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Department of Sustainable Agricultural Systems
Institute of Agricultural Engineering

Operational Sensors in Agriculture

Institute of Agricultural Engineering

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Department of Sustainable Agricultural Systems
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Overview

1. Precision farming
2. Sensor systems for precision crop farming
3. Challenges for the future development

1. Sectors of precision farming

precision farming

- precision crop farming
  - precision row crop farming
  - precision field crop farming
- precision live stock farming
  - precision animal manag.
  - automation and robotics

1. A short sidestep: precision live stock farming

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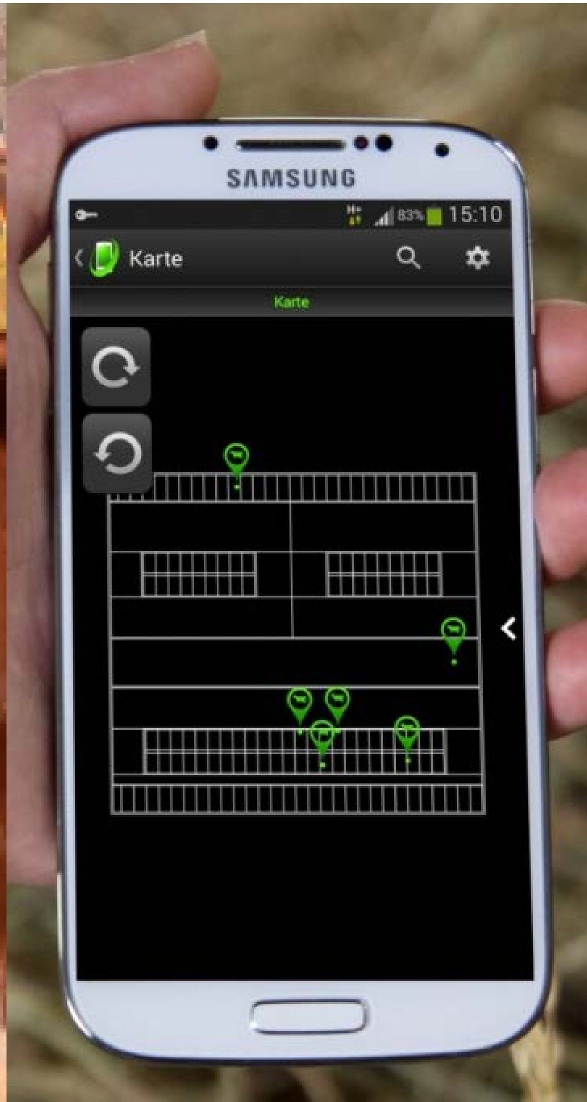

1. precision crop farming
the vision of the early 90ies

(Auernhammer and Schueller 1991)

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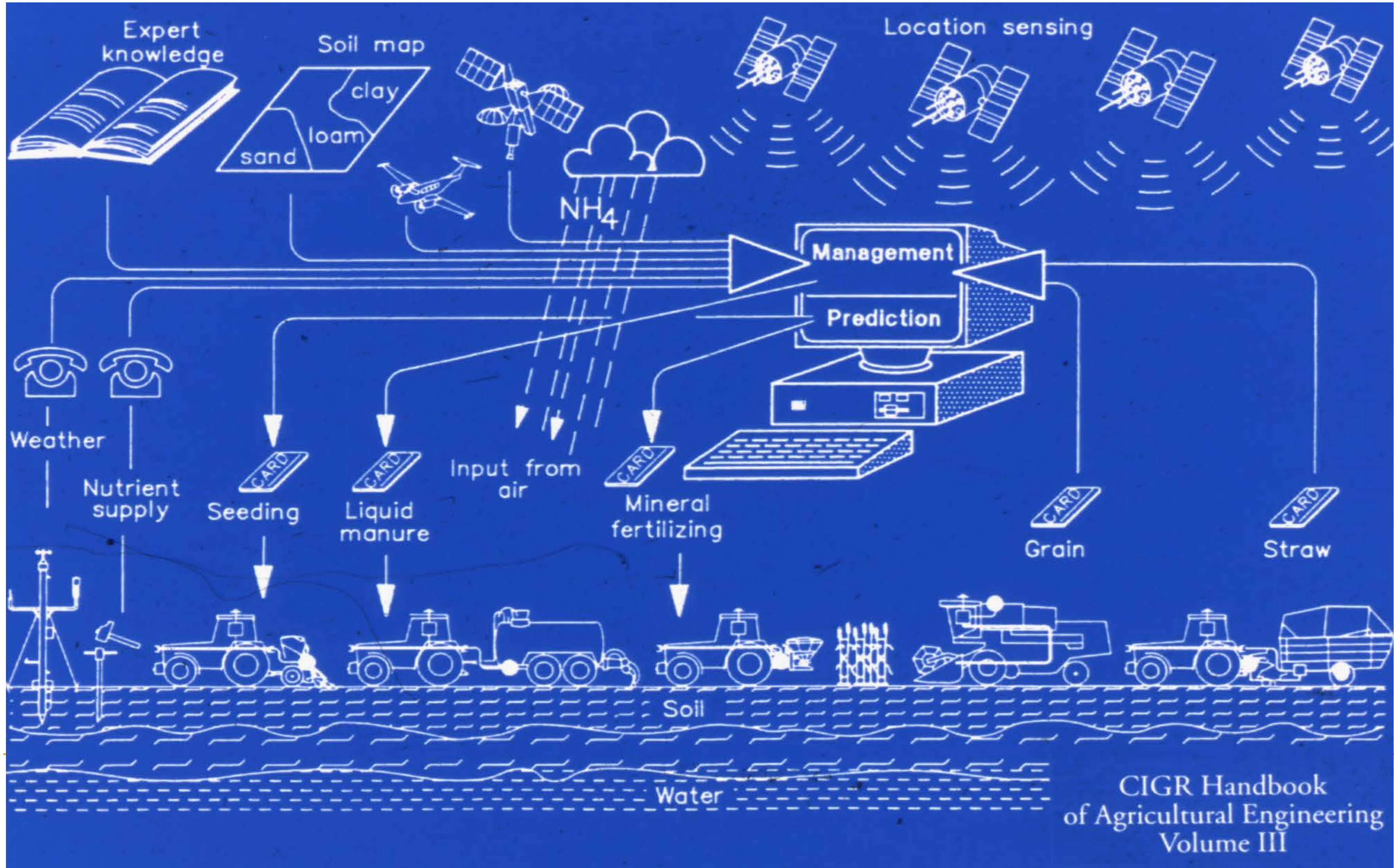


2. Sensors for precision crop farming: Positioning

currently 4 technologies for satelite navigation :

- autonomous (GPS, GLONASS, BeiDou, GALLILEO),
- wide area differential GPS (WADGPS),
- precise point positioning DGPS (PPP DGPS),
- real time kinematic (RTK)

Positioning accuracy

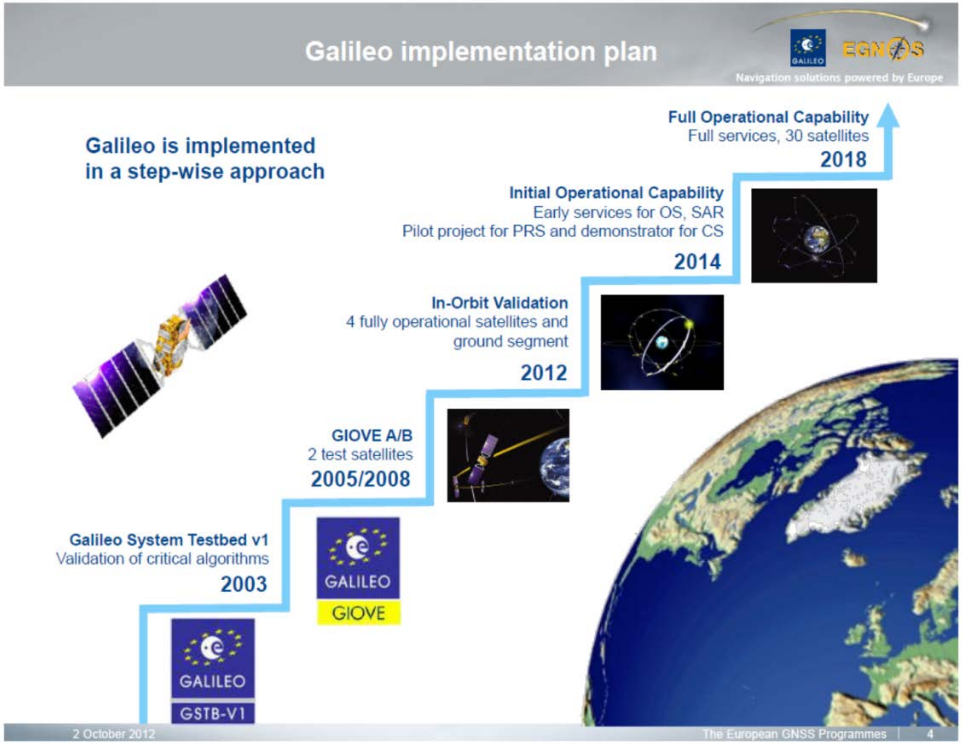
(Circular Error Probability, CEP):

autonomous: <10m

WA DGPS: 0.5-2m

PPP DGPS: 0.04-0.5m

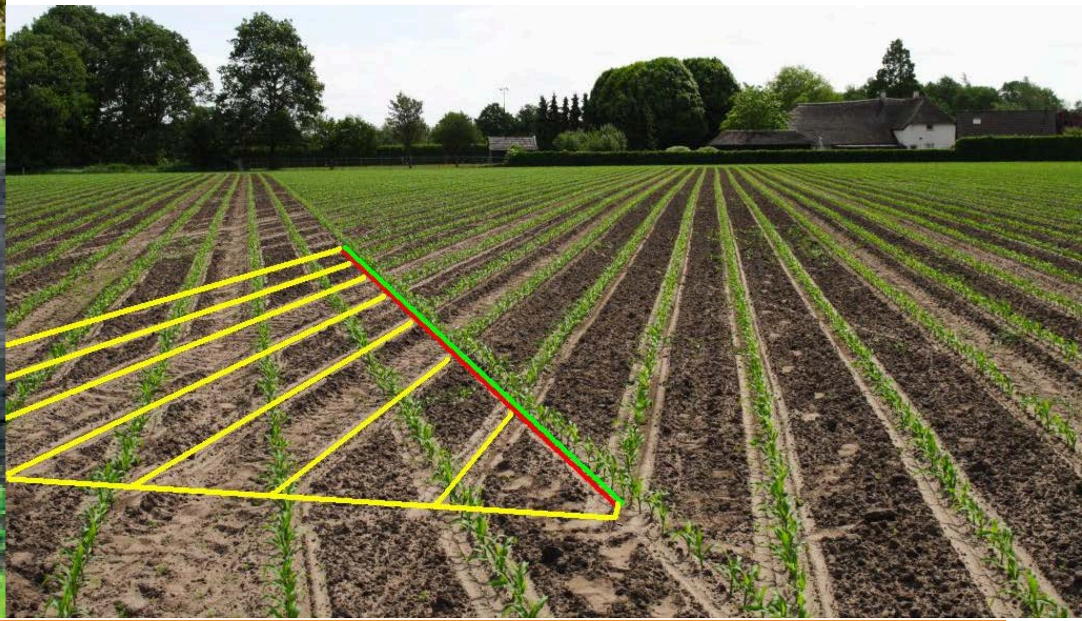
RTK: 0.015 - 0.05 m



Hayes, 2012, European Commission,; IGS-workshop, Olztyn, Poland

2. Sensors for precision crop farming: Reduced overlap by automatic steering system and RTK-georeferred seeder

reduction of resource input (seeds, fuel, fertilizer, pesticides, working time)
about 15%



2. Sensors for precision crop farming Mapping or online N sensoring for the fertilizer broadcasting

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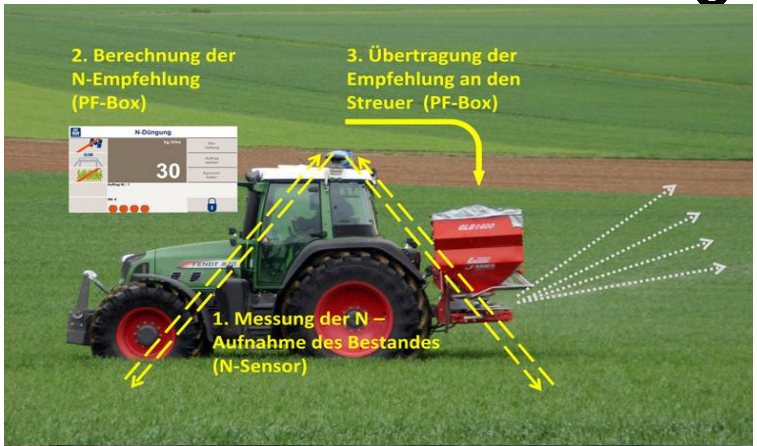
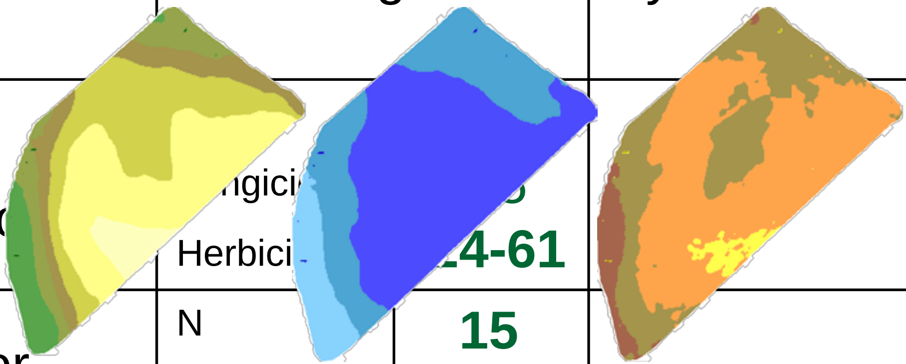
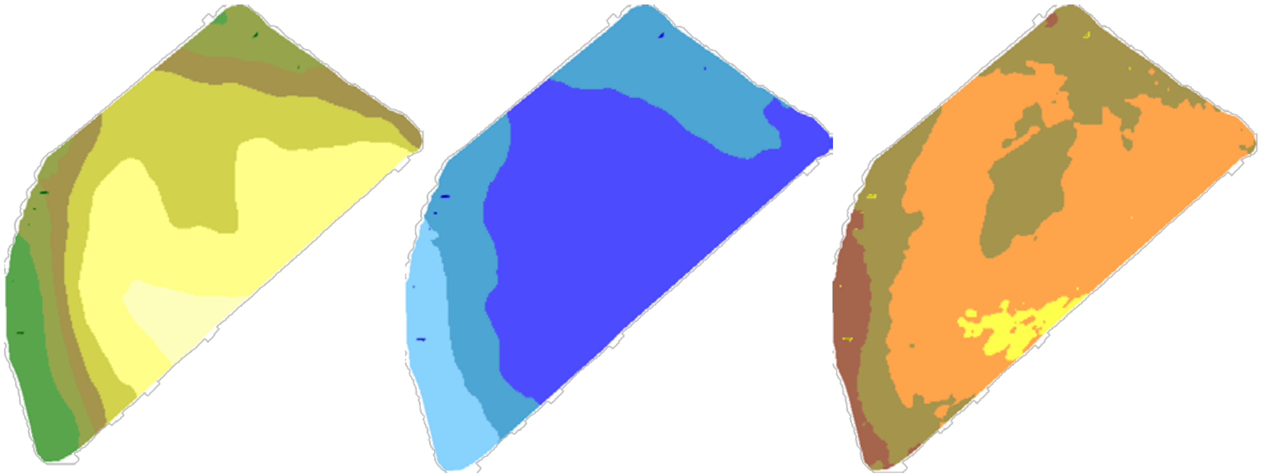


	Potential savings %		Increase of yealds %
X Map appr	ngici Herbici	4-61	
Senor approach	N Fungicide Herbicide	15 30 20-60	1-2



2. Sensors for precision crop farming

Map information



Were do I get the data?

How do I get the data?

How can I use this data?

models/senitivity

management (GIS/FIMS)

2. Sensors for precision crop farming

Traditional field scouting

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2. Sensors for precision crop farming

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Available soil sensors

Mechanical
- Fuel consumption — 0
- Draft force — 0
- Vertical penetrometer — ?
- Horizontal penetrometer — 0

Chemical
- Galvanic — ?
- Ion-selective electrodes (pH) — +
- Field effect transistors — 0
- Artificial nose — −
- Antibodies — −

Optical
- Vis-NIR spectroscopy — ? 0
- Imaging — ? 0
- Raman spectroscopy — −
- Plasma spectroscopy — −

Electrical
- Geo-electrical — +
- TDR — 0
- Geo-radar — 0
- THz — −

Radioactivity
- Gamma spectrometry (pass.) — +
- Impulse-neutron (active) — −
- XRF — 0

Acoustical („seismics“)
- Response to sound — −

Pneumatic
- Movement of air in soil — −

Soruce: Gebbers (2014)

+ Commercially available / accepted

? Commercially available, not accepted / adopted

0 Under development / promising

− Research only

2. Sensors for precision crop farming

Soil information: EM-measurement

Topsoil Mapper (TSM)

GEOPROSPECTORS

2. Sensors for precision crop farming
Soil information: EM-measurement

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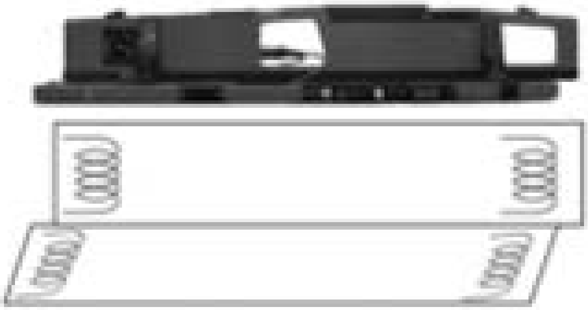
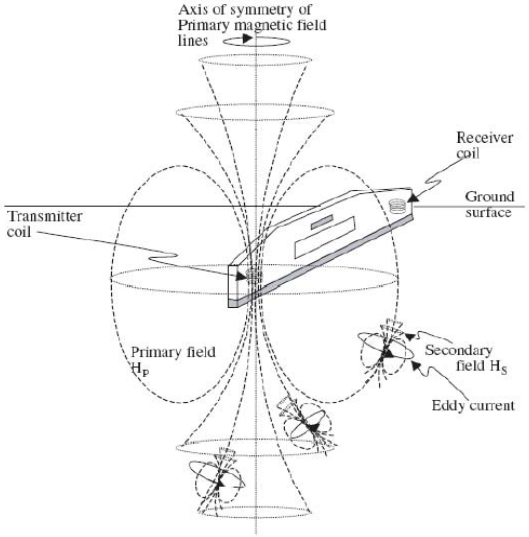
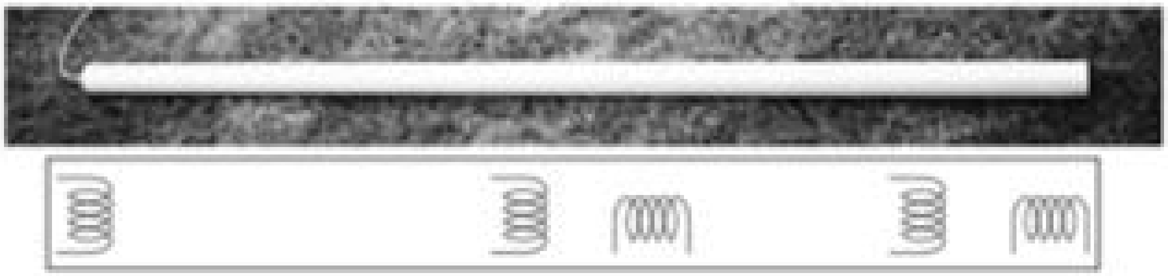


EM38





TSM

2. Sensors for precision crop farming: Soil information TSM

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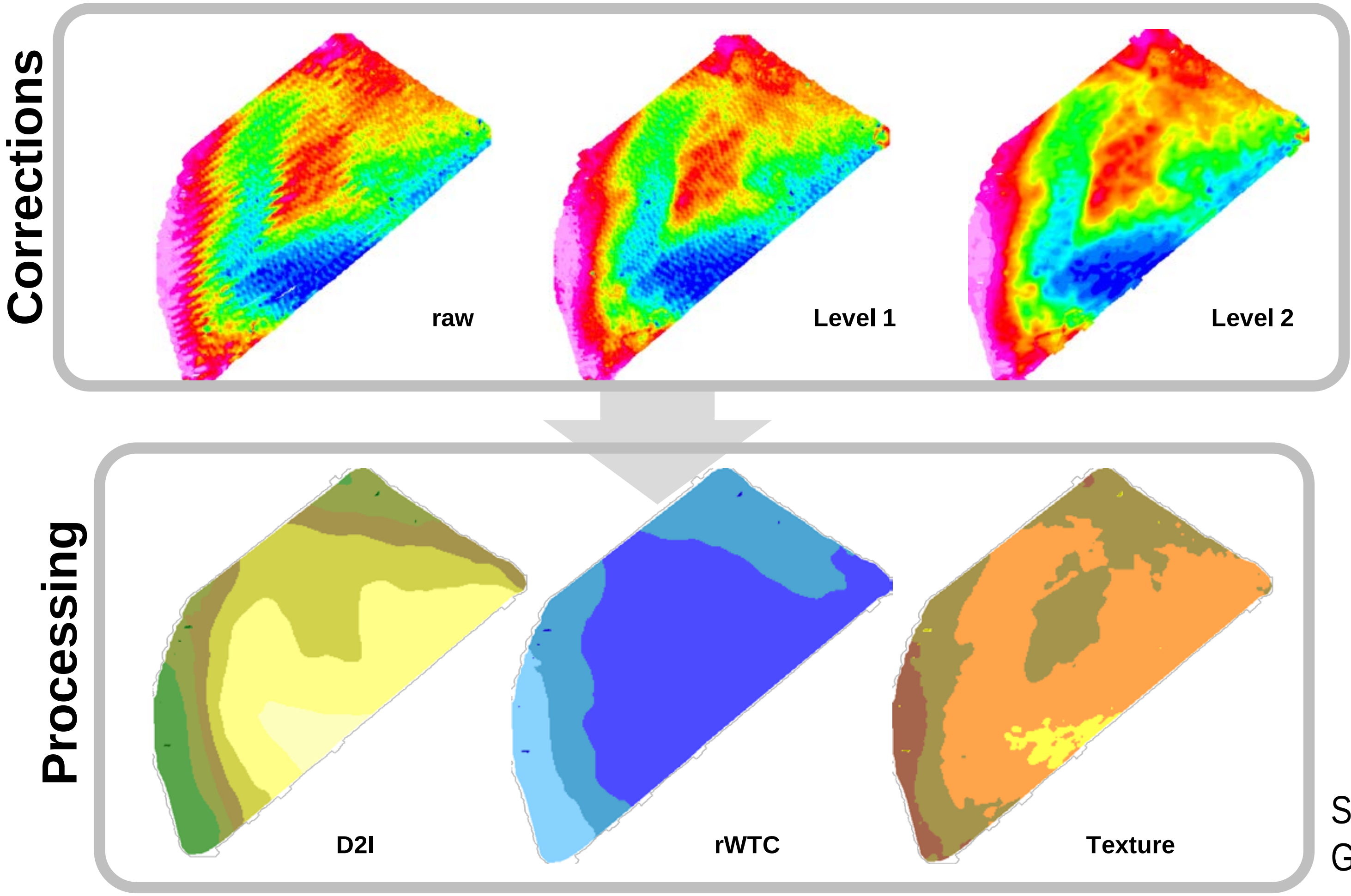

Source: Geoprospectors

2. Sensors for precision crop farming: Soil information D2I TSM

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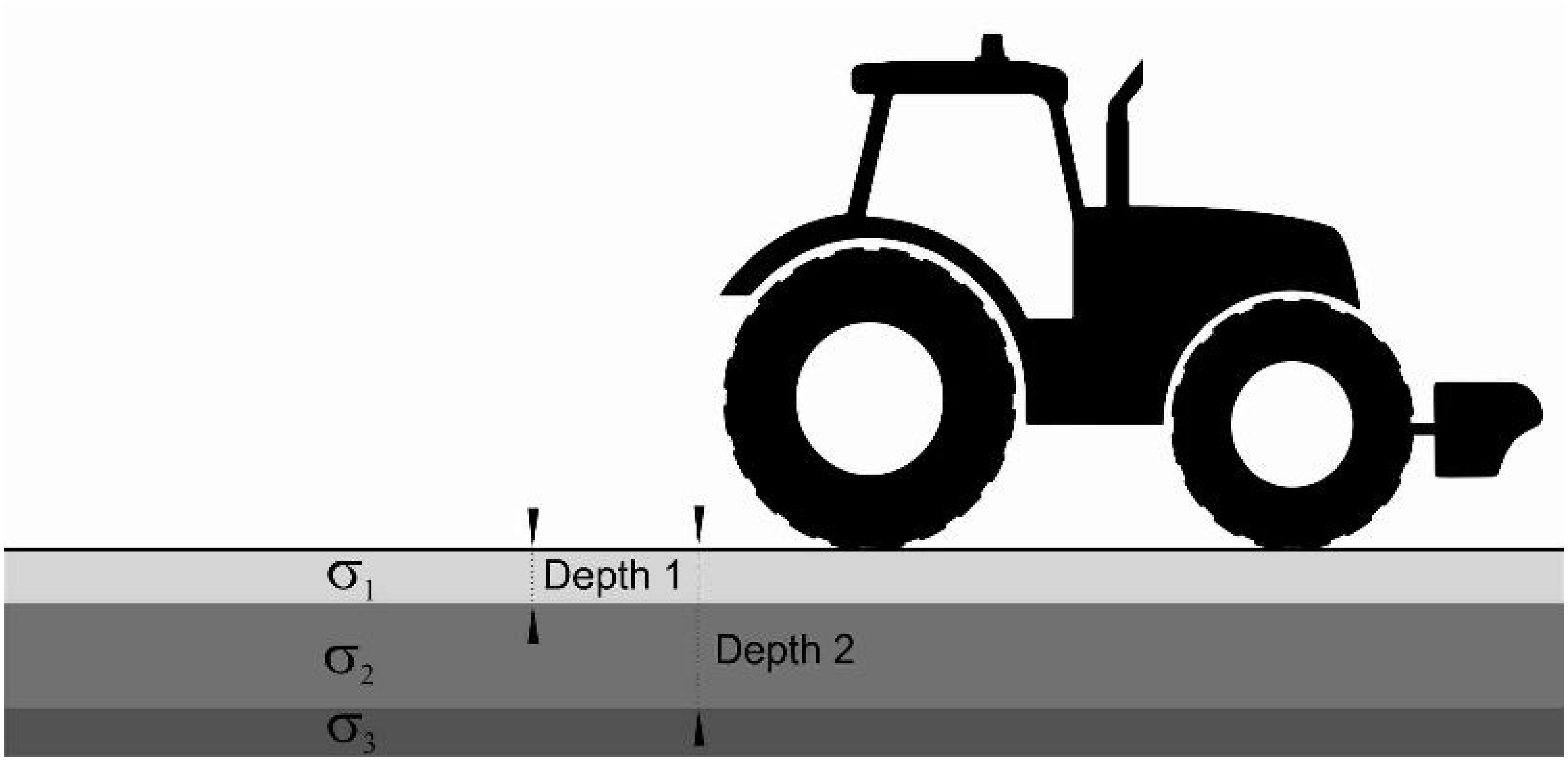

Source: Geoprospectors

2. Sensors for precision crop farming: Soil information D2I TSM

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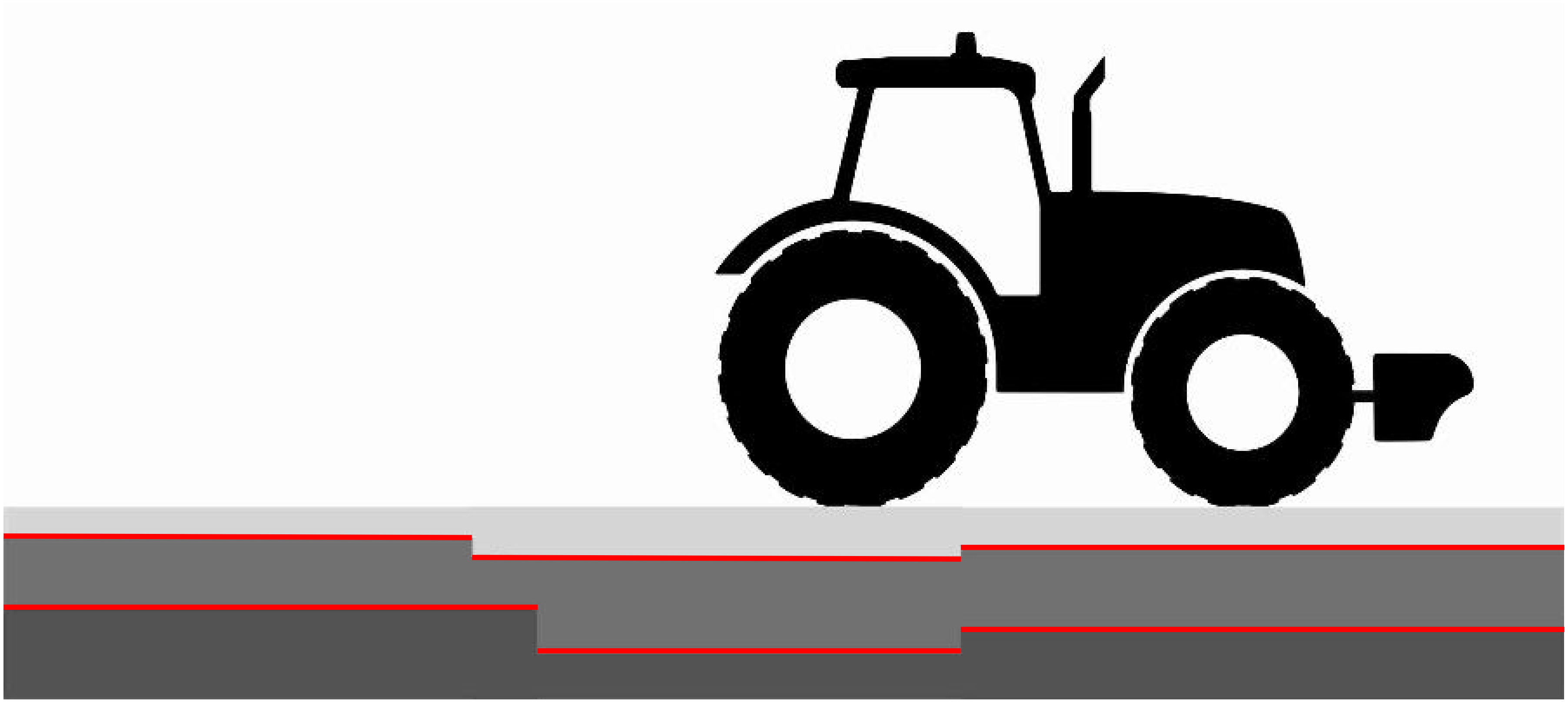

Source: Geoprospectors

2. Sensors for precision crop farming: Soil information D2I TSM

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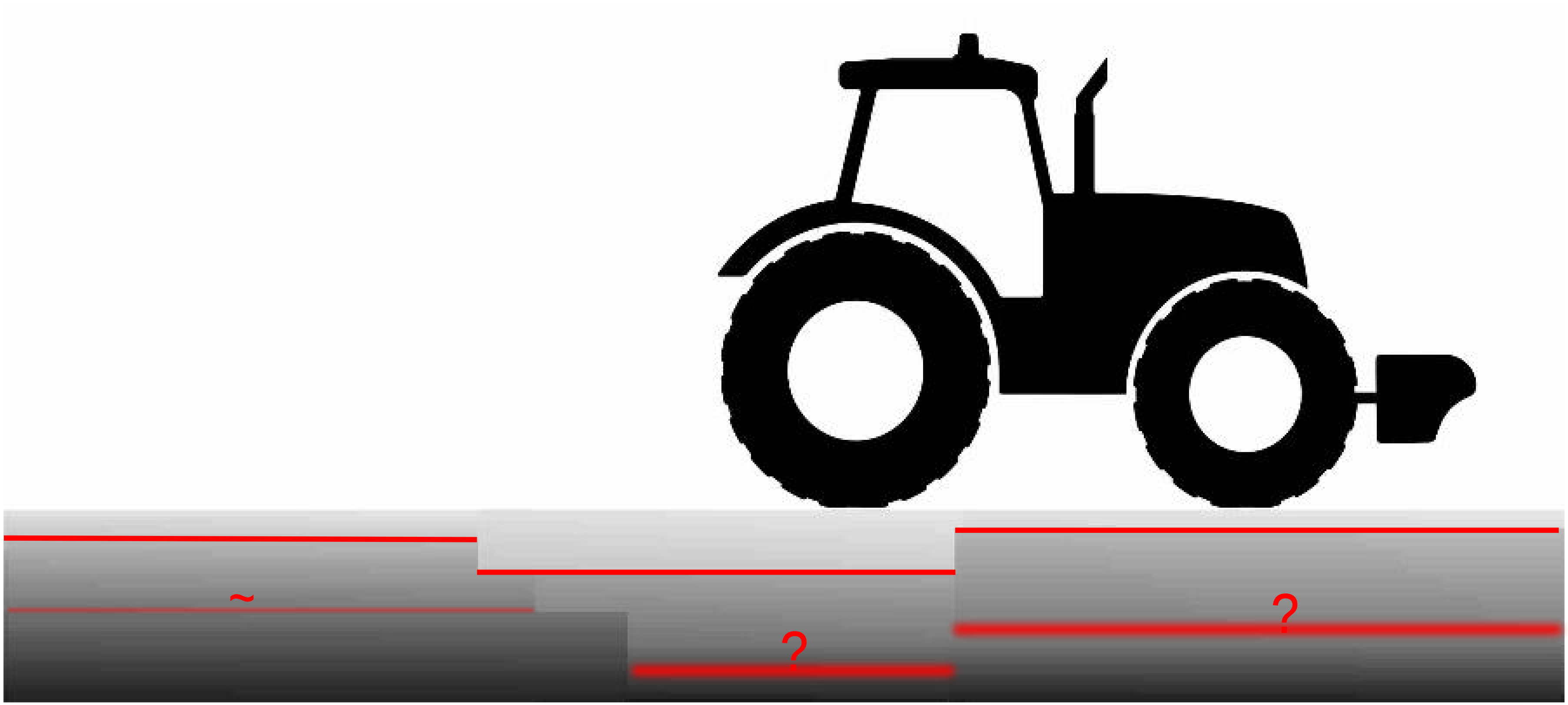

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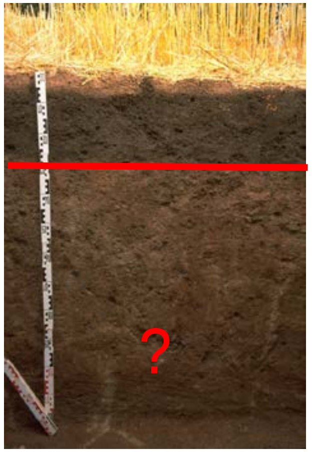
2. Sensors for precision crop farming: Soil information TSM



Brown earth
Source: LfU, Bayern

Podsol
Source: Herzberger

Meadow soil
Source: LfU, Bayern

Pseudogley
Source: LfU, Bayern

Pelosol
Source: LfU, Bayern

Para brown earth on sand

2. Sensors for precision crop farming: Automatic monitoring of quality

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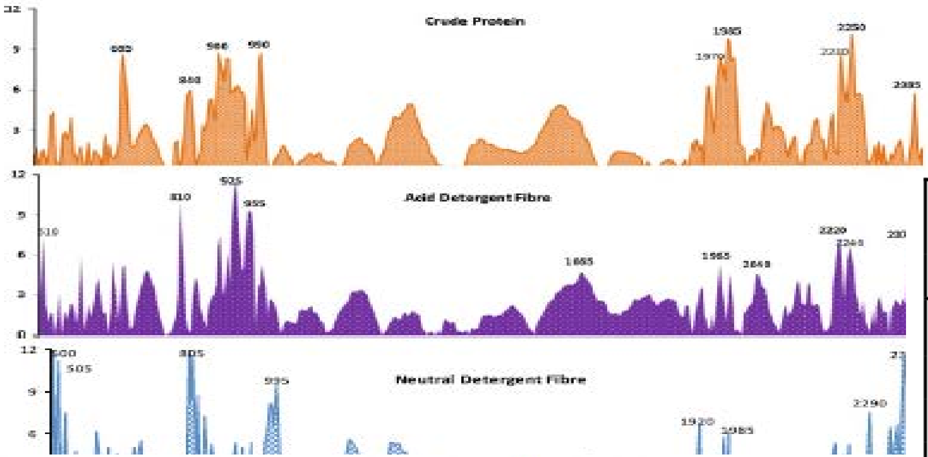
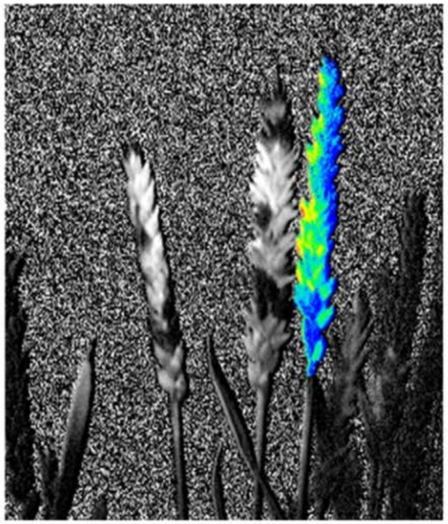
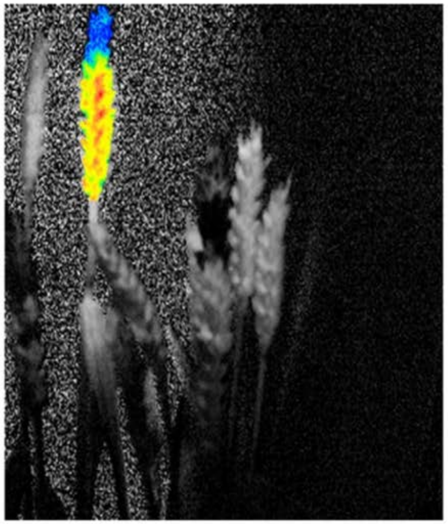
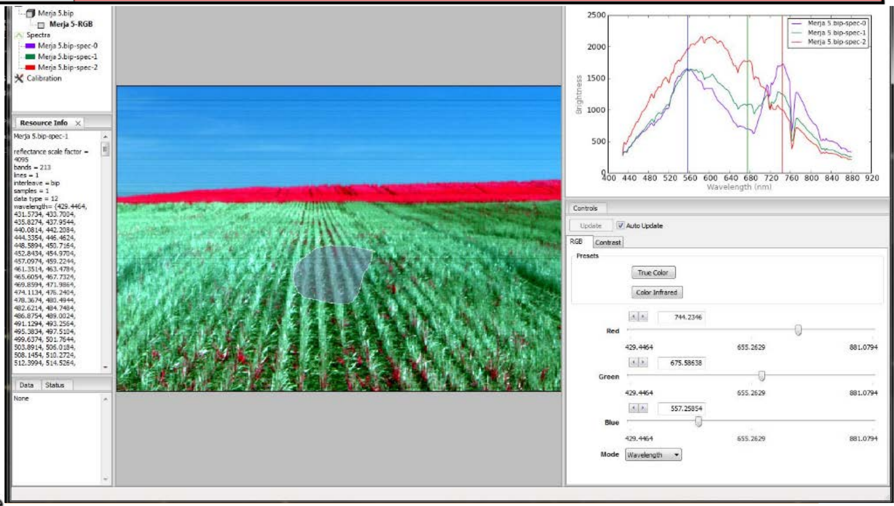


Parameter	TM %	Roh-prot. % FM	Roh-faser % FM	Roh-asche % FM	Roh-fett % FM	Methan-gas[1)] nl/kg	NEL MJ FM	ME MJ FM
Probenzahl	102	102	103	102	102	103	103	103
MIN_Wert	23,3	2,3	5,1	1,1	0,4	60,1	1,3	2,2
MAX-Wert	45,2	4,3	12,1	2,3	1,0	112,9	2,4	4,1
Mittelwert	36,4	3,0	9,1	1,6	0,7	93,1	2,0	3,4
r^2	0,990	0,939	0,907	0,789	0,837	0,984	0,980	0,983


degree of infection: 90%


degree of infection: 30%


F_V/F_M false colour scale



2. Sensors for precision crop farming: Automatic monitoring of yields and yield qualities

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2. Sensors for precision crop farming: implementation into harvester

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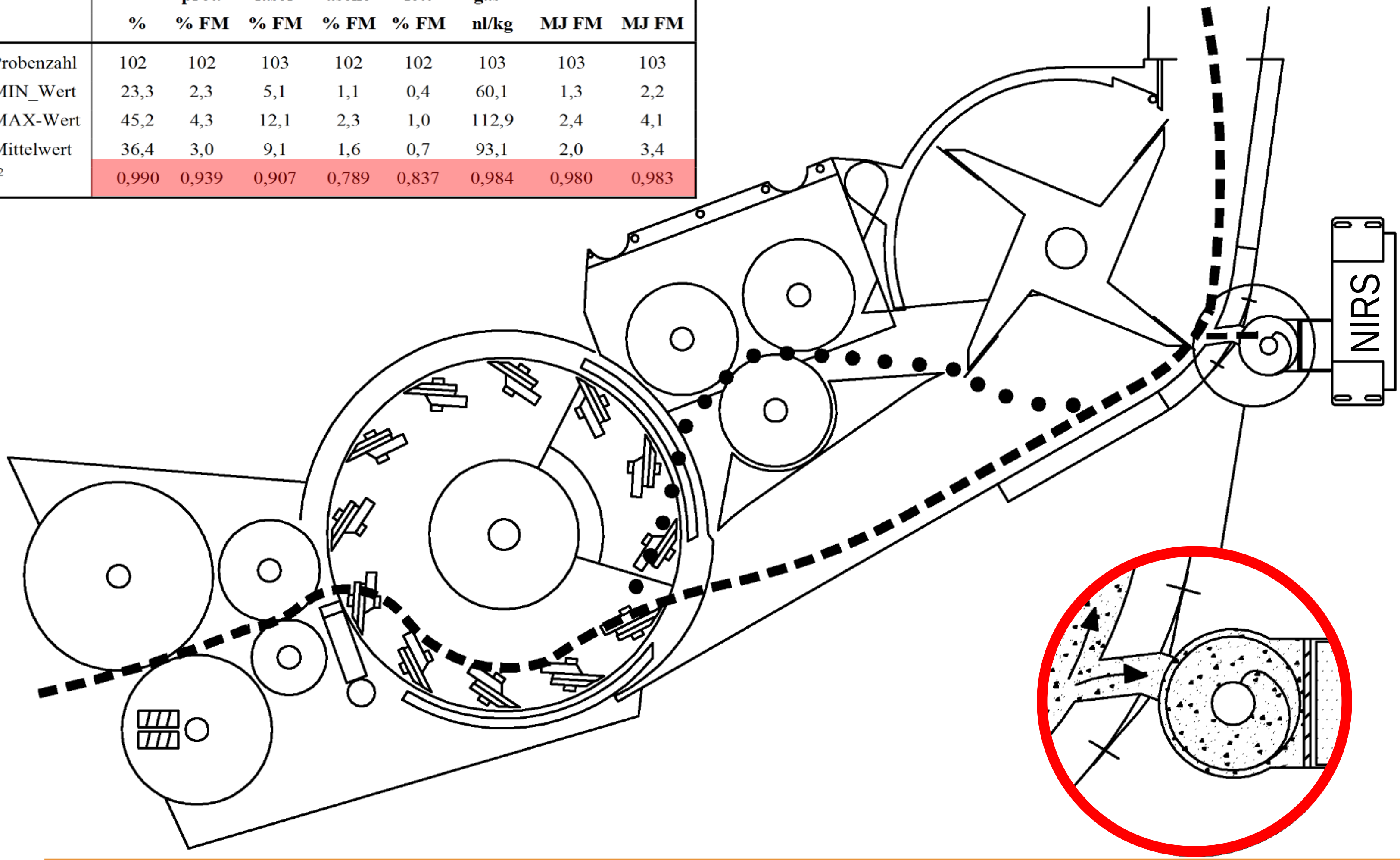
Parameter	TM %	Roh-prot. % FM	Roh-faser % FM	Roh-asche % FM	Roh-fett % FM	Methan-gas[1)] nl/kg	NEL MJ FM	ME MJ FM
Probenzahl	102	102	103	102	102	103	103	103
MIN_Wert	23,3	2,3	5,1	1,1	0,4	60,1	1,3	2,2
MAX-Wert	45,2	4,3	12,1	2,3	1,0	112,9	2,4	4,1
Mittelwert	36,4	3,0	9,1	1,6	0,7	93,1	2,0	3,4
r^2	0,990	0,939	0,907	0,789	0,837	0,984	0,980	0,983



2. Sensors for precision crop farming:
Effects of site specific fertilization on yield and protein content in durum wheat

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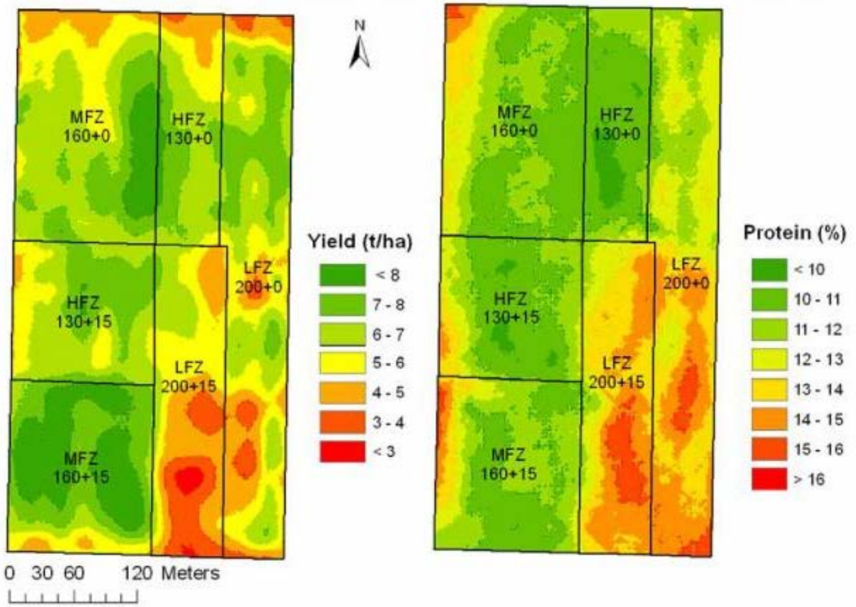

Figure 2. Maps of wheat yield (left) and grain protein (right), divided in the different management zones: HFZ (130+0 N, 130+15 N), MFZ (160+0 N, 160+15 N), LFM (200+0 N, 200+15 N).

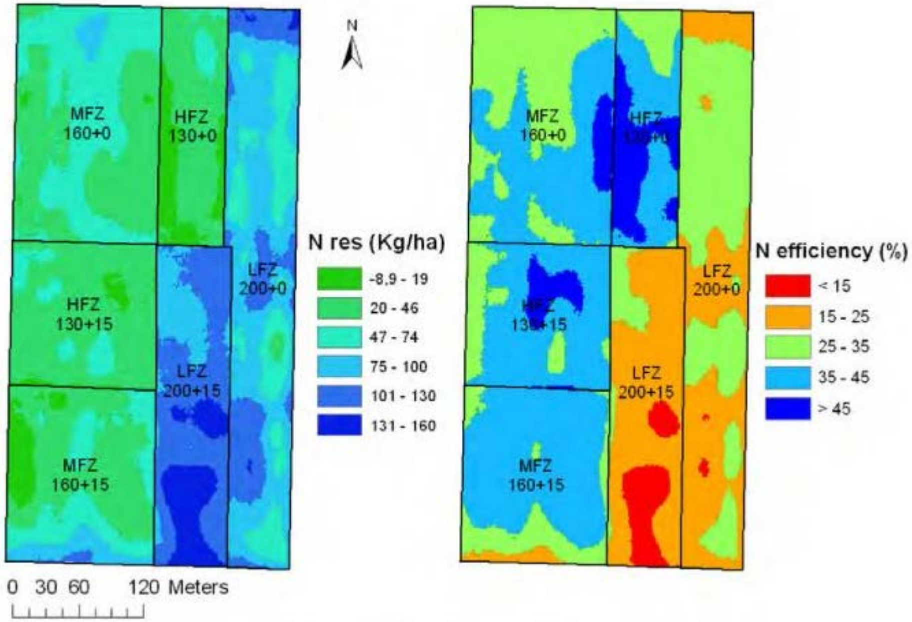

Figure 4. Maps of apparent N balance (left) and N use efficiency (%) (right).

Source: Morari, F. et al. 2013: Precision agriculture ´13

3. Challenges: Data processing (amount + real time)

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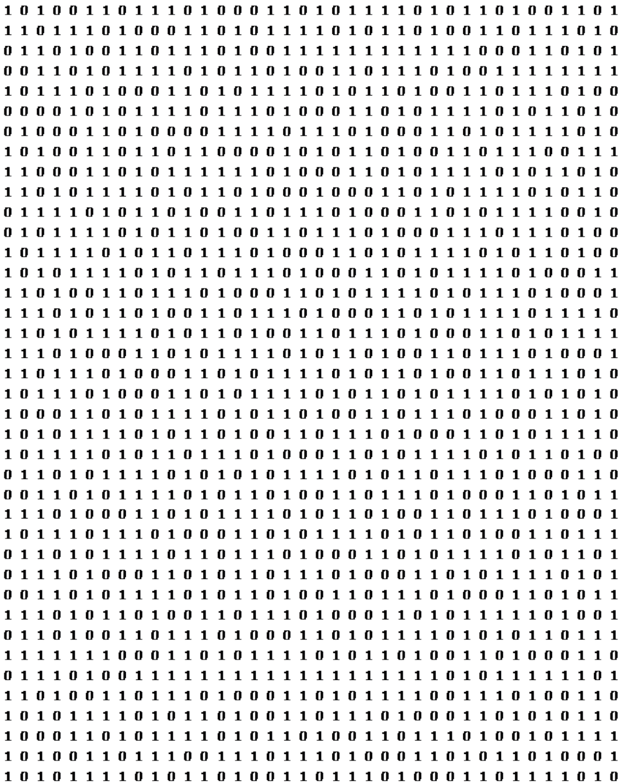
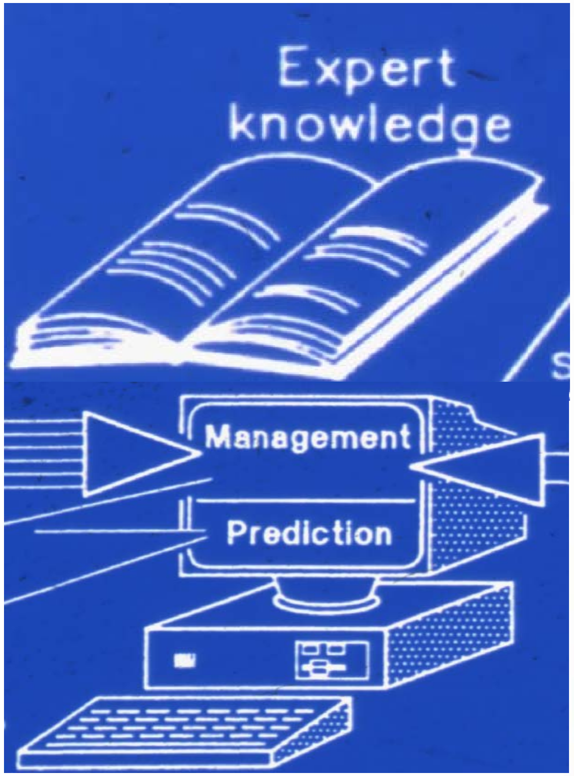
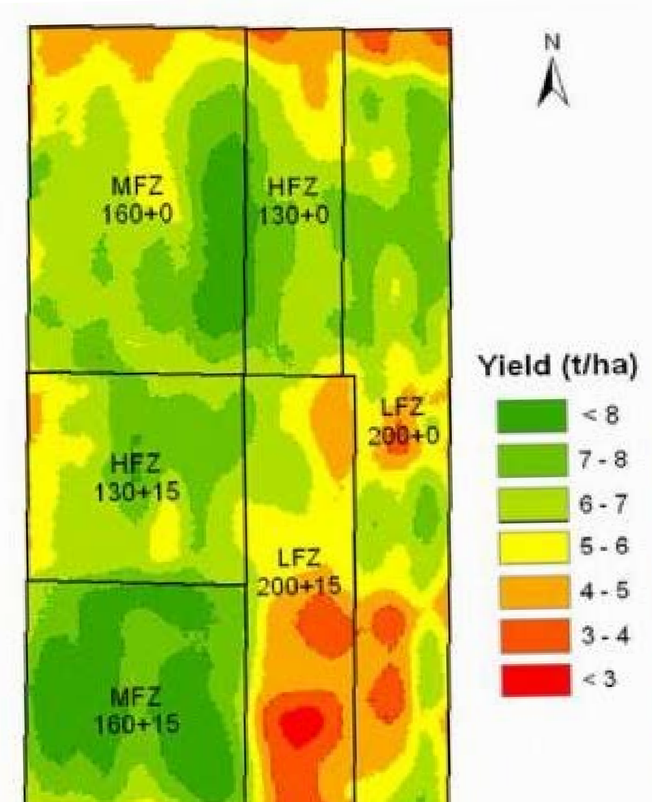
What we get



What we want





We drown in a sea of data and thirst for information

3. Challenges:
the vision of the early 90ies
(Auernhammer and Schueller 1991)

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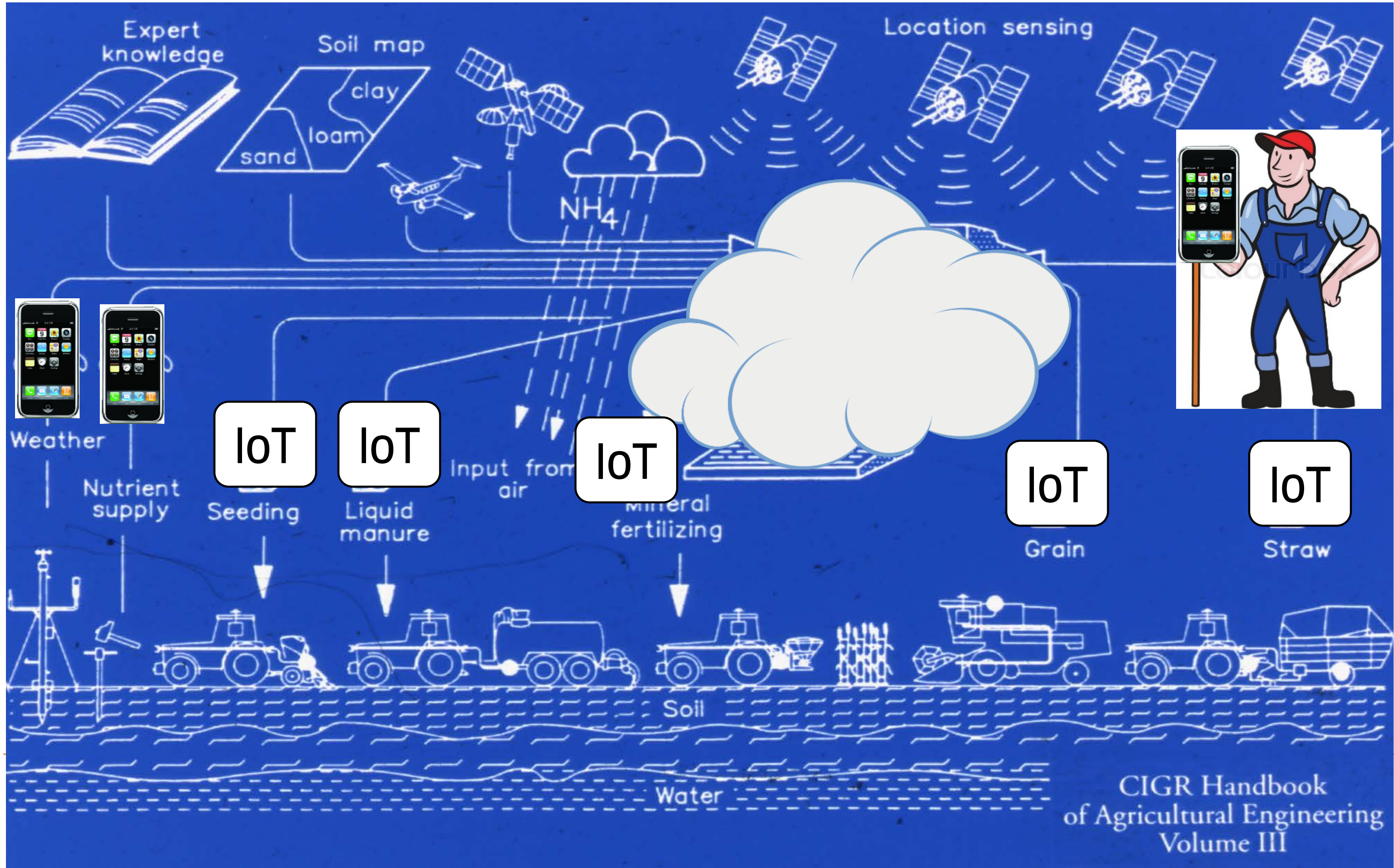

3. Challenges: Sensor fusion and data processing

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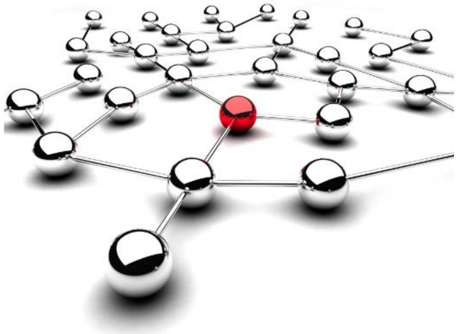
manufacture independent open interfaces

- communication between human-machine, machine-tools and machine-machine



sensor and information fusion opens:

- automation of processes and data documentation
- Serverarchitecture (internal – external – cloud)
- data warehouse for expert systems and administrative tools

- „open link“ for ICT in agri- and horticulture
- development of new „Apps“ open immense possibilities for users

Cell phone
= Swiss army knife

3. Challenges: Open interfaces for ICT

- Doubling of processor speed every 18 month
- Doubeling of transfer speed every 9 month
- Number of mobile telefones increased from 750 Mio. (2000) to 6 Mrd. (now)

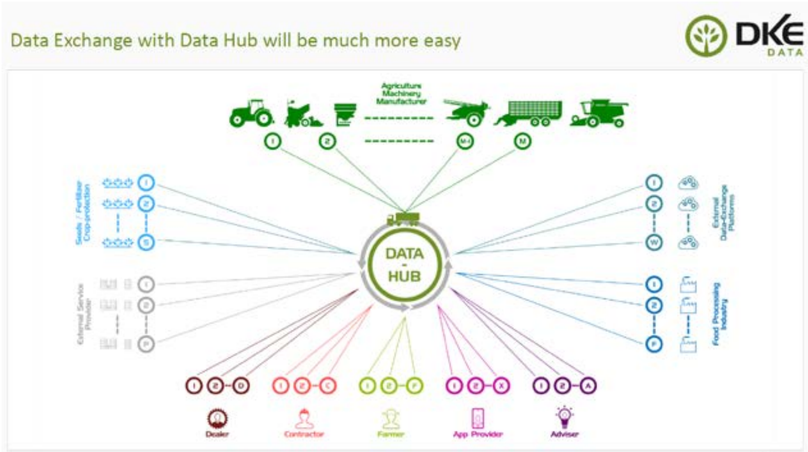
3. Challenges:
Open data link for ICT

AEF Certified ISOBUS www.aef-isobus-database.org

Standard for communication tractor-implement

agriOpenLink

Source: Sonnen (2016)



Standard for open data link

3. Challenges:
Open data link for ICT

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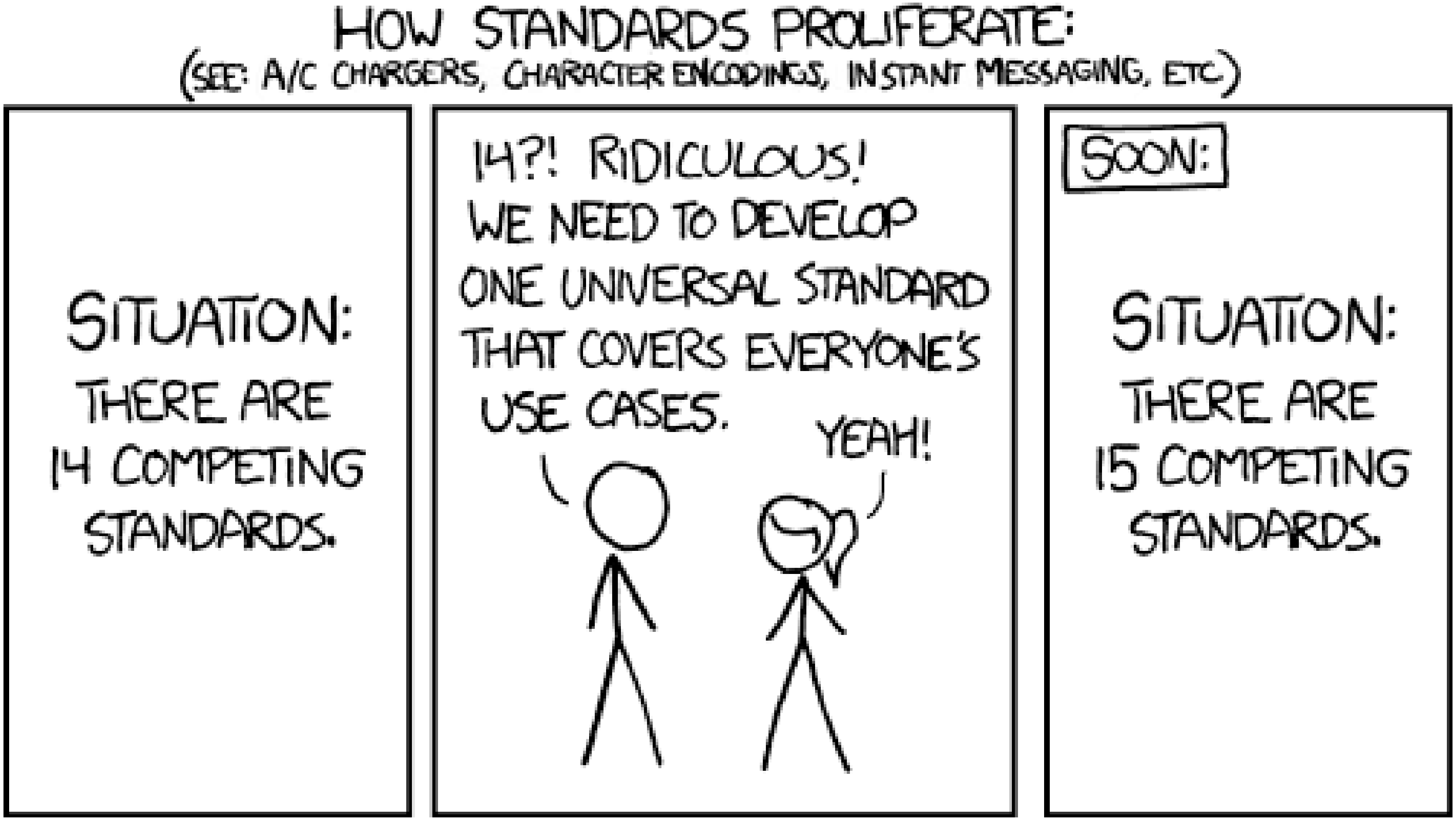

Source: https://xkcd.com/927/

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