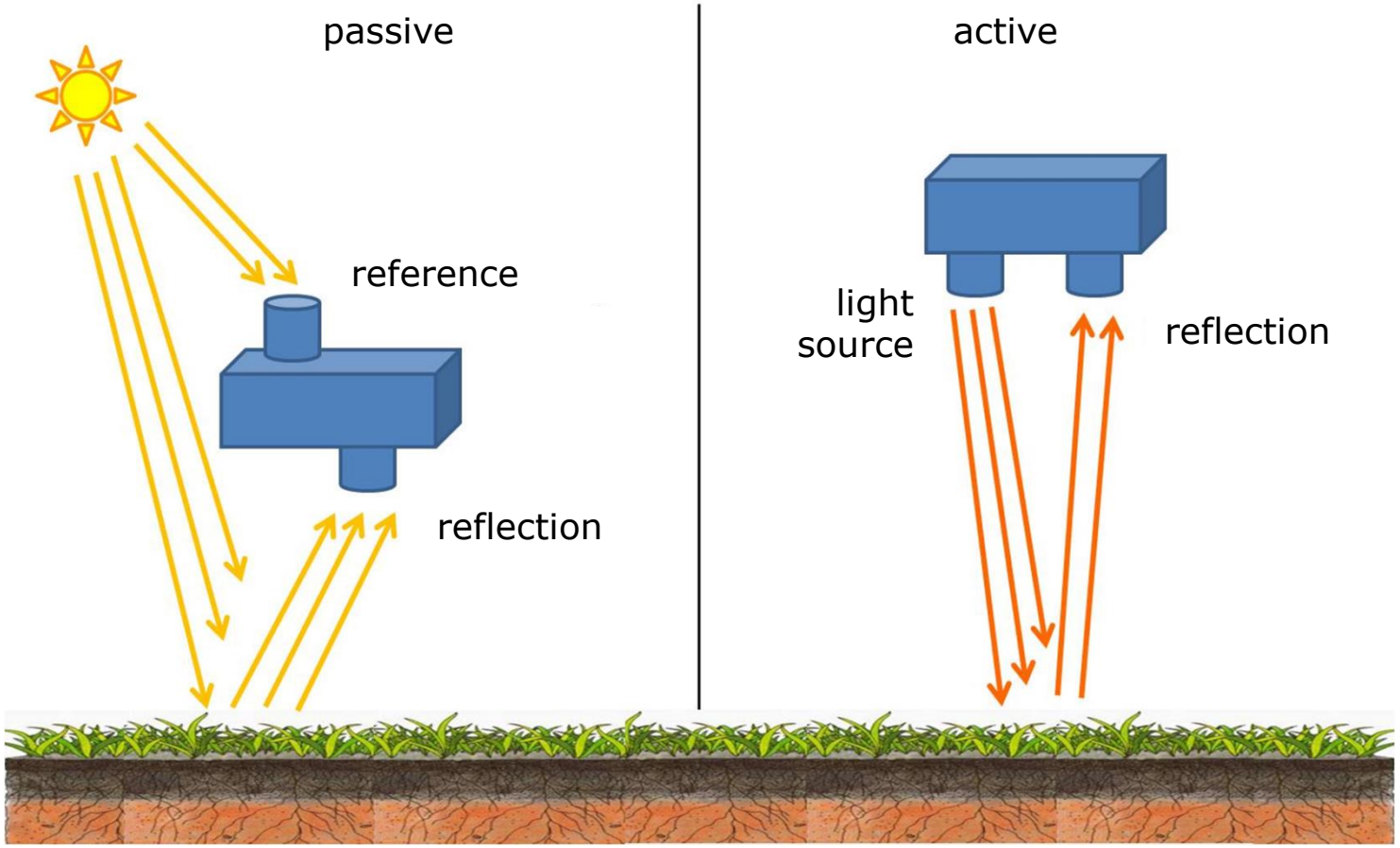


Real-time Sensing



Source: Yara

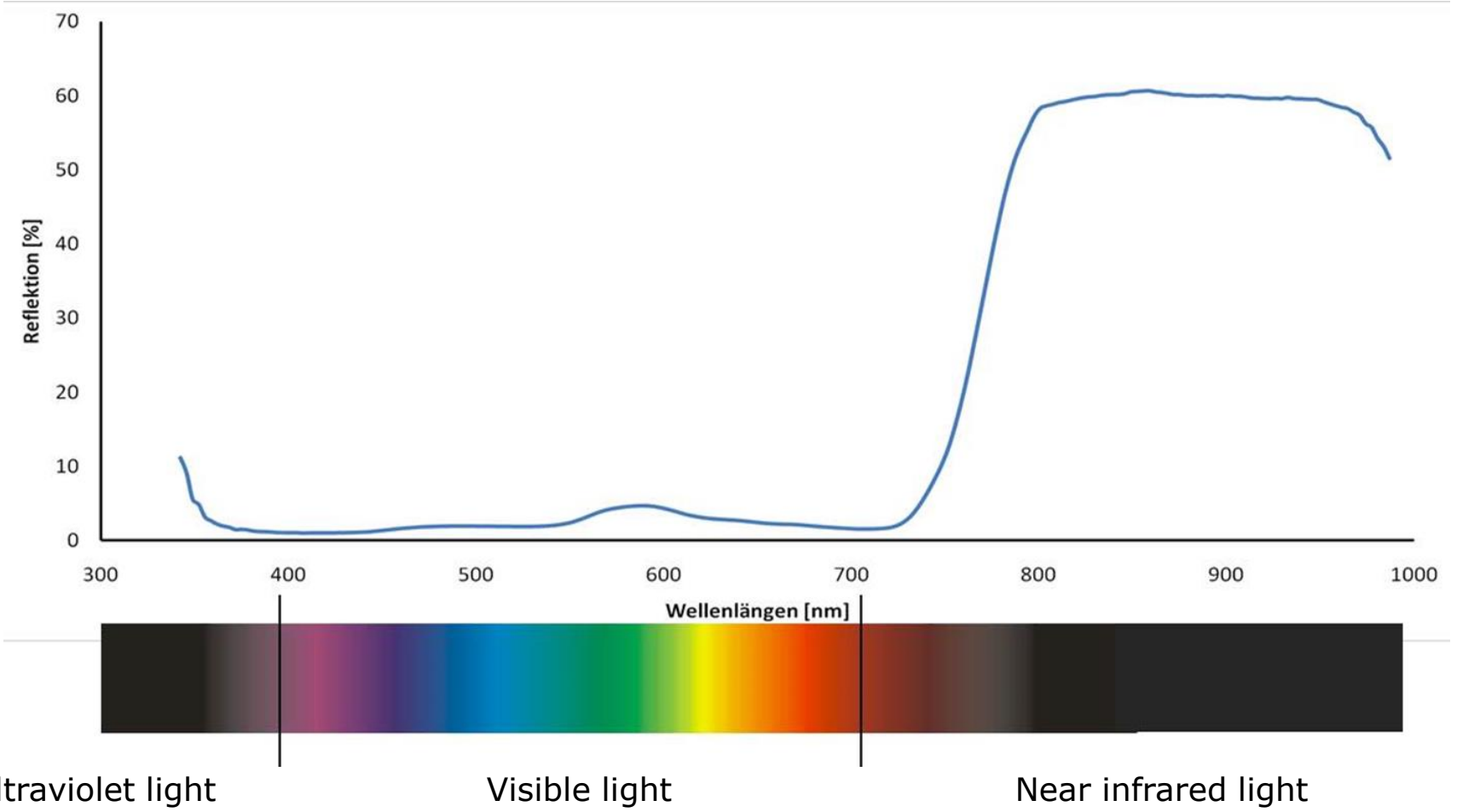
Sensor-based System
Passive and Active Sensors



Sensor-based Crop Management (N fertilization, fungicide etc.)

Sensor name	*Principle*	*Company*
1 Crop meter 2 Crop sensor	Mechanical (resistance, angle) Optical (Reflection active light)	Claas Agrosystems
3 N-Sensor 4 ALS	Optical (Reflection natural light) Optical (Reflection active light, XENON)	Yara / Agricon
5 Greenseeker	Optical (Reflection active infrared, LED)	LandData Eurosoft (Trimble)
6 Mini Veg N 7 Isaria	Optical (Laser induced fluorescence) Optical (Reflection active light, LED)	Fritzmeier, Germany
8 CropCircle	Optical (Reflection active light, LED)	GoodSoil
9 CropSpec	Optical (Reflection active light, laser)	TopCon / Yara
10 Multiplex	Optical (Reflection active light)	Force-A (Orsay, France)

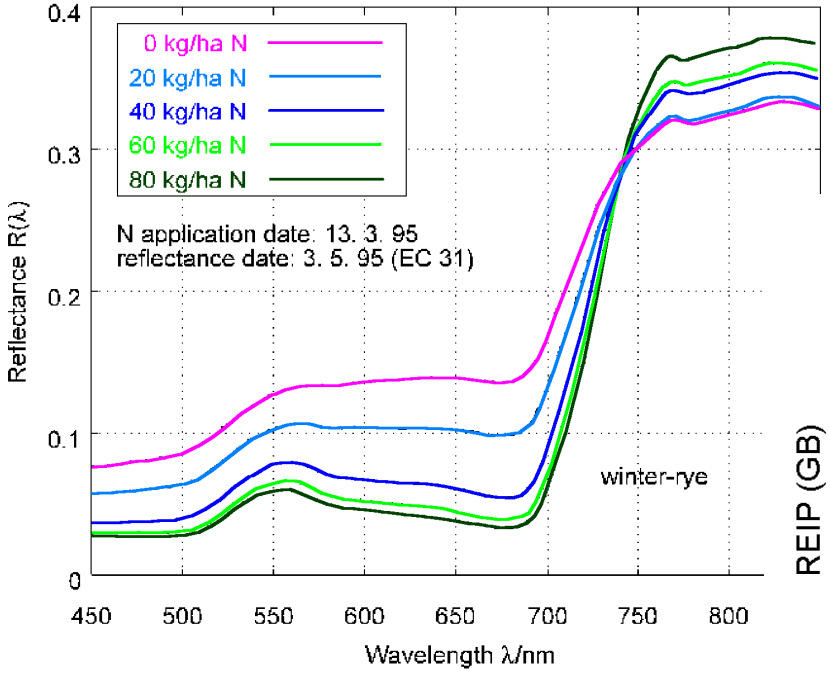
Typical Light Reflection for Biomass



Optical Sensors – Reflexion Indexes

- REIP $700 + 40\frac{(R_{670} + R_{780})/2 - R_{700}}{R_{740} - R_{700}}$
- NIR/NIR $\frac{R_{780}}{R_{740}}$
- NDVI $\frac{R_{780} - R_{670}}{R_{780} + R_{670}}$
- NIR/RR $\frac{R_{780}}{R_{670}}$
- NIR/R $\frac{R_{780}}{R_{700}}$

Optical Sensing of Nitrogen Demand

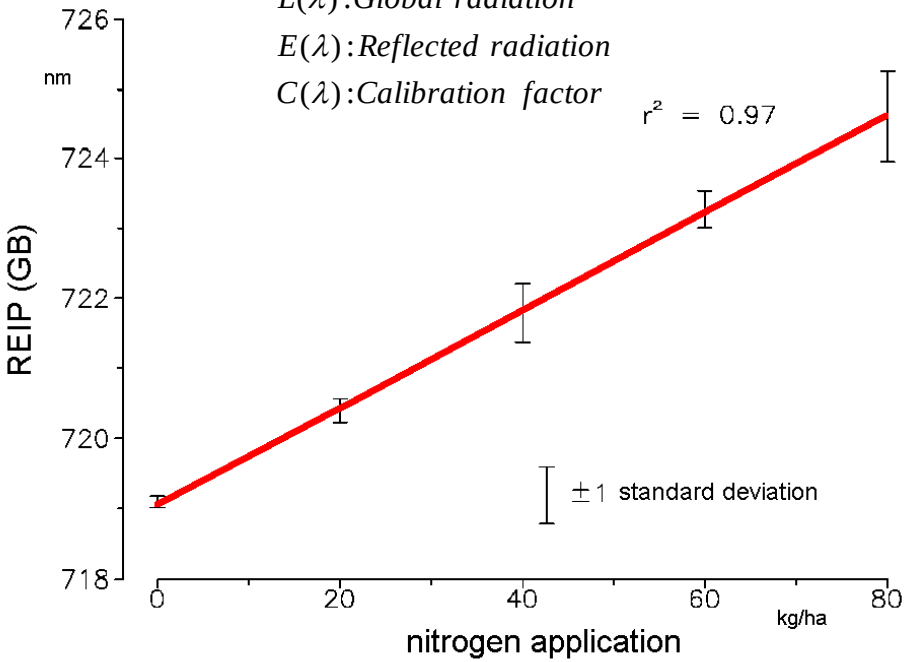


$$R(\lambda) = \frac{L(\lambda)}{E(\lambda)} \cdot C(\lambda)$$

$L(\lambda)$: *Global radiation*

$E(\lambda)$: *Reflected radiation*

$C(\lambda)$: *Calibration factor*



Source: Reusch, YARA

Summary – System Descriptions

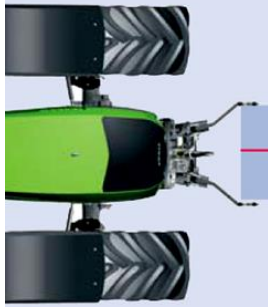
- Map based
  - Soil sampling
  - Lab analysis
  - Data processing and analysis
  - Creation of application map
  - Execution / Application

- Sensor based
  - Calibration
  - Crop data acquisition
  - Data processing
  - Execution / Application

All on-the-go (realtime)

Global Navigation Satellite System (GNSS) – Automatic Steering Systems

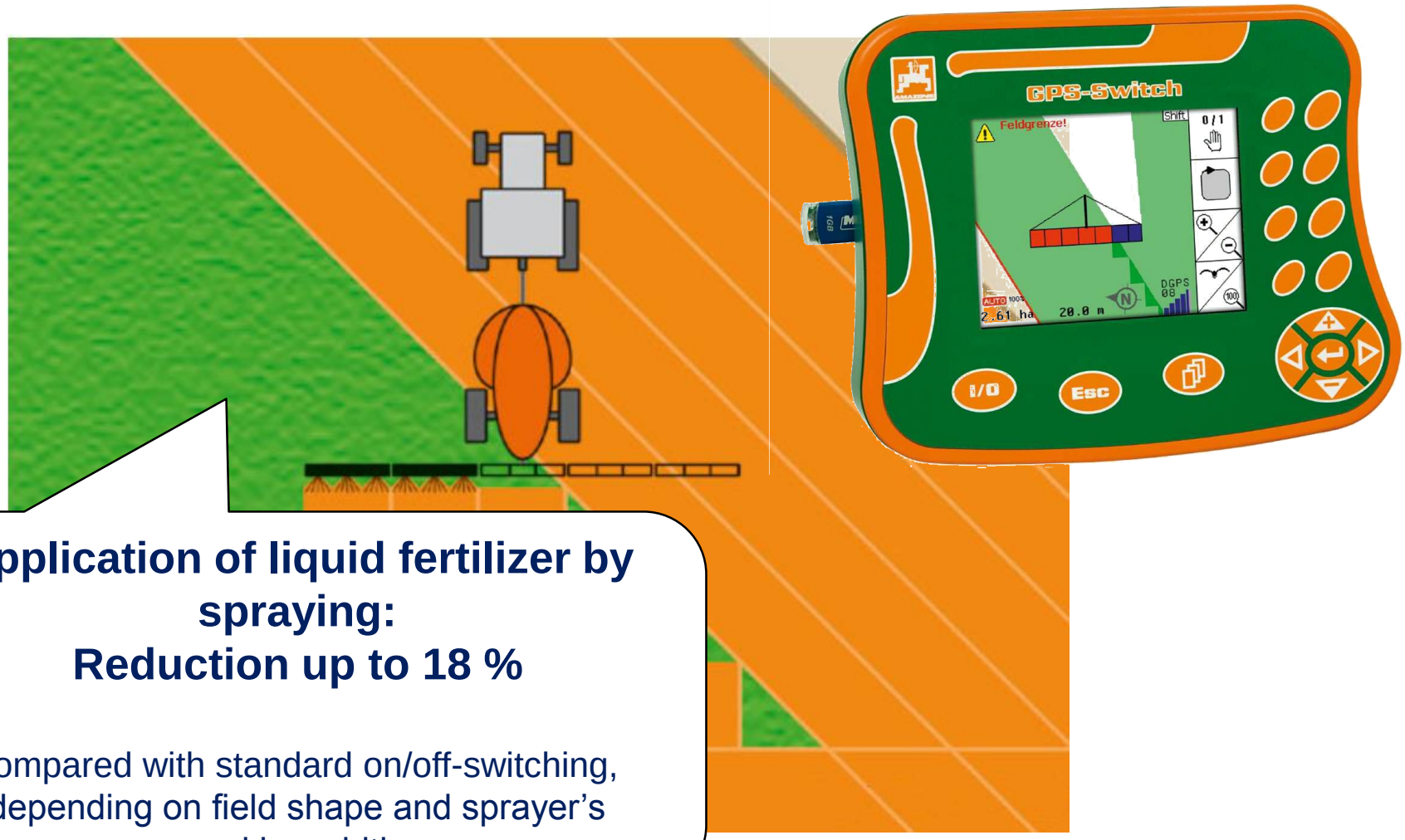
Automatic Steering Systems
GNSS Positioning Accuracy & Applications



EGNOS (Basic version)	OMNISTAR HP	BASELINE HD	RTK
Accuracy +/- 15–30 cm	Accuracy +/- 5–10 cm	Accuracy +/- 4–6 cm	Accuracy +/- 2–3 cm
With integrated eDif correction	Dual frequency DGPS	Mobile single frequency receiver	Permanently installed equipment
No license required	Worldwide correction signal service	Proprietary correction signal	Proprietary correction signal
	Correction signal service required	3-5 km range	15-20 km range
	Permanently available	No license required	For the farm's entire fleet, including multiple farm use
		For the farm's entire fleet	Correction signal also available from Class dealers

Source: Agrosystems

Section Control – GNSS-Switch



Application of liquid fertilizer by spraying:
Reduction up to 18 %

compared with standard on/off-switching, depending on field shape and sprayer's working width.

Section Control – GNSS-Switch

Source: Kverneland Group

Optical Systems

Source: Claas

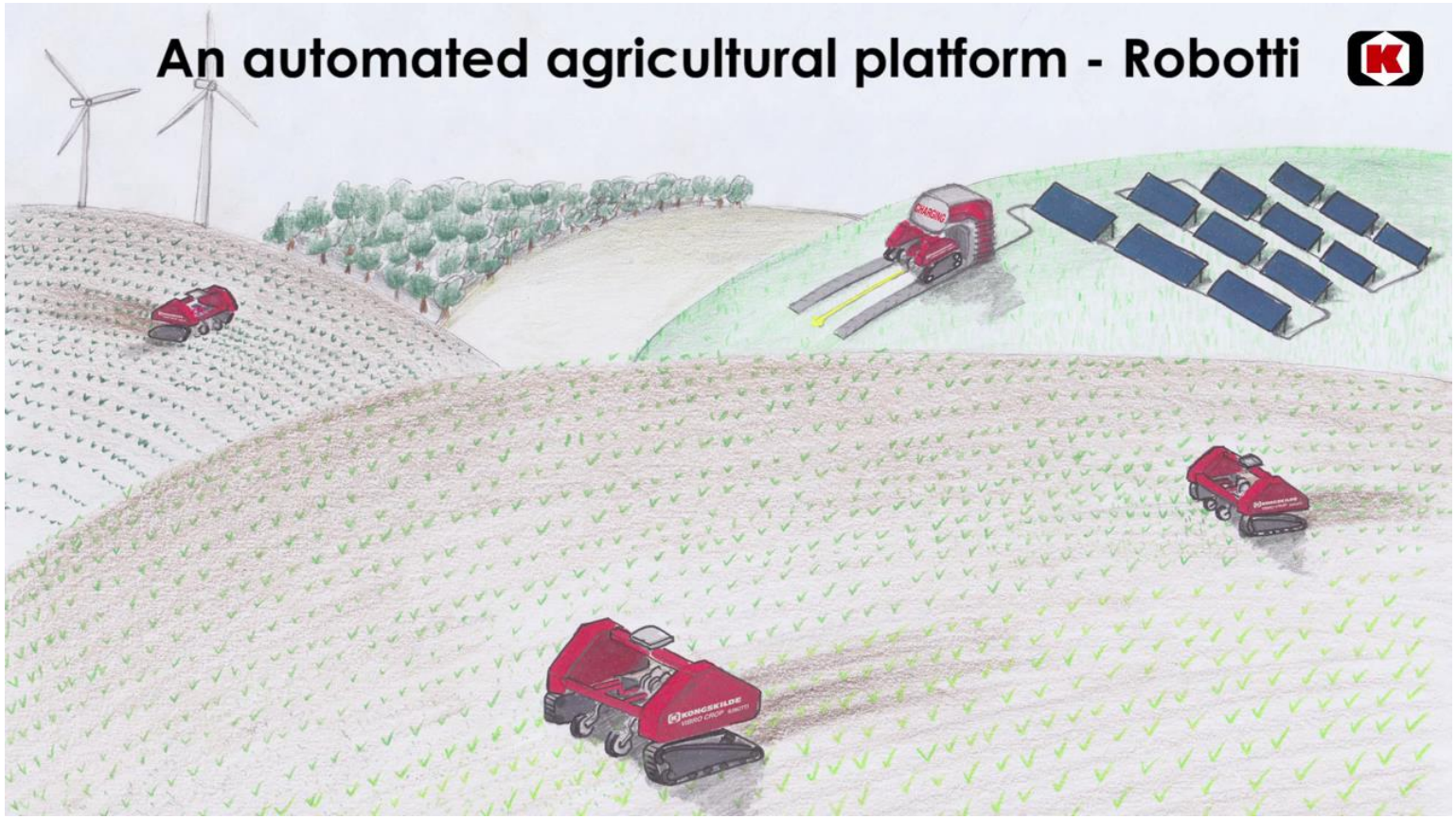
Optical Systems

CLAAS CAMPILOT

CLAAS AUTOFIL

Source: Claas

Robots in Agriculture (1)



Source: Kongskilde

Robots in Agriculture (2)

Source: Naio Technologies

Source: ecoRobotix

Robots in Agriculture (3)

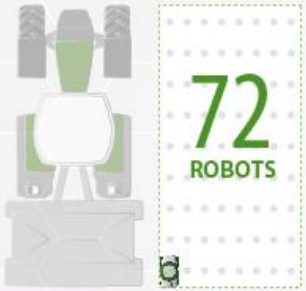
Source: Zhang & Noguchi, 2017

SAFETY

- Small and light weight
- Less power
- Less heat

COMFORT

- Autonomous operation
- Telemetric maintenance
- New value services



PRODUCTIVITY AND RELIABILITY

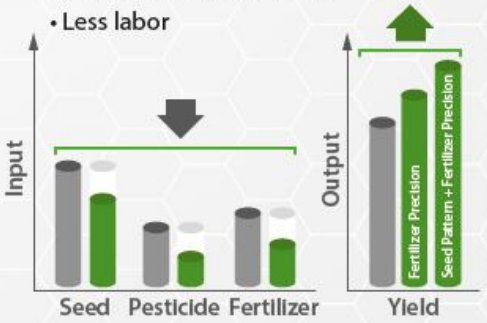
- Use 1, 10, 100… units
- Work 24/7 (climate change)
- Quick service

COST AND INVEST REDUCTION

- No cab, no operator environment
- Minimum sensors, less material
- Easy production and assembly

EFFICIENCY

- More yield
- Less seeds and chemicals
- Less labor



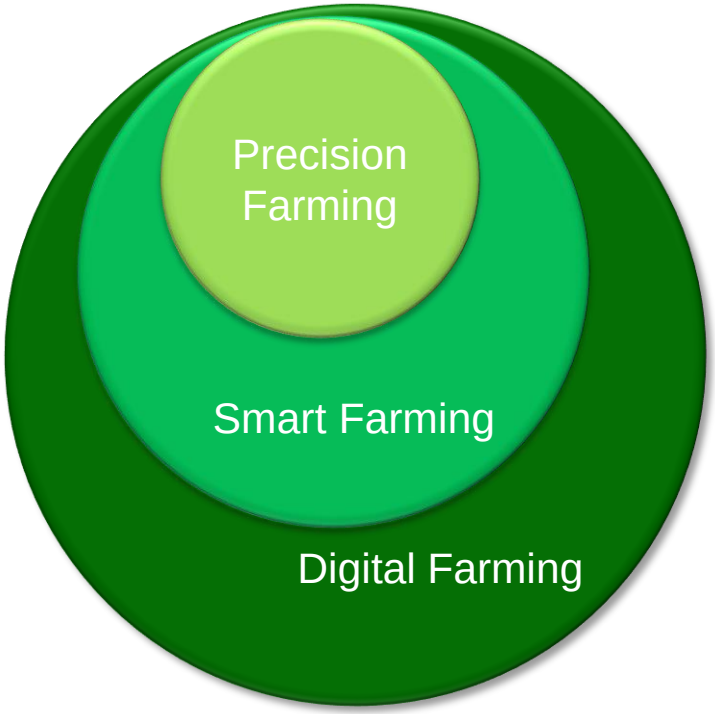
SUSTAINABILITY

- Less soil damage
- Low energy, reduced CO_2
- Low noise, no oil spillage
- Ready for renewables

Source: AGCO Fendt

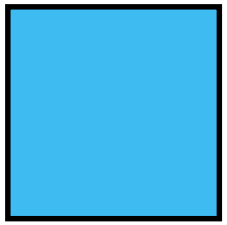
Outlook
Digital Farming - Definition of Terms

- Precision Farming
  - Site-specific treatment
    Variable dose rates with
    sensors & application technology
  - Automation
    autosteering, section control,
    complex machine functions and logistics
- Smart Farming
  - Real time systems
  - fusion & analysis of information
  - Decision support
- Digital Farming & Farming 4.0
  - Internet of things (IoT), machine to machine communication (M2M)
  - Cloud computing
  - Big data



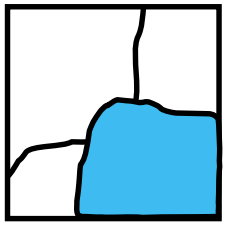
Outlook
Digital Farming - Definition of Terms

- Conventional or traditional farming



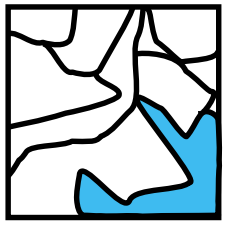
Uniform dose rate per field

- Precision Farming



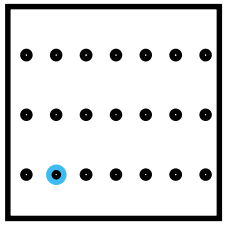
Map & soil based, site specific & offline, variable dose rate

- Smart Farming



Sensor & crop based, site specific & real time, variable dose rate

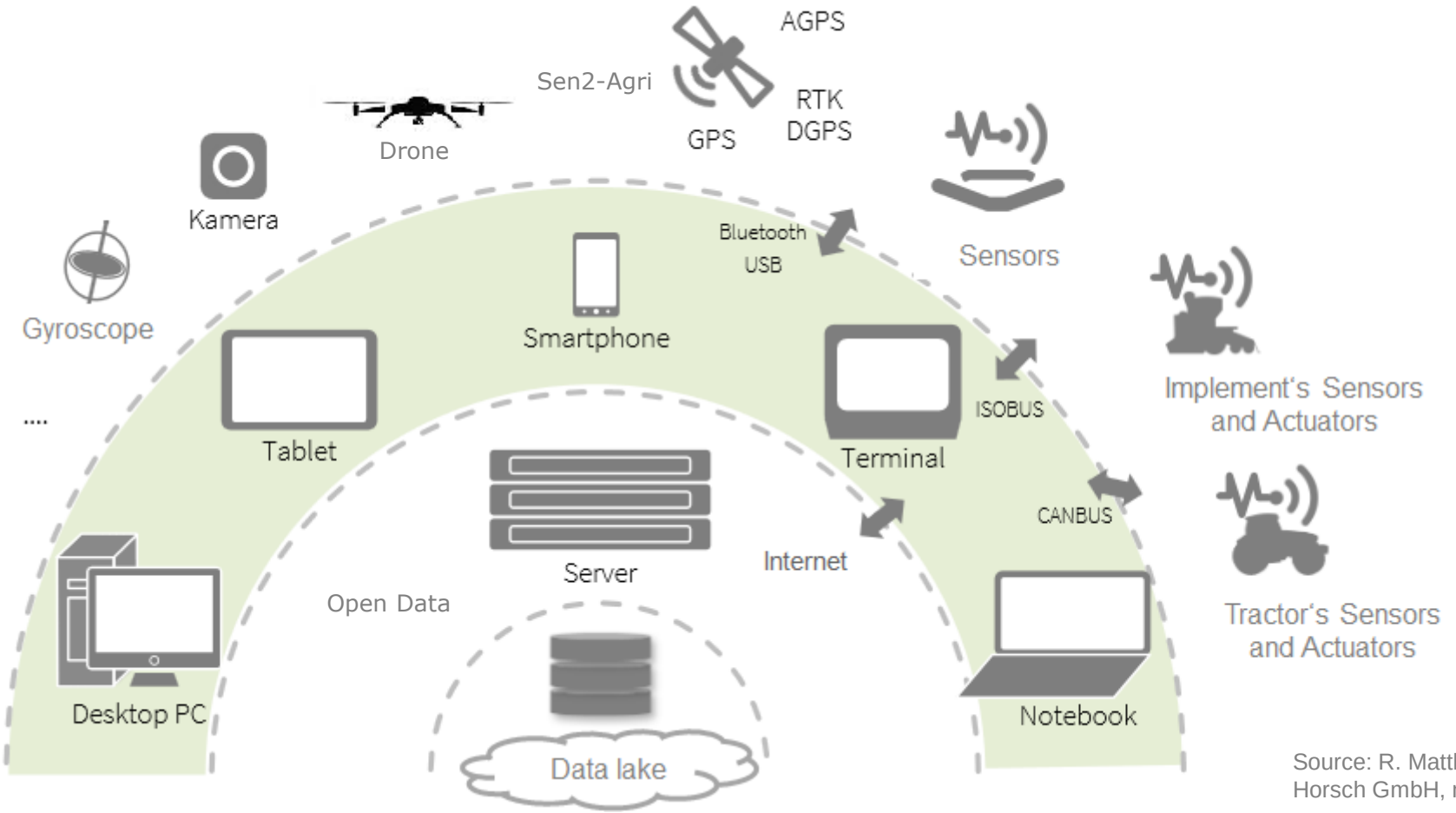
- Digital Farming



Multi parameters, single plant, variable & individual dose rate

Previous Technological Infrastructure

Today's Technological Infrastructure

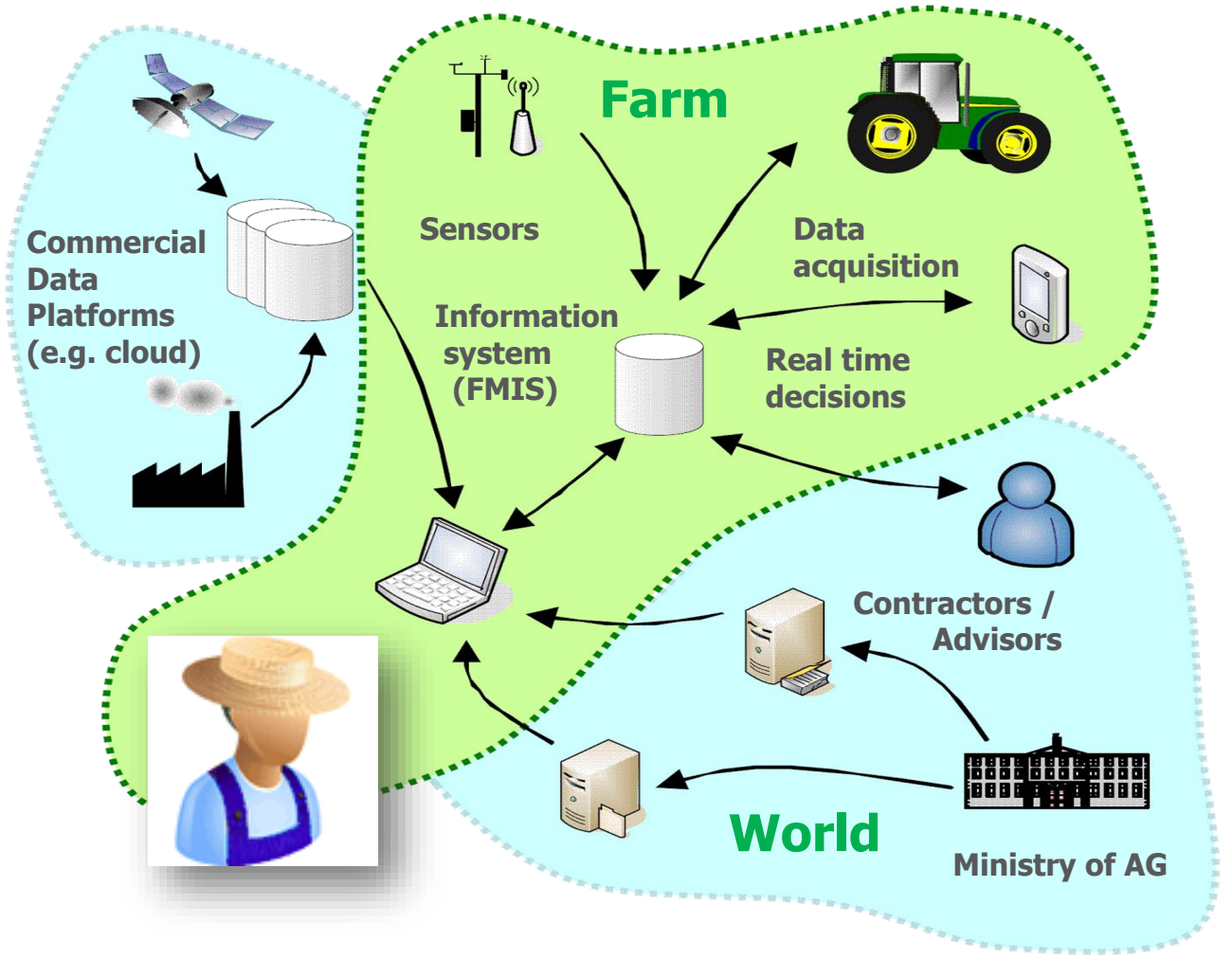


Source: R. Matthias; Horsch GmbH, modified

- **The level of technological infrastructure has become more complex**
- **The potential for exploiting this infrastructure is manifold**

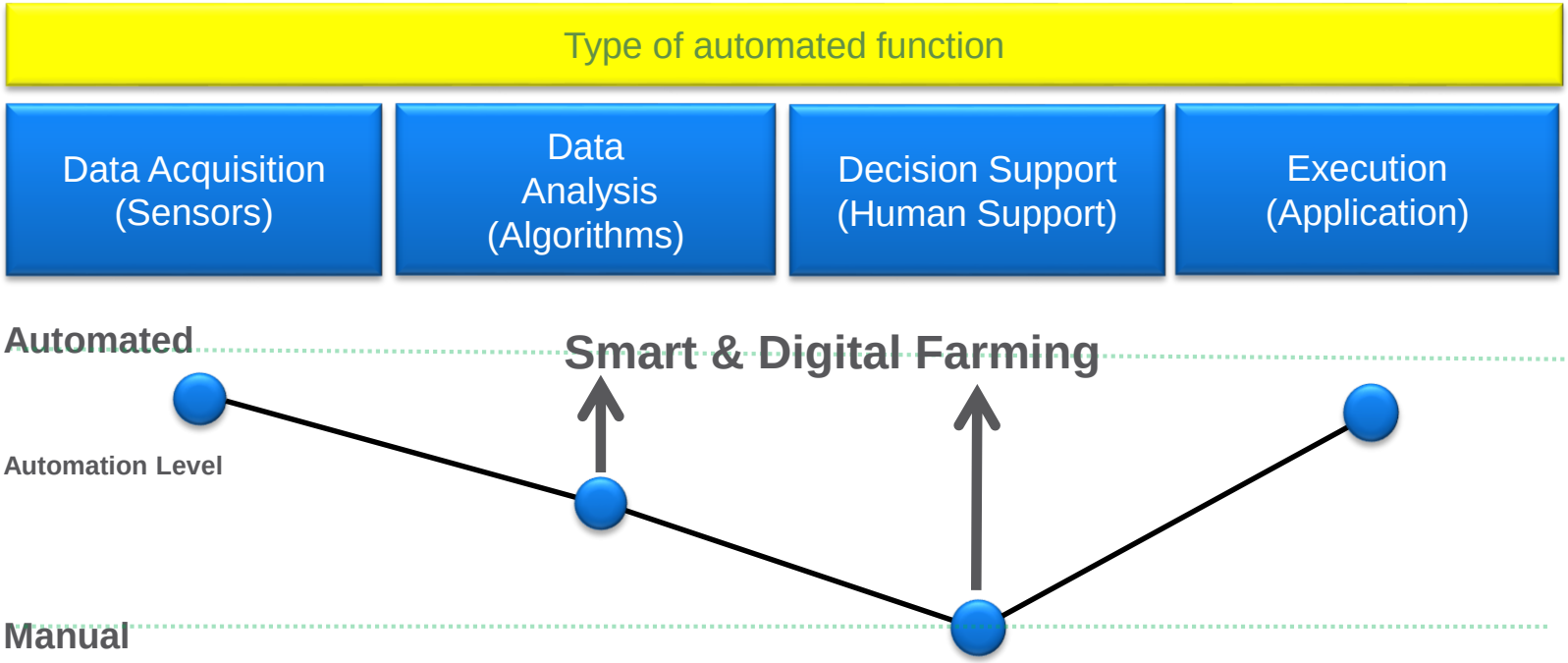
Networks (M2M)

- Internal:
  - Farm
  - Processes
  - Machines
- External:
  - Farm
  - Partners
  - Internet
- REQUIREMENT
  - Mobile communication
  - Standardised interface & data formats



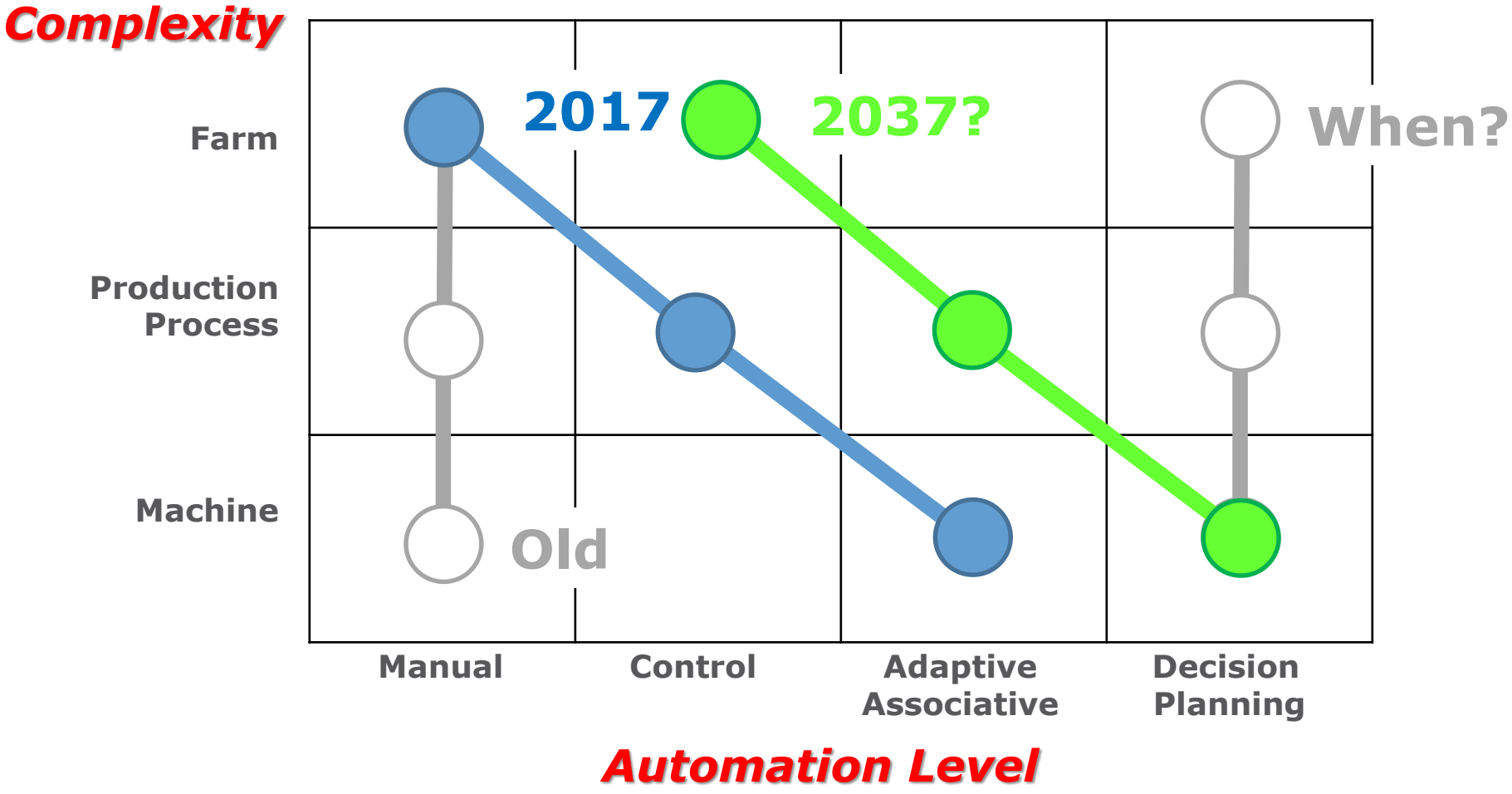
Source: FutureFarm, modified

Smart & Digital Farming



Source: Parasuraman et al. 2000, modified

Conclusion – Robotic Systems und Automation Level



Summary

- Precision Farming is an integrating technology to increase resource efficiency.
- It uses modern sensing methods to describe crop plant growing conditions in real time.
- It applies farming inputs to the fields with a high accuracy in terms of amount (dose rates) and spatial distribution and resolution.
- New development in technology as machine communication (IoT), cloud computing and big data analysis are the next steps to improve the overall sustainability of agricultural production systems.

THE END

Thanks for your attention!