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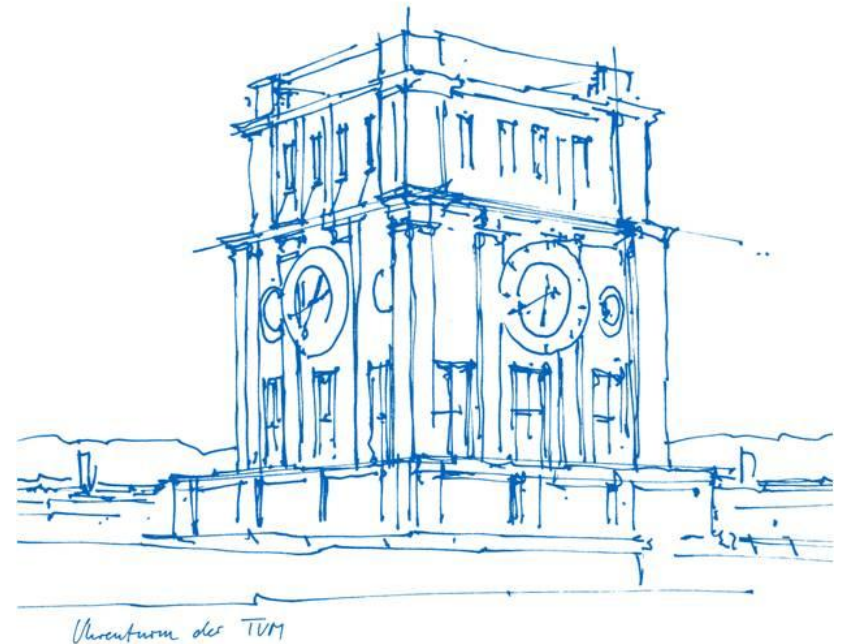
# Automatic Guidance Systems

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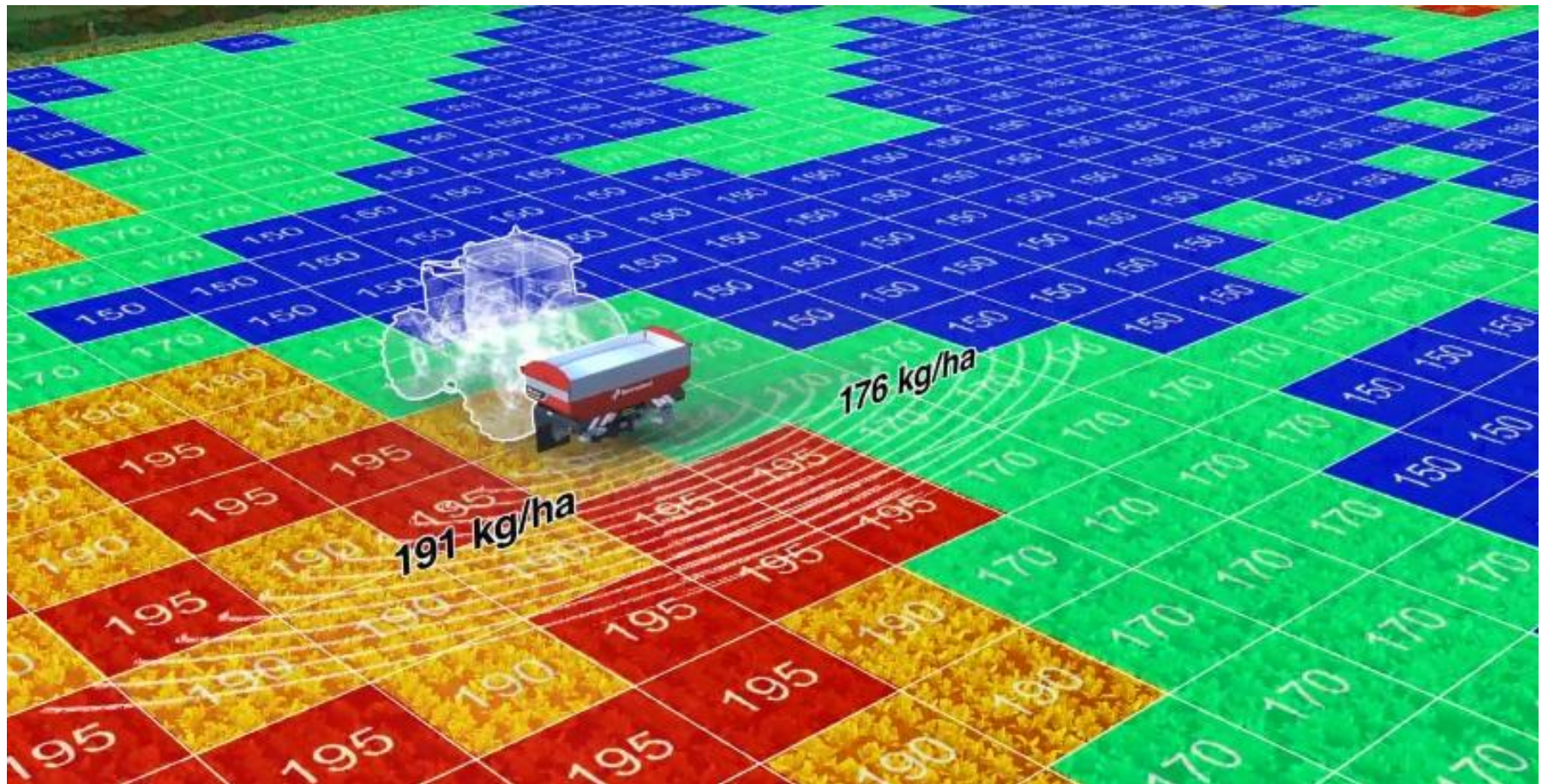
Agricultural Systems Engineering



GPS tells us where we are –

Automatic Guidance Systems get us to where we  
want to be

GPS tells us where we are –  
AGS get us to where we want to be





# Automatic Guidance Systems



Source: CNH

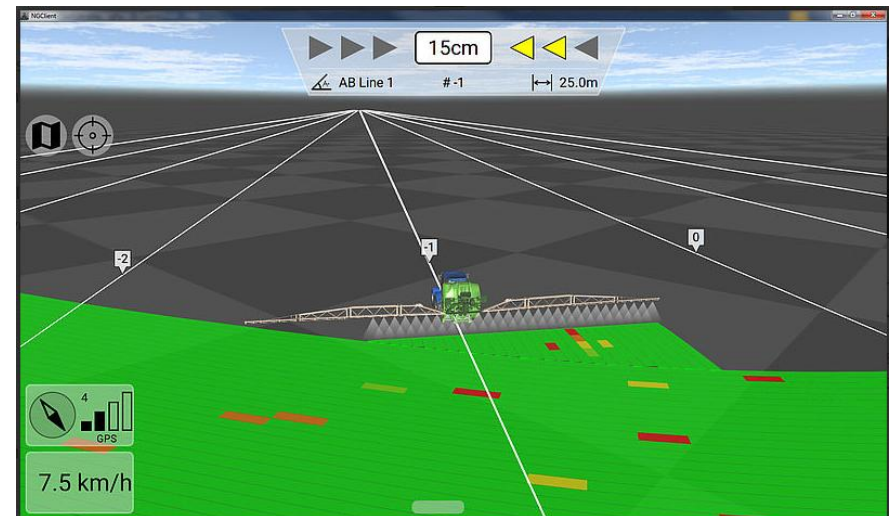
# Automatic Guidance Systems



# Automatic Guidance Systems



Source: Reichhardt



Source: LACOS



# Benefits of Automatic Guidance Systems

- Documentation (Where am I anyway?)
- Reduced skips and overlaps (input savings)
- Lower operator fatigue
- Ability to work in poor visibility conditions
- Clout increase
- Soil conservation (CTF)

# History of steering aids

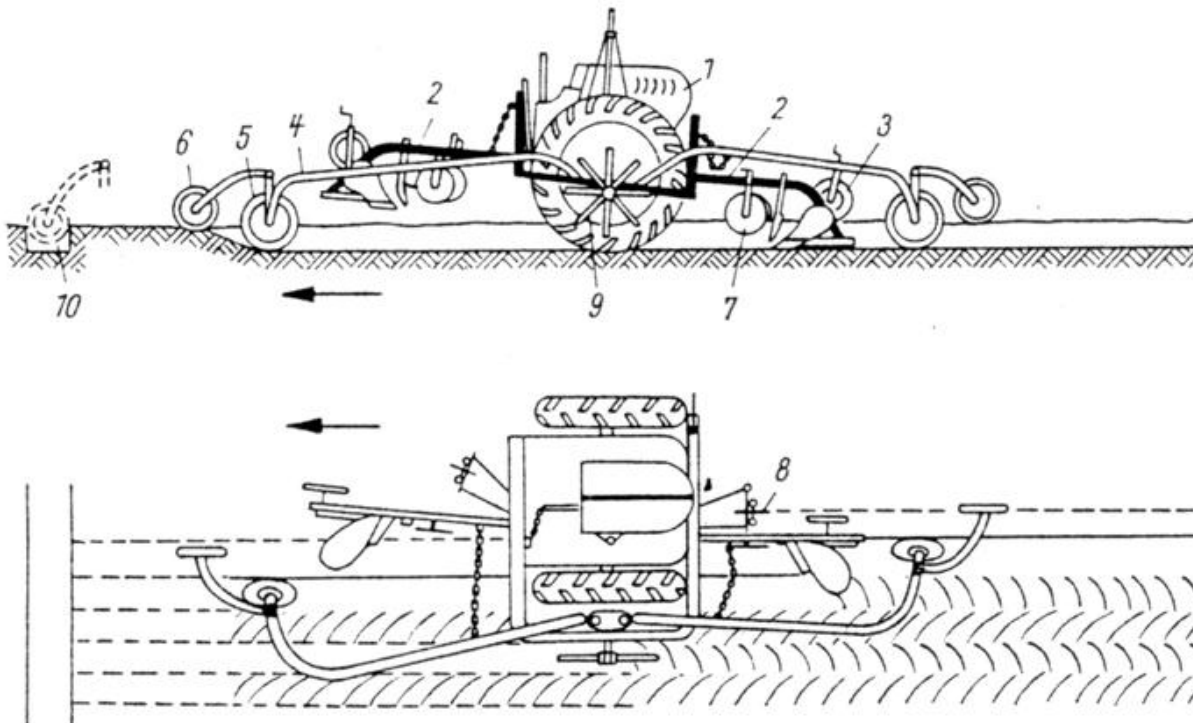


# Steering aids & automated steering



Mechanical guidance along the plow furrow (Hungary)

# Mechanical „Plow-Robot“



1. Diesel engine
2. Plow frame
3. Support wheel
4. Contact frame
5. Furrow wheel
6. Feeler wheel
7. Disc coulter
8. Disc coulter for correction of furrow arcs
9. Impulse wheel
10. Cross furrow

Scheme of an automated plow machine  
(MITTELBACH 1963)

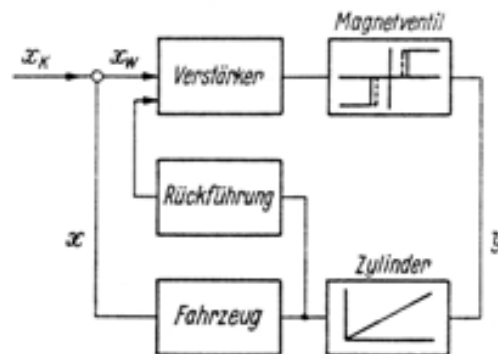
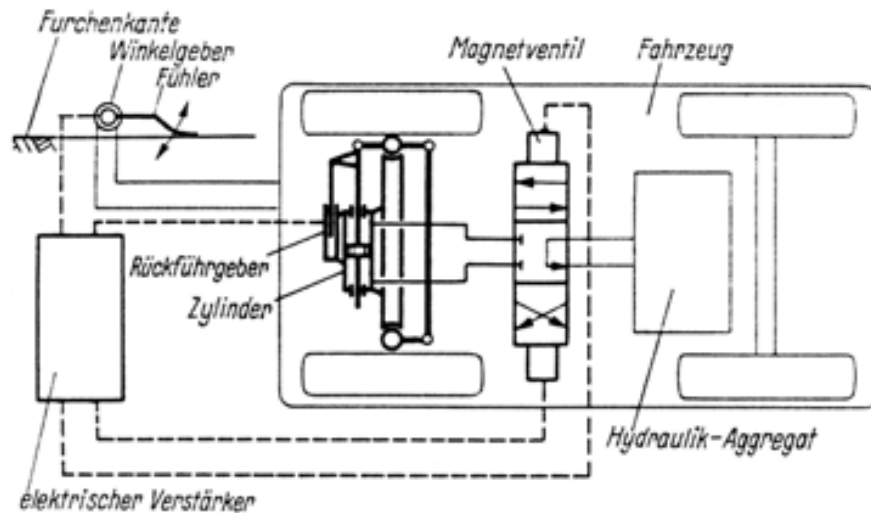


# Eicher Agri-Robot



Source: topagrar

# Electro-hydraulic steering during plowing



$x$  Regelgröße  
 $x_K$  Sollwert  
 $x_W$  Regelabweichung  
 $y$  Stellgröße



Automated steering (elektro-hydraulic) during plowing,  
Research by BATEL 1968



# Track markers for seeders & planters



Source: Amazone

# Sighting aids on the tractor



# Foam marking systems for sprayers



Quelle: John Deere



# Row guidance with mechanical pressure sensors



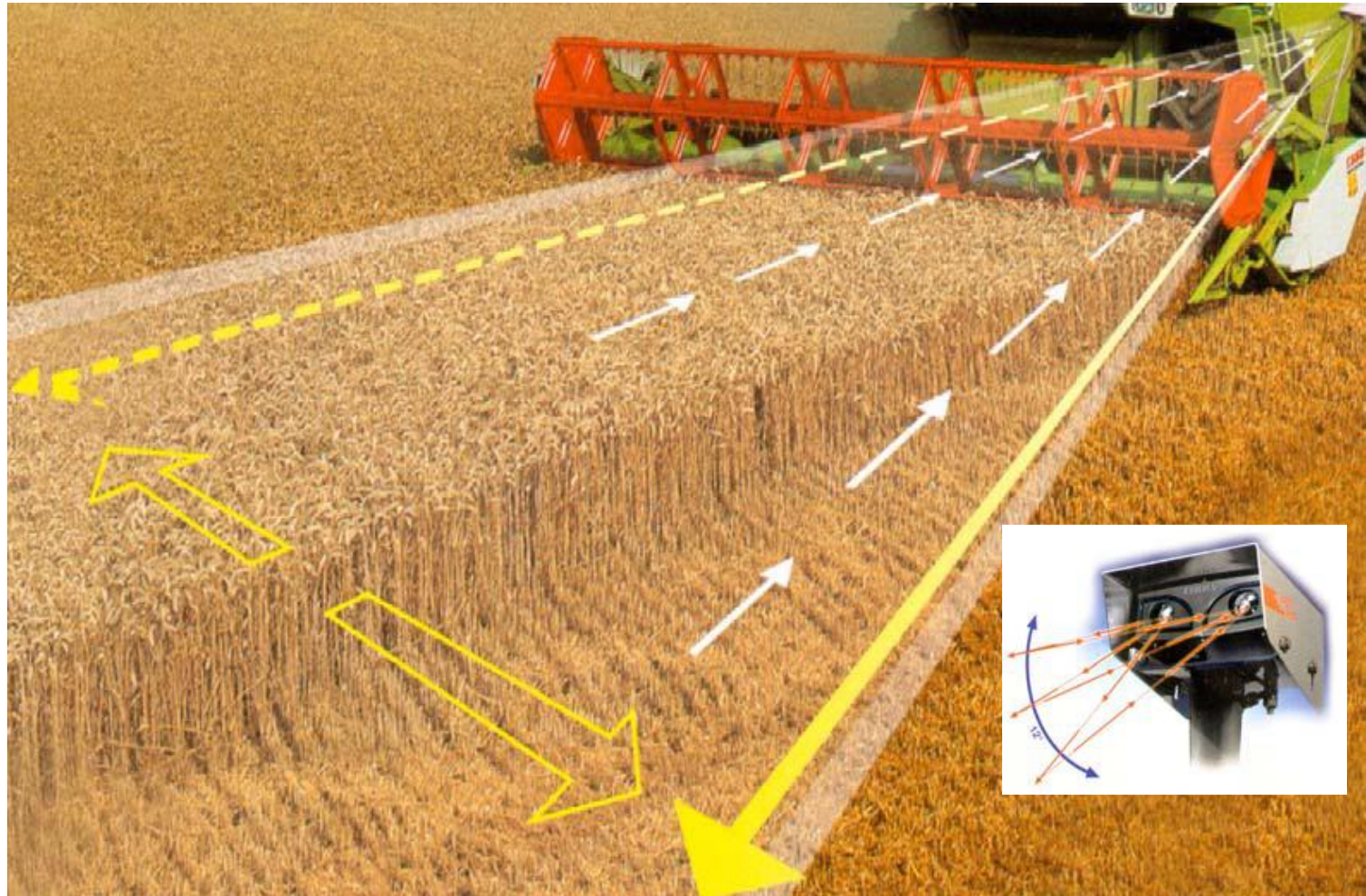
Mechanical sensors  
detect plant rows

Usable with:

- Corn
- Sugar beets
- Potatoes



# Laser scanning the crop edge



# Classification

# Terms and definitions

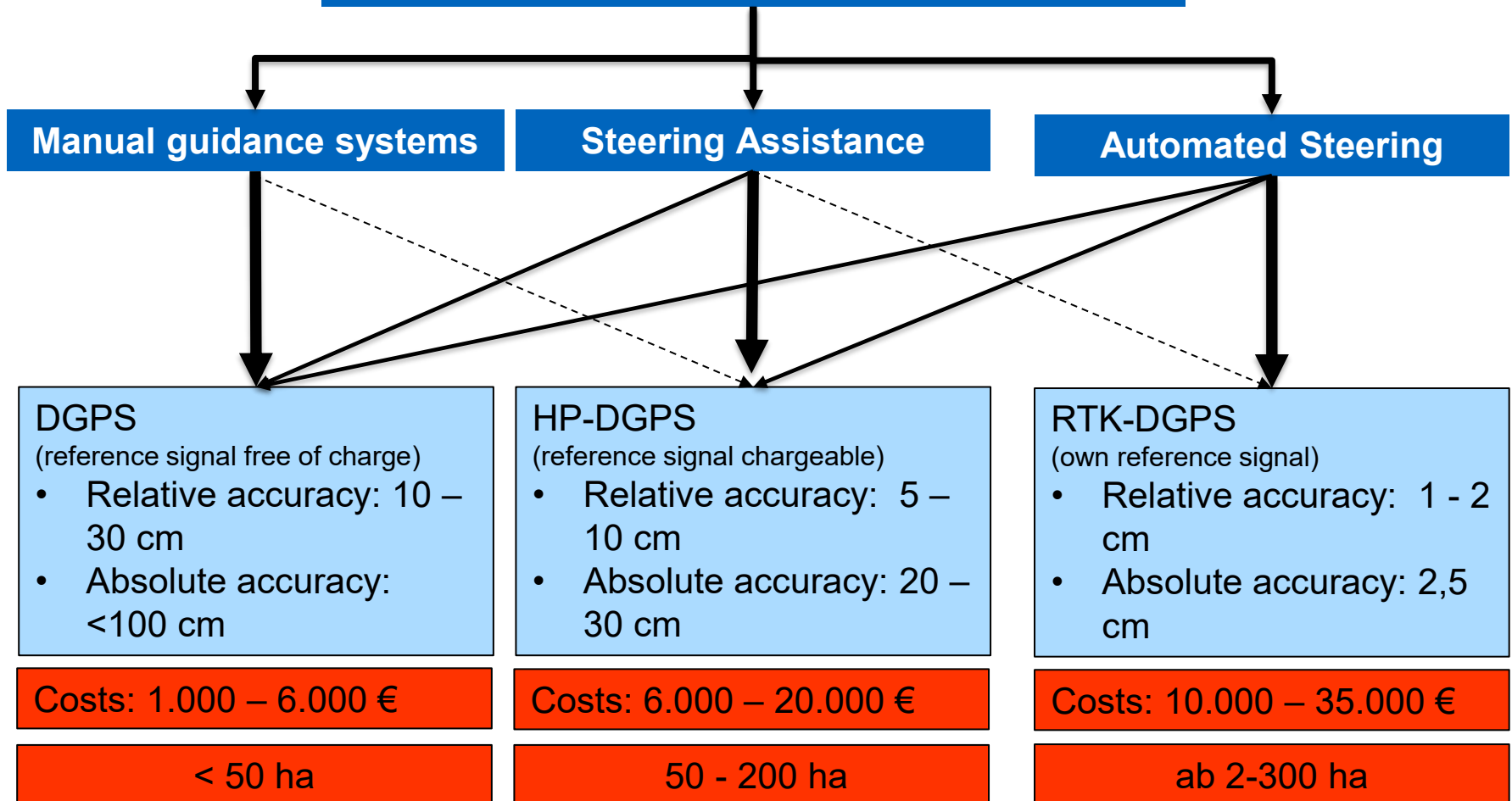
Auto-steer: Automatic/Automated Steering, Assisted Steering, Steering Assistance,

Auto-guidance: Automatic Guidance,

Parallel driving: Parallel tracking, Parallel Driving

**-> Terms are not clearly delineated and often times mixed in the manufacturer's descriptions**

# Automatic Guidance Systems



source: translation based on Zier, Hank, Wagner 2008



## Manual guidance systems

## Steering Assistance

## Automated Steering

### Control intervention

- No intervention in the machine control system
- Driver controls according to optical signal

- Direct intervention in machine control system via electric motor or steering hydraulics
- Vehicle must be **in** the lane when the system is activated

- Direct intervention in the steering hydraulics by the system
- Vehicle must be **close to** the lane when the system is activated

### Usage

Soil cultivation, application of fertilizer & spraying



Sowing row crops (seed drill)



Mechanical weeding, sowing of row crops (precision seeding), planting perennial crops

# Expansion stages: Manual Guidance Systems

Optical indicators for the operator to recognize the need to make steering adjustments

Known as:

- Lightbars
- parallel tracking device
- navigation aids



Source: Trimble.com 2018

# Expansion stages: Steering Assistance

## Mechanical steering device installed on steering column

### Trimble EZ-Steer:

- Retrofit (combination with EZ-Guide 250 possible)
- Friction wheel motor takes over steering



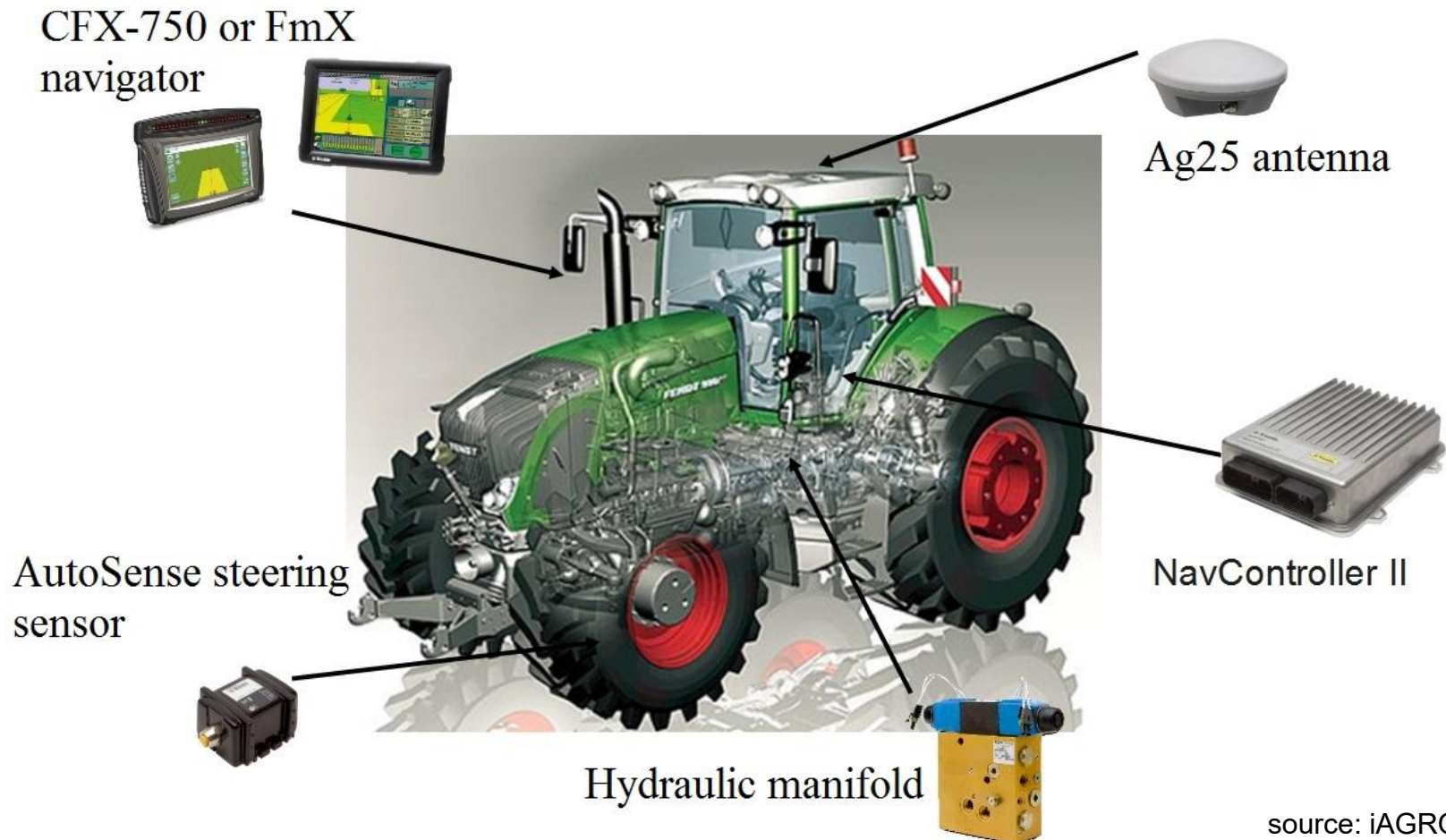
### Trimble EZ-Pilot:

- Retrofit (electrically driven steering wheel)
- Gear attachment directly on steering column
- Mixture of EZ-Steer and autopilot systems



# Expansion stage: Automatic Guidance System

Integrated or retro-fitted electro-hydraulic control system



source: iAGRO 2018

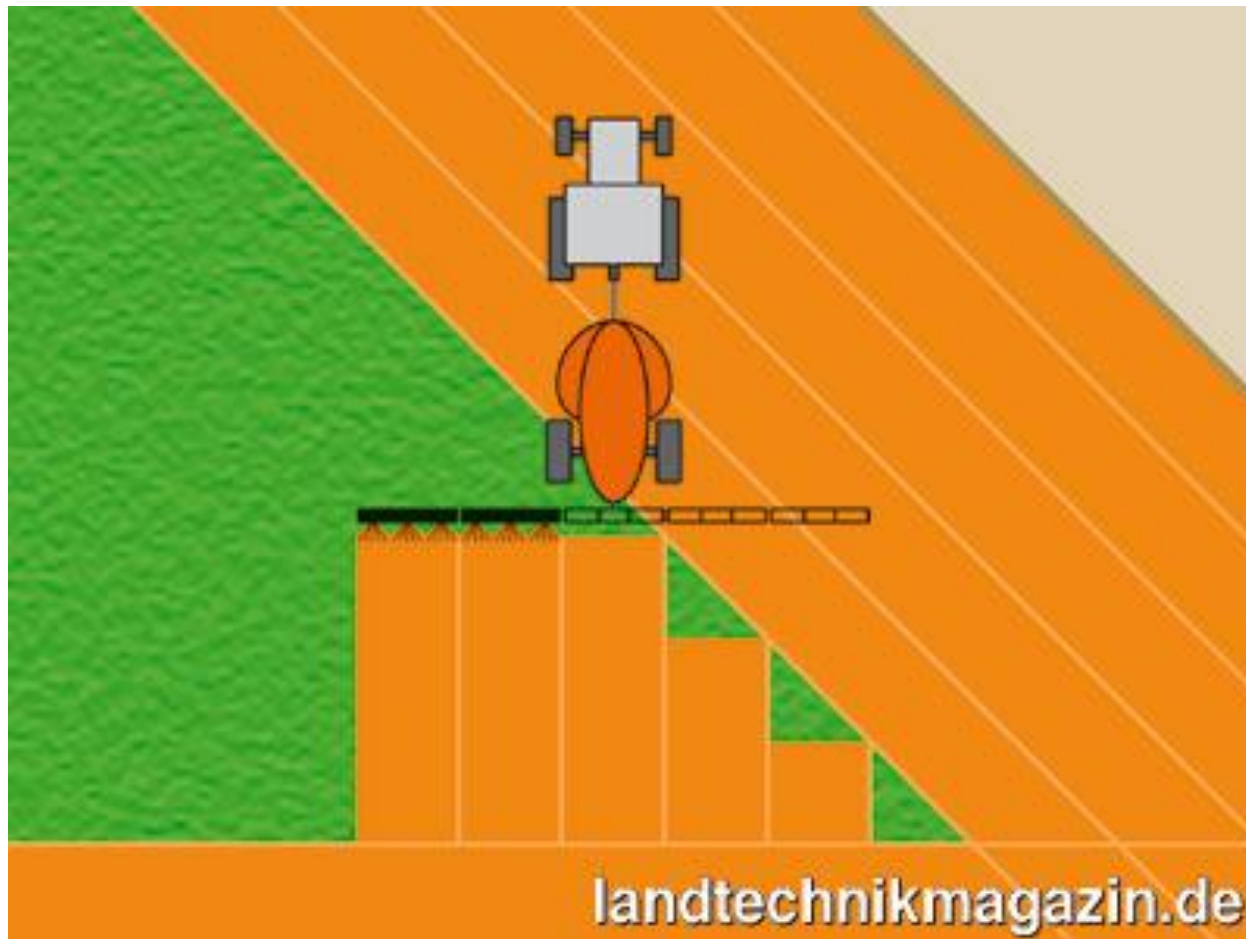


# Economic aspects & efficiency considerations

# Minimum viable area for AGS application

Farm	Steering System	Number of systems	Annually costs (€)	Ø Savings (€/ha)	Minimum viable area (ha)
A	Manual Guidance Systems	1	210	4,40	48
	Steering Assitance	1	1785	8,50	210
	Automated Steering	1	4613	16,60	278
B	Manual Guidance Systems	1	210	4,40	48
	Steering Assitance	1	1785	9,10	196
	Automated steering	1	4613	18,30	253
C	Manual Guidance Systems	2	420	7,10	59
	Steering Assitance	2	3570	9,60	371
	Automated Steering	2	9226	22,80	405
D	Manual Guidance Systems	2	420	7,60	55
	Steering Assitance	2	3570	10,30	348
	Automated Steering	2	9226	25,50	362

# Section control



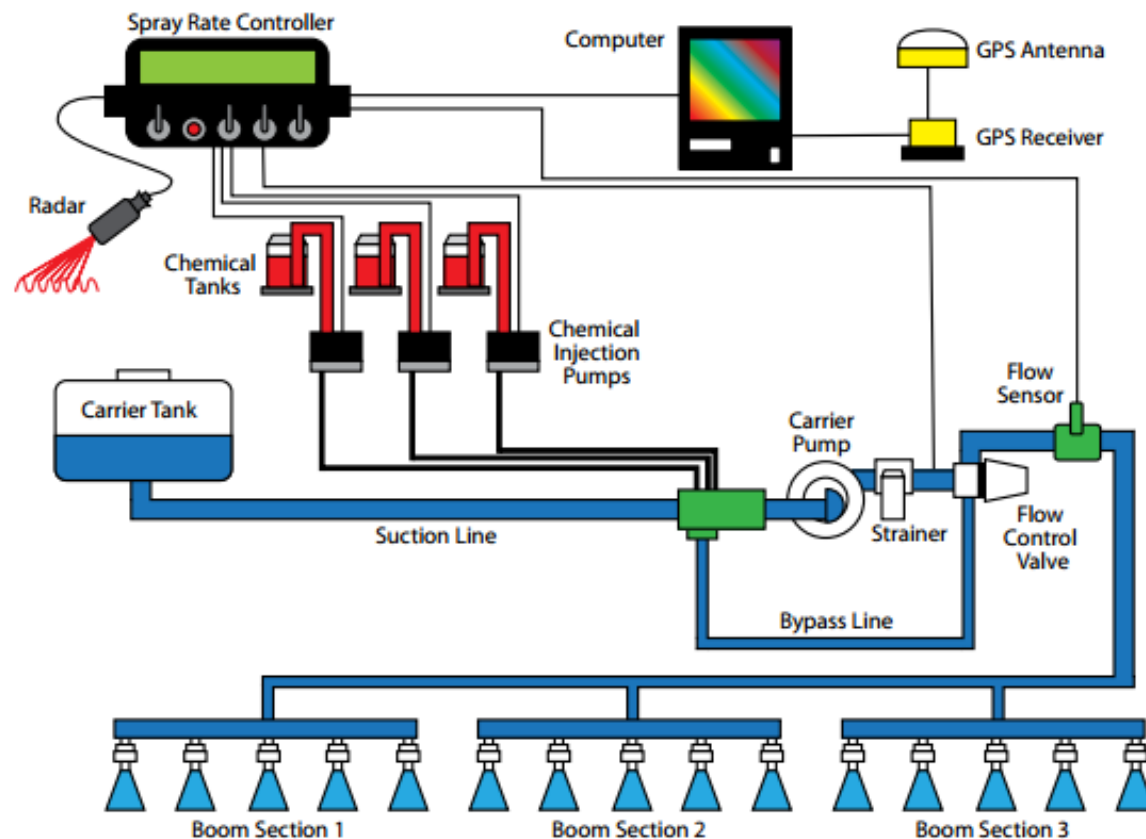
# Section control





# Section control

## Variable Rate Control – Sprayer



# Economical aspects of Section Control

## Übersicht 3: Einsparpotenzial beim Einsatz der Teilbreitenschaltung mit Section Control

Schlag	Flächen- größe	Getreidedrille mit GPS, ohne TBS		ZR-Einzelkorndrille mit GPS und TBS		Saldo Drill- fläche
Hornbreite	<b>9,17 ha</b>	9,66 ha	5,1 %	9,23 ha	0,7 %	- 4,4 %
Butterkamp	<b>8,70 ha</b>	9,19 ha	5,3 %	8,76 ha	0,7 %	- 4,6 %
Birkenkamp	<b>8,59 ha</b>	9,11 ha	5,7 %	8,69 ha	1,2 %	- 4,6 %
Im Drecke	<b>12,5 ha</b>	12,92 ha	3,3 %	12,68 ha	1,4 %	- 1,8 %
Große Feld	<b>15,76 ha</b>	16,13 ha	2,3 %	15,95 ha	1,2 %	- 1,1 %
Schwarze Land	<b>4,95 ha</b>	5,07 ha	2,4 %	5,01 ha	1,2 %	- 1,2 %
Kleine Feld	<b>7,81 ha</b>	8,13 ha	3,9 %	8,02 ha	2,6 %	- 1,3 %
<b>Saldo Drillfläche</b>			<b>4,0 %</b>		<b>1,3 %</b>	<b>- 2,7 %</b>

Mit Teilbreitenschaltung (TBS) fallen die doppelt gesäten Flächen deutlich geringer aus.

# Economic impact of AGS

The economic effects of AGS are based on a number of different effects, some of which have only been precisely investigated and recorded to date, and others which are difficult to evaluate in monetary terms:

## 1. Working time requirement:

Savings arable farming 0,05-0,15 h/ha\*a (HOLPP 2006)

Savings arable farming 5-10 % (KLÖPFER 2005)

Savings arable farming 5-12 % (ZIER, HANK und WAGNER 2008)

Reduction of turning times by 35 % (own measurements)

## 2. Workload:

Reduction of operator fatigue especially under difficult operating conditions

## 3. Expenditure on Inputs (seed, fertilizer and pesticide):

Savings 2-6% (HOLPP 2006)

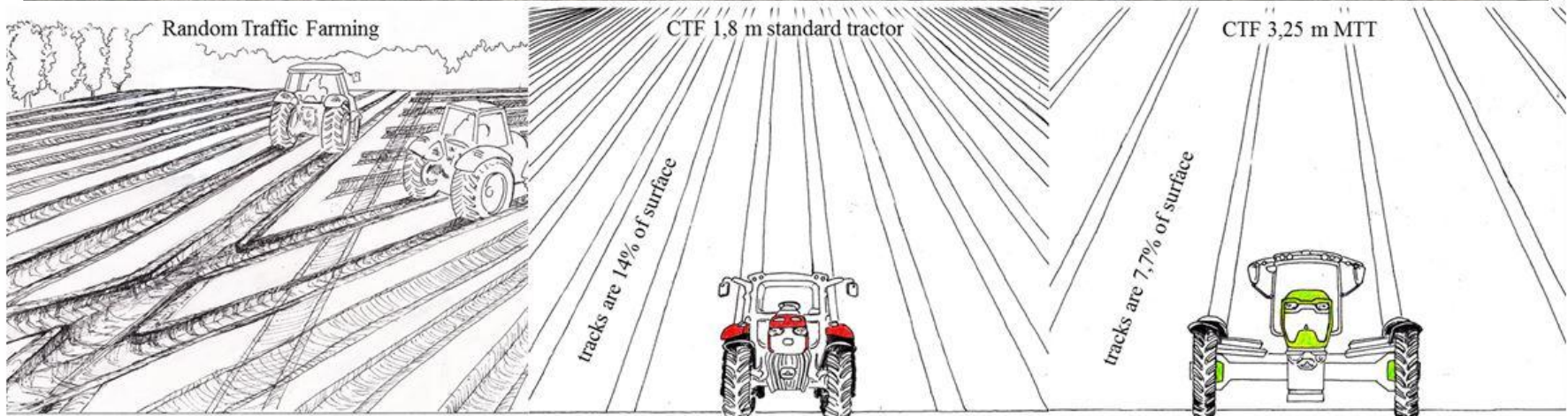
Savings 5-10 % (KLÖPFER 2005)

Seed savings 5-9 % (ZIER, HANK und WAGNER 2008)

# Perspectives



# Controlled Traffic Farming (CTF)



source: multitooltrac.com

# Strip Tillage





# Fendt GuideConnect (2012!)



Quelle: Fendt

# Japanese „GuideConnect“

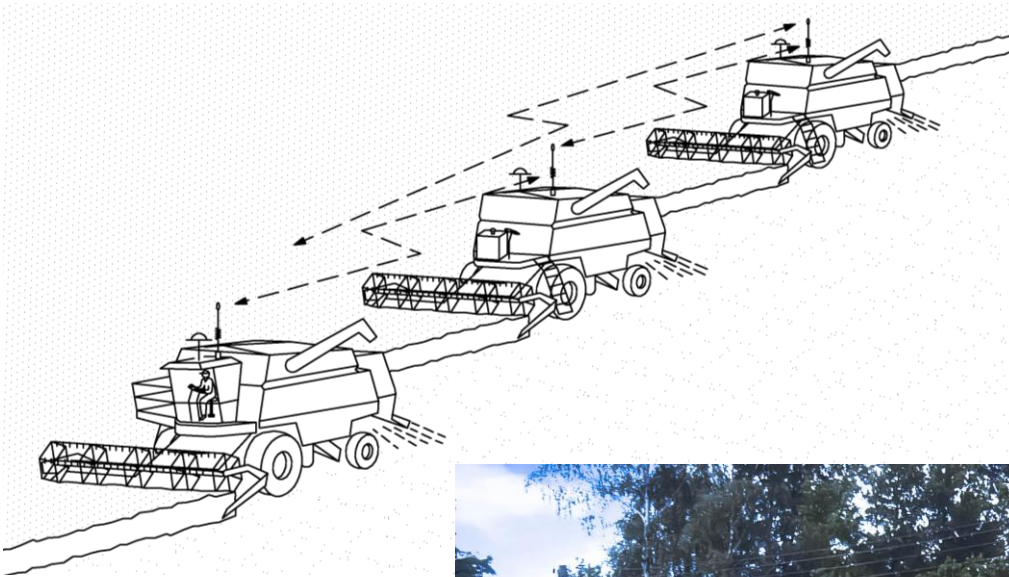




# Beginnings of autonomous tractors



# AGS as a basis for autonomous machines and field robotics







Quellen: Case IH; AGCO; 2018

# Take homes

- What are the advantages of Automatic Guidance systems in agriculture?
- How did they develop historically?
- How are the basics of satellite navigation related to the selection of the right guidance system?
- How can we classify AGS in 3 different expansion stages?

