Innovations in Application Technology for Crop Protection

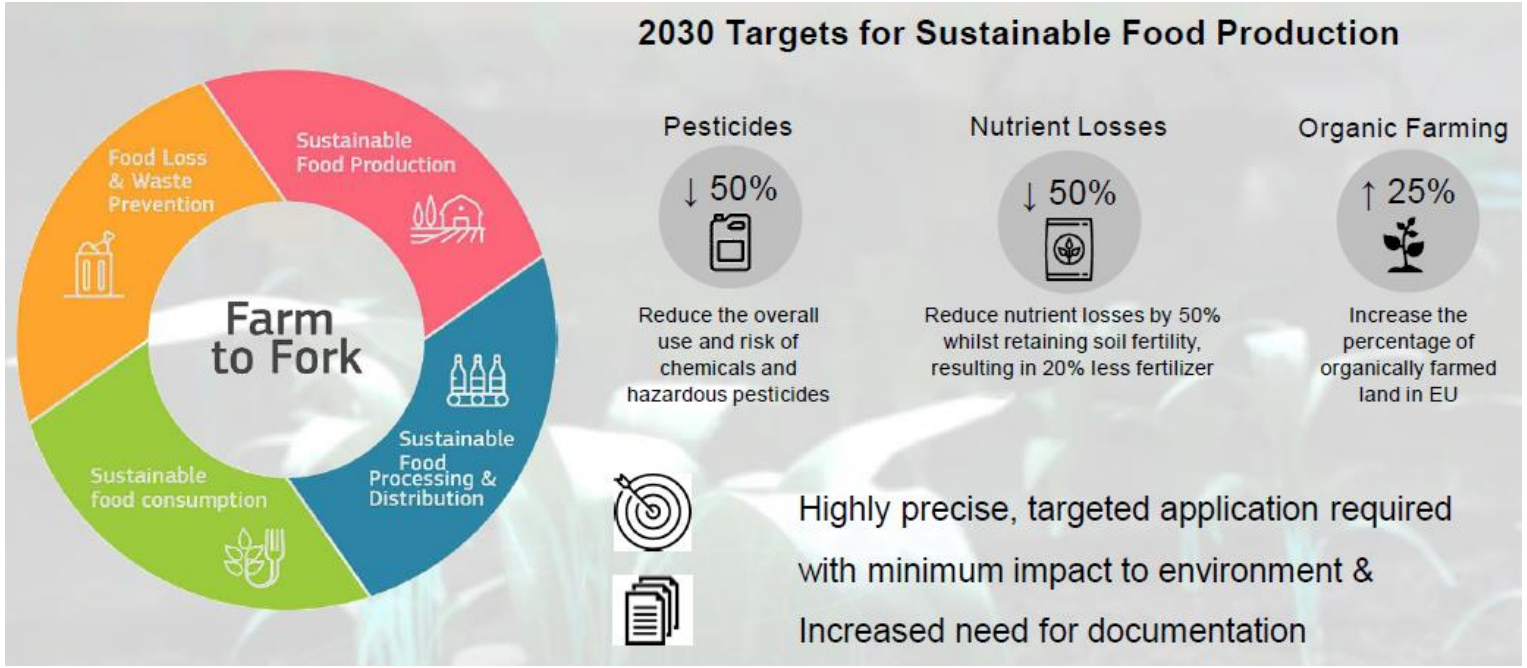
Dr. Peter Hloben, Deere & Co.

14. May 2024, Assemblée Générale Belplant, Leuven, Belgium

Key Challenges in Crop Protection

- Growing problems with **resistances** against herbicides, fungicides
- Reduced **portfolio availability** of plant protection products
- More and tighter (application) **restrictions**
- Biological effectiveness while meeting up to 95-99% **drift reduction**
- Narrower **operating windows** to spray at optimum timing
- Higher complexity and more **expertise** required for spraying
- **Public & legal pressure** to minimize use of chemicals

EU Targets



- EU reduction targets SUR “delay” ➡ Member States targets
- Continuous development of new technologies (Volume & Drift reduction)
- The support of new technologies uptake is desired

CEMA

State-of-the-Art (for Professionals)

Basic technologies necessary for precision application:

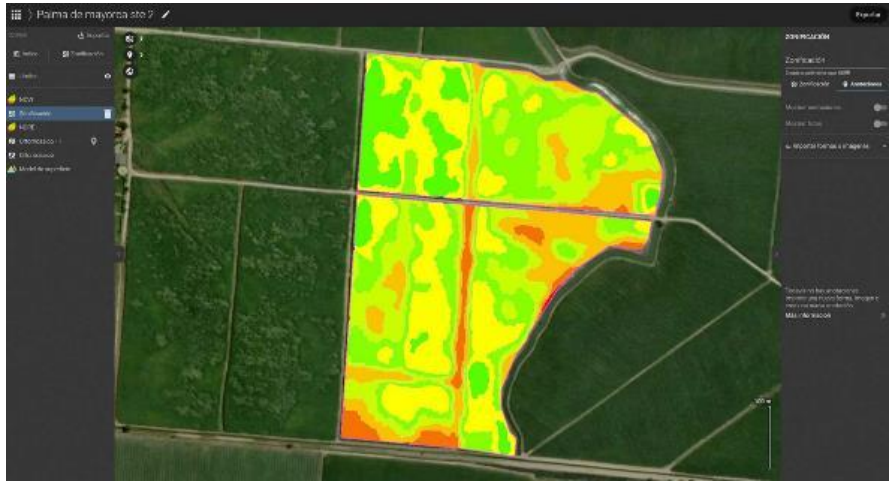
- Application task map
- Task controller (ISOBUS)
- GNSS receiver
- Boom Section or Individual Nozzle Control
- Automatic boom height adjustment

IVA study* on technology adoption in Germany:

Section control or INC: **ca. 56%**

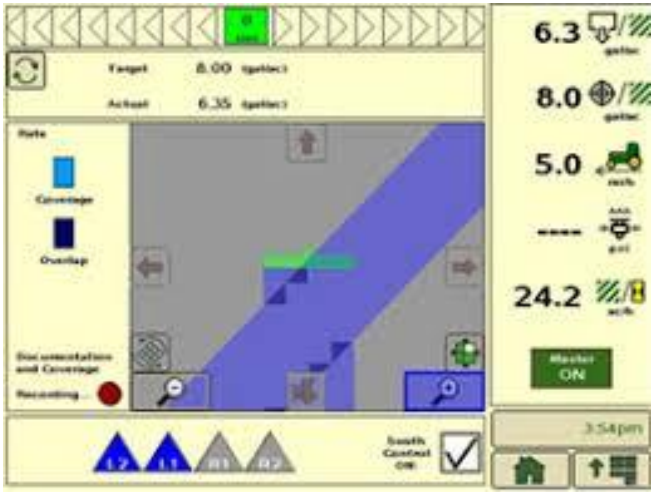
Use of Weed/Application map: **ca. 24 %**

*Source: https://www.iva.de/sites/default/files/2022-07/Technik%20im%20Pflanzenschutz_Ergebnisbericht_220722.pdf



Source: Pix4D

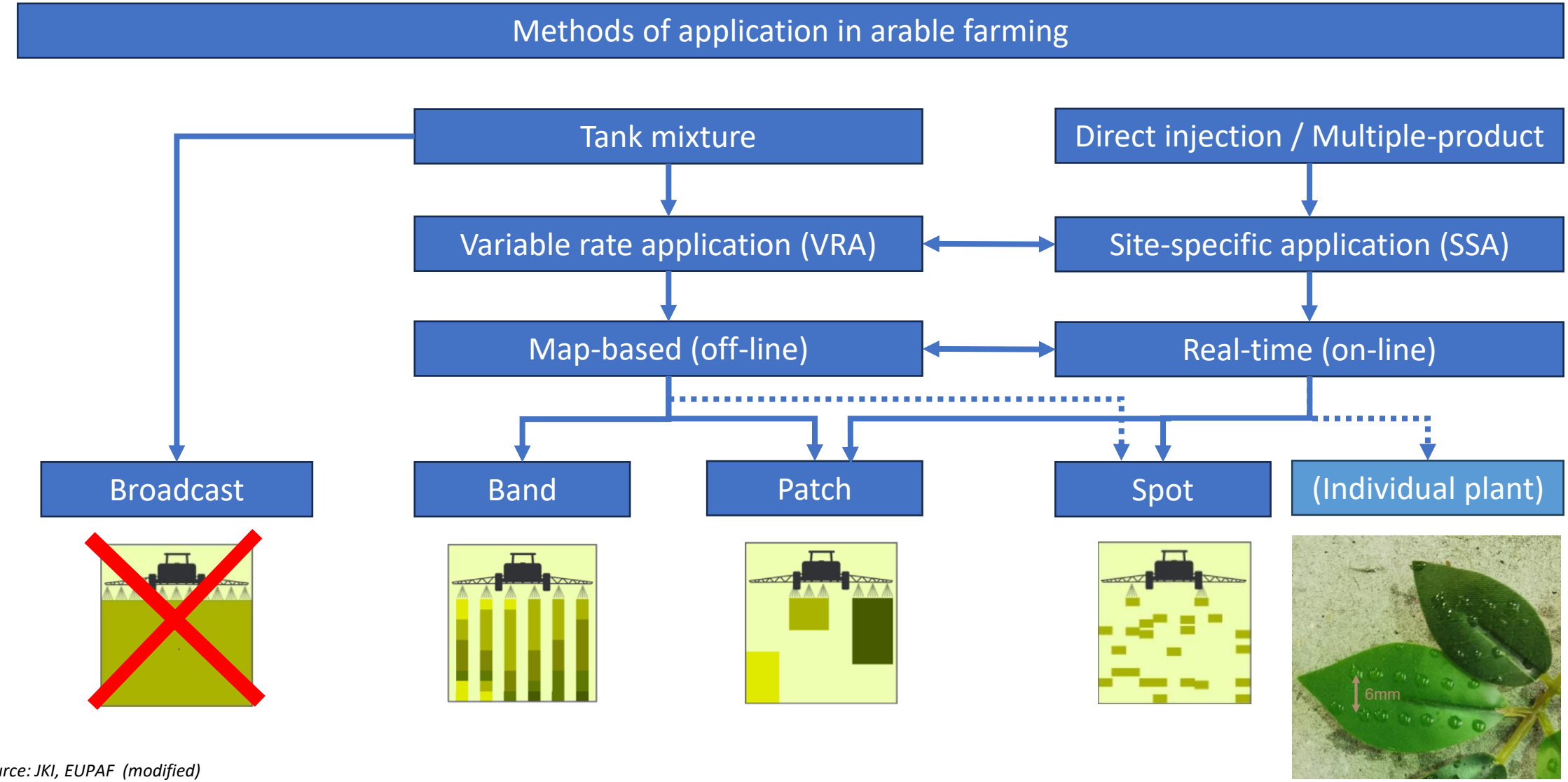
Source: Deere&Co.



Source: Deere&Co.

Technological Innovations - Field Crops

Methods of Application – Field Crops



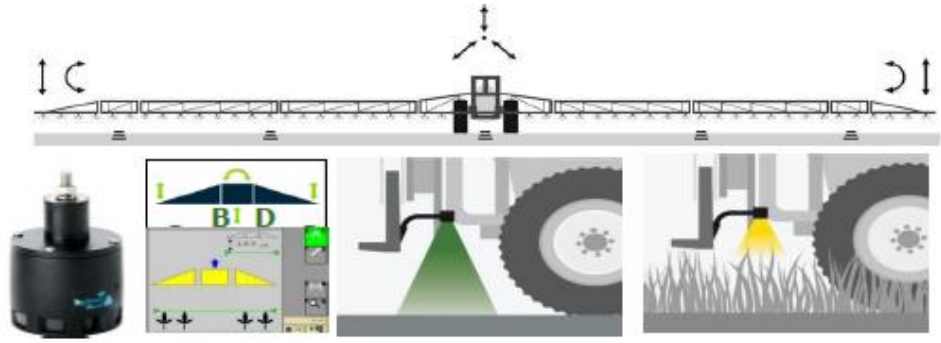
Source: JKI, EUPAF (modified)

Key Technologies for High Precision Application

High Precision 3D Boom Control

Technology Developments

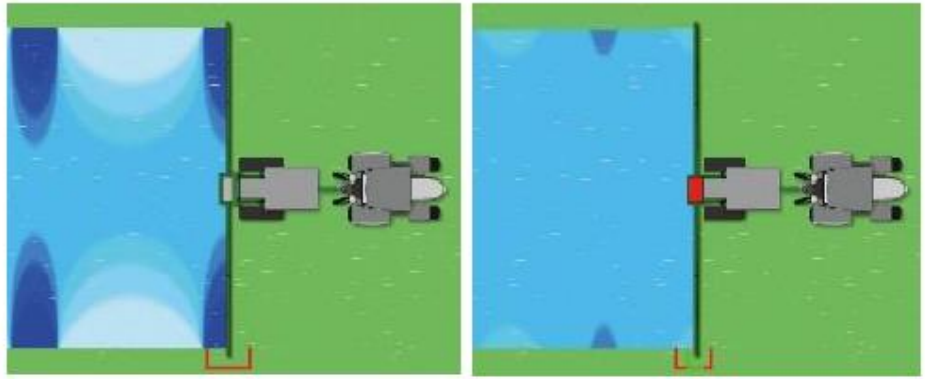
- Automatic boom height and inclination control of spray nozzles and the angle of the individual boom arms
- Distance measurement to the ground, crop canopy or hybrid mode
- Advanced boom yaw control of horizontal movements
- High-strength, stable, lightweight construction (e.g. carbon fiber)



Source: Deere&Co

Benefits and Customer Value

- Better longitudinal and lateral distribution of spray liquid
- Reduction of over and underdosing
- Less spray drift and better crop penetration
- **Precondition** for precise and selective application



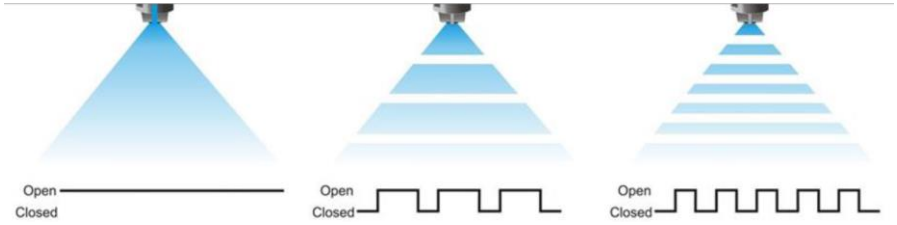
Source: Amazone

Key Technologies for High Precision Application

Individual Nozzle Control with PWM

Technology Developments

- Individual nozzle control
- Pulse Width Modulation (PWM)
- Curve compensation
- Volume flow adjustment of each individual nozzle position



Source: TeeJet

Source: Deere&Co

Benefits and Customer Value

- Much wider speed range with constant rate and droplet size
- Variable application rate with constant spray quality
- Application rate control per individual nozzle possible
- Droplet size and flow rate can be set completely independently

Key Technologies for Selective Application

Band Spraying with Boom Sprayer

Technology Developments

- Targeted row or band spraying with field sprayers
- Nozzles with a narrow spray angle (30 or 40°) and rectangular distribution
- Adjustable nozzle spacing for adaptation to row widths
- Highly precise nozzle positioning, and boom row guidance required
- Implement guidance technology enabler

Benefits and Customer Value

- High-precision mechanical weeding combined with band spraying on row
- Targeted application of other PPPs in early growth stages in row crops
- Significant savings potential depending on row spacing and band width
- Low wind spraying conditions required

Source: Amazone

Source: Lemken

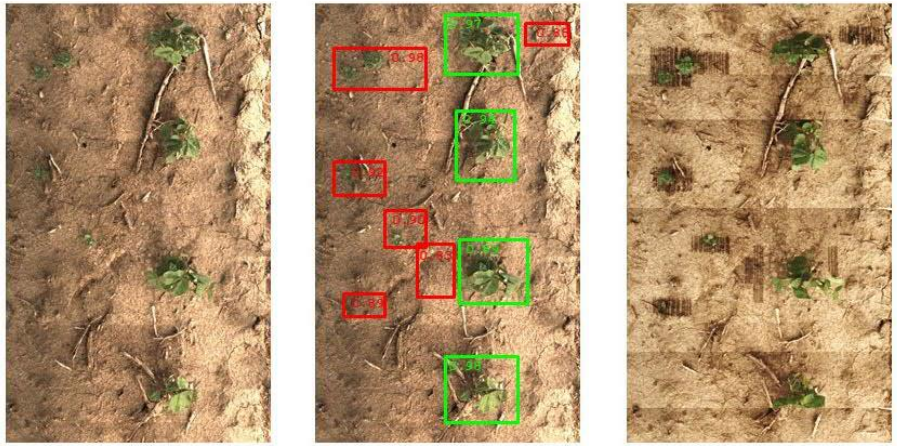
Source: Deere

Key Technologies for Selective Application

Selective Application of Herbicides with Weed Identification

Technology Development

- Online cameras to differentiate between weeds and crops
- AI and machine learning technology
- Algorithms developed per crop and weed species
- Selective application of herbicides in various stages of development
- Solution approaches with single tank mix or dual application systems



Source: Deere&Co

Benefits and Customer Value

- Highest potential for non residual herbicide savings (50-90%)
- Less crop stress and growth depression
- More effective weed control through optimized dosage
- Minimizing the environmental impact
- Single or double product application

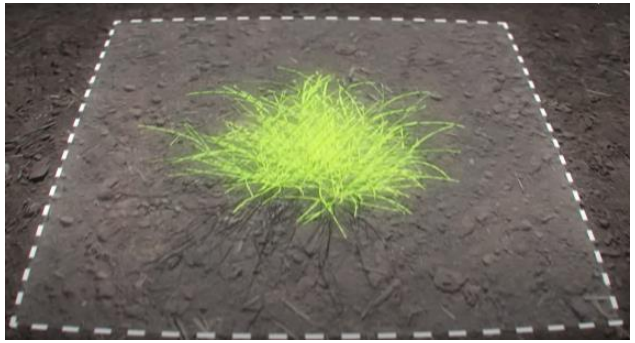
See & Spray™ Select Plus

- System description

Weed Detection Technologies:

Application of total herbicides with “green objects” detection

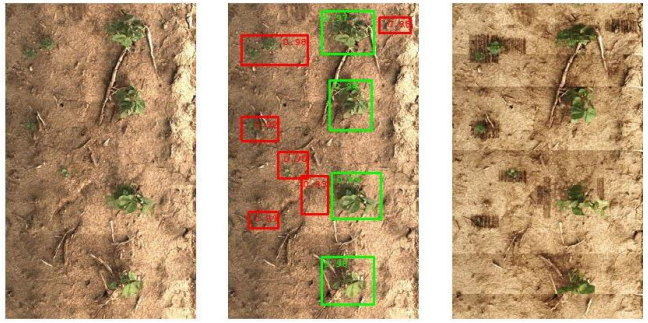
- Green on Brown



Selective application of herbicides with weed detection in crops:

- Green on Brown with rows extraction

- Green on Green



S&S™ Select Plus - System Description

- Originally developed for customers with fallow as part of the cropping rotation
- Further developed for rows extraction and used for spraying weeds within row plant production systems
- Single product application
- Hit-rate equal to broadcast spraying
- Saving up 2/3 of the normal use*

*The actual savings depend on weed density and row spacings. Higher savings are possible with low weed density.

S&S™ Select Plus - System Description

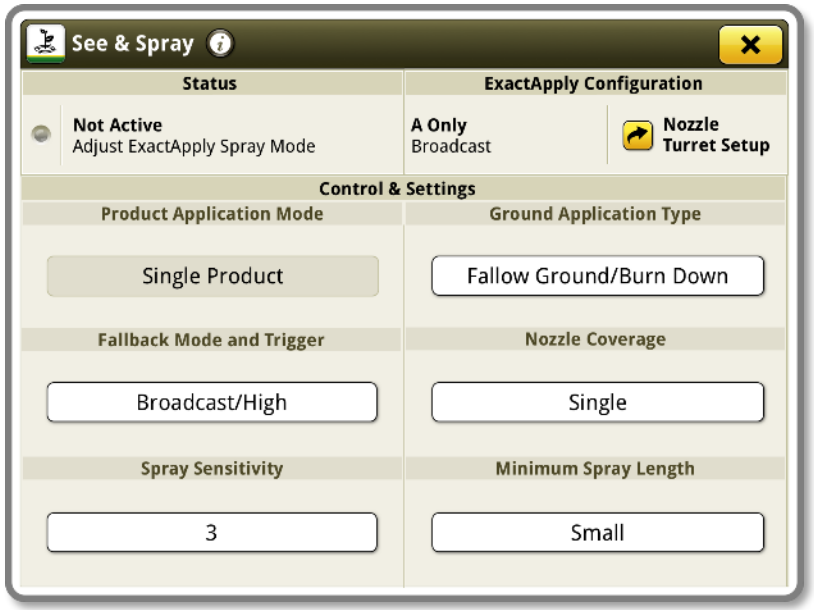
Camera Technology

- Captures field images on the go
- Identifies green objects on brown soil
- Camera spacing: 100 cm (nozzle spacing 50 cm)

Processing Controllers

- Analyze 196 m^2/s at 19 km/h (36 cameras)
- Determines if a green weed/plant is present
- Actuates the correct spray nozzle
- Herbicide hits the weed
- All within **200 milliseconds**

S&S™ Select Plus - System Description



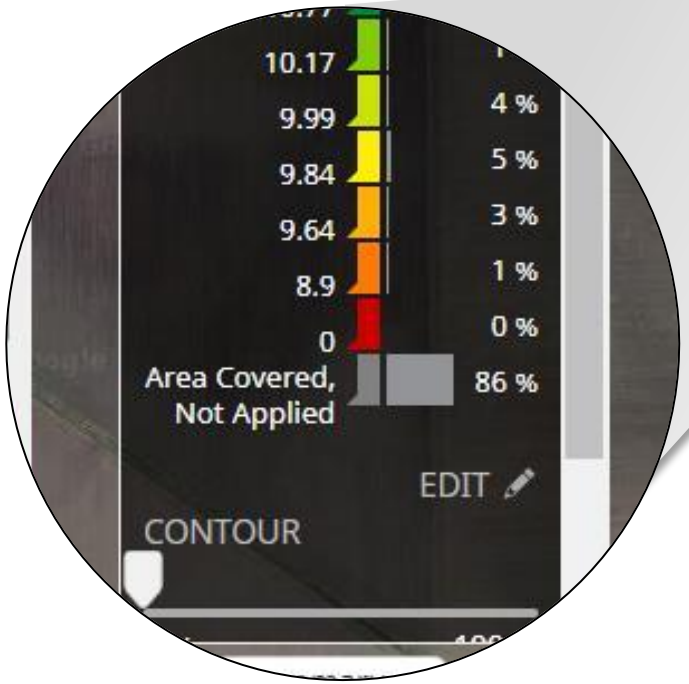
Operation and Control

- Utilizes ON/OFF (INC) control for See&Spray™
- Switch between See&Spray™ and broadcast from the cab.
- Multiple run page modules to enable on-the fly adjustments
- Ability to dial-in setting preferences
- Diagnostics

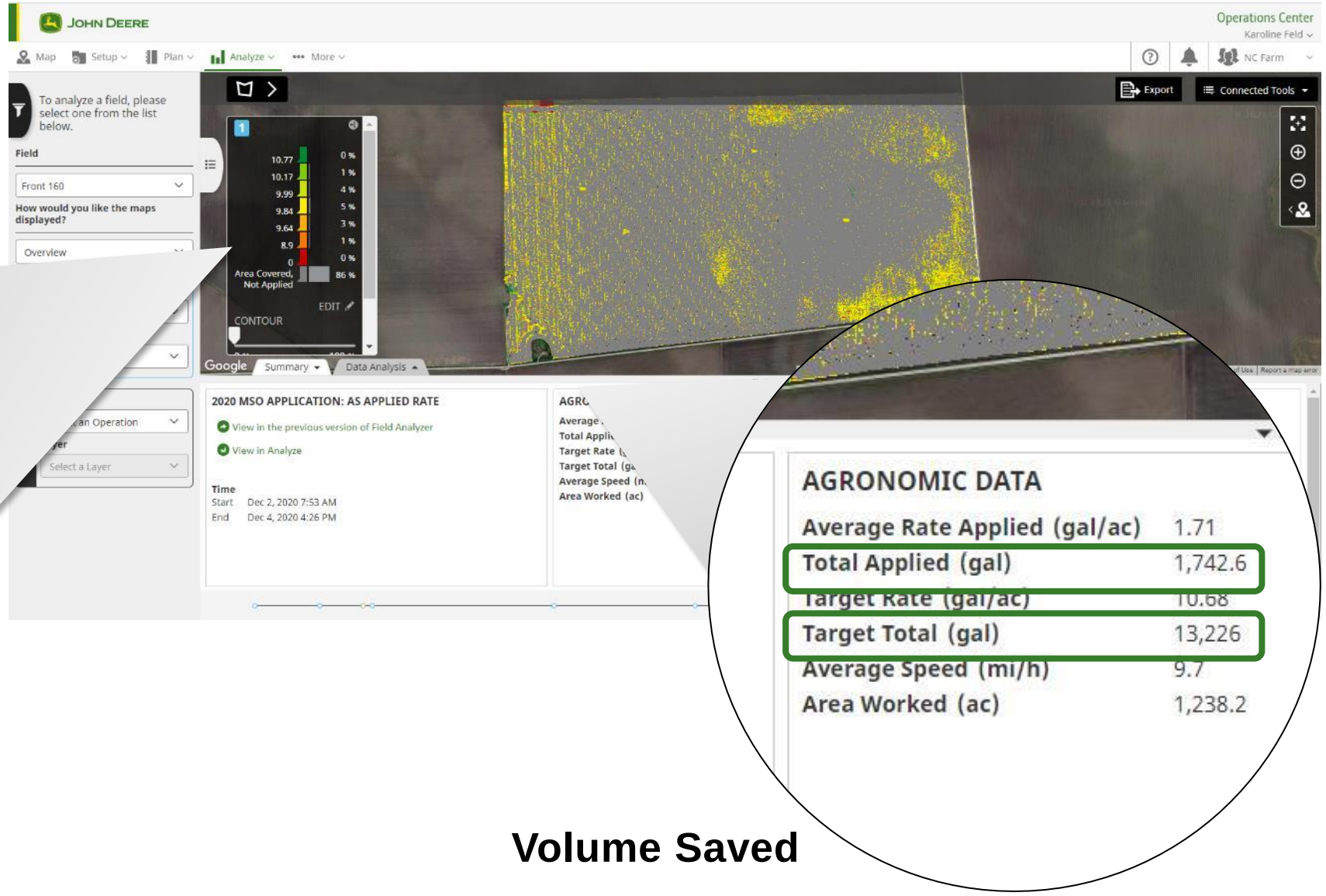
S&S™ Select Plus - System Description

Records:

- where chemical has been applied
- how much
- area covered, but not applied



Area Covered



Volume Saved

Evaluation of TA Technology

Evaluation of Targeted Application Technology

Agronomical Evaluation

- perenial field trials
- plant / production system specific
- production spraying
- agronomical evaluations & statistics
- yield & savings focused

Technical Evaluation

- standardized method(s)
- controlled environment
- simple & robust
- hit rate / **accuracy** focused

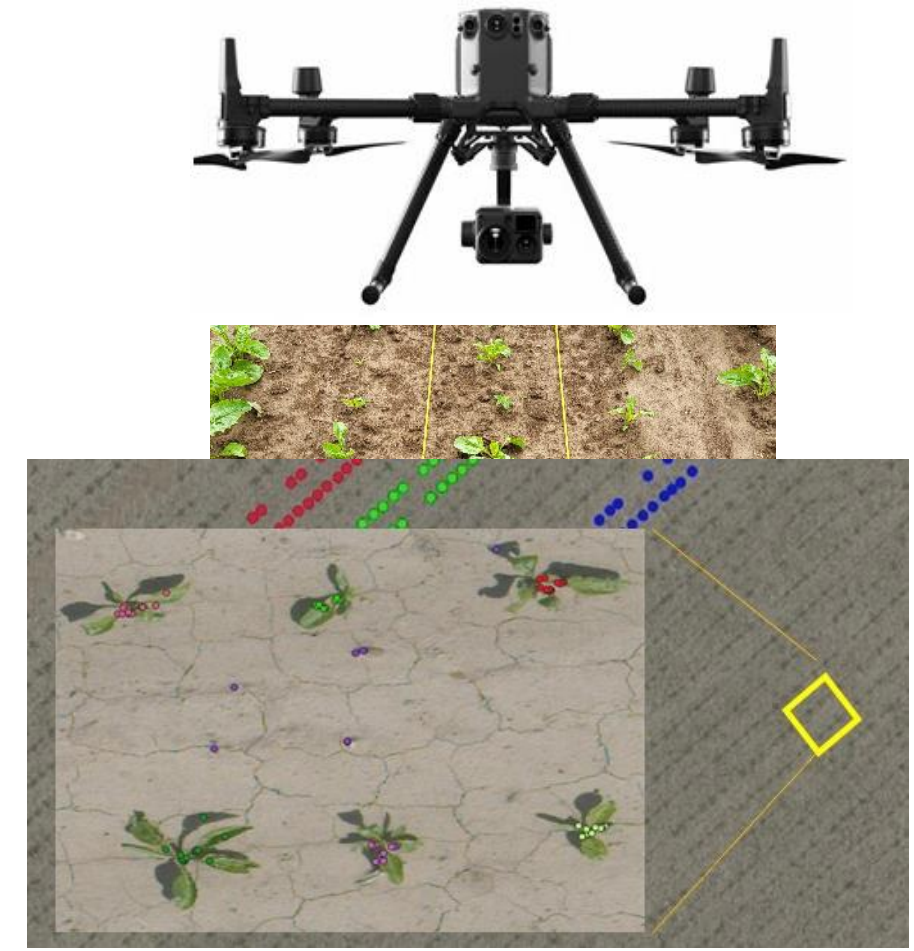
Agronomical Evaluation – Automated Scouting

Agronomical trials:

- Productive spraying: Typical spray mixes and application rates

- Manual scouting with frames:
  - Size: Various sizes, for row crops: **0,5 x 1,0 m, fixed**
  - Number of frames: **min. 0,5 % of tested area**

- **Automatic scouting (with UAVs):**
  - Full plot scan
  - Scan of scouting frames (before and after application)



Source: WEED AI

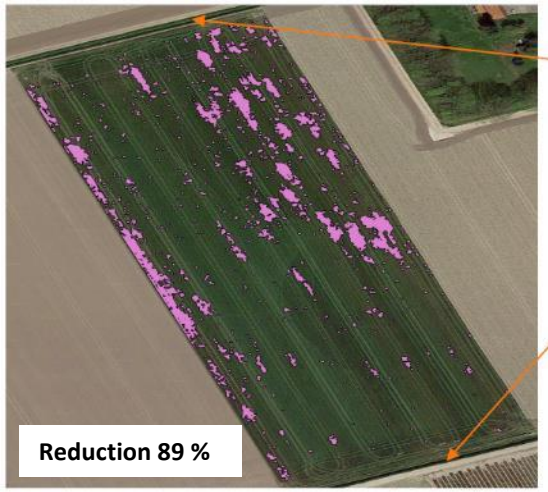
Targeted Application – EUPAF Activities

Can targeted (patch/spot) spraying reduce risk ?

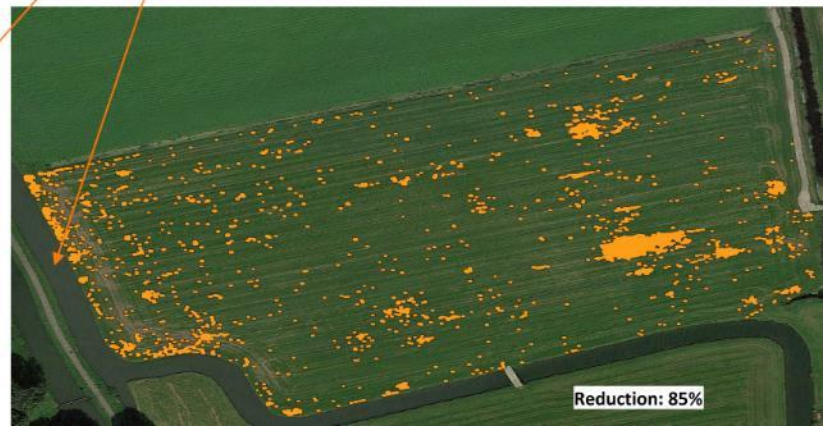
Changes in the risk assessment of PPP are necessary, but …

- Exposure scenarios are not available yet: Environmental concentrations and human exposure (including consumers) are not known.

Source: Keller et al.



Ditches



Source: van Boheemen, WUR

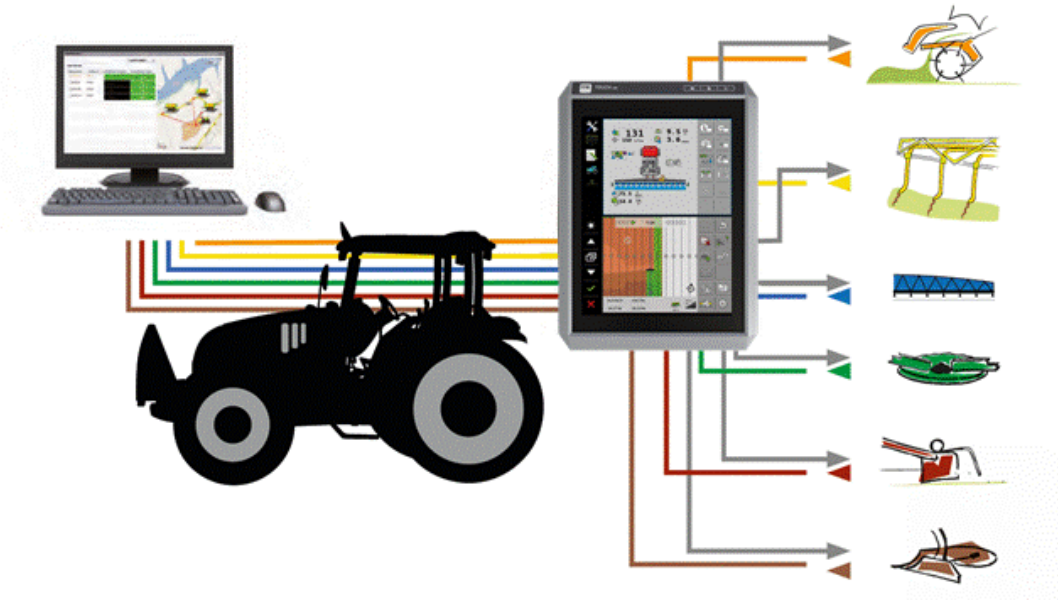
Technological Innovations – Data Networks

Data Collection - ISOBUS

AGRICULTURAL INDUSTRY ELECTRONICS FOUNDATION

ISOBUS is one-dimensional connection between **Terminal– Implement – Software**

The future is **multi-dimensional** => Diverse platforms will replace one software.



Source: Müller Elektronik

Source: Fliegl

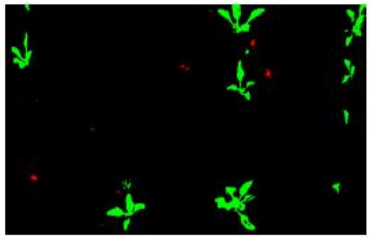
Multi-Dimensional Data Platform for Smart Spraying

Camera /sensor

Light

TASK Controller

Connectivity Unit



Precision Application Technology

Digital Tools

Smart Spraying Solution

Agronomical Intelligence

Weed maps

Documentation & Reporting

Agronomical Recommendations

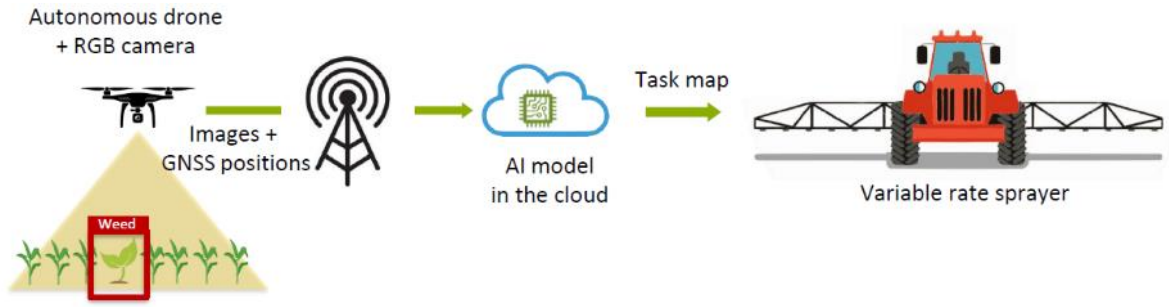
Sensitivity Level

Agronomical and technical support

Example: Multi-Dimensional Data Platform

A case study (ILVO):

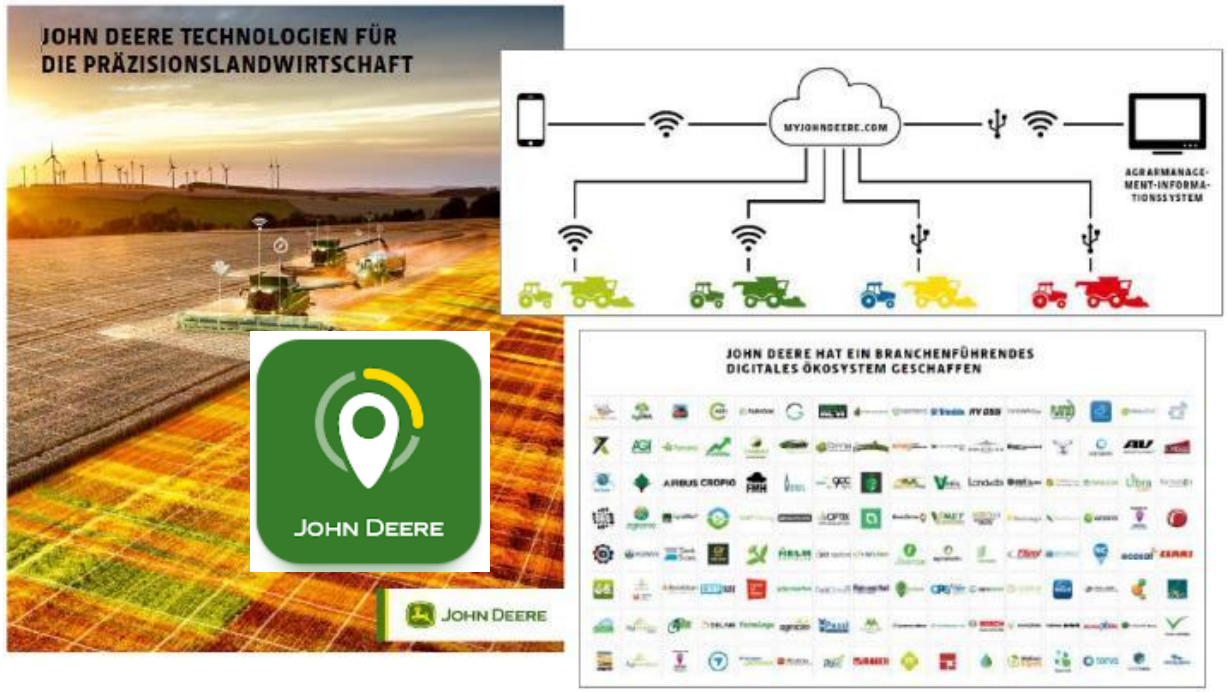
- Semi-real time TA in maize. TASK map can be prepared within ca. 15 minutes (5G network):



Weed detection map **Weed density map** **TASK map**

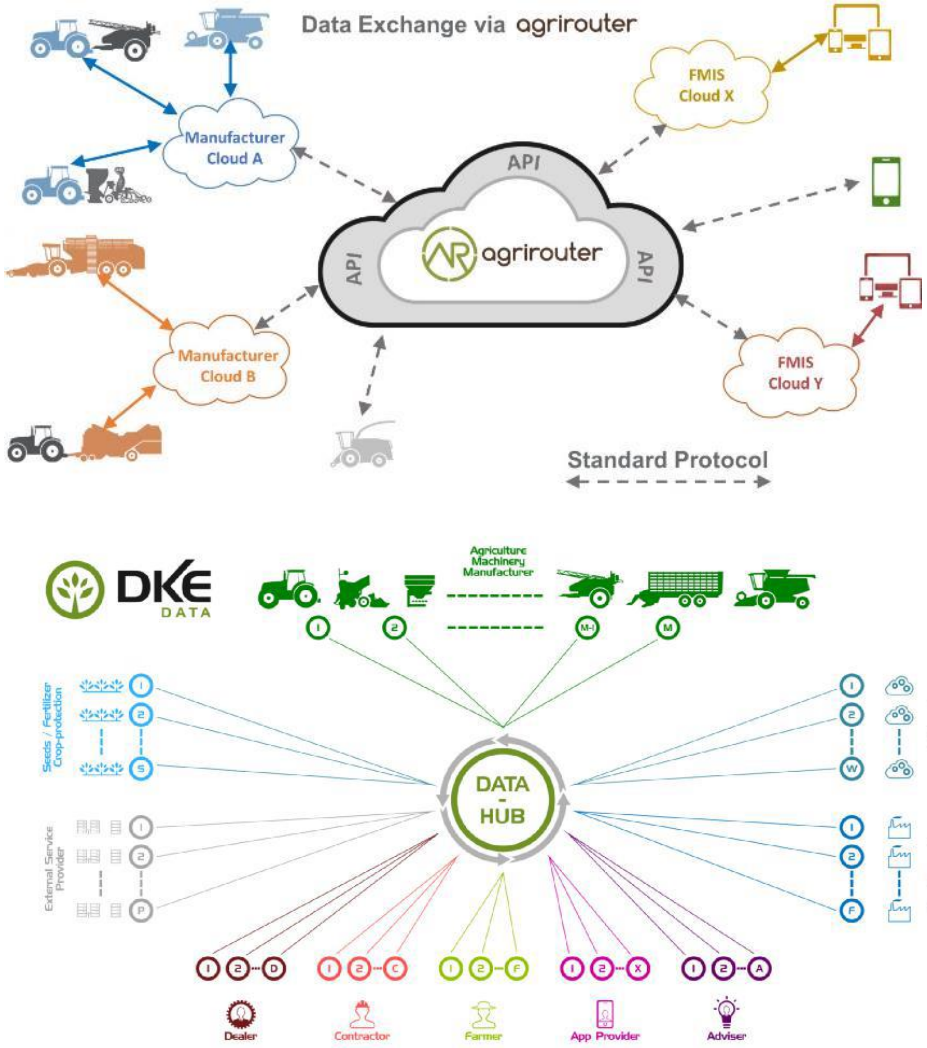
Source: ILVO

Data Platfoms & Apps (Examples…)



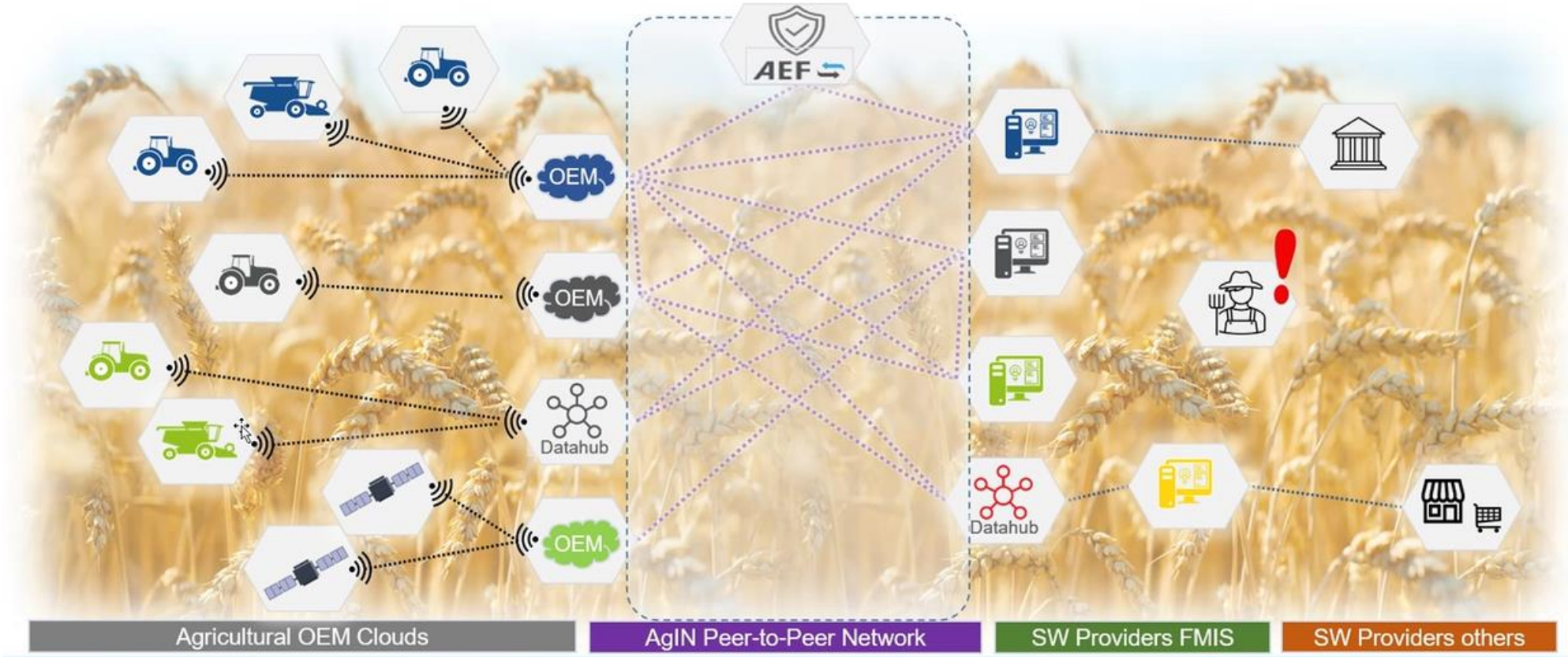
John Deere Operational Centre

DKE Agrirouter



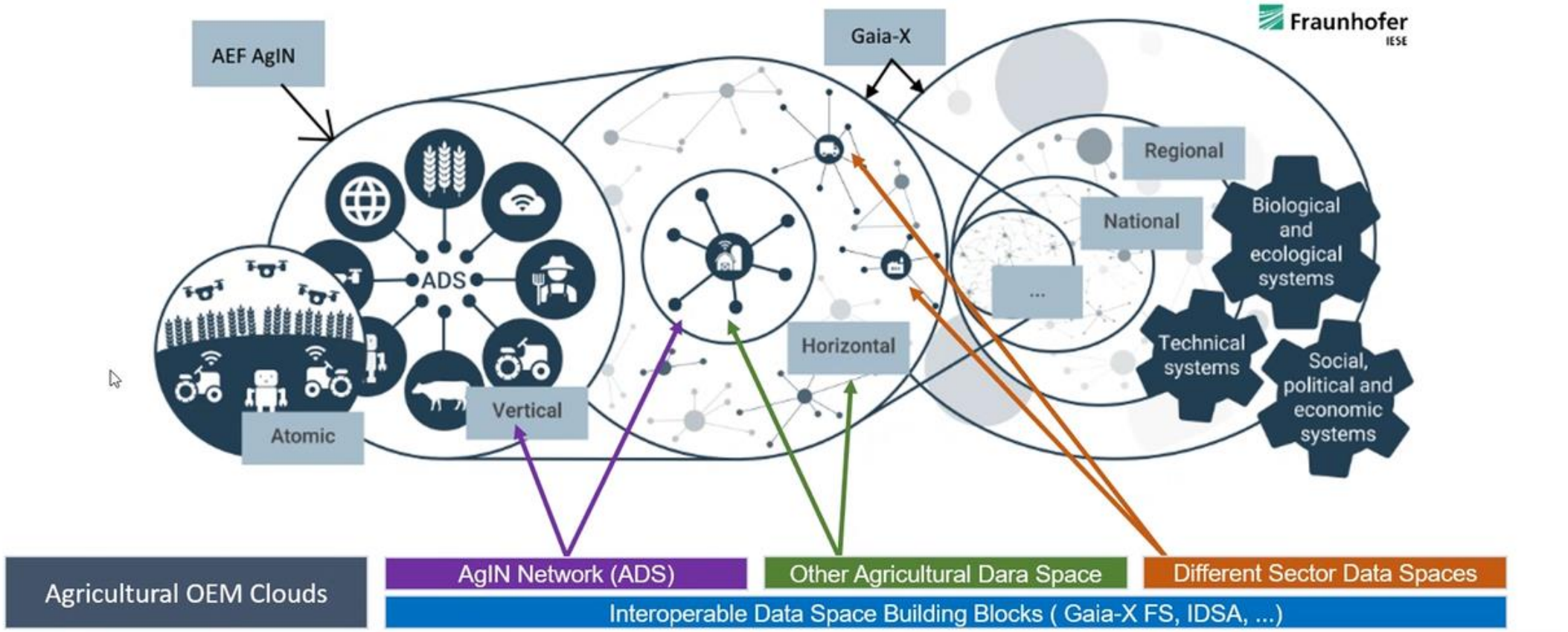
AgIN – Agricultural Interoperability Network

A CEMA/AEF project: a base for a „structural interoperability“ and Peer-to-Peer Network



AgIN – Agricultural Interoperability Network

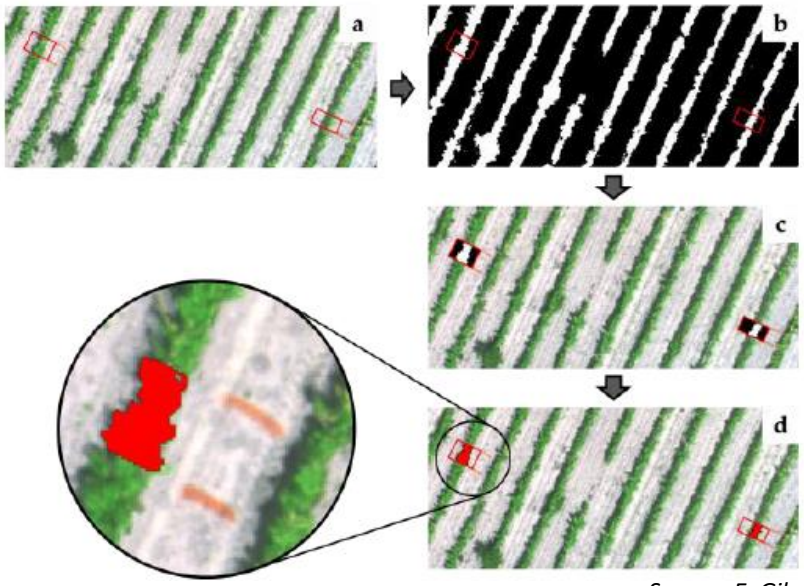
Close co-operation with European initiative Gaia-X and AgGateway



Technological Innovations - Bush & Tree Crops

Key Technologies for Targeted Application in B&T Crops

Canopy / Tree Detection



Source: E. Gil

Technology Development

- Online cameras / NIR (NVDI) Sensors for detection of the crops and their grow stage or detection of trunks
- Satellite / Aerial Photos
- Algorithms developed for different canopy types, e.g. correlation between NVDI and TRV (m^3)

Benefits and Customer Value

- Optimization of dosage of PPP e.g. Cu up to 32% per season (by spray pressure control)

Source: WUR

Key Technologies for Targeted Application in B&T Crops

Autonomy

Technology Development

- Fully autonomous orchard sprayers
- Tractors with cab filtration (cat. 1- 4)

Benefits and Customer Value

- Reduction of operator's exposure to PPP (contamination)
- Extension of spray (working) time

Source: Deere&Co

Key Technologies – Aerial Application

UASS (Drones)

Source: DJI .com

Technology Development

- Tank volume 10 - 30 L
- Flying time: 5 - 15 min
- Flying speed: 15 - 50 km/h
- Spray Height: 2,0 - 3,5 m (forestry 10 m)
- **CDA - controlled discharge atomizers** (rotary nozzles) – very low pressure
- Automated flying passes - GNSS controlled

Source: Dr. Steve Li, Auburn University

Benefits and Customer Value

- Alternative to aerial spraying by aircrafts, usage in forestry, steep vineyards
- Can spray at wet soil conditions – rice fields

Key Technologies – Aerial Application

UASS (Drones)

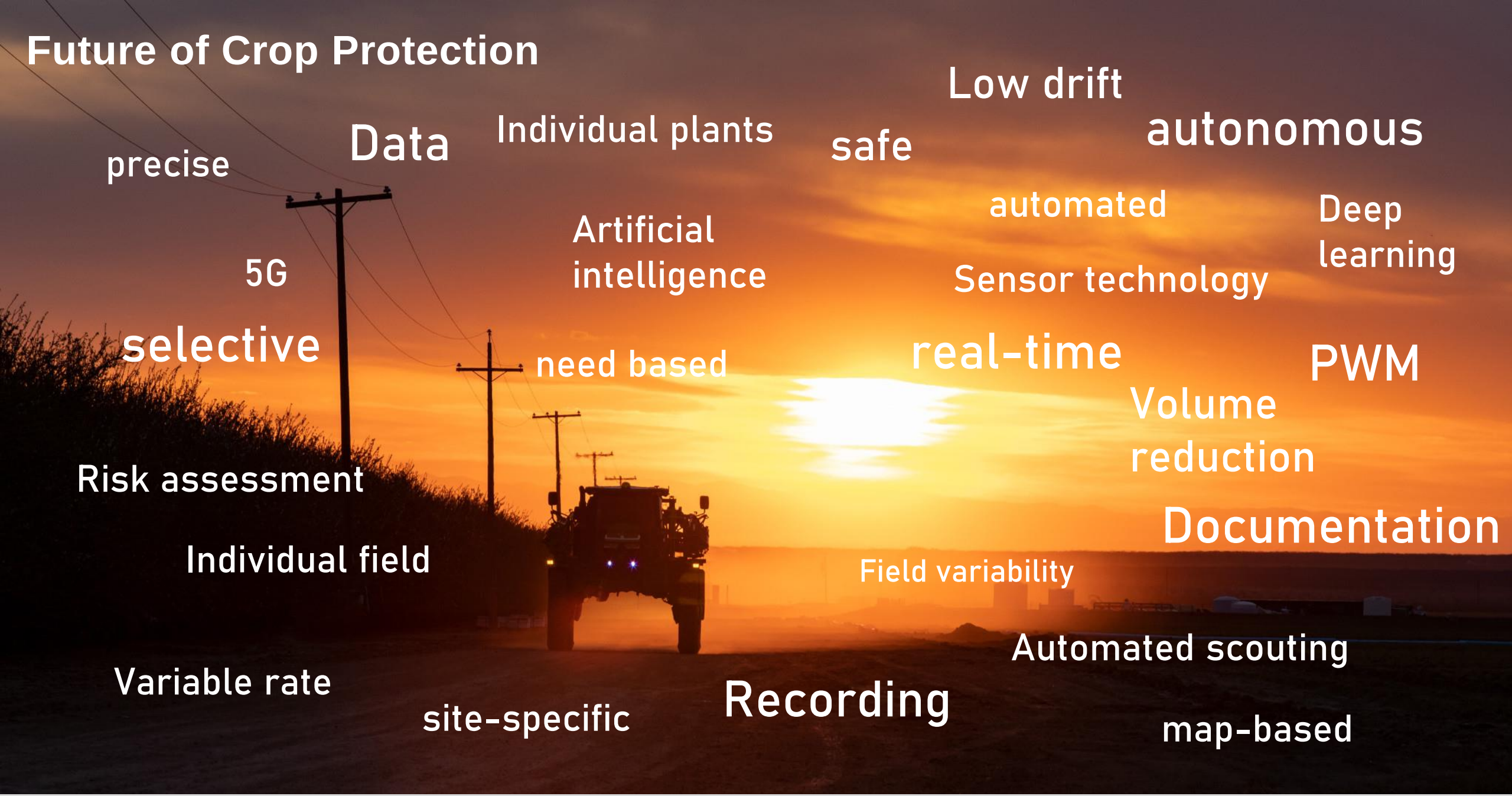
Limitations

- 5-15 min flying time – Productivity ?
- Operating window: during daytime only – visual contact needed
- Low application rate: 15 – 20 l/ha
- Not enough research data comparing drone performance (e.g. efficacy and spray drift) to ground sprayers
- Operational restrictions: max. payload and operational licenses

“Drone sprayers will hardly replace ground or conventional aerial application technology, but they may complement existing spray practices.”

Source: Internet

Source: Internet


Future of Crop Protection
Low drift
Data
Individual plants
autonomous
precise
safe
automated
Deep learning
Artificial intelligence
5G
Sensor technology
selective
real-time
PWM
need based
Volume reduction
Risk assessment
Documentation
Individual field
Field variability
Automated scouting
Variable rate
Recording
site-specific
map-based


JOHN DEERE