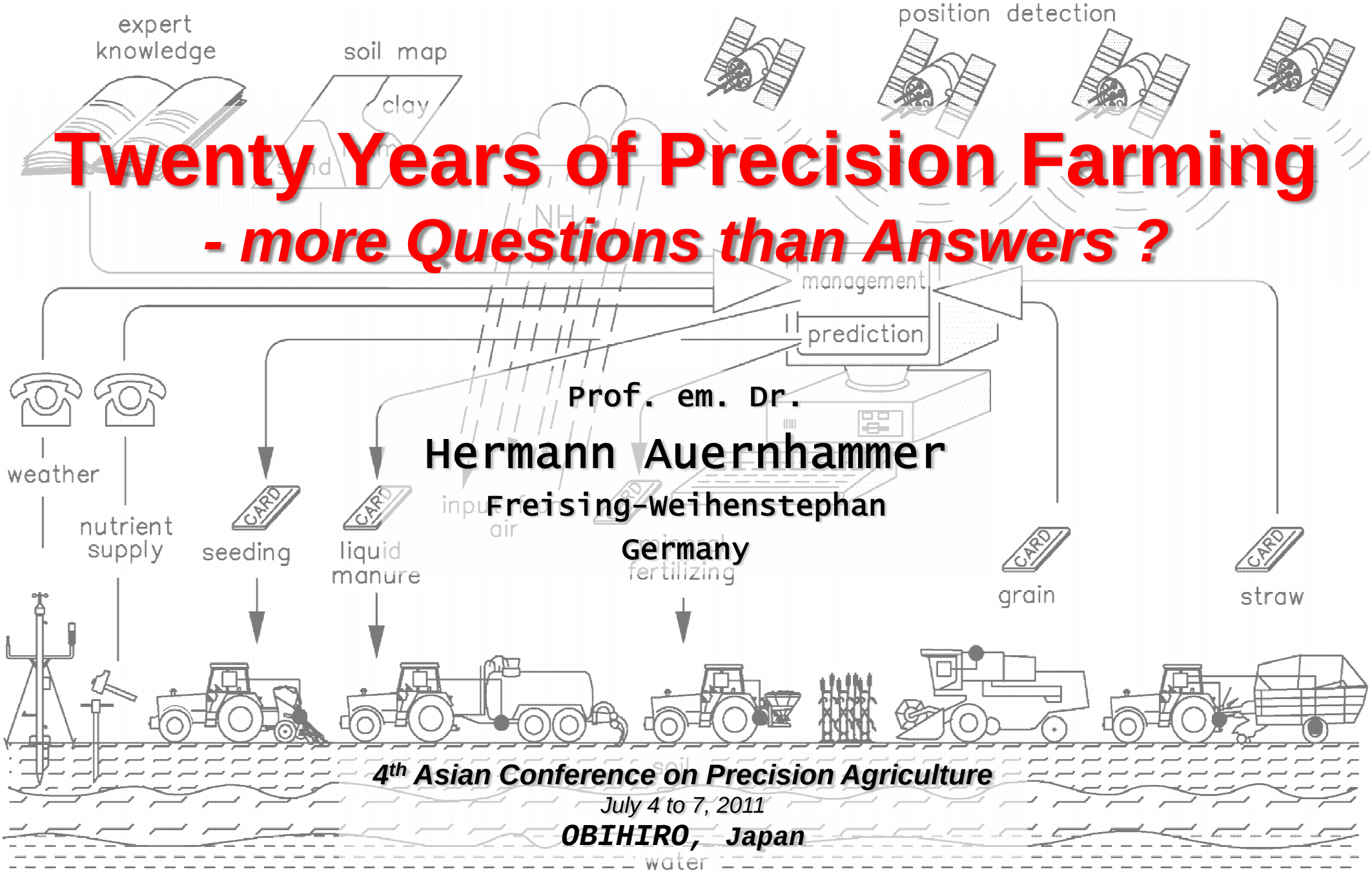

Twenty Years of Precision Farming

- more Questions than Answers ?

Prof. em. Dr.

Hermann Auernhammer

Freising-Weihenstephan

Germany

4th Asian Conference on Precision Agriculture

July 4 to 7, 2011

OBIHIRO, Japan

Agenda

1. Visions from yesterday
2. First steps in the 80th
3. Precision Farming in the 90th
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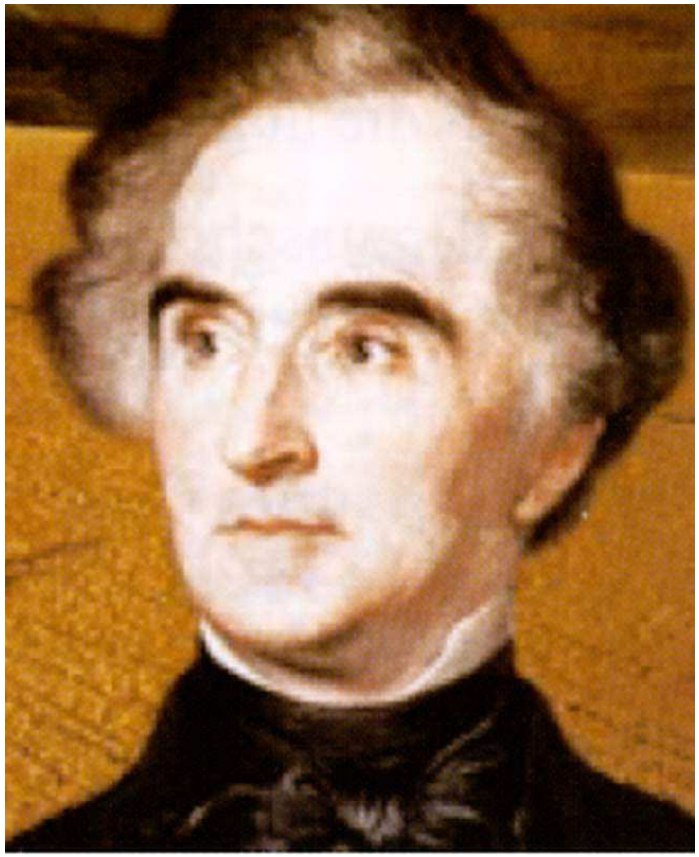
The Vision by J. v. Liebig

„... . One day (it was **around 1850**) Liebig said:

The farmer will be able to assess the exact yield during harvest like a bookkeeper is doing in a well controlled factory; then by simple calculations he could determine highly precise all substances which he has to replace in each field, also by amount, to restore the fertility (85).



→ ***"Precision Farming by Balance on Field-scale" !***

Brock, H.: Justus von Liebig. Braunschweig: Vieweg Verlagsgesellschaft 1999, p. 148, own translation

The (A) first vision/dream of Precision Farming in 1770 ?

As we will get soon a new map from our prince-bishop it would be also desirable to have a similar one where, with an adjusted enlargement, the nature of the soil should be shown. This could be done simply by different colors e.g. with **dark green** for the best grazing areas, a **lighter green** for the average and a more **lighter green** for the worst ones.

…

One could also mark every spot with numbers according to the depth of the different soils from a certain supposed line, like it is done in nautical maps …

Beside this map we need another one in which the situation in a depth of 6, 7 or 8 shoes is shown, so that, if the first map will be layered above the second one, the nature there could be seen. One would investigate this with an earth drill and would do the location geographically …

Source: Möser, J. A useful Appendix to the Journal of Intelligence of Osnabrück, May 26, 1770 (own translation)

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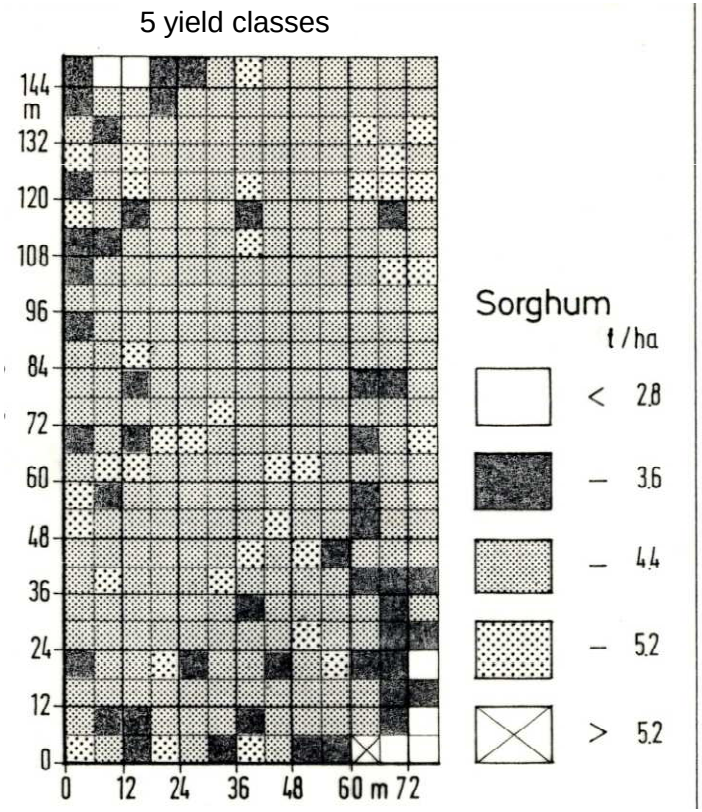
The first step into „Precision Farming“ in the 80s

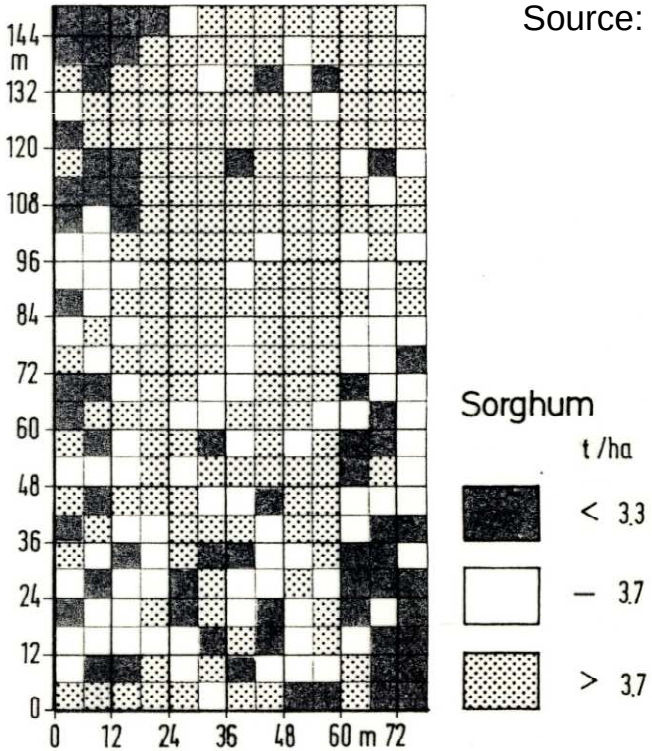
Mid80s Scientific investigations on Yield monitoring and Mapping

(see also: de Baerdemaeker, J., R. Delcroix, and P. Lindemans (1985); Searcy, S. W., J. K. Schueller, Y. H. Bae, S. C. Borgelt, and B. A. Stout (1989)

5 yield classes



3 yield classes



Source: Schueller, J. K., and Y. H. Bae (1987)

? May GPS enable real-time localization with no local infrastructure ?

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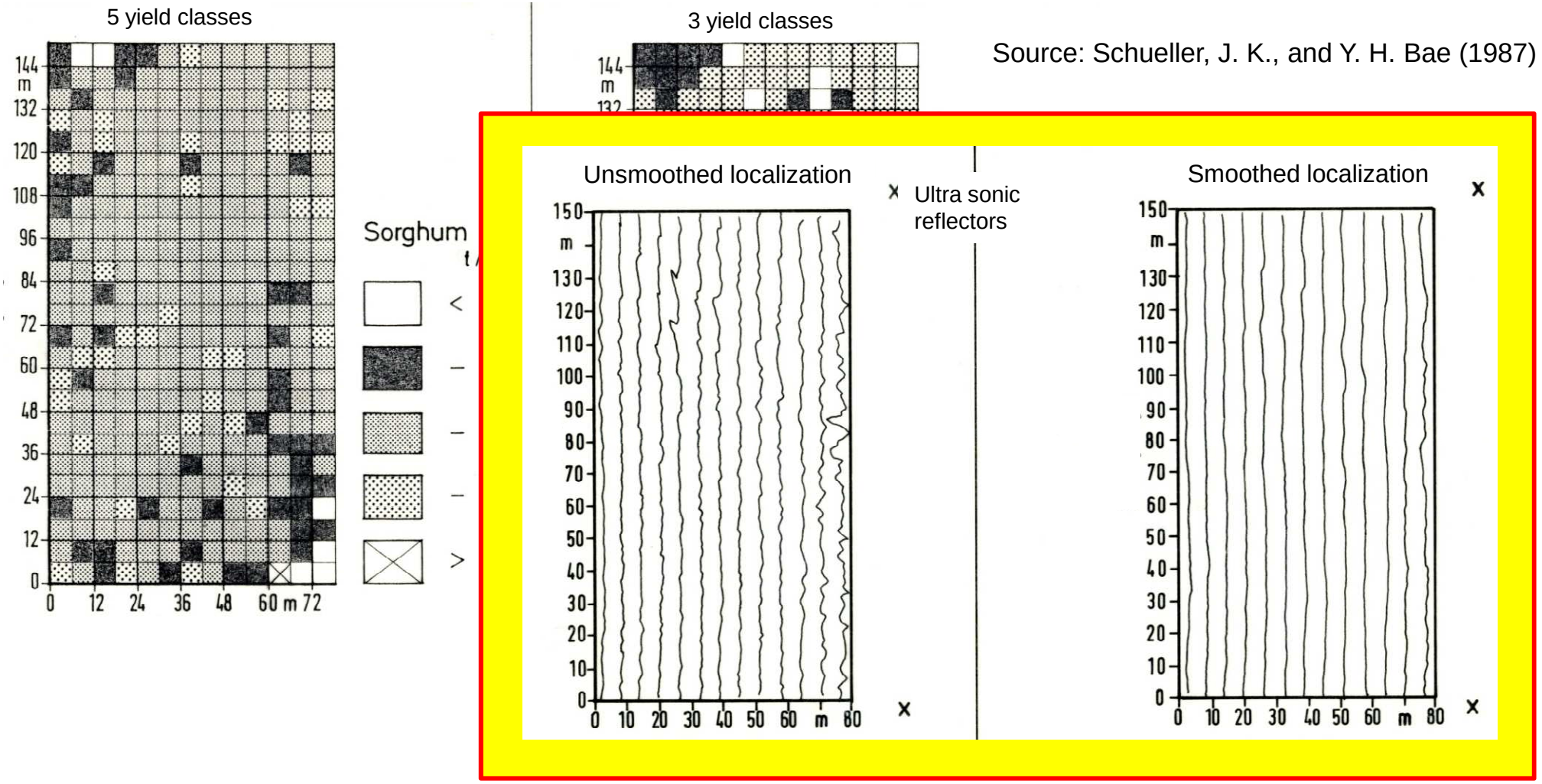
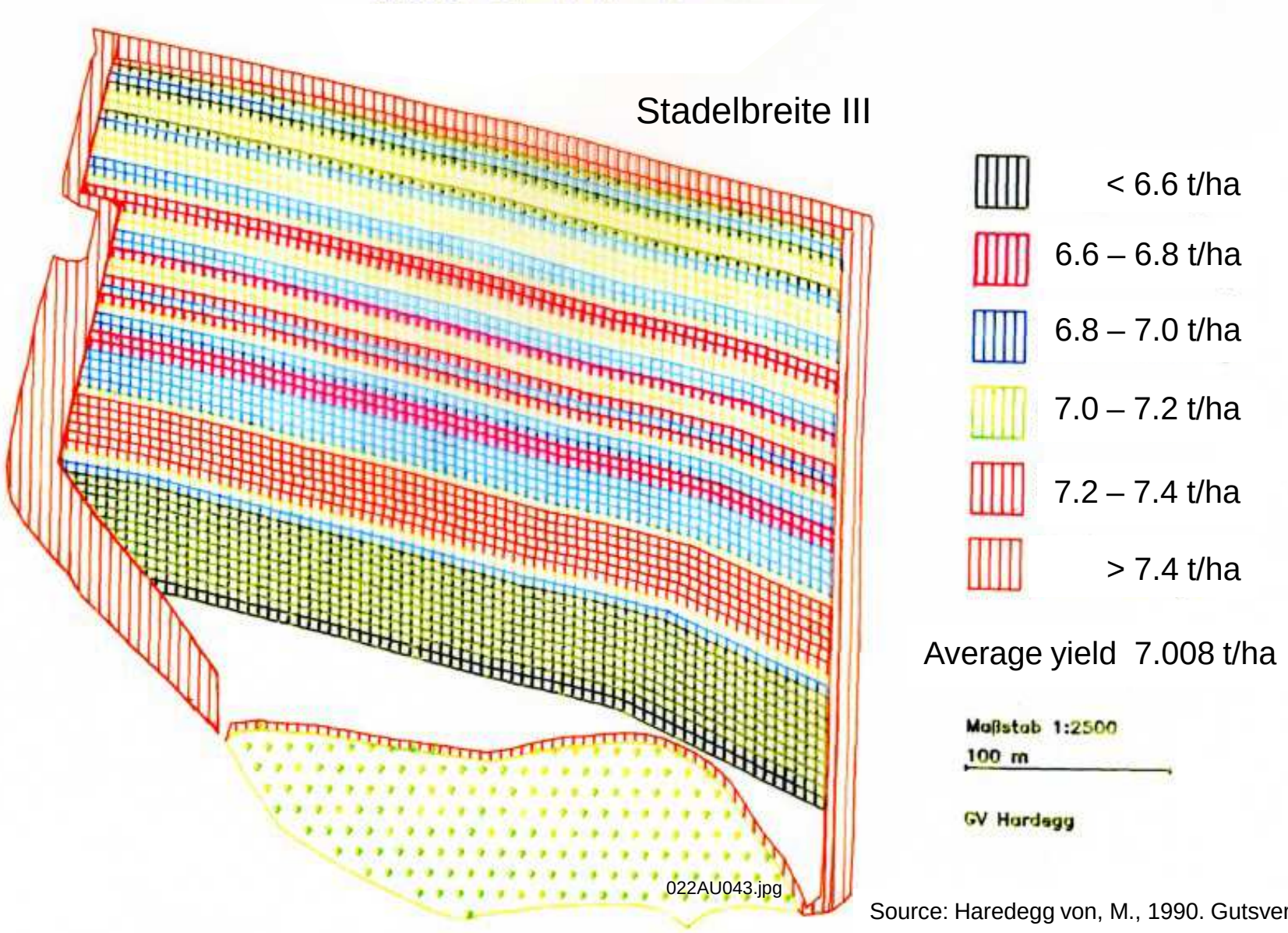


Source: Schueller, J. K., and Y. H. Bae (1987)

? May GPS enable real-time localization with no local infrastructure ?

The first step into „Precision Farming“ in the 80s

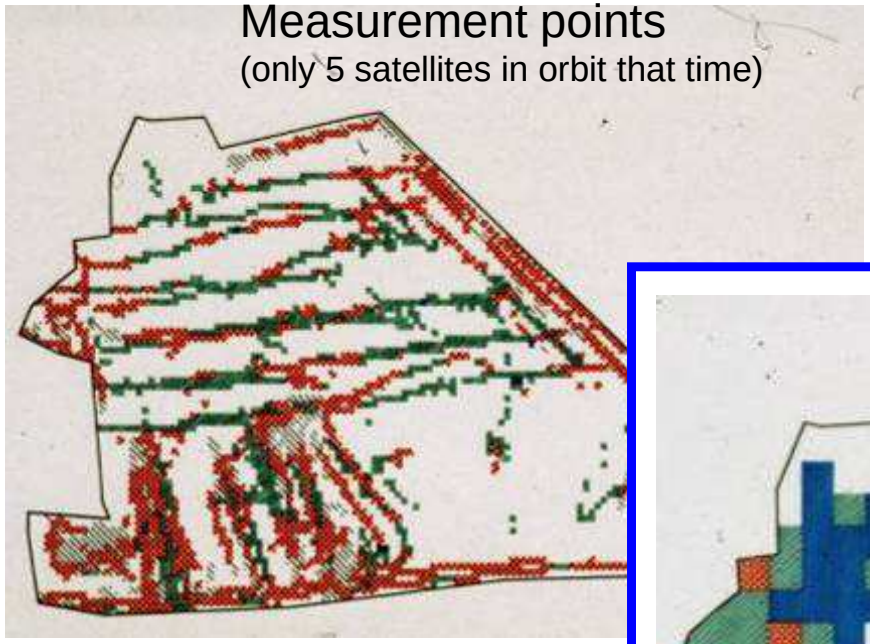
1988 Yield monitoring at farm level (Winter wheat, CLAAS Yield-O-Meter, yield localization by combine tracks, no location sensor , Hardegg Farm, Austria)

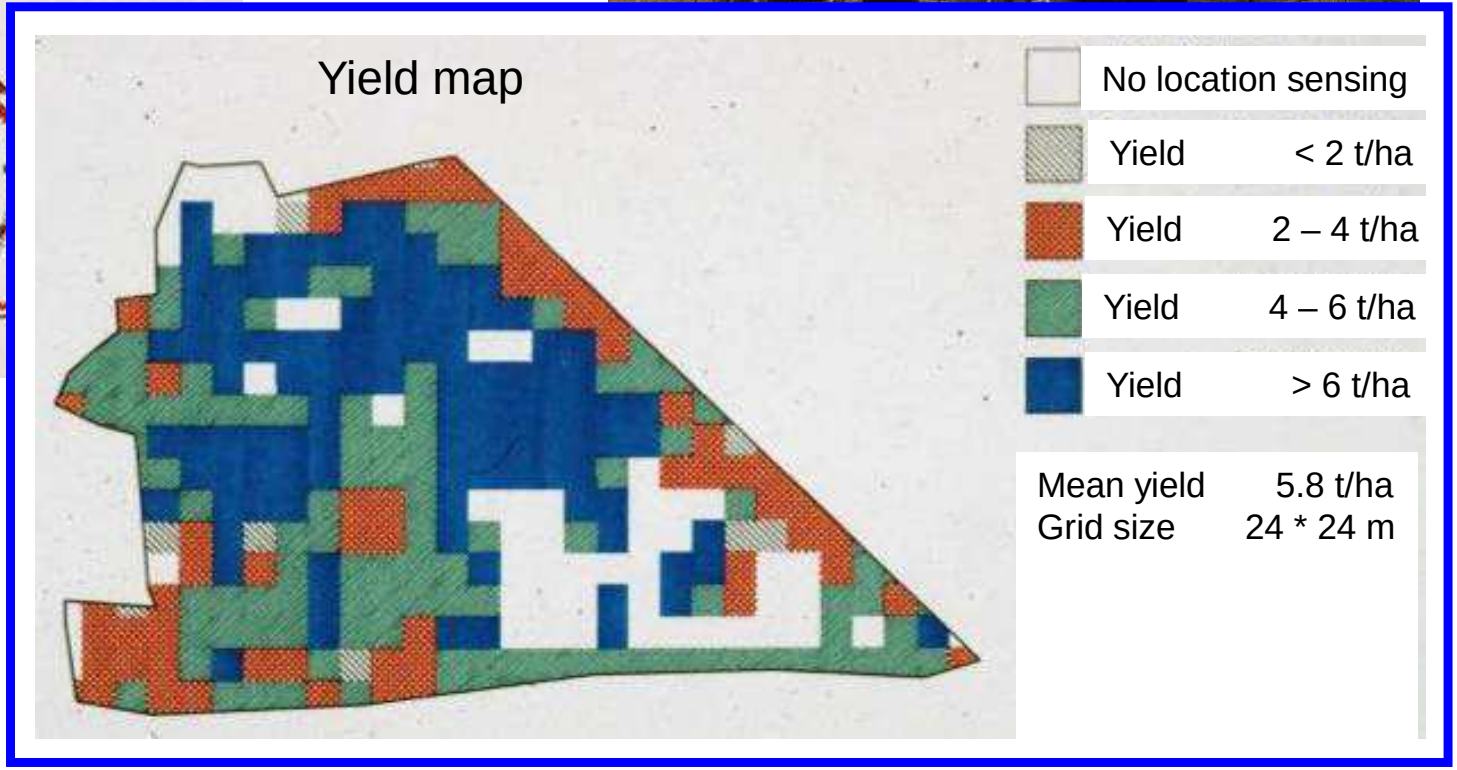


Source: Haredegg von, M., 1990. Gutsverwaltung Hardegg, 6.3.1990

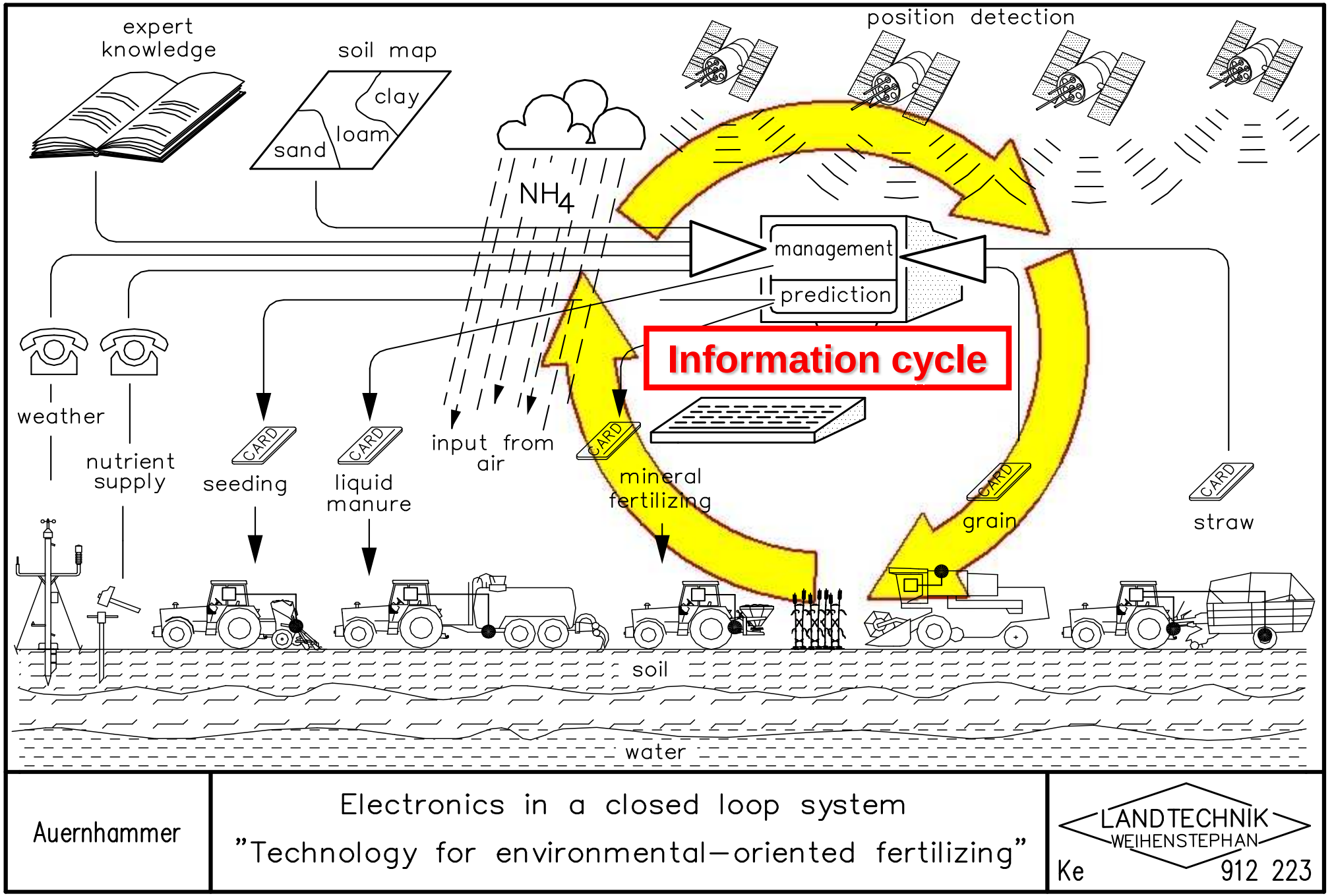
The first step into „Precision Farming“ 1990

1990 A commercially available combine harvester with a **yield sensor** was equipped with a **GPS receiver** in Weihenstephan and tested on 25 ha of winter wheat *(Data safeguarding with KERMIT took more time than harvesting !)*





Precision Farming 1991 – brain to information driven



Automated Agriculture in the 21st Century, St. Joseph (USA) 1991, pp. 494-402

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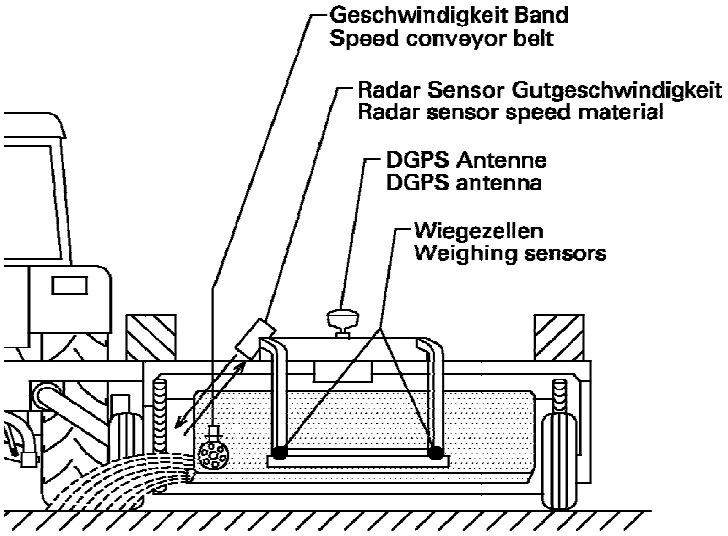
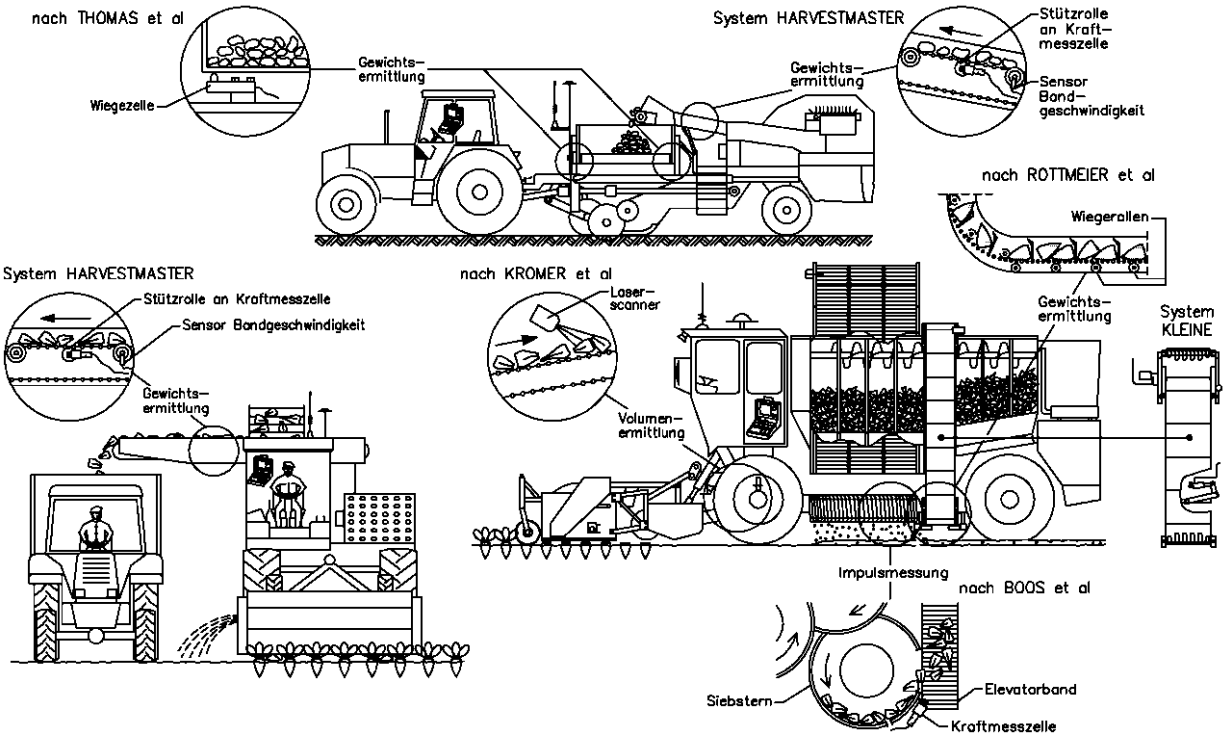
Precision Farming in the 90th - Yield monitoring

Yield monitors for all crops

- After the combine harvesters solutions for (nearly) all crops came up (sugar beets, potatoes, pea nuts, cotton, rice, forage harvesters, balers, …)
- Farmers as well as scientists realised, that the accuracy of a yield sensor is different to those of weigh bridges for commercial use
- Different solutions for data transmission to the farm PC and for yield mapping are available





See also: Vansichen and de Baerdemaeker, 1993; Wilkersen et al., 1994; Wild et al., 1994, Schueller et al., 1999; Durrence et al., 1999; Shinners et al., 2000

Precision Farming in the 90th – Site-specific applications

Site specific applications

- Mainly focused on fertilization
- Mapping approach typically used on large scale farming systems based on soil sensing and yield mapping
- Real-time (Sensor) approach typically used in high yielding areas with sufficient rain fall for N-application
- Both, spin spreaders as well as pneumatic spreaders with company specific controllers and often farm-specific solutions in use

Mapping approach
EM38 collecting soil data on-the-go

Real-time approach:
Sensor system „Kiel“, REUSCH, 1994-1997

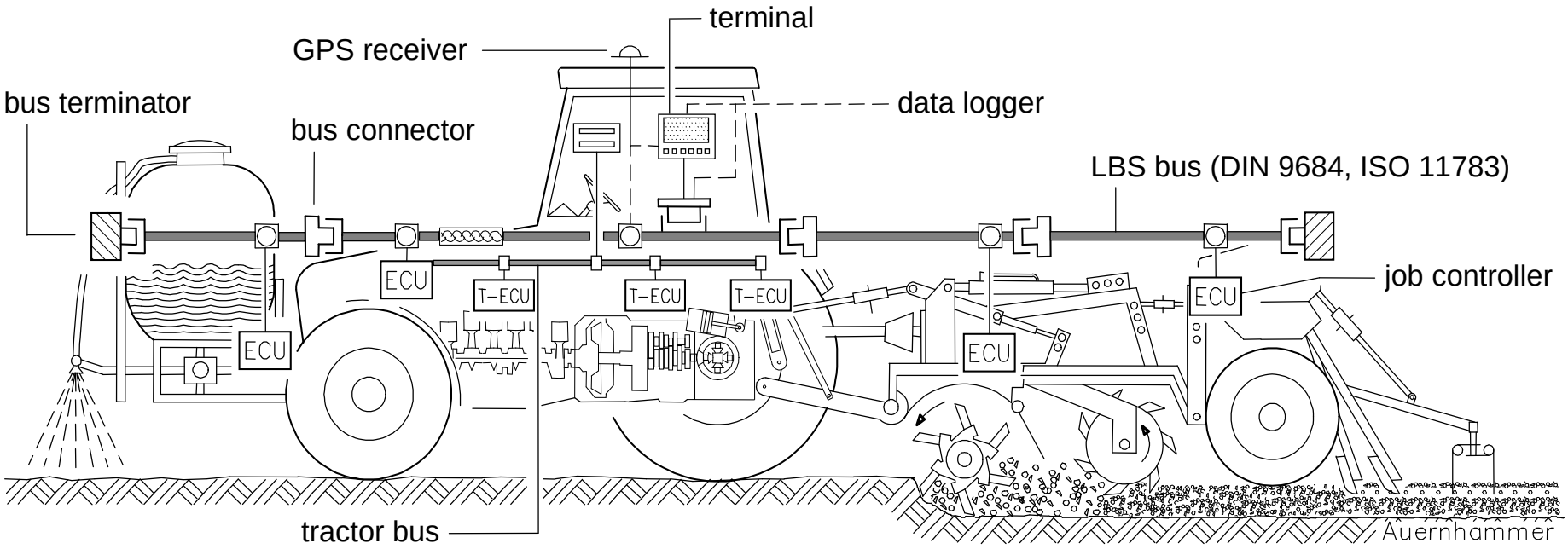
Non-standardized control of fertilizer spreaders by multi-purpose controllers

See also: Carter et al., 1993: Reusch, 1997

Precision Farming in the 90th – Electronic communication

Electronic tractor implement communication

- The European LBS-standardization ($D_{leading\ group}$, NL, DK, F, GB) started 1987
- There was a very early decision to use CAN with ECU's and a "Virtual Terminal" and also to have a connection to the On-Farm management computer
- Standardisation was finished in 1997
- Besides the LBS-standardization the ISOBUS-standardization was initiated by the "LBS-standardization group" in 1990



See also: de Baerdemaeker, J., R. Delcroix, and P. Lindemans. 1985; Searcy, S. W., J. K. Schueller, Y. H. Bae, S. C. Borgelt, and B. A. Stout. 1989)

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Precision Farming 1st decade 2000 – Auto guidance

Auto guidance

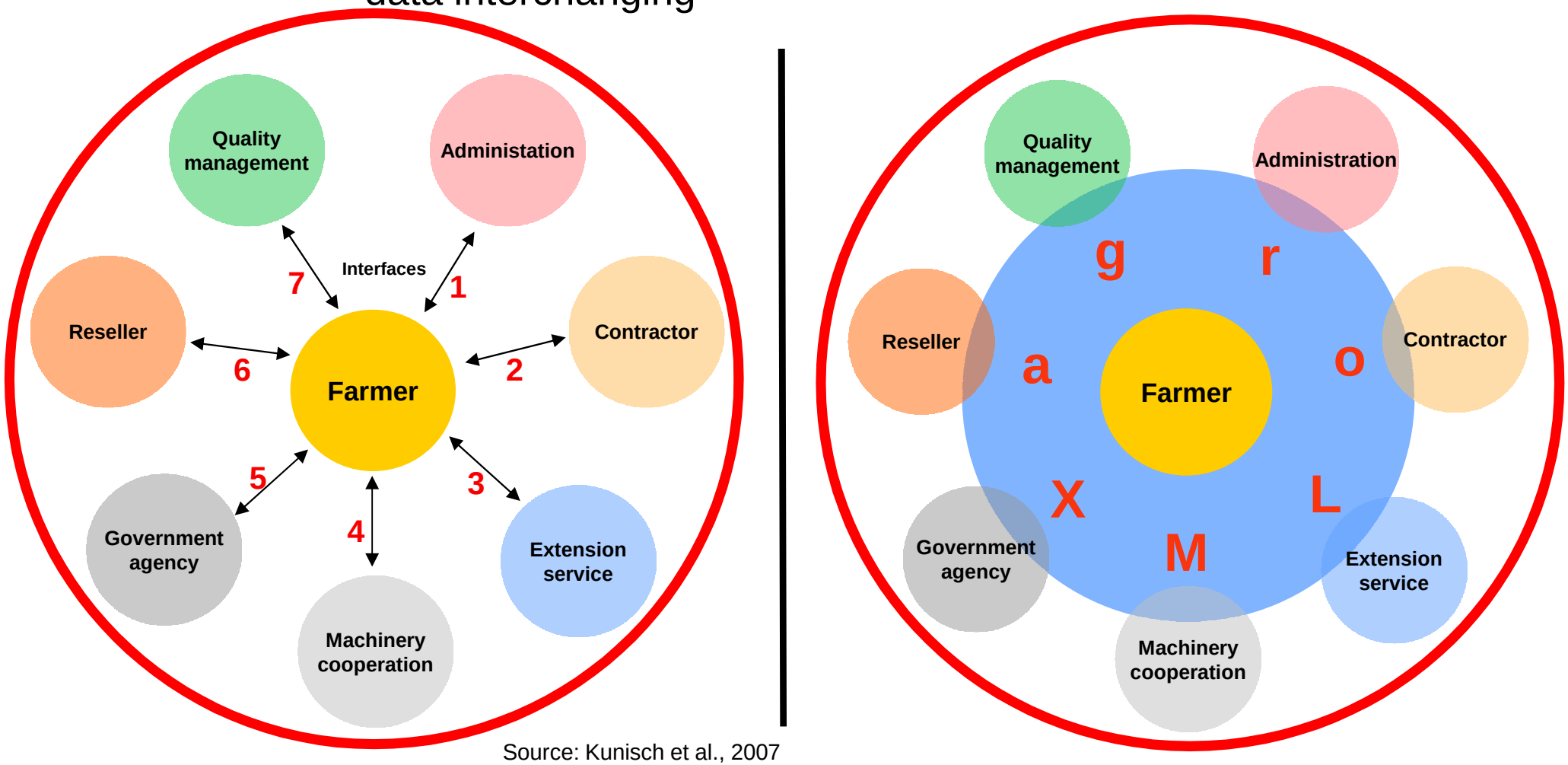
- Different solutions came up to improve the work and to remove high workload from the driver
- Laser guidance for combines
- RTK-Auto guidance for parallel working with no overlapping and work time extension also to night times, fog, dust, others
- Auto turning at headland with headland management systems

See also: de Baerdemaeker, J., R. Delcroix, and P. Lindemans. 1985; Searcy, S. W., J. K. Schueller, Y. H. Bae, S. C. Borgelt, and B. A. Stout. 1989)

Precision Farming 1st decade 2000 – Overall farm communication

AgroXML

- Farm management has increased information exchange
- Any new communication partner has own data specifications and interfaces
- Data manipulation and data transformation is time consuming
- An exchange standard gives freedom, data security and simple data interchanging

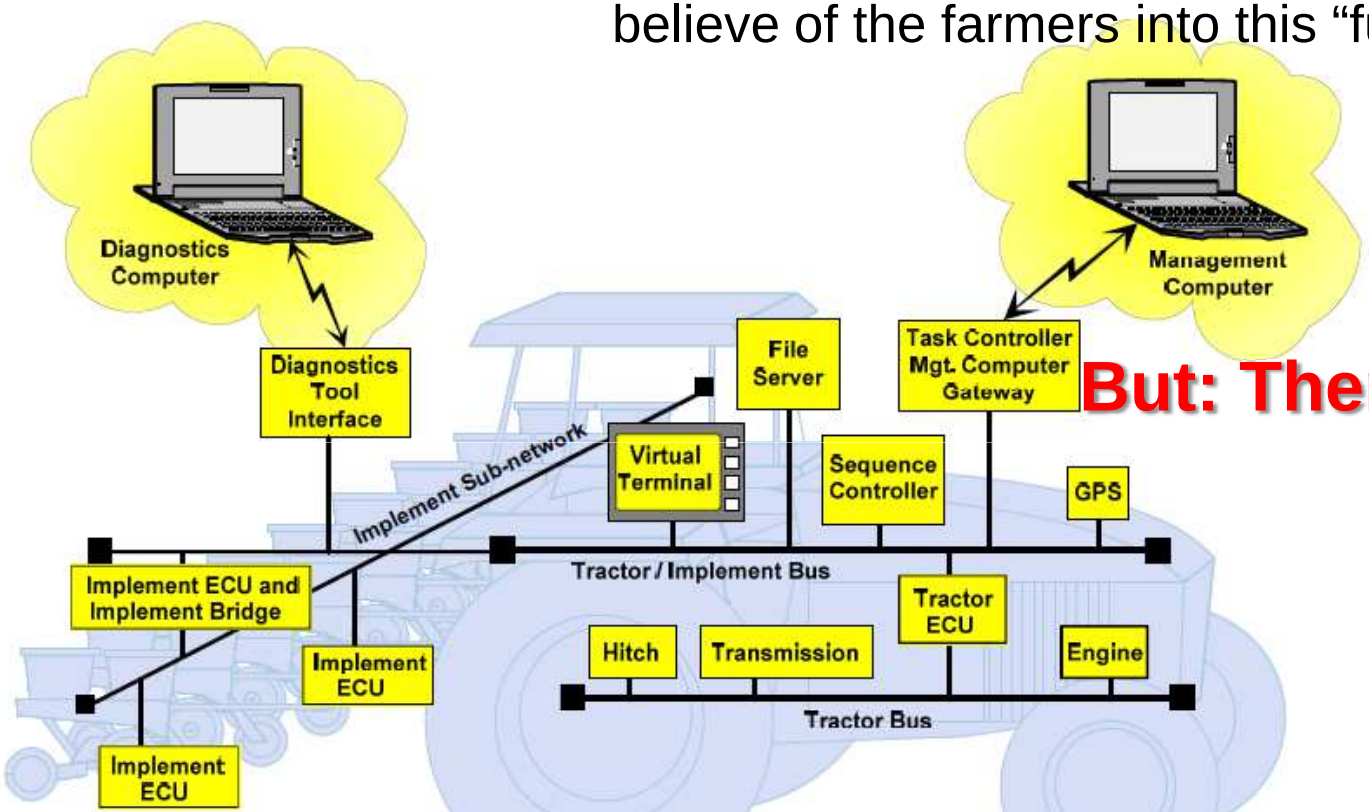


Source: Kunisch et al., 2007

Precision Farming 1st decade 2000 – Communication & diagnostics

ISOBUS

- The standard (beginning in 1990) is still under development, extension and revision
- Many well-sounding announcements during the last two decades were given (and forgotten)
- Still less, low or no real commitments to the standard in the Ag industry
- Bilateral proprietary solutions came up and reduced the believe of the farmers into this “future technology”



But: There is no alternative !

Source: Stone, M. L. (2011). ISO 11783 Part 10 Task controller and management information system data interchange. ASABE AET. http://shieldedpair.net/downloads/ISO%2011783%20Part%2010.pdf

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Commonalities related to “Precision Farming”

Scientists

- Have very often restricted understanding of “real farming” of today and tomorrow
- Are often “Lone Fighters” or have no teamwork abilities / facilities
- Should do more in sensor development and sensor integration
- **Should things make simple**

Manufacturers

- Have still problems with ICT, especially related to in-house acceptance and in-house integration
- Try to be dominant and have company-specific “add on’s”
- Have a certain distrust to standards
- **Need pressure from competitors**

Farmers

- Are willing to accept and adopt ICT solutions, bigger farms more than smaller ones
- Lost believe in well formulated announcements
- Be often “alone with their problems”
- Prefer “simple solutions”
- **Need more farm-specific/regional-specific solutions**

Commonalities related to “Precision Farming”

Scientists

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- Are o
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- **Shou**

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- Have
  accep
- Try to
- Have
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- Are w
  more

Two main results (constraints) **of today** (in 2010)

No fit to farm management (heterogeneity, nitrogen fertilisation)

No real widely accepted communication standard

? **How to overcome the constraints** (each solution creates new expectations, results and constraints) ?

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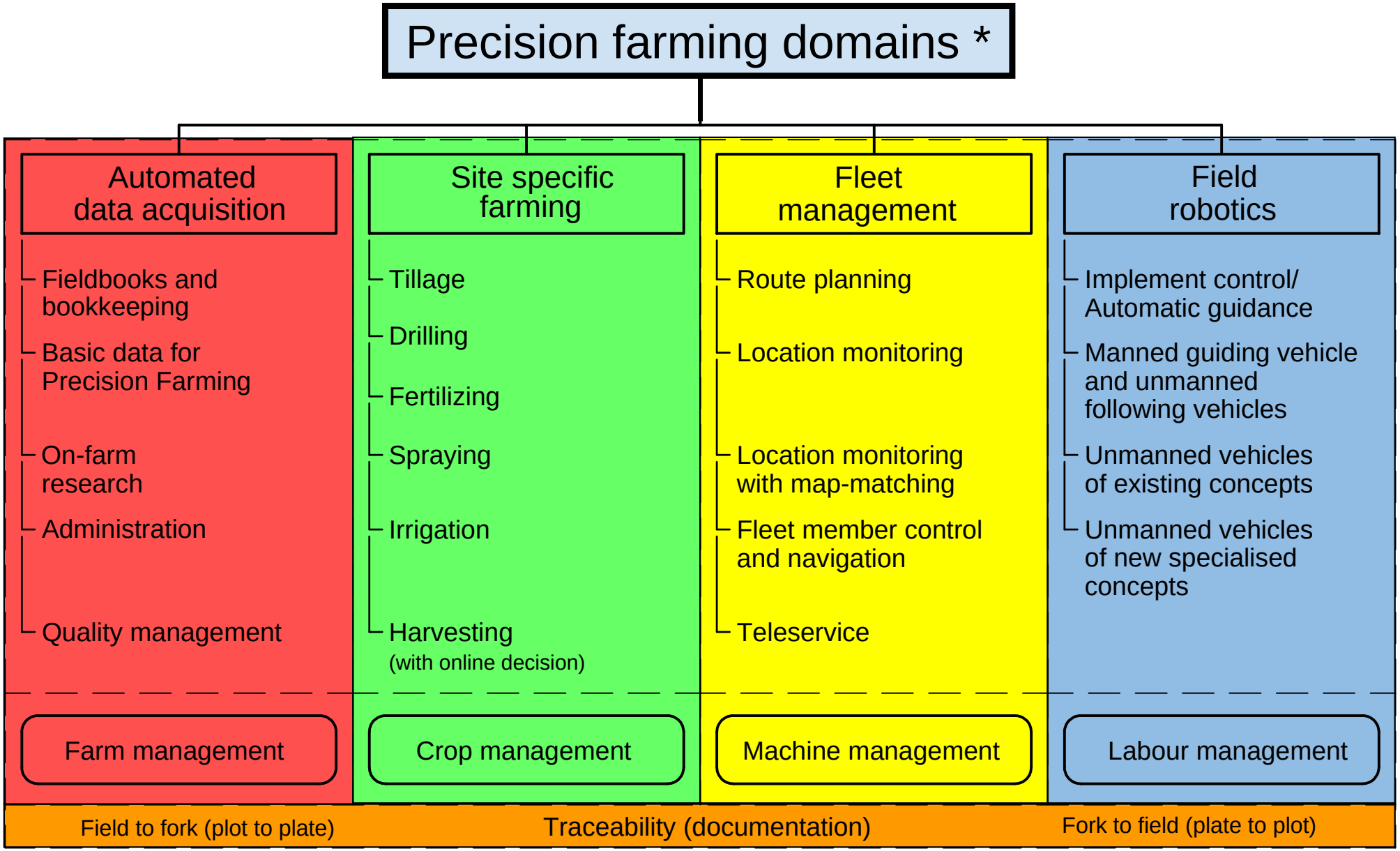
„Precision Farming“ more than “Site-specific Farming”

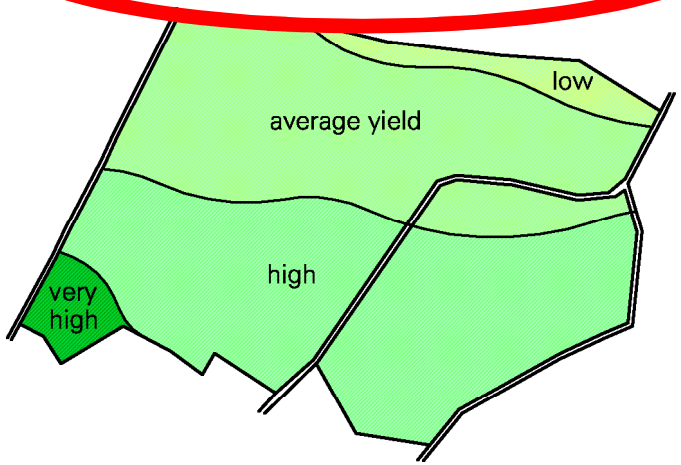


*) First draft established 2001, Dec 4 by the author

The two directions of Site-specific Part Field Management

Site-specific crop management

Large-scale farming

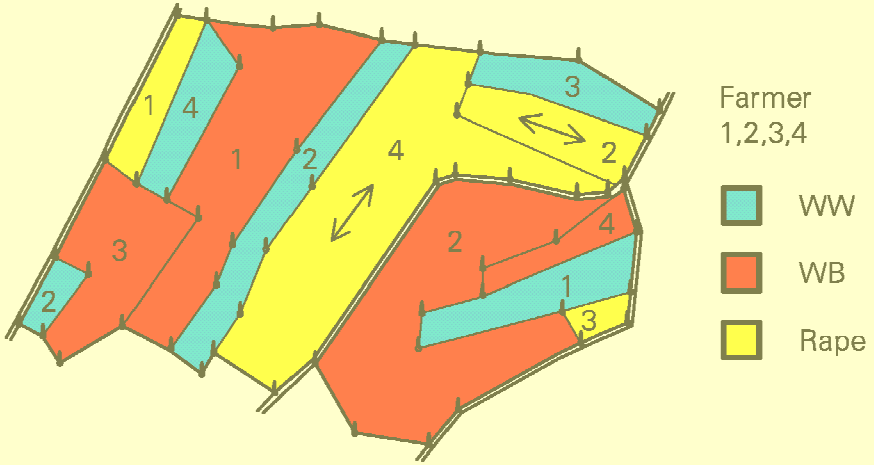


Derivation and determination of homogeneous partfields

- Determination of heterogeneities
- Determination of management zones (same yields) under consideration
  - · Technical differentiation
  - · Economical efficiency
  - · Ecological efficiency

Part field determination by minimum field sizes
(> 3 ha to > 10 ha)

Small-scale farming



Consideration of part fields from different land lords in a transborder field

- Assembling of small fields with equal crop rotation
- Definition of part fields from ownership/field operators
- Field operations by common operation target
  - · Ownership
  - · Common yield target
  - · Heterogeneity

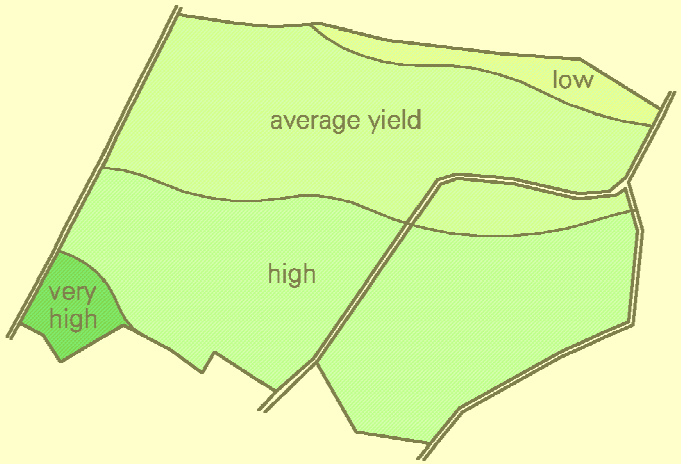
Size of transborder fields limited by existing infra structure (roads, ditches, ...) and crop rotation

The two directions of Site-specific Part Field Management

It is estimated that **2.6 billion people or 40 percent** of the world's population are small farmers. The large majority of them cultivate **less than five acres of land.** *(http://www.greenpeace.org/usa/en/campaigns/genetic-engineering/our-vision/small-scale-farming/)*

Site-specific crop management

Large-scale farming



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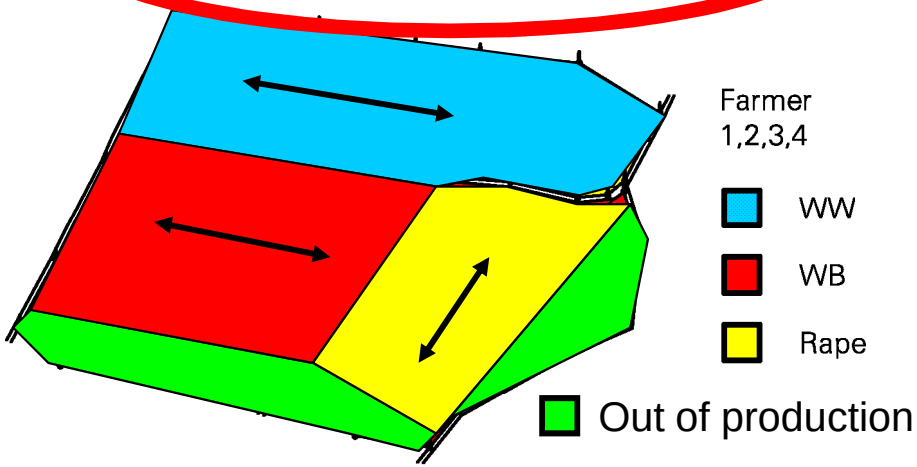

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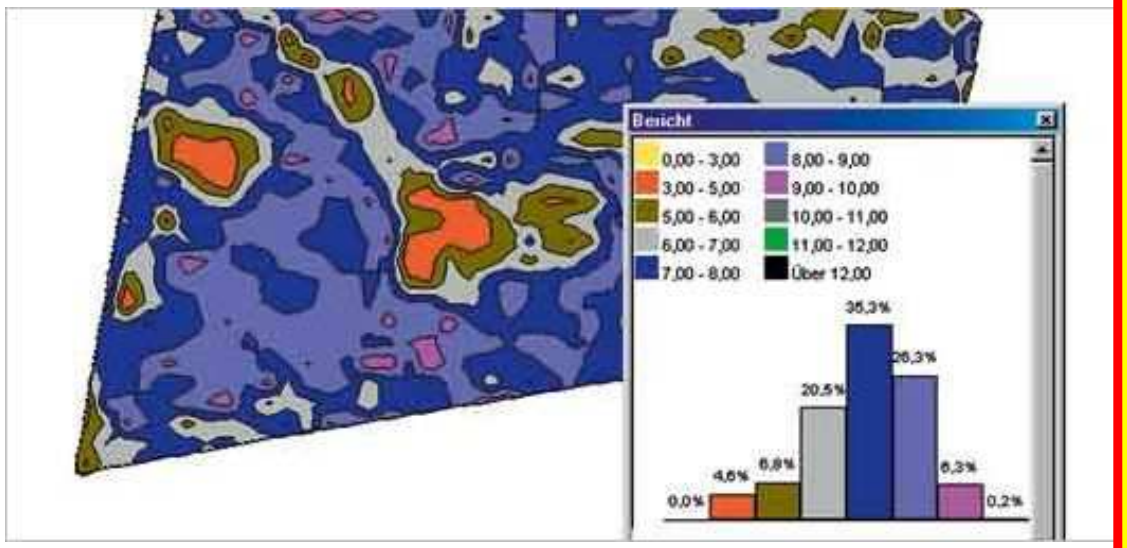
Yield maps – what we get !



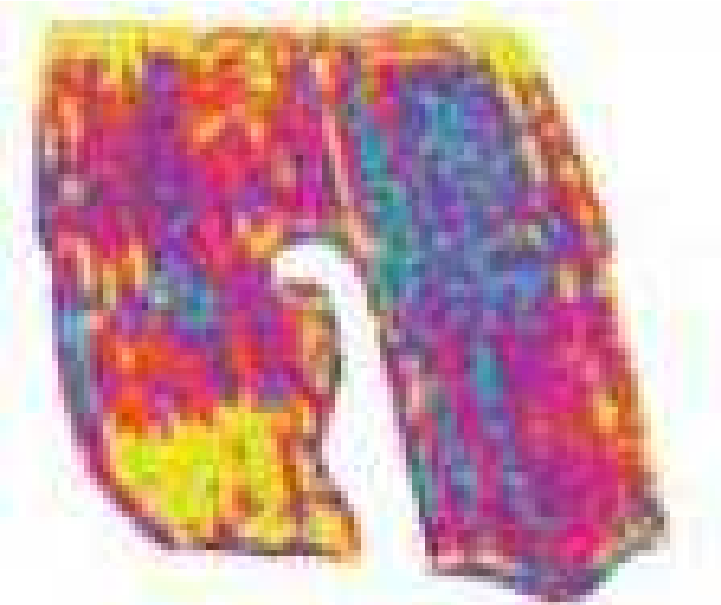
http://www.claas.com/countries/generator/cl-pw/de/products/agrarmanagement/ertrag

Downloaded July 7, 2009

Coloured pictures!

Why:

- Yield classes separated by 1 t/ha ?
- Colour “black” is highest yield (black means “mourning”) ?
- Other colours used by other companies ?



http://www.deere.de/de_DE/products_ag/ams1/ertragskartierung.html

Downloaded July 7, 2009

What to do if a farmer is:

- Using combines of different companies on same field at same crop ?
- Using combines of different companies year by year ?
- Having combinable and non-combinable crops in the rotation?
- …

Yield maps – what we need !

1) Yield means **absolute yield** (dry matter, protein, starch, ...)

2) Yield classes must be separated by need/capability of adjacent technology, related to a
   - significant **different amount** (precisely controllable),
   - minimum **working length** (system reaction time),
   - minimum **acreage** (field size, field shape, working width of implements)

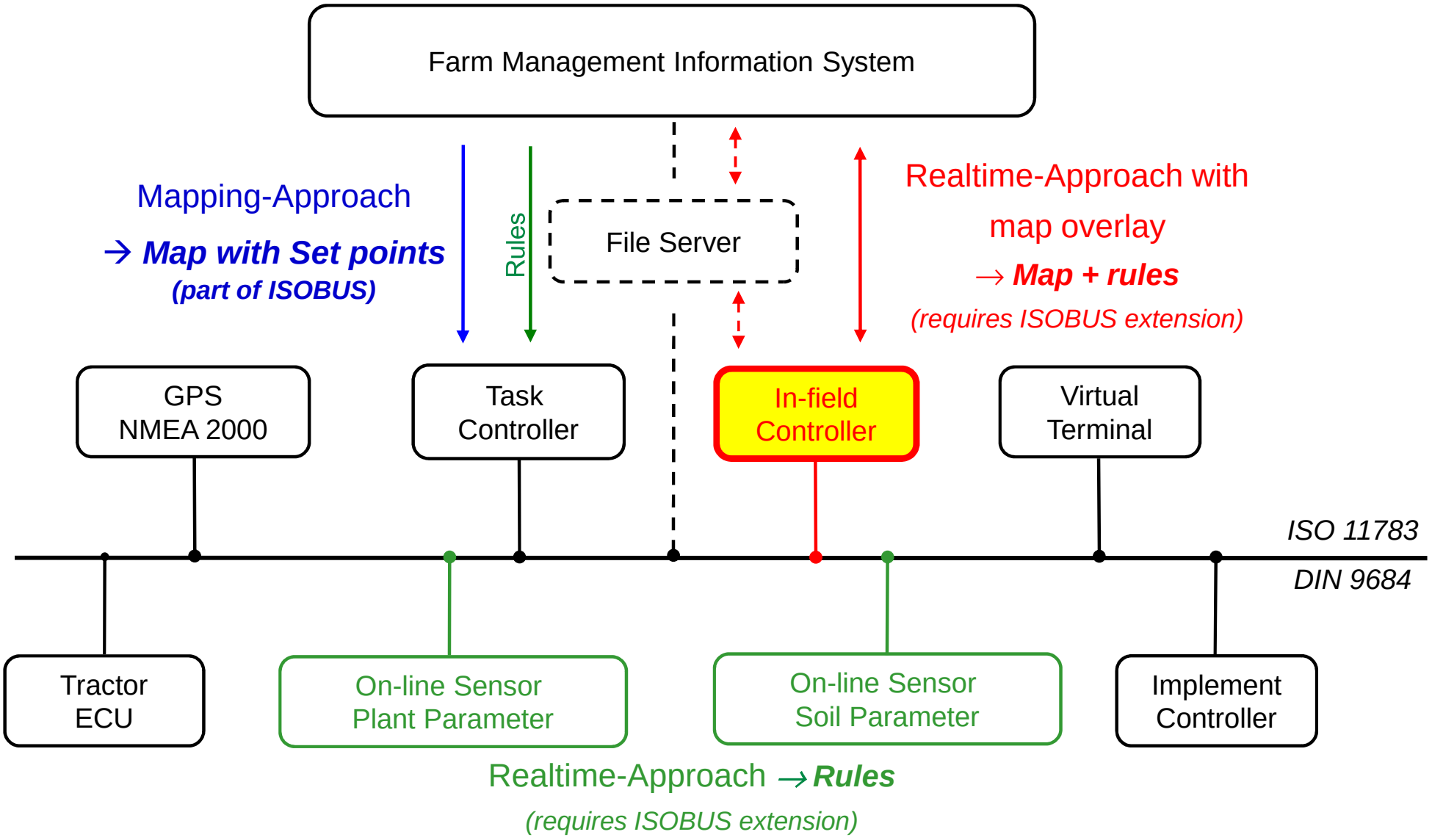
3) A decision tree differs to a maximum of 4 different yield types
   - **no** in-field yield variation (uniform application/processing),
   - **high** and **low** yield zone(s),
   - **low**, **average** and **high** yield zone(s)
   (- very low, low, average, high and top yield zone(s))

4) Standardised colours enable simple understanding and true reproducibility like “traffic lights”, related e.g. to
   - economics (**red “expences higher than revenues”,** yellow “…”, green “ … “)
   - quality (**red “poor”,** yellow “..”, green “ … “)
   - environment (**red “high pollution”,** yellow “…”, green “ … “)

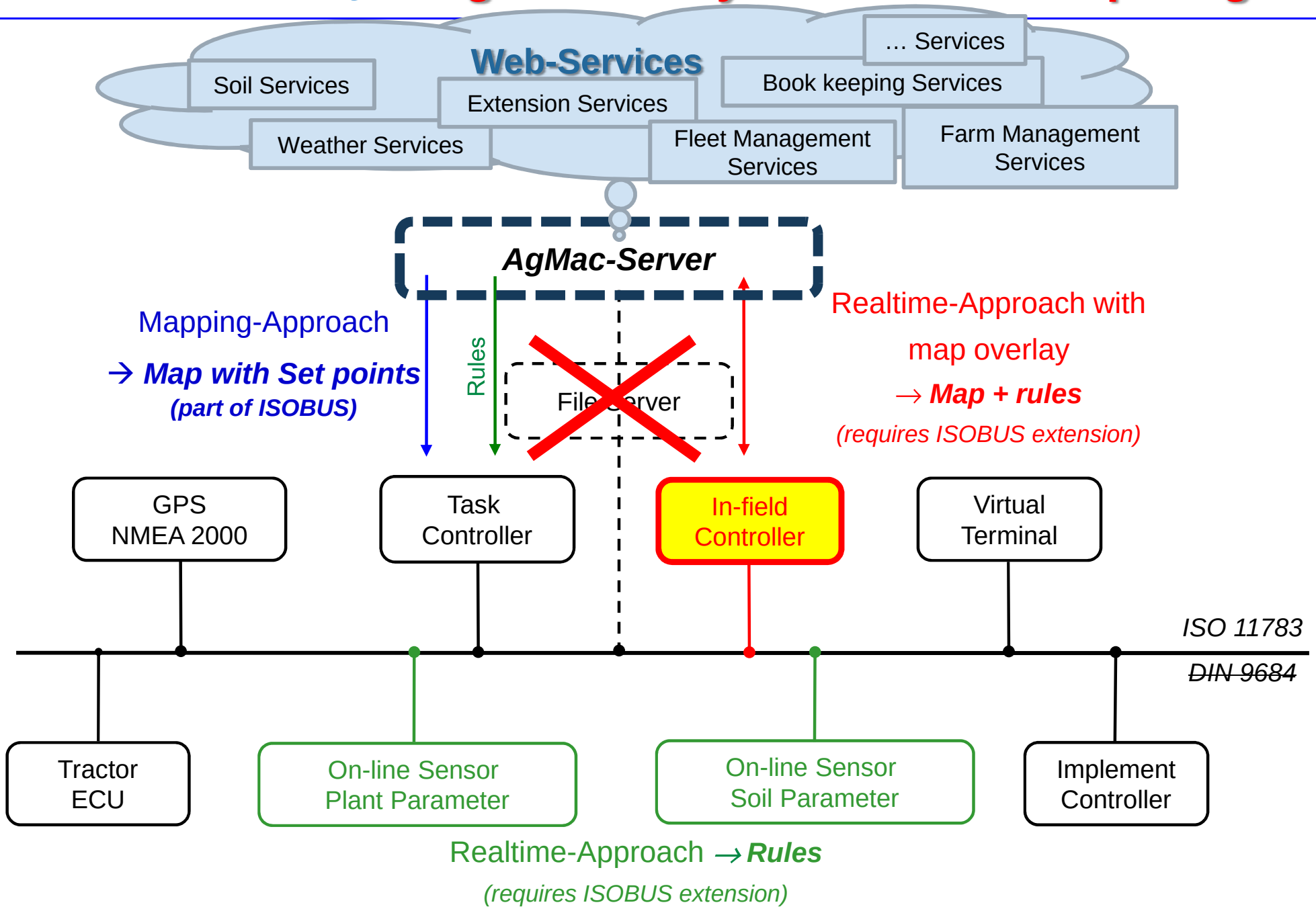
→ **No beneficial On-farm use without an ISO-standard !**

ISOBUS - On-the-go implement control with sensor fusion

ISOBUS compliant “In-field Controller” (by OSTERMEIER 2005)



Precision Farming – "Ag-Machinery and Cloud Computing"



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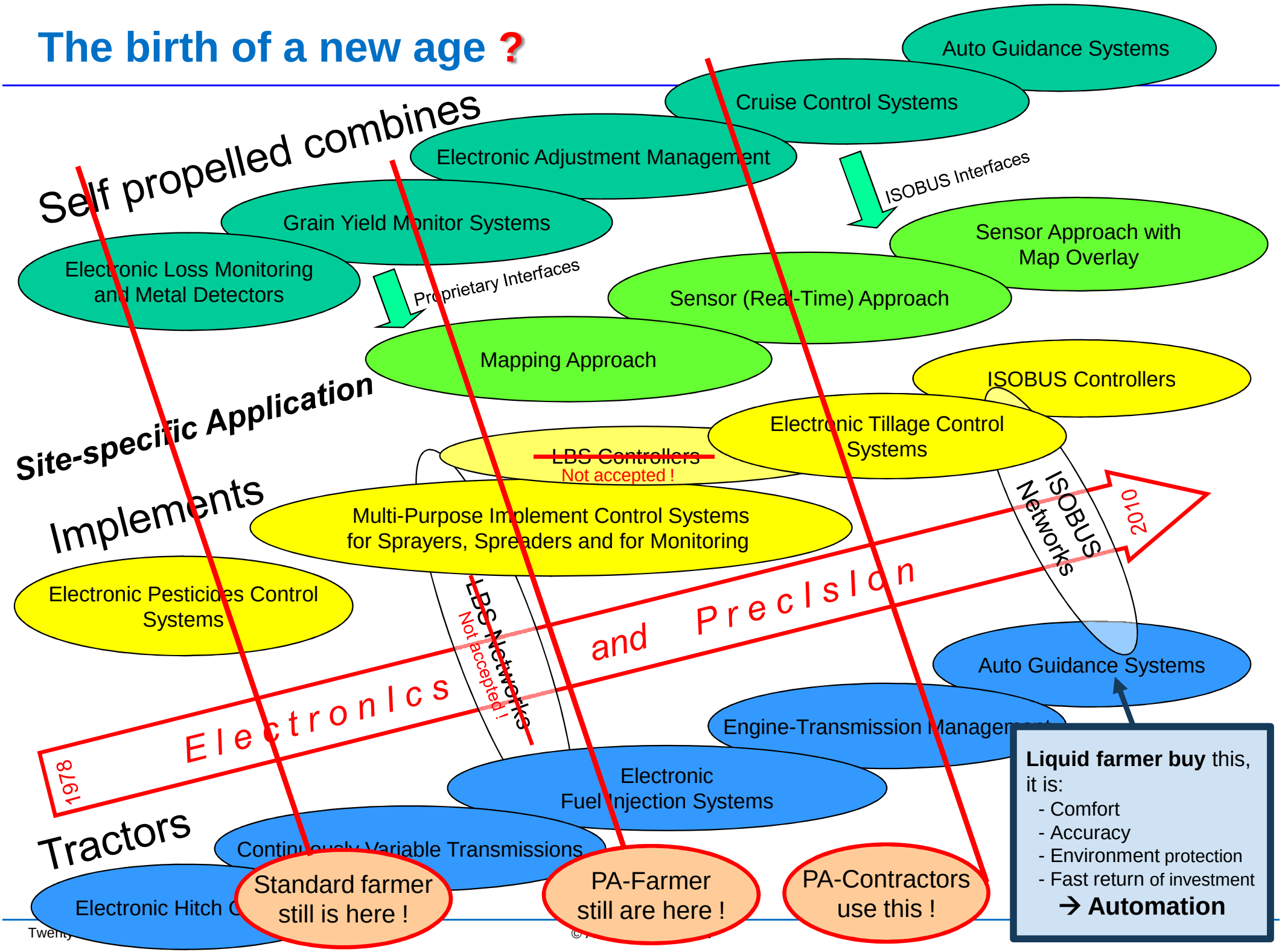
The birth of a new age ?



High power automation - heavy pull-type versa powerful drive ?

1978: Big Bud with 900 hp

Most powerful tractor worldwide

58,9 t of weight (15.3 hp/t)

2006: BigX 1000 by KRONE with 1020 hp

Most powerful agricultural machine worldwide

14,9 t of weight without header (68.5 hp/t)

→ **A dwarf !!!**

Higher power density

less mass
less fuel consumption
less soil compaction
less resource consumption (material, energy, …)

→ **Self-driven** instead of **pull-type** technology for **tomorrow !**

Low power automation – small robots

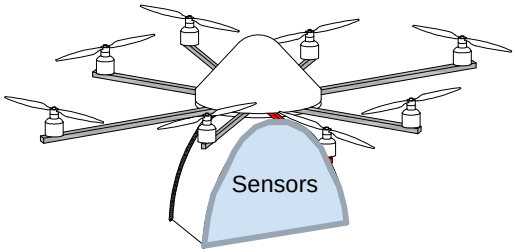
Are we able to harvest with this technology from 50 up to 180 t/ha in a limited time span?

→ *N o !!!*

Source: Blackmore, S.: A specification for an autonomous mechanisation system. Guangzhou (China) 2008

Mini-Robot – the two types of tomorrow and after tomorrow ?

In the air
(at a virtual rope)



Intelligent platform type

- Highest maneuverability
- Lowest soil compaction
- Self-contained through solar technology and GNSS

Specified to:

- Permanent monitoring
- Cognitive abilities related to part fields and to single plants
- Mechanical/physical plant protection measures
- Chemical plant protection measures if required

Simple (stupid) ones like

- Vacuum cleaners
- Lawn mowers

→ Lets work them twice or even more times at the same spot, its only important that it does everything in a certain time and went back to the maintenance station !

Mini-Robot – the two types of tomorrow and after tomorrow ?

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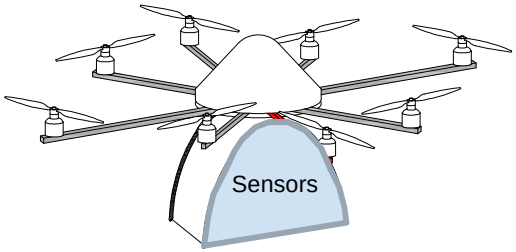


Intelligent platform type

- Highest maneu
- Lowest soil co
- Self-contained

Specified to:

- Permanent mo
- Cognitive abilit plants
- Mechanical/ph
- Chemical plan

Wise only, if

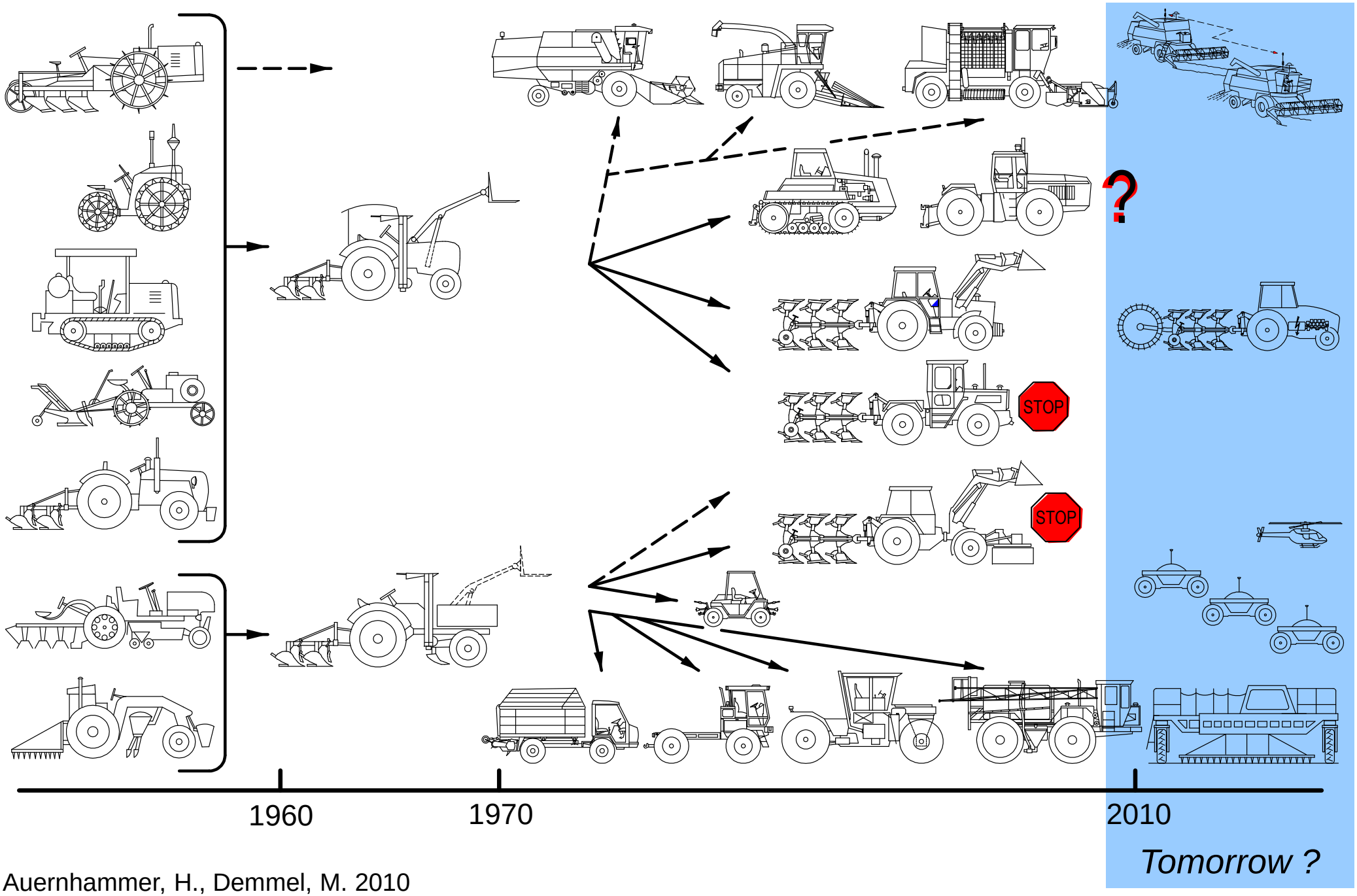
- **Restricted area**
- **Enough time for finishing**
- **Specific tasks**
- **High value crops**
- **Selective harvesting**
- **…**

Simple (stupid) ones like

- Vacuum cleaners
- Lawn mowers

→ Lets work them twice or even more times at the same spot, its only important that it does everything in a certain time and went back to the maintenance station !

Self propelled farm machinery - yesterday to tomorrow



Auernhammer, H., Demmel, M. 2010

Tram line → controlled traffic system of 3dr millennium

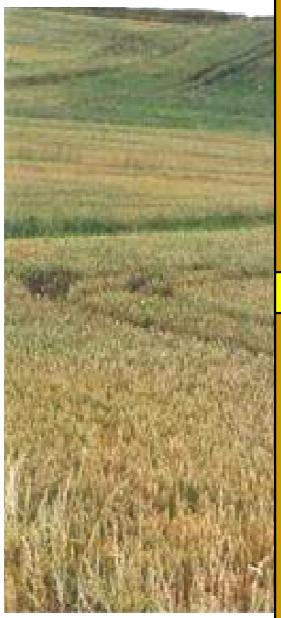
This is farming of today (not only in Europe) !

- **Well known and experienced by farmers since the 70th**
- **Used for fertilization (2 to 3 passes) and spraying (1 to 2 passes) operations mainly, sometimes also for harvesting in "skipped passes" (when tram line distances correlates with multiple harvester working widths)**
- **Less overall soil compaction**
- **No significant reduction in yield**

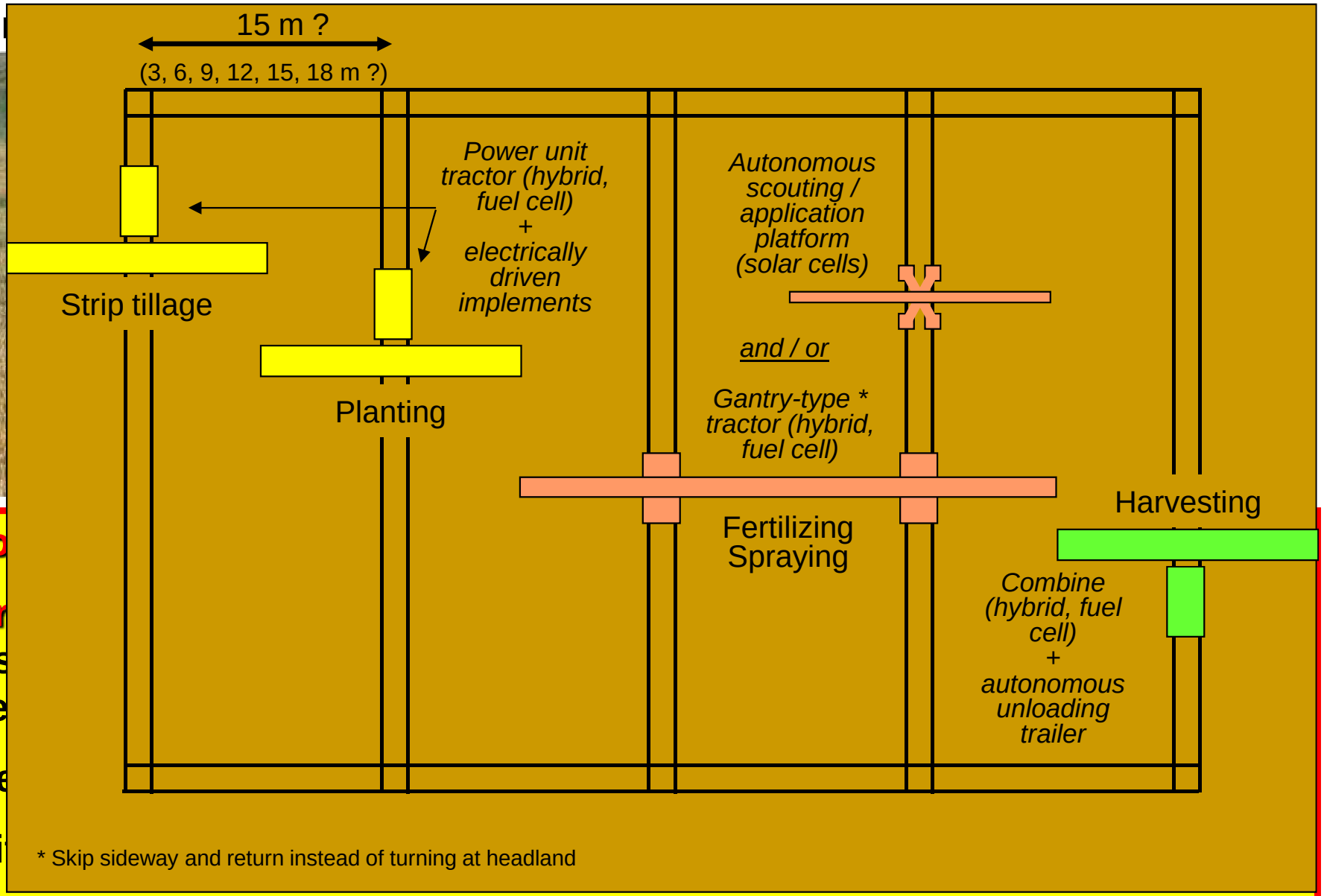
→But still organized for wide-span application technology only ! ??? and with "Auto guidance systems" too !!! ?

Tram line → controlled traffic system of 3dr millennium

This is farmi



- Well kno
- Used for
  mainly, s
  distance
- Less ove
- No signi



→ But still organized for wide-span application technology only ! ???
and with "Auto guidance systems" too !!! ?

Tram lines - in grassland production too ?

Cultivation system of today

Cutting, tedding and windrow technology with increasing working width

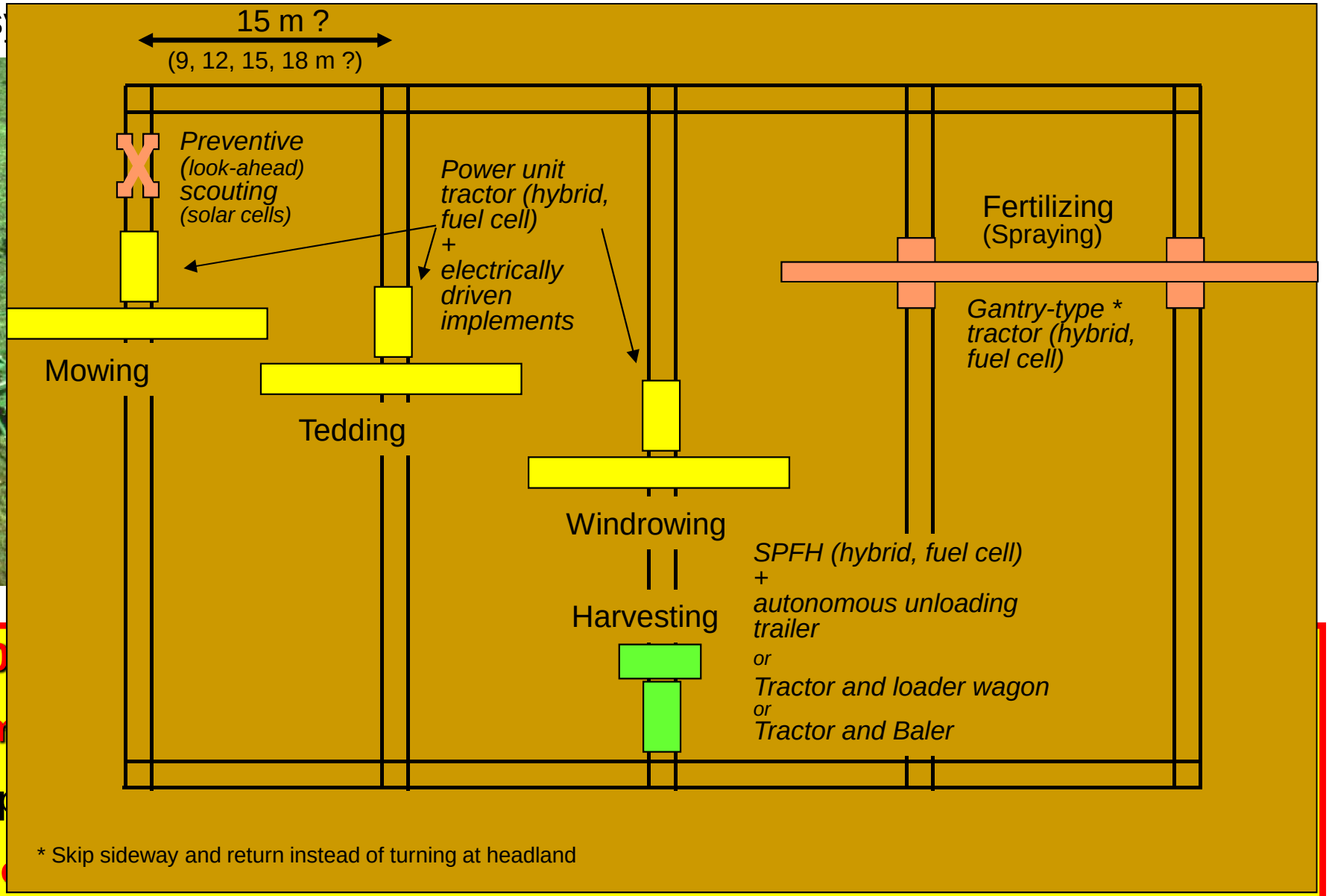
(up to 15 m)

But:

- **Up to 40 % losses during preparation !**
- **Soil compaction in grassland not directly to see !**
- **Also application errors show lower depreciation in yield and quality !**
- **Driving on the feed is still accepted !**
- **Also the „rustic rotary technology“ is still accepted !**

Tram lines - in grassland production too ?

Cultivation s



- Up to 40
- Soil com
- Also app
- Driving
- Also the „rustic rotary technology“ is still accepted !

Systematic of Agricultural Robotics (Auernhammer 2009)

Robotics in Agricultural Farms

Medium & Large – Robots (2015) *

Are working as half or fully autonomous **machine systems** at scalable productivity

Technology available

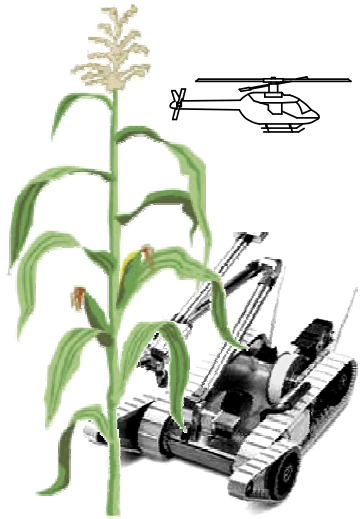
First applications as leader-follower systems in research

Mini – Robots (2015)

Are working **around** plants from seed to harvest or in front of heavy self driven units

Singular solutions exist

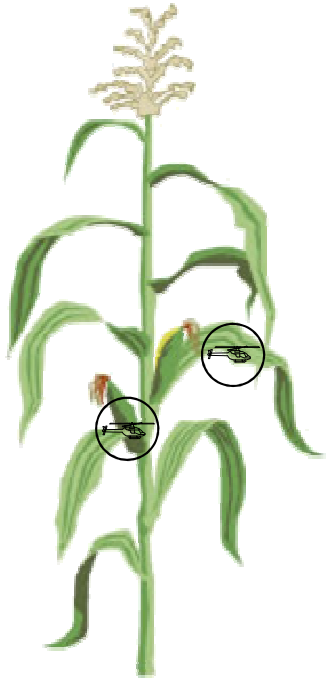
Handling of large masses in short time is limited



Micro – Robots (2020)

Are working **at** the plant to improve health and growth

First ideas and applications known



Nano – Robots (2030)

Are working **within** the plant to improve health

Future vision

* Expected to be at farm level

Agenda

1. Visions from yesterday
2. First steps in the 80th
3. Precision Farming in the 90th
4. Precision Farming in the 1st decade 2000
5. A critical valuation of Precision farming today
6. Adoptions to the needs of the farmers
7. Automation for tomorrow

8. Conclusions

Conclusions

Yield sensors and electronics came up as door-openers for Precision Farming in the early 90th

Electronic controllers for precise application in fertilizer spreaders and sprayers are today state-of-the art

ISOBUS would guarantee standardized electronic communication but is still not in use on farm level for some reasons

Site-specific application still suffers due to poor adoption to the needs of farmers, but real-time application systems are greatly accepted and mainly used by contractors as well as by large farm units

As far as precision farming is more than site-specific treatment farmers prefer **auto-guidance** systems to gain comfort through automation and fast return of investment

Automation and **alternative energies** will gear agricultural mechanisation after handwork, animal draft and mobile crude oil power into a new age

Precision farming then will really come to the farm level if science and industry are willing and able to cope the new challenges