Automated Process Data Acquisition within Standardized Communication Systems and its Practical Applications

Prof. Dr. Hermann Auernhammer
Dipl.-Ing.agr. M. Rothmund

Centre of Life Sciences Weihenstephan
Department of Bio Resources and Land Use Technology
Crop Production Engineering

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Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
2. Standardized technologies
3. Process data acquisition systems
4. Data processing
5. Practical applications
6. Conclusions

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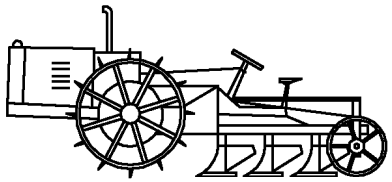
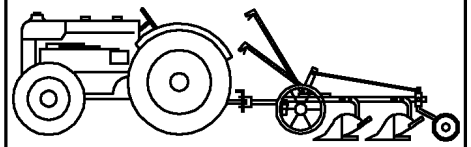
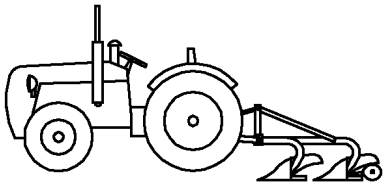
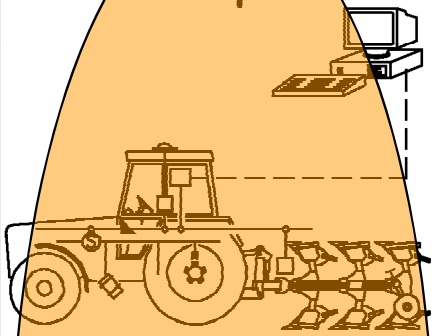
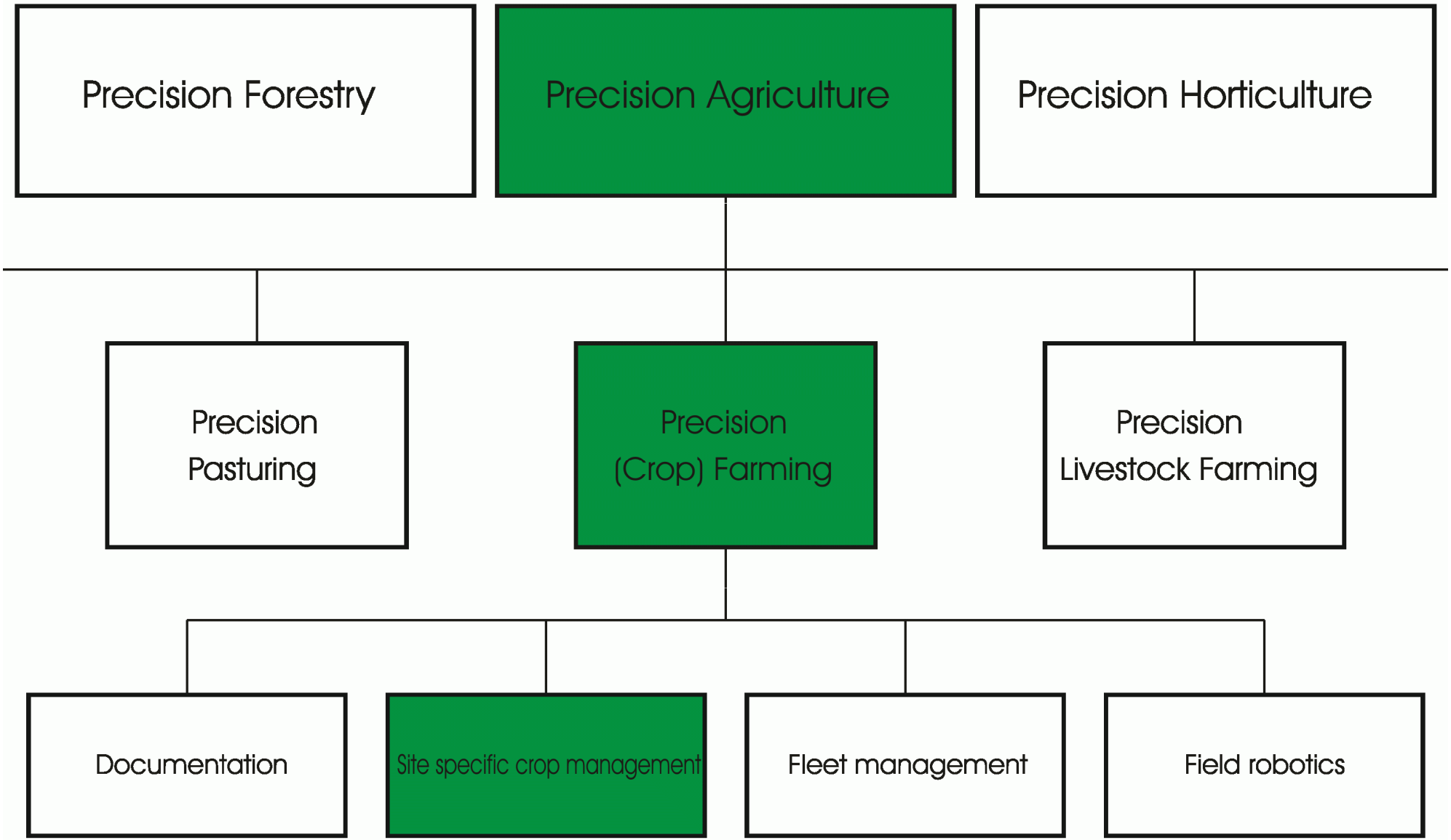
Milestones in tractor usage

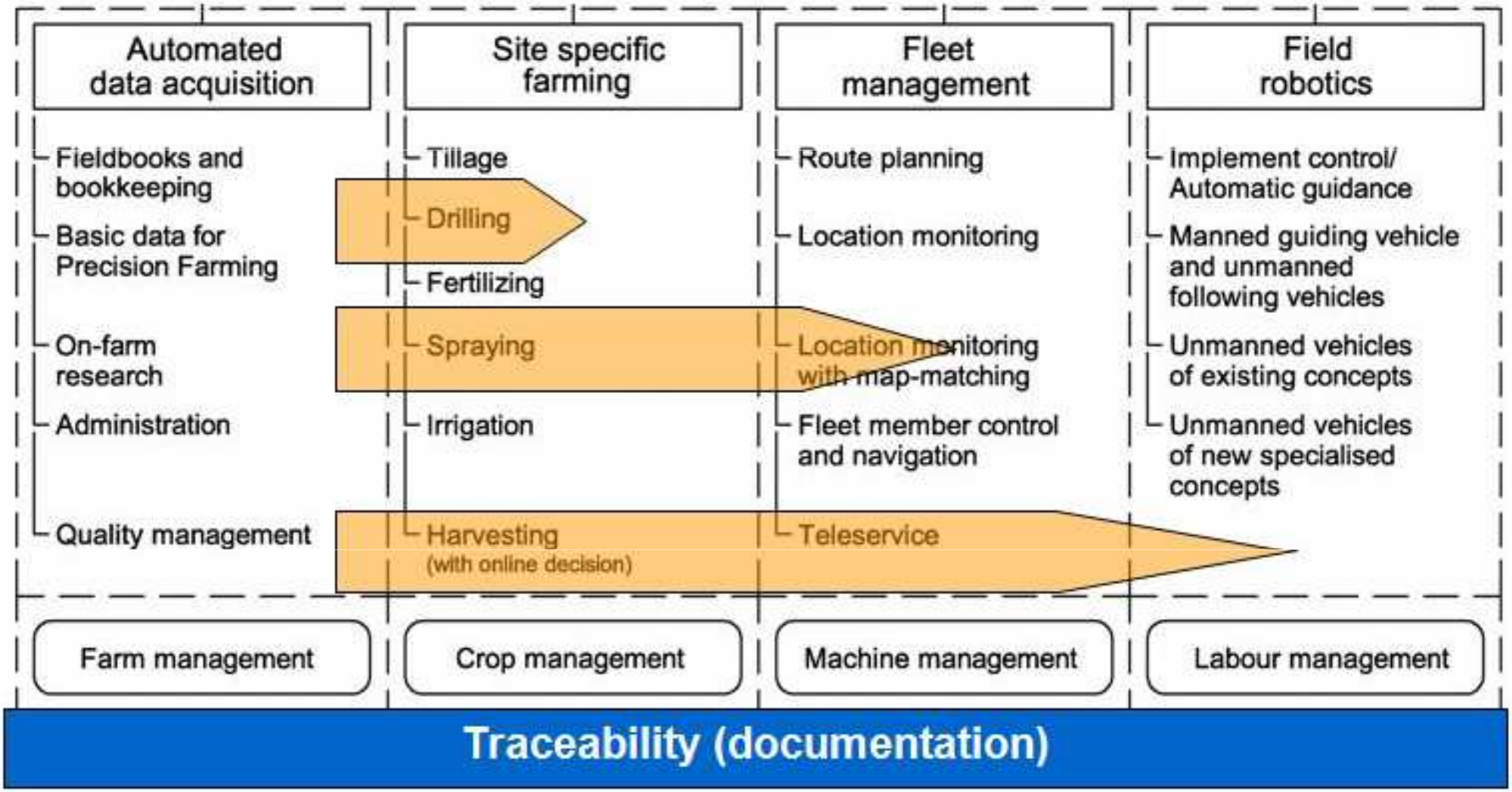
No.	1	2	3	4
Design				
Innovation	Combustion engine + Rotary force	Pneumatic tyre	Hydraulic system + Three–point–hitch	Electronics + Communication
Benefits	"Biological" independence	Mobility	Automotive properties	"Technical" intelligence
Charac–teristics	Self propelled working machine	Universal tractor	Tractor implement unit	**Process element within a communication system**

IT on the farm

Information technology in land use systems



Information technology (IT) applications in crop farming



Process data acquisition in crop production

Task / Mechanisation

Acquisition technology	Manual work	Stationary equipment: In-house Storage	Stationary equipment: Field Irrigation	Mobile equipment: Tractor-implement combination: Implement without elektronics	Mobile equipment: Tractor-implement combination: Implement with elektronics	Mobile equipment: Special machinery: Telehandler	Mobile equipment: Special machinery: Combines	Assessment: Advantage	Assessment: Disadvantage
Manual (form + PC)	++	++	+	+	+	+	+	Low investment needs Low costs Low intellectual requirements	Little in-depth Incomplete High temporal effort
Pocket PC	+	+	+	+	+	+	+	Low investment needs Low costs Paper super fluous Reduced temporal effort	Little in-depth Incomplete In sufficient software
Pocket PC + GPS	+/-	+/-	+	+	+	+	+	Position is included More details possible Low costs Paper super fluous Reduced temporal effort	Little in-depth Incomplete In sufficient software
Use of installed sensor technology	--	--	+/-	+/-	++	+/-	+	Low additional costs Automatic acquisition Objective measurements complete Detailing possible	Only partitions ascertainable Additional costs No standardisation
Special acquisition technique	???	-	+	+	++	+	++	Automatic acquisition Objective measurements complete Detailing fulfilled	Higher additional costs No standardisation
Integrated automatic acquisition	???	-	+	++	++	++	++	Automatic acquisition Standardisation Objective measurements User specific configurable Detailing according to requirements	Standards necessary Higher costs Complet data processing Current software required

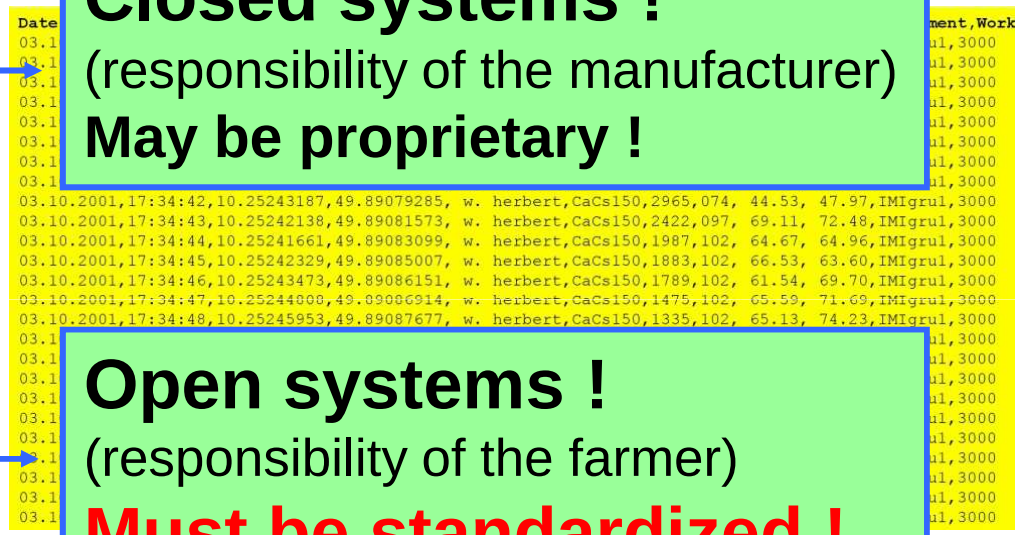
++ = Very well possible -- = Not possible

Open systems

Closed systems

Two types of data acquisition sources

Closed systems !
(responsibility of the manufacturer)
May be proprietary !



Open systems !
(responsibility of the farmer)
Must be standardized !

Automated Process Data Acquisition within Standardized Communication Systems

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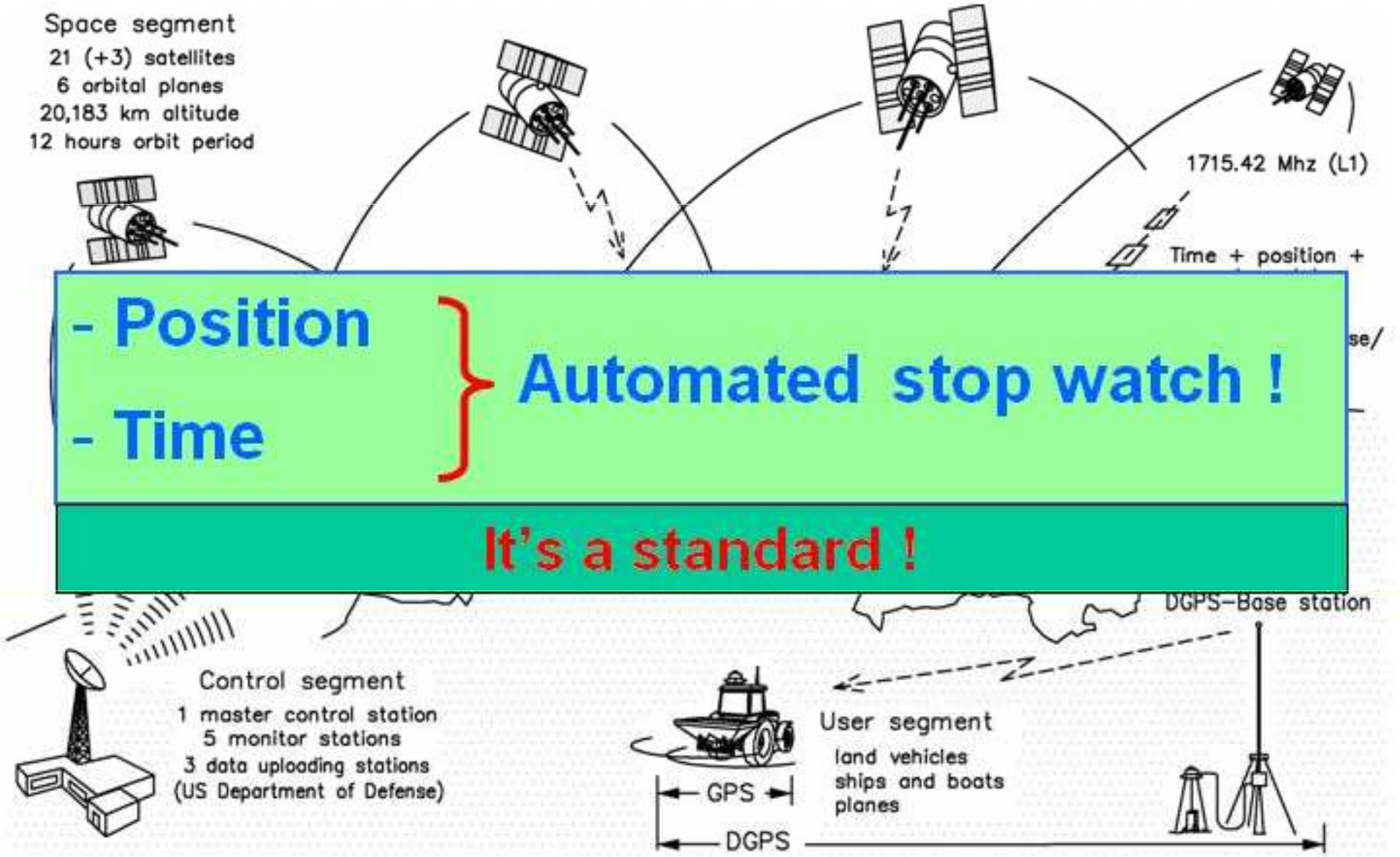
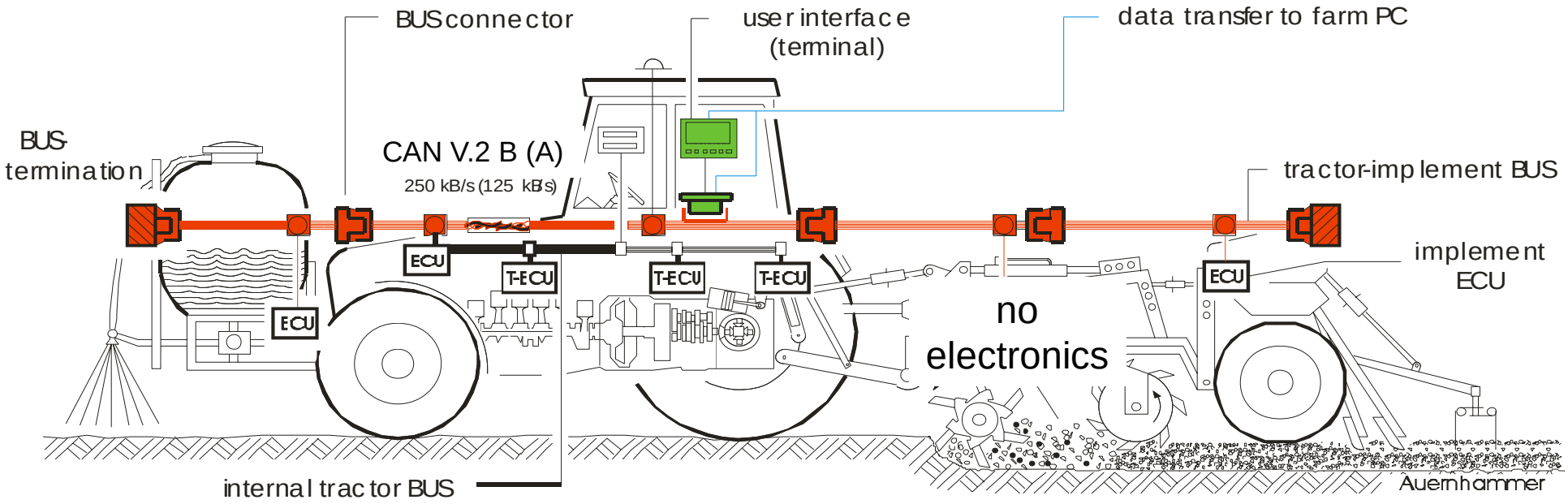
GPS (Navstar / Galileo)



Standardized electronic communication (ISOBUS)

Implements (the tractor is an implement) **are able to communicate**

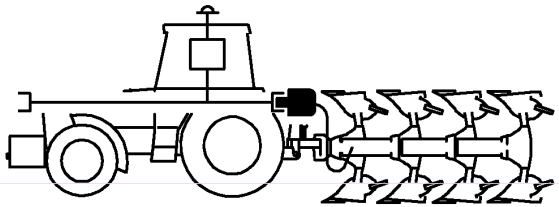
- with the **driver** (is well known)
- with the **tractor** (implement controls tractor)
- with other **implements**
- with the farm **management**



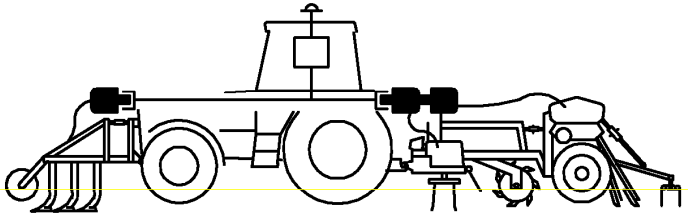
But only,
if all have own intelligence and communication facilities !

Implement Indicator – the missing link !

- used with “stupid technology” -



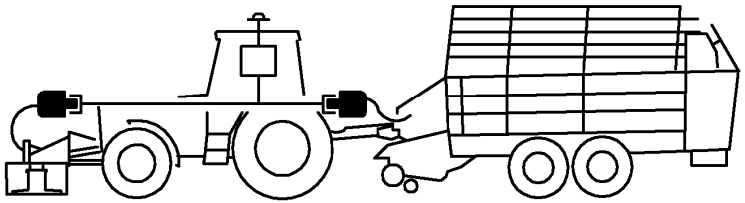
Primary soil preparation



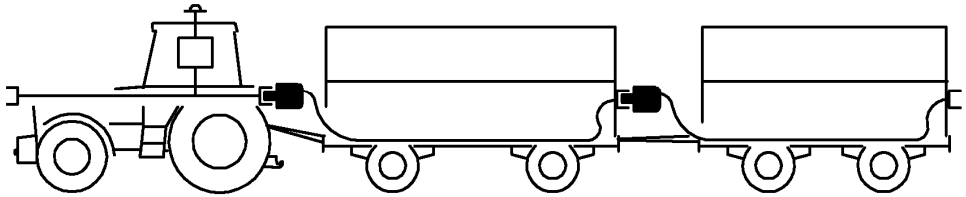
Minimum tillage

These are examples of so called „stupid implements“, they don’t use any electronics

Forage harvesting

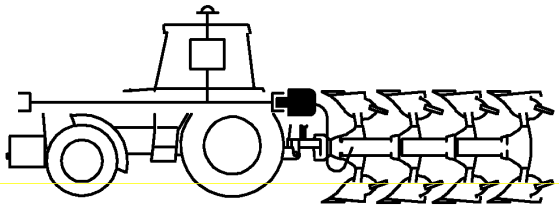


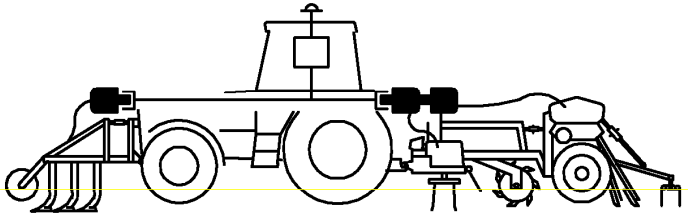
Transportation



Implement Indicator – the missing link !

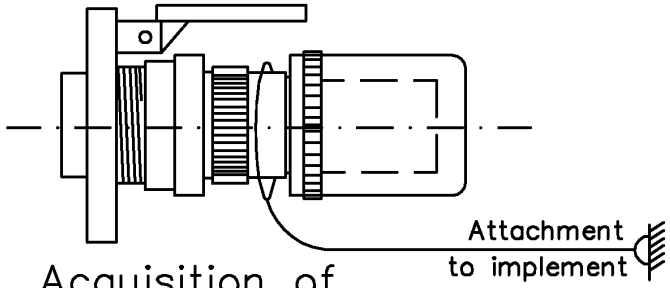
- used with “stupid technology” -





Primary soil preparation

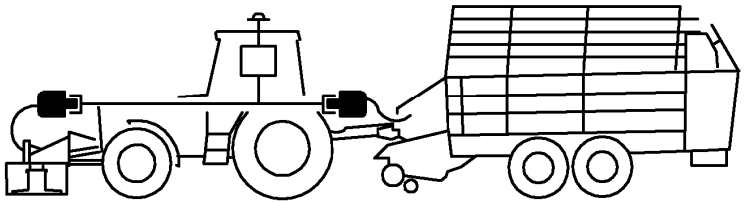
Implement indicator (IMI)
- Adress request
- Icon
- Alive
- Basic parameters



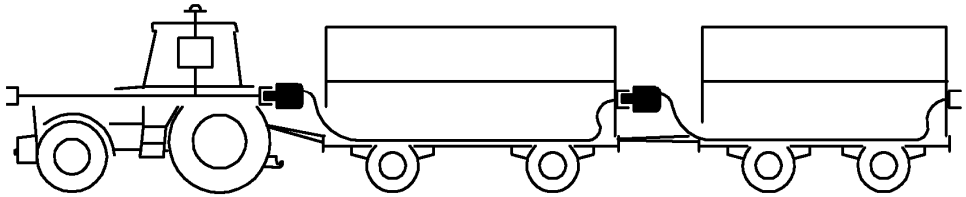
Acquisition of
- Mounting time
- Operational time
- Performance

Just a small piece of electronics,
(may be in the connector)
and these implements are intelligent !

Forage harvesting



Transportation



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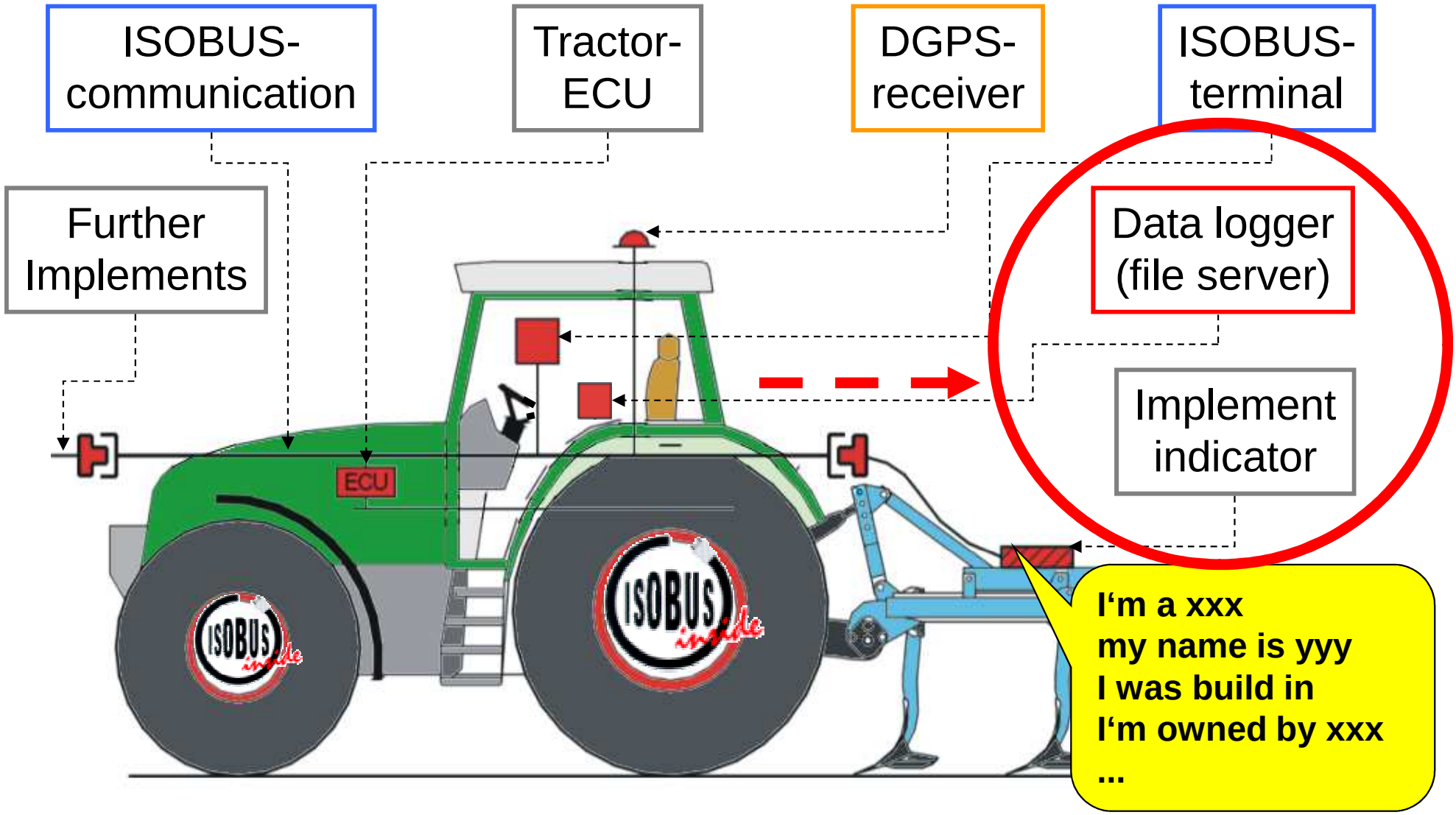
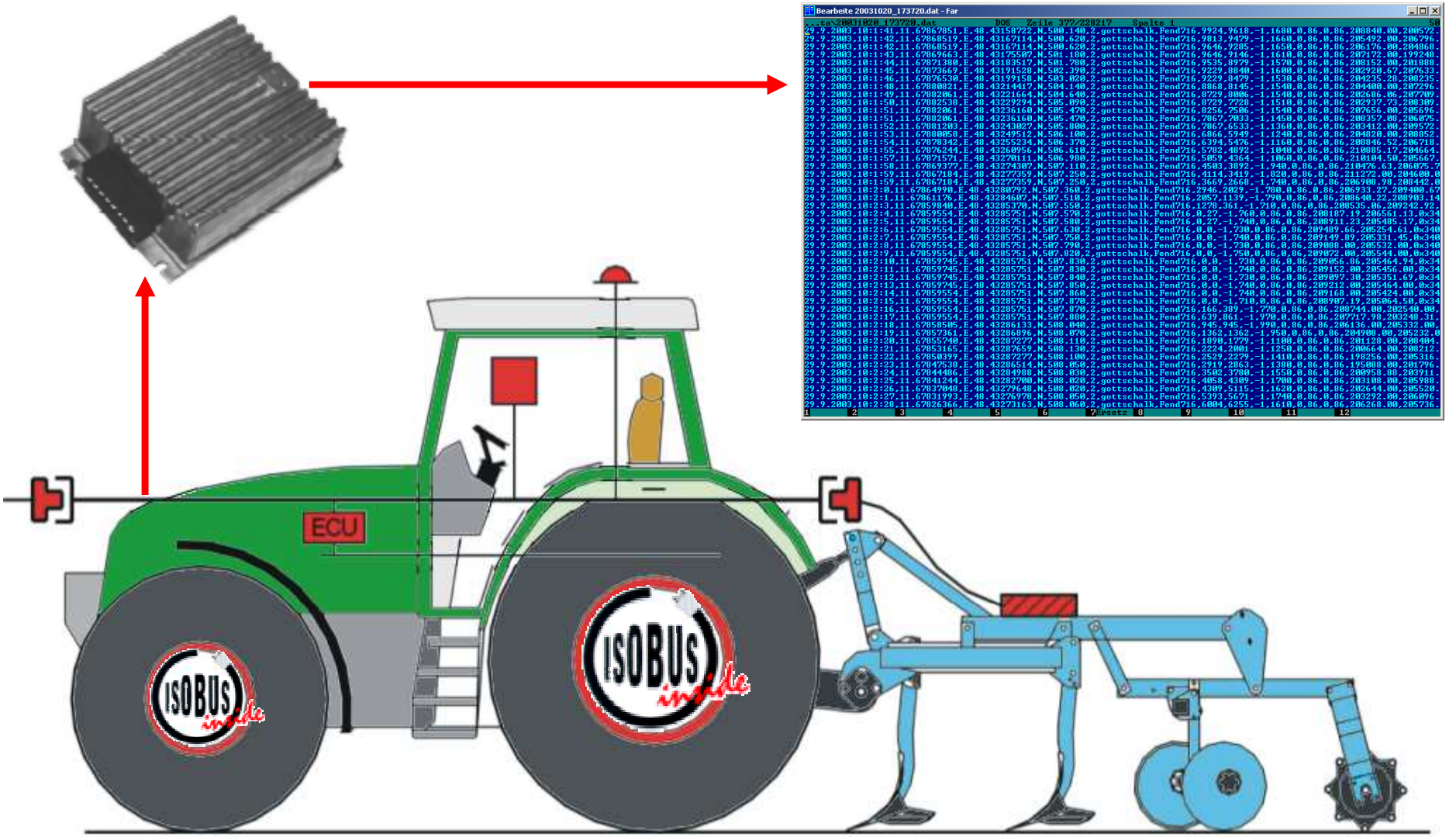
Automated process data acquisition system



Automated process data acquisition – data file



Example of raw data: ASCII-format, relational data model

Date,	Time,	Longitude,	Latitude,	Tractor	Speed	Pos	Left,	Right,	Implement	Ww	AppVol	Sum,	Sensor1	Napp
04.06.2004	17:34:33	10.25254822	49.89058304	CaCs150	3002	043	-33.14	-28.80	IMIgru1	3000	141.23	000	MiniVegN	56
04.06.2004	17:34:34	10.25253296	49.89060593	CaCs150	3014	044	-30.73	-29.01	IMIgru1	3000	142.81	000	MiniVegN	65
04.06.2004	17:34:35	10.25251865	49.89062881	CaCs150	3010	041	-31.48	-32.75	IMIgru1	3000	143.45	000	MiniVegN	63
04.06.2004	17:34:36	10.25250340	49.89065170	CaCs150	3024	040	-28.70	-20.93	IMIgru1	3000	141.64	000	MiniVegN	68
04.06.2004	17:34:37	10.25248814	49.89067841	CaCs150	2950	046	-24.75	-23.14	IMIgru1	3000	140.68	000	MiniVegN	59
04.06.2004	17:34:38	10.25247288	49.89070129	CaCs150	2925	046	-10.68	-07.17	IMIgru1	3000	138.83	000	MiniVegN	62
04.06.2004	17:34:40	10.25245857	49.89074707	CaCs150	3050	046	-29.31	-29.85	IMIgru1	3000	139.34	000	MiniVegN	71
04.06.2004	17:34:41	10.25244522	49.89076996	CaCs150	3102	047	-20.56	-14.57	IMIgru1	3000	140.64	000	MiniVegN	75
04.06.2004	17:34:42	10.25243187	49.89079285	CaCs150	2965	074	44.53	47.97	IMIgru1	3000	142.58	000	MiniVegN	82
04.06.2004	17:34:43	10.25242138	49.89081573	CaCs150	2422	097	69.11	72.48	IMIgru1	3000	144.89	000	MiniVegN	81
04.06.2004	17:34:44	10.25241661	49.89083099	CaCs150	1987	102	64.67	64.96	IMIgru1	3000	145.91	000	MiniVegN	79
04.06.2004	17:34:45	10.25242329	49.89085007	CaCs150	1883	102	66.53	63.60	IMIgru1	3000	147.39	000	MiniVegN	81
04.06.2004	17:34:46	10.25243473	49.89086151	CaCs150	1789	102	61.54	69.70	IMIgru1	3000	150.93	000	MiniVegN	75
04.06.2004	17:34:47	10.25244808	49.89086914	CaCs150	1475	102	65.59	71.69	IMIgru1	3000	151.56	000	MiniVegN	71
04.06.2004	17:34:48	10.25245953	49.89087677	CaCs150	1335	102	65.13	74.23	IMIgru1	3000	149.73	000	MiniVegN	66
04.06.2004	17:34:49	10.25245190	49.89087296	CaCs150	0885	102	66.03	70.37	IMIgru1	3000	149.82	000	MiniVegN	56
04.06.2004	17:34:50	10.25243187	49.89086151	CaCs150	2411	102	58.13	59.14	IMIgru1	3000	150.47	000	MiniVegN	49
04.06.2004	17:34:51	10.25241184	49.89084244	CaCs150	2423	102	65.75	77.14	IMIgru1	3000	150.85	000	MiniVegN	44
04.06.2004	17:34:52	10.25240803	49.89082336	CaCs150	2380	102	67.16	82.57	IMIgru1	3000	149.29	000	MiniVegN	43
04.06.2004	17:34:53	10.25242043	49.89080048	CaCs150	2341	103	62.48	67.99	IMIgru1	3000	151.74	000	MiniVegN	43
04.06.2004	17:34:54	10.25243187	49.89078140	CaCs150	2356	100	64.83	73.53	IMIgru1	3000	148.43	000	MiniVegN	47
04.06.2004	17:34:55	10.25244522	49.89076233	CaCs150	2315	100	64.04	70.60	IMIgru1	3000	147.74	000	MiniVegN	46
04.06.2004	17:34:56	10.25245667	49.89074707	CaCs150	2200	100	64.29	71.46	IMIgru1	3000	144.59	000	MiniVegN	51
04.06.2004	17:34:57	10.25246811	49.89073181	CaCs150	2032	100	63.30	71.32	IMIgru1	3000	142.16	000	MiniVegN	55
04.06.2004	17:34:58	10.25247478	49.89072037	CaCs150	1235	100	61.00	75.36	IMIgru1	3000	142.98	000	MiniVegN	53
GPS (position and time)				**tractor**					**implements**				**sensors**	

Logging frequency: **1Hz**

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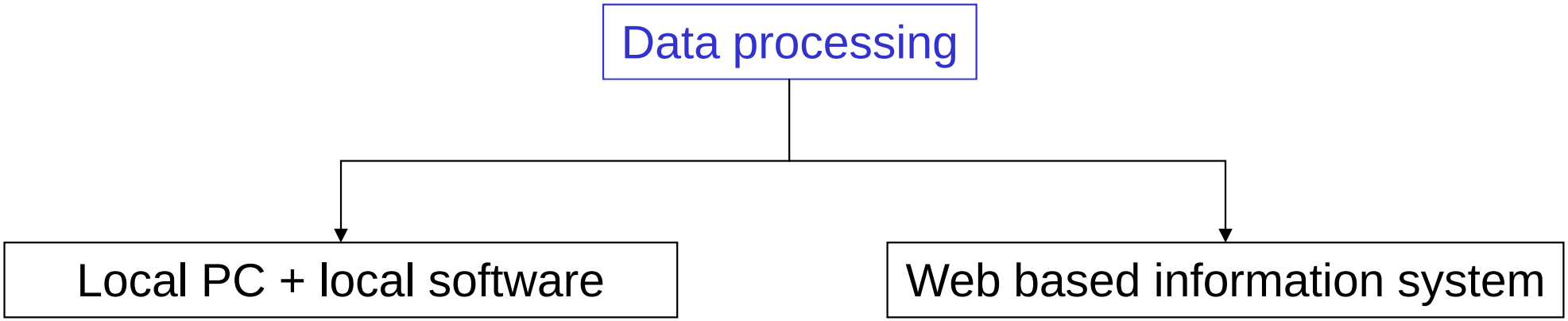
Data processing in different organizations



- First attempt in 2000 / 2001
- Based on Microsoft Access®
- Complete data processing, data management and analyzing tool
- Not capable for huge data amounts

» Laborious to install and update on many farms

- Modelling and prototyping since 2002
- Use of OpenSource software only
- User interface via Web browser
- DB model for high performance

» Central data management
(Automated data processing)

Data processing – spatial data classification

Date,	Time,	Longitude,	Latitude,	Tractor,	Speed,	Pos,	Left,	Right,	Implement,	Ww,	AppVol,	Sum,	field
04.06.2004,	17:34:33,	10.25254822,	49.89058304,	CaCs150,	3002,	043,	-33.14,	-28.80,	IMIgru1,	3000,	141.23,	000,	d01
04.06.2004,	17:34:34,	10.25253296,	49.89060593,	CaCs150,	3014,	044,	-30.73,	-29.01,	IMIgru1,	3000,	142.81,	000,	d01
04.06.2004,	17:34:35,	10.25251865,	49.89062881,	CaCs150,	3010,	041,	-31.48,	-32.75,	IMIgru1,	3000,	143.45,	000,	d01
04.06.2004,	17:34:36,	10.25250340,	49.89065170,	CaCs150,	3024,	040,	-28.70,	-20.93,	IMIgru1,	3000,	141.64,	000,	d01
04.06.2004,	17:34:37,	10.25248814,	49.89067841,	CaCs150,	2950,	046,	-24.75,	-23.14,	IMIgru1,	3000,	140.68,	000,	d01
04.06.2004,	17:34:38,	10.25247288,	49.89070129,	CaCs150,	2925,	046,	-10.68,	-07.17,	IMIgru1,	3000,	138.83,	000,	d01
04.06.2004,	17:34:40,	10.25245857,	49.89074707,	CaCs150,	3050,	046,	-29.31,	-29.85,	IMIgru1,	3000,	139.34,	000,	d01
04.06.2004,	17:34:41,	10.25244522,	49.89076996,	CaCs150,	3102,	047,	-20.56,	-14.57,	IMIgru1,	3000,	140.64,	000,	d01
04.06.2004,	17:34:42,	10.25243187,	49.89079285,	CaCs150,	2965,	074,	44.53,	47.97,	IMIgru1,	3000,	142.58,	000,	d01
04.06.2004,	17:34:43,	10.25242138,	49.89081573,	CaCs150,	2422,	097,	69.11,	72.48,	IMIgru1,	3000,	144.89,	000,	d01
04.06.2004,	17:34:44,	10.25241661,	49.89083099,	CaCs150,	1987,	102,	64.67,	64.96,	IMIgru1,	3000,	145.91,	000,	none
04.06.2004,	17:34:45,	10.25242329,	49.89085007,	CaCs150,	1883,	102,	66.53,	63.60,	IMIgru1,	3000,	147.39,	000,	none
04.06.2004,	17:34:46,	10.25243473,	49.89086151,	CaCs150,	1789,	102,	61.54,	69.70,	IMIgru1,	3000,	150.93,	000,	none
04.06.2004,	17:34:47,	10.25244808,	49.89086914,	CaCs150,	1475,	102,	65.59,	71.69,	IMIgru1,	3000,	151.56,	000,	none
04.06.2004,	17:34:48,	10.25245953,	49.89087677,	CaCs150,	1335,	102,	65.13,	74.23,	IMIgru1,	3000,	149.73,	000,	none
04.06.2004,	17:34:49,	10.25245190,	49.89087296,	CaCs150,	0885,	102,	66.03,	70.37,	IMIgru1,	3000,	149.82,	000,	d02
04.06.2004,	17:34:50,	10.25243187,	49.89086151,	CaCs150,	2411,	102,	58.13,	59.14,	IMIgru1,	3000,	150.47,	000,	d02
04.06.2004,	17:34:51,	10.25241184,	49.89084244,	CaCs150,	2423,	102,	65.75,	77.14,	IMIgru1,	3000,	150.85,	000,	d02
04.06.2004,	17:34:52,	10.25240803,	49.89082336,	CaCs150,	2380,	102,	67.16,	82.57,	IMIgru1,	3000,	149.29,	000,	d02
04.06.2004,	17:34:53,	10.25242043,	49.89080048,	CaCs150,	2341,	103,	62.48,	67.99,	IMIgru1,	3000,	151.74,	000,	d02
04.06.2004,	17:34:54,	10.25243187,	49.89078140,	CaCs150,	2356,	100,	64.83,	73.53,	IMIgru1,	3000,	148.43,	000,	d02
04.06.2004,	17:34:55,	10.25244522,	49.89076233,	CaCs150,	2315,	100,	64.04,	70.60,	IMIgru1,	3000,	147.74,	000,	d02
04.06.2004,	17:34:56,	10.25245667,	49.89074707,	CaCs150,	2200,	100,	64.29,	71.46,	IMIgru1,	3000,	144.59,	000,	d02
04.06.2004,	17:34:57,	10.25246811,	49.89073181,	CaCs150,	2032,	100,	63.30,	71.32,	IMIgru1,	3000,	142.16,	000,	d02
04.06.2004,	17:34:58,	10.25247478,	49.89072037,	CaCs150,	1235,	100,	61.00,	75.36,	IMIgru1,	3000,	142.98,	000,	d02
GPS (position and time)				**tractor**					**implements**				**field**

Data processing – spatial data classification

Date,	Time,	Longitude,	Latitude,	Driver,	Tractor,	Speed,	Pos,	Left,	Right,	Implement,	Wo
03.10.2001,	17:34:33,	10.25254822,	49.89058304,	w. herbert,	CaCs150,	3002,	043,	-33.14,	-28.80,	IMIgru1,	3000
03.10.2001,	17:34:34,	10.25253296,	49.89060593,	w. herbert,	CaCs150,	3014,	044,	-30.73,	-29.01,	IMIgru1,	3000
03.10.2001,	17:34:35,	10.25251865,	49.89062881,	w. herbert,	CaCs150,	3010,	041,	-31.48,	-32.75,	IMIgru1,	3000
03.10.2001,	17:34:36,	10.25250340,	49.89065170,	w. herbert,	CaCs150,	3024,	040,	-28.70,	-20.93,	IMIgru1,	3000
03.10.2001,	17:34:37,	10.25248814,	49.89067841,	w. herbert,	CaCs150,	2950,	046,	-24.75,	-23.14,	IMIgru1,	3000
03.10.2001,	17:34:38,	10.25247288,	49.89070129,	w. herbert,	CaCs150,	2925,	046,	-10.68,	-07.17,	IMIgru1,	3000
03.10.2001,	17:34:40,	10.25245857,	49.89074707,	w. herbert,	CaCs150,	3050,	046,	-29.31,	-29.85,	IMIgru1,	3000
03.10.2001,	17:34:41,	10.25244522,	49.89076996,	w. herbert,	CaCs150,	3102,	047,	-20.56,	-14.57,	IMIgru1,	3000
03.10.2001,	17:34:42,	10.25243187,	49.89079285,	w. herbert,	CaCs150,	2965,	074,	44.53,	47.97,	IMIgru1,	3000
03.10.2001,	17:34:43,	10.25242138,	49.89081573,	w. herbert,	CaCs150,	2422,	097,	69.11,	72.48,	IMIgru1,	3000
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03.10.2001,	17:34:46,	10.25243473,	49.89086151,	w. herbert,	CaCs150,	1789,	102,	61.54,	69.70,	IMIgru1,	3000
03.10.2001,	17:34:47,	10.25244808,	49.89086914,	w. herbert,	CaCs150,	1475,	102,	65.59,	71.69,	IMIgru1,	3000
03.10.2001,	17:34:48,	10.25245953,	49.89087677,	w. herbert,	CaCs150,	1335,	102,	65.13,	74.23,	IMIgru1,	3000
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03.10.2001,	17:34:50,	10.25243187,	49.89086151,	w. herbert,	CaCs150,	2411,	102,	58.13,	59.14,	IMIgru1,	3000
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03.10.2001,	17:34:52,	10.25240803,	49.89082336,	w. herbert,	CaCs150,	2380,	102,	67.16,	82.57,	IMIgru1,	3000
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03.10.2001,	17:34:54,	10.25243187,	49.89078140,	w. herbert,	CaCs150,	2356,	100,	64.83,	73.53,	IMIgru1,	3000
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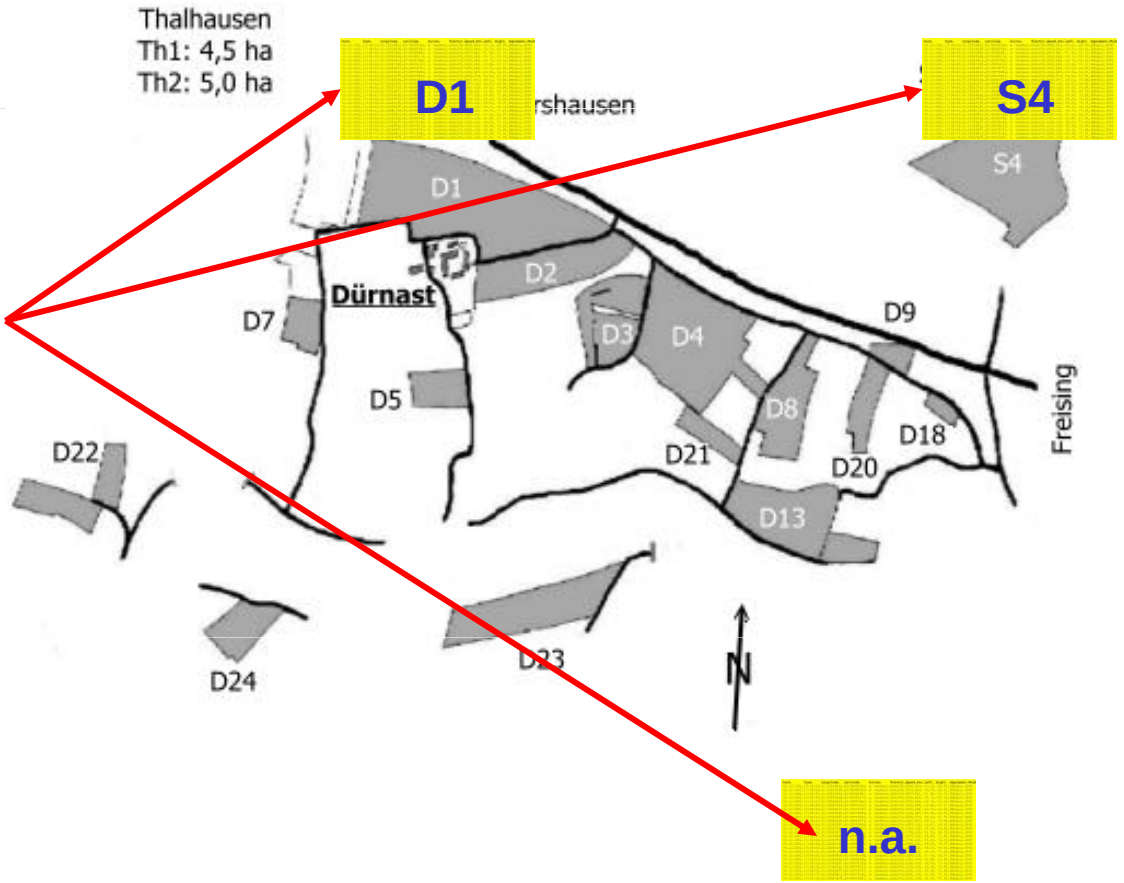
03.10.2001,	17:34:57,	10.25246811,	49.89073181,	w. herbert,	CaCs150,	2032,	100,	63.30,	71.32,	IMIgru1,	3000
03.10.2001,	17:34:58,	10.25247478,	49.89072037,	w. herbert,	CaCs150,	1235,	100,	61.00,	75.36,	IMIgru1,	3000

Row data



Data processing – process analysis

Operation 1 (field 1, tractor 2, grubber, date 1)

data point 1: speed, hitch position, draught force,...)
data point 2: speed, hitch position, draught force,...)
...
data point 2: speed, hitch position, draught force,...)

- working time, turn-over time,...
- average working speed
- average draught force
- ...

Operation 2 (field 2, tractor 1, sprayer, date 2)

data point 1: speed, PTO speed, application volume,...)
...
data point 1: speed, PTO speed, application volume,...)

- working time, turn-over time,...
- average working speed
- average application volume
- all-up application volume
- ...

Operation 3 (field 1, tractor 1, seeder, date 3)

...

Automated Process Data Acquisition within Standardized Communication Systems

1. The information age
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3. Process data acquisition systems
4. Data processing
5. **Practical applications**
6. Conclusions

Example of operation statistics: tillage (stubble mulching)

date	start time	end time	field	tractor	implement	procedure
2000.08.14	12:33 pm	06:48 pm	S04	Fendt714	grubber	tillage

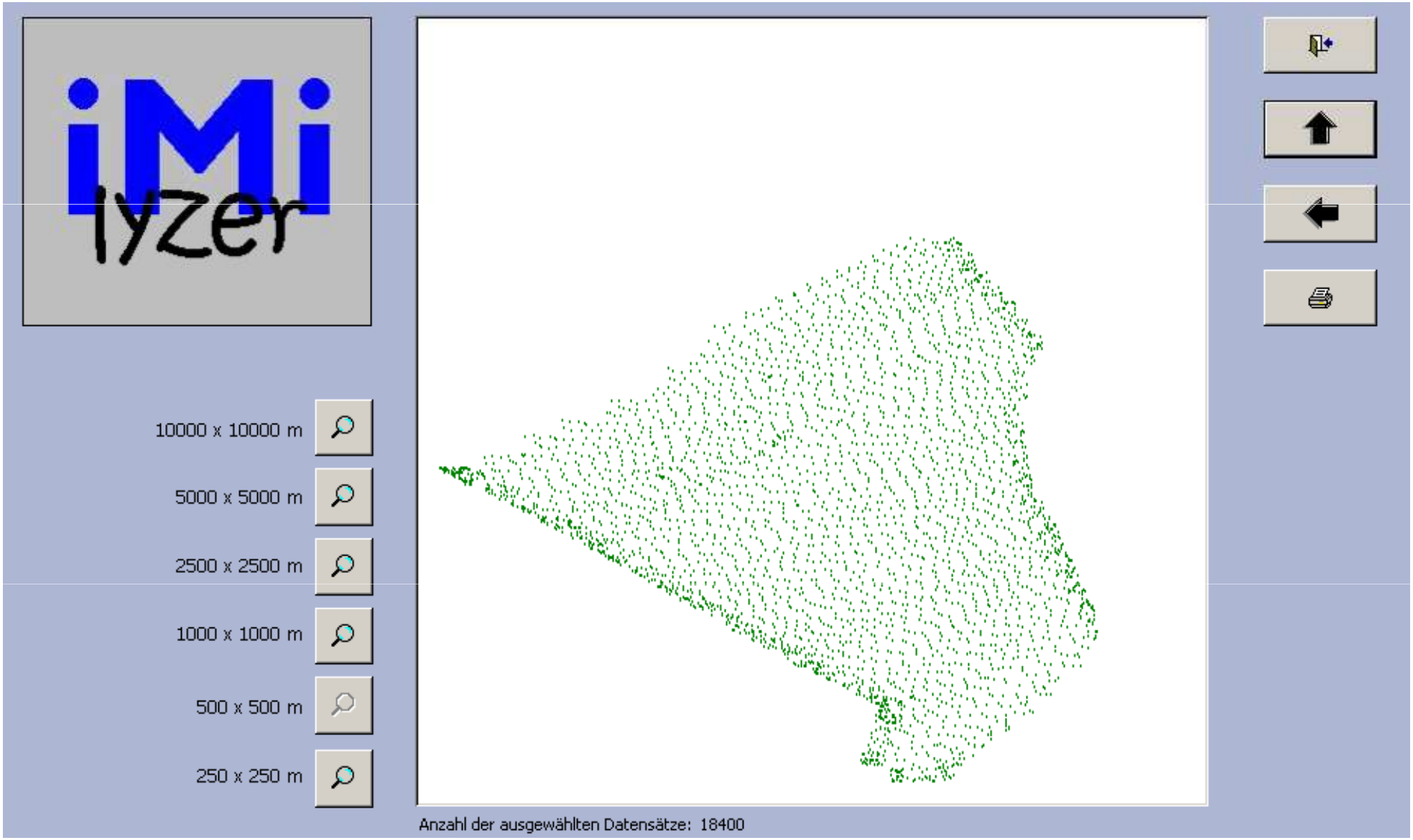
used time in field				
total	*working*	*turning*	*standing*	*time / field*
6.02 h	75 %	18 %	7 %	0.72 h/ha

Used as a document of the task of a contractor (proof, invoice)

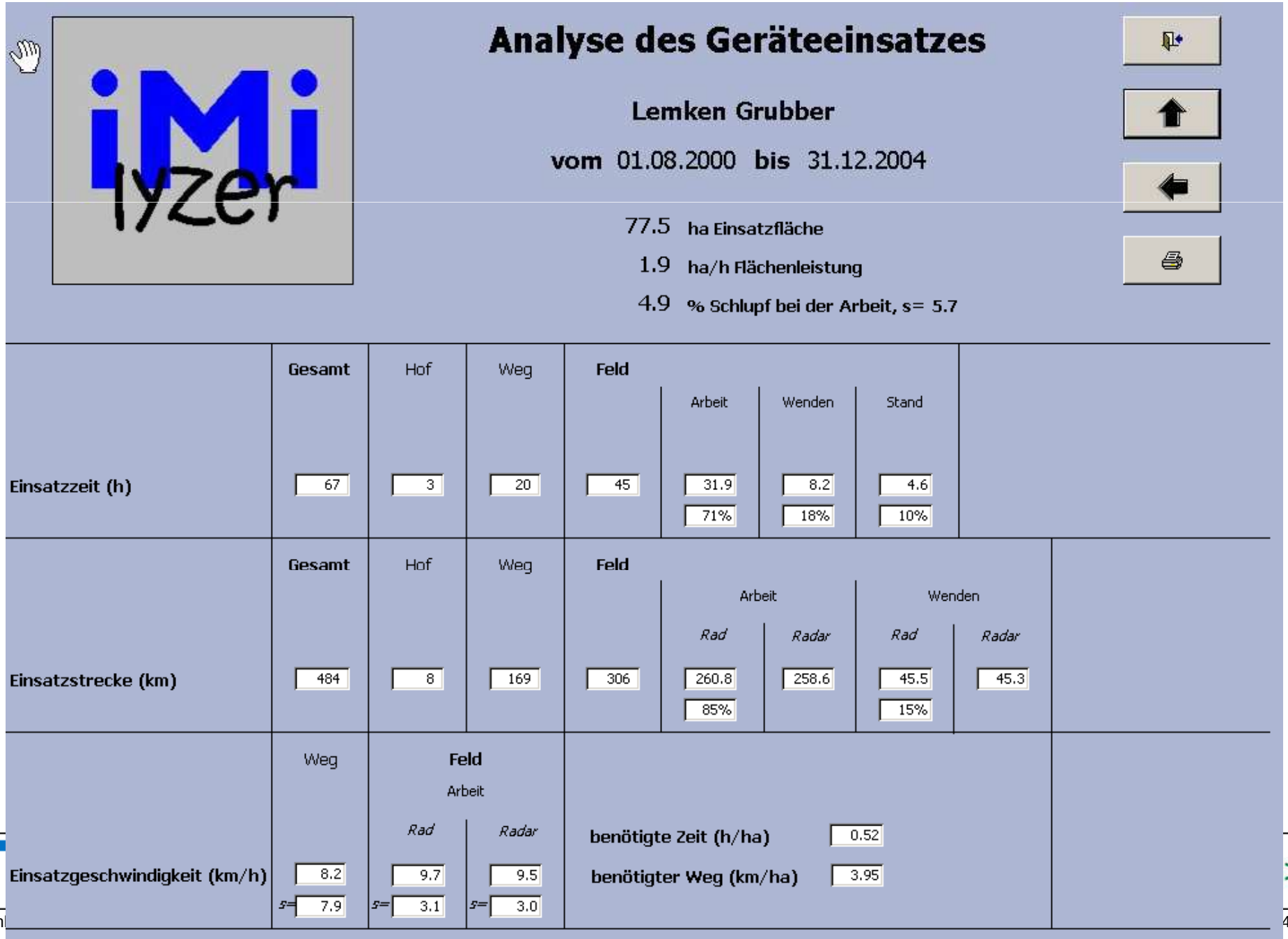
8.82 km/h	1.76 km/h	0 RPM	0 RPM

cultivated area	draft force at work	
sum	*sum*	*stddev*
8.37 ha	25.96 kN	8.16 kN

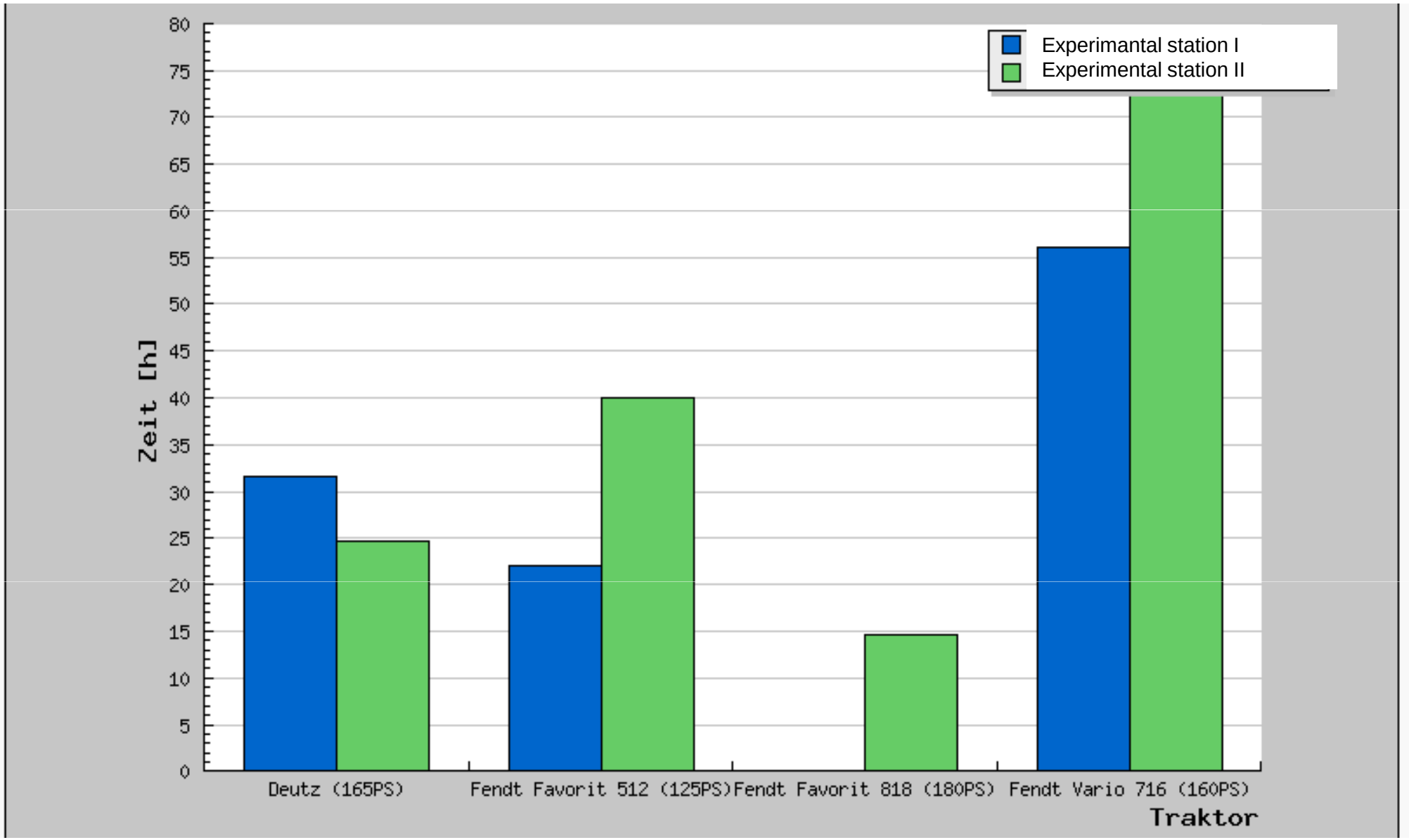
Data processing (visualized data points)



Data processing (detailed analysis of an implement)



Use of tractors on different farmsteads



Use of a Tractor (e.g. along a year per week)

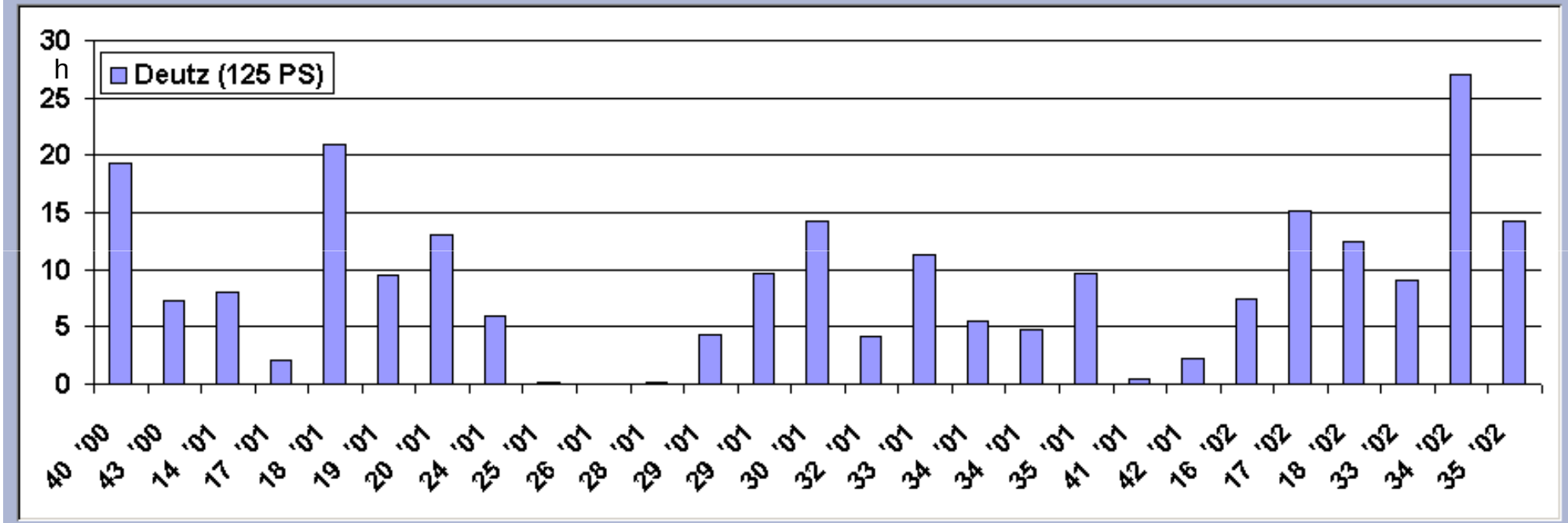
iMi lyzer

wöchentliche Einsatzzeit

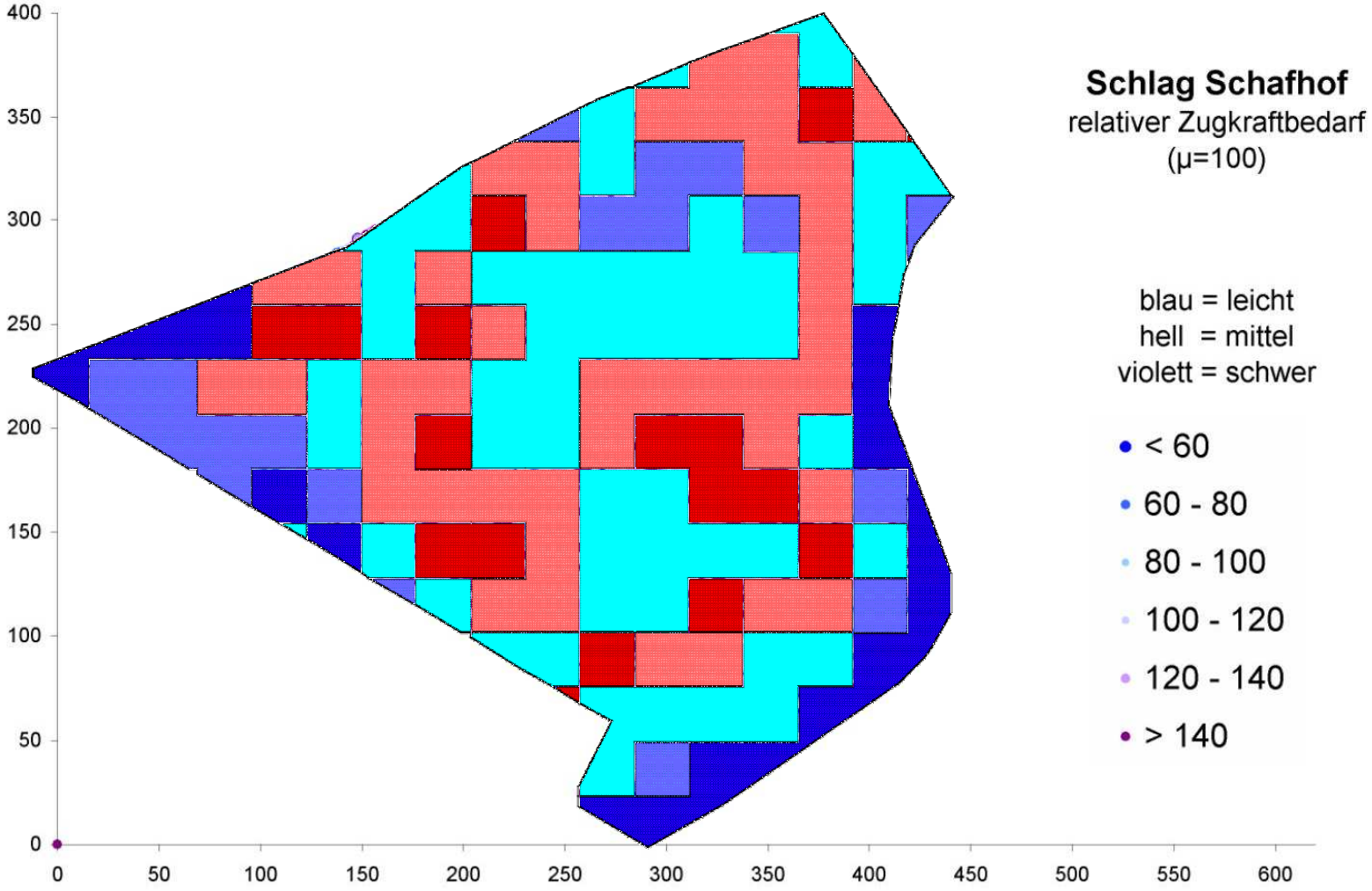
der ausgewählten Traktoren

vom 01.08.2000 bis 31.12.2004

Versuchsstation Dürnast



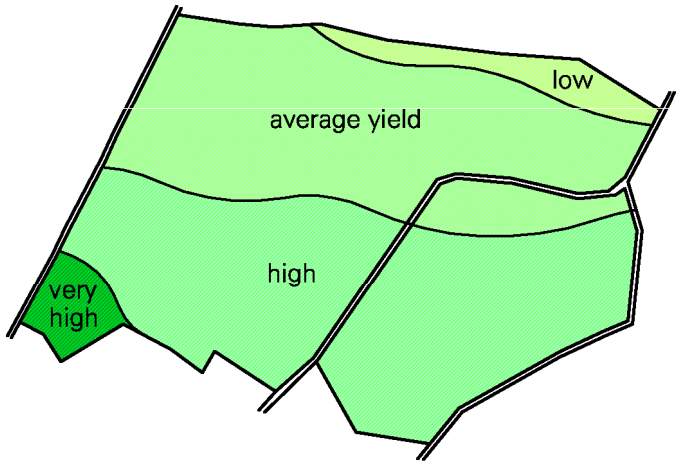
Practical applications – soil resistance map



Part field management approaches of site-specific crop management

Site-specific crop management

Large-scale farming



Derivation and determination of homogeneous partfields

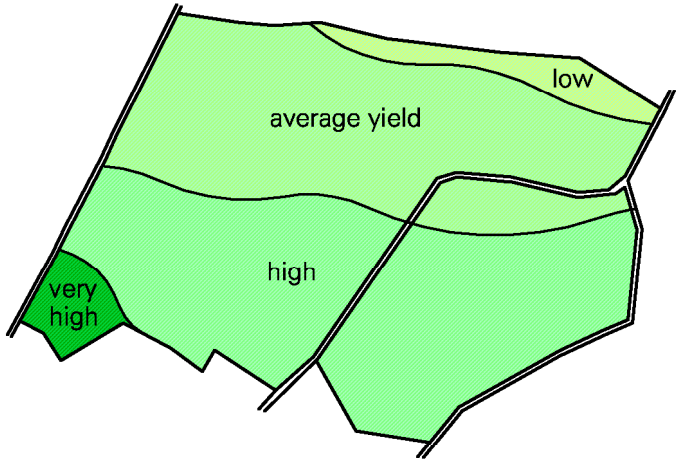
- Determination of heterogeneities
- Determination of management zones (same yields) under consideration
  - · Technical differentiation
  - · Economical efficiency
  - · Ecological efficiency

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

Part field management approaches of site-specific crop management

Site-specific crop management

Large-scale farming



Derivation and determination of homogeneous partfields

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  - Technical differentiation
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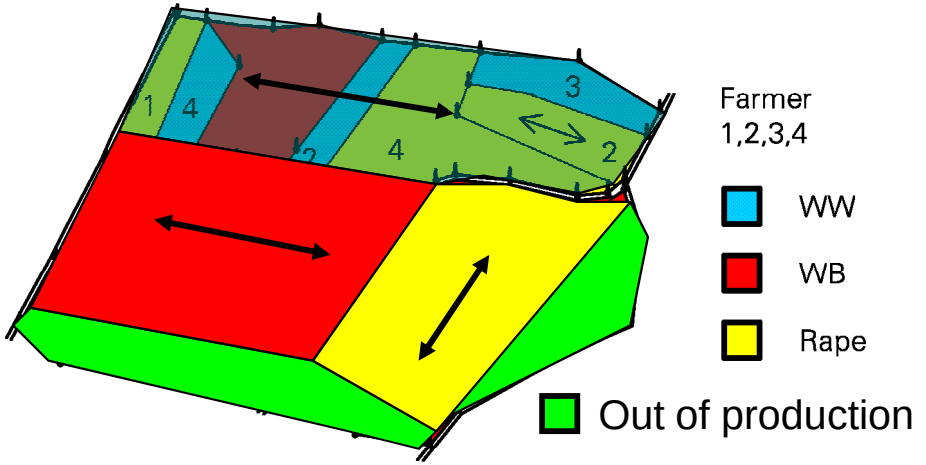
Small-scale farming



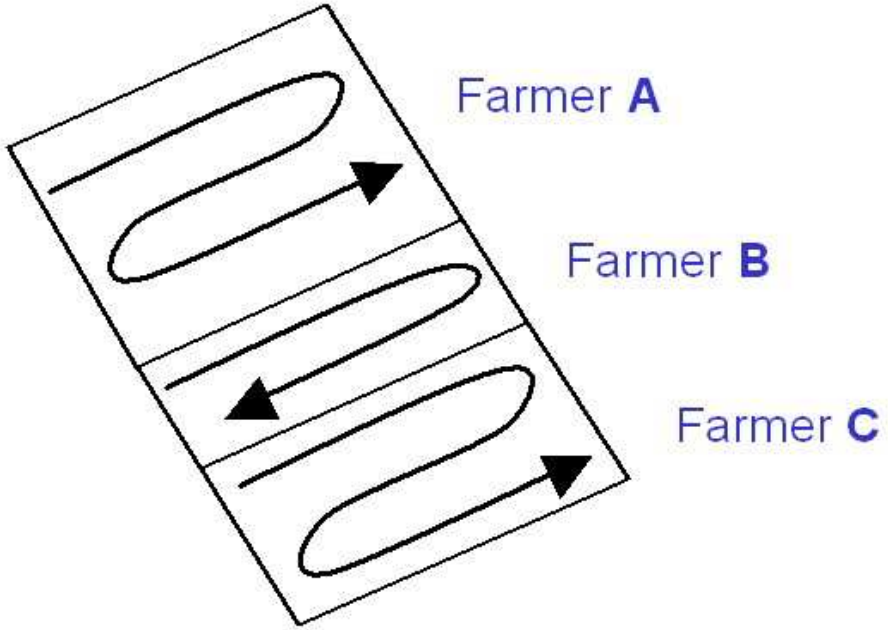
Consideration of part fields from different land lords in a transborder field

- 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

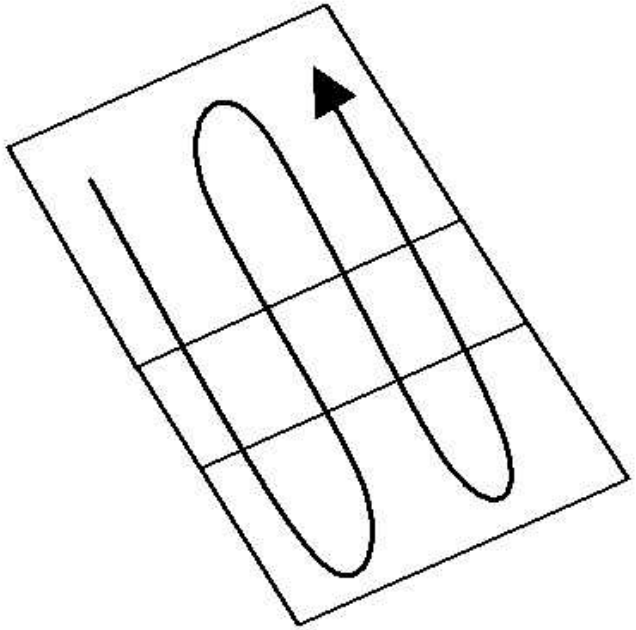
Size of transborder fields limited by existing infra structure (roads, ditches, ...) and crop rotation

Practical applications – transborder farming

Previous use of single plots

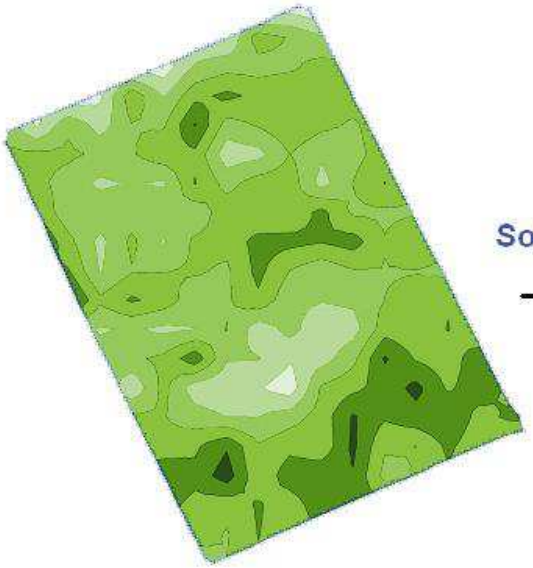


Joint use of the transborder farming field lengthwise



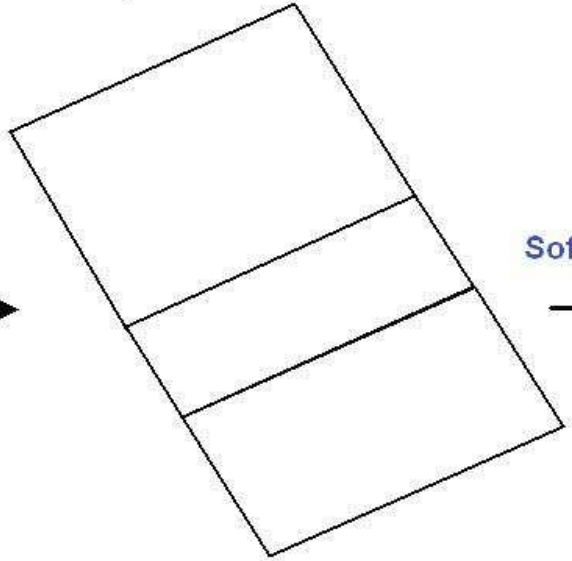
Practical applications – transborder farming

online-acquisition of operating-times, application- and yield-volumes



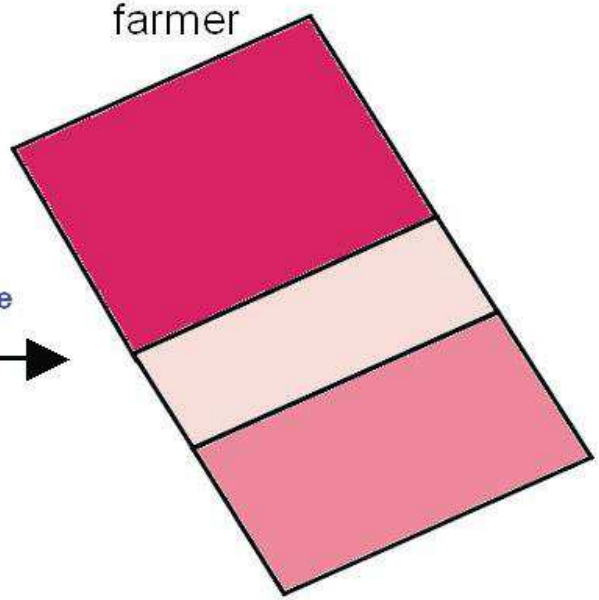
Software

allocation of times and volumes within the outlines of parcels



Software

property based validation for each participating farmer



Standards from “On-farm research”

Working time $t_x = 0.35 * l_w + 2.8$

Working sequences $w_t = w_a + w_b + w_c + ... + w_n$

Fuel consumption $f_w = kW_{tractor} * v * g * ...$

...

Basic knowledge and basic figures for scientific investigations and advisory services !

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Conclusions

- A well-founded documentation will be the base of many agricultural applications in the future.
- Automated data acquisition is the fit way to provide spatial and temporal high-resolutions and safe documentations.
- The huge amount of raw data needs to be processed by easy-to-use and safe data processing systems.
- A Web based data management and information system is able to provide safety and effective information management for the farmer - avoiding problems with local installed software, time and costs.
- In the project on hand a first approach has been realized using “open source” software components.