The role of mechatronics in crop product traceability

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The role of mechatronics in crop product traceability

1 Introduction

2 Overview on precision crop farming

3 Applications of mechatronics
- Automated data acquisition
- Site-specific crop management
- Fleet management
- Guidance and field robotics

4 Traceability
- Efficient sensors
- Distributed controllers
- Standardized communication
- Integrated security / safety concepts

5 Conclusions

Food and society

People in industrialized countries lost the relationship to food production and the real production itself:

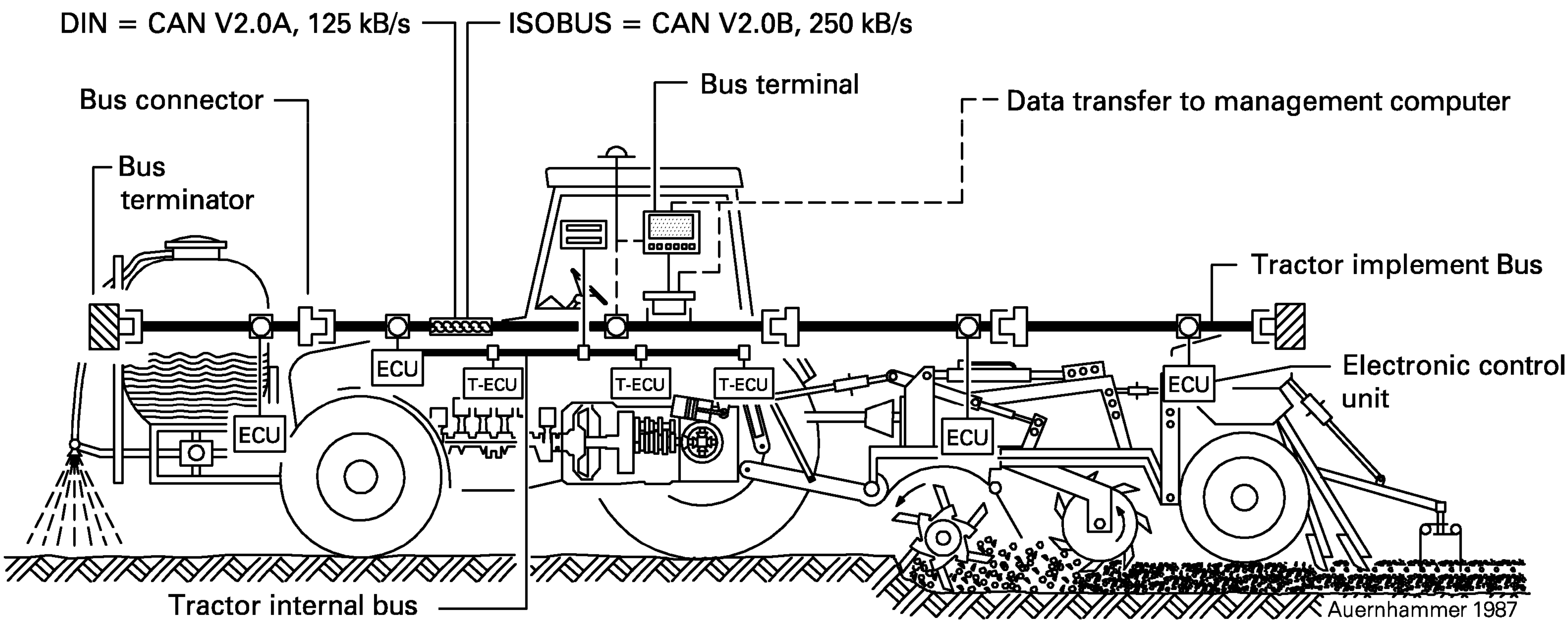
- Milk comes from the super market. If milk has a connection to the cow it is because of TV advertising for chocolate with the colourful (violet) cow.

- The well-protected environment is required by all people, agriculture is the primary enemy of the environment.

- Crises like BSE and Foot and Mouth Disease support the consumer in his distrust against agriculture – agriculture means environmental pollution and profit.

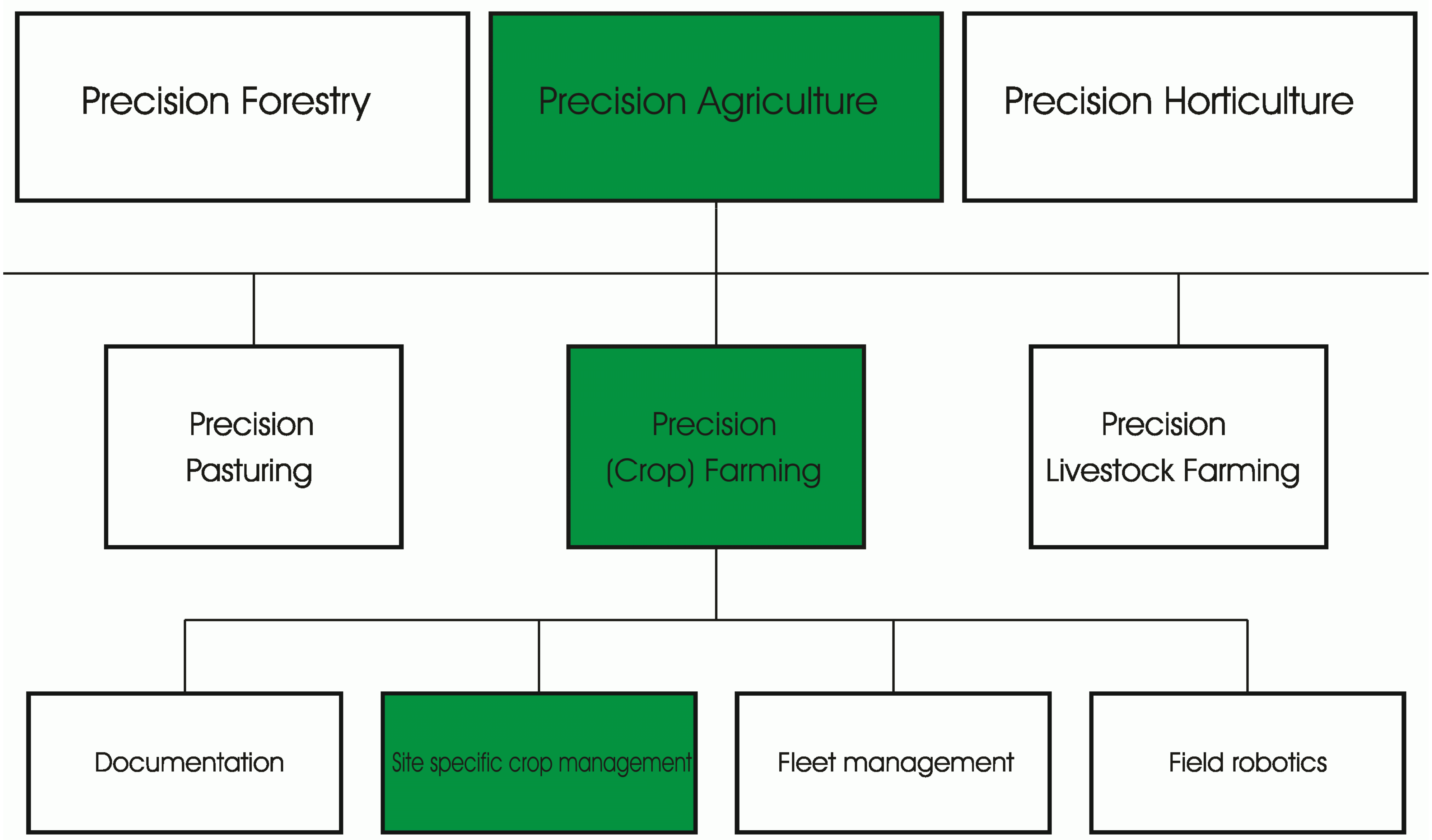
- The work in the house and in the garden, with flowers and pets, loved by almost all people, leads to a self-overestimation – everyone becomes a specialist in agriculture.

Landwirtschaftliches BUS-System (LBS) by DIN 9684/2-5 and ISO 11783 (ISOBUS)



T-ECU Tractor internal Electronic Control Unit

Information technology in land use



Information technology (IT) applications in arable farming

Precision Farming

Automated data acquisition
- Fieldbooks and bookkeeping
- Basic data for Precision Farming
- On-farm research
- Administration
- Quality management

Site specific farming
- Tillage
- Drilling
- Fertilizing
- Spraying
- Irrigation
- Harvesting (with online decision)

Fleet management
- Location monitoring
- Central equipment monitoring and control
- Route planning with autonomous sequence control
- Route planning with central sequence control
- Obstacle/danger signalising (map matching)

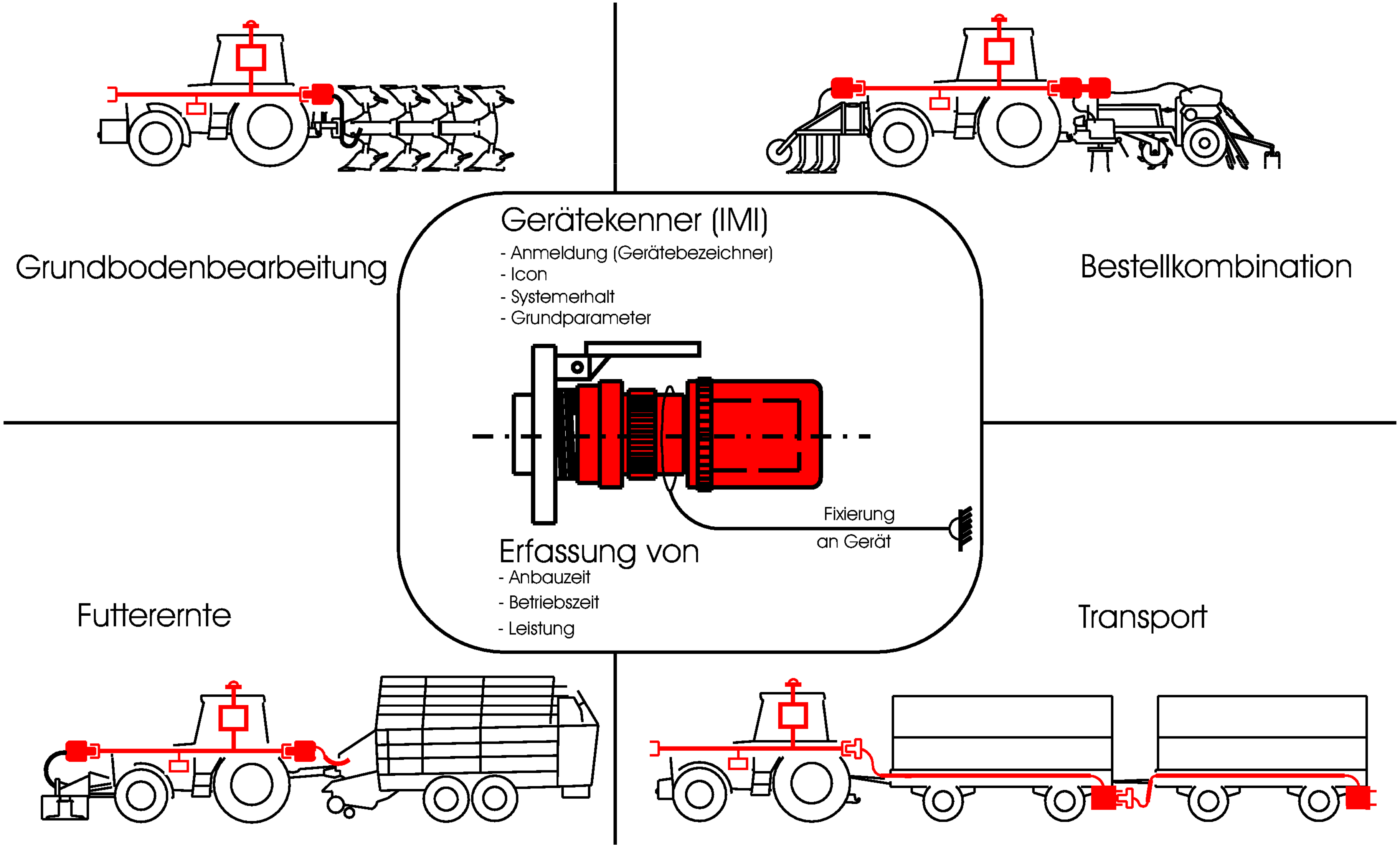
Field robots
- Implement control/ Automatic guidance
- Manned guiding vehicle and unmanned following vehicles
- Unmanned vehicles of existing concepts
- Unmanned vehicles of new specialised concepts

Farm management	Crop management	Machine management	Labour management

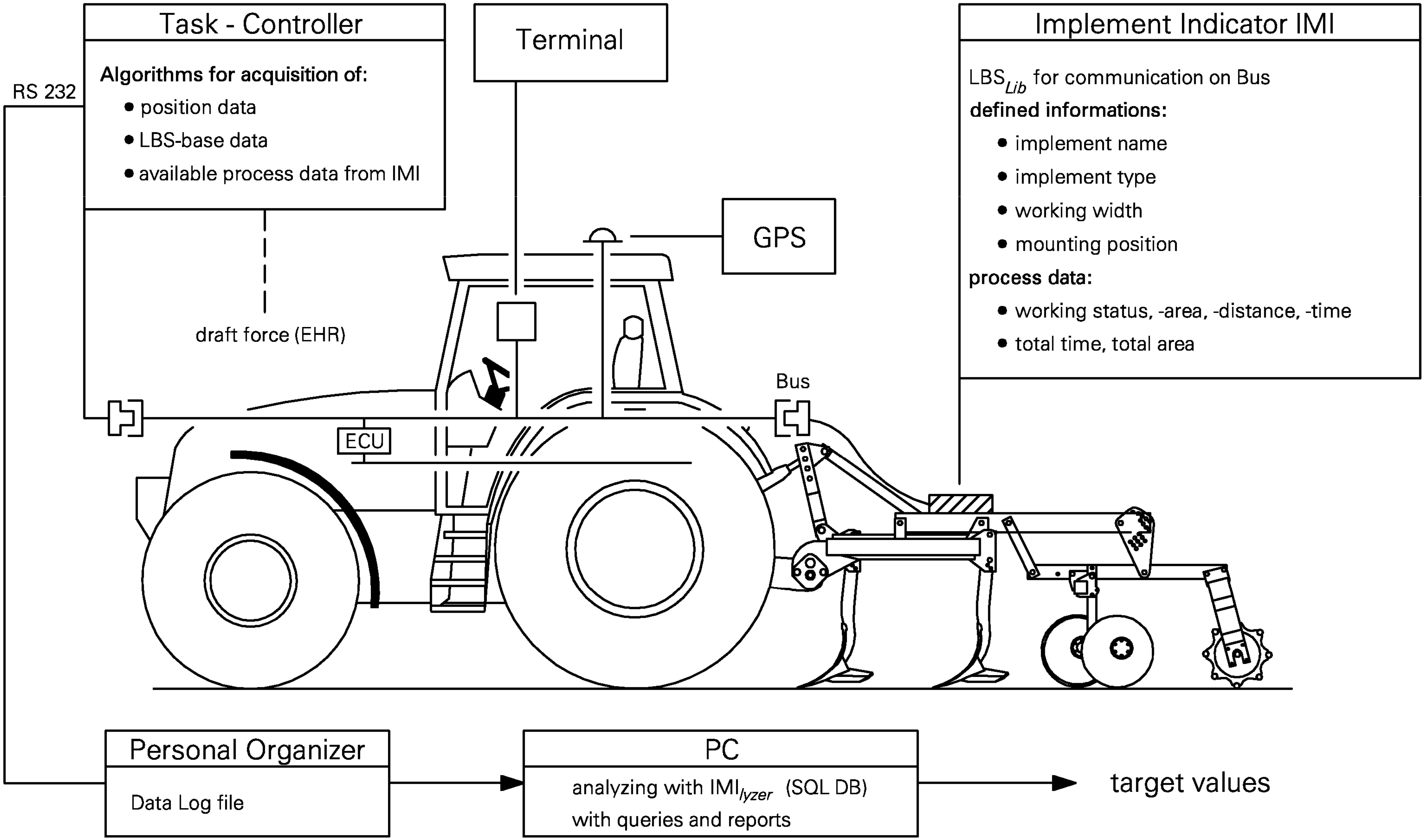
Traceability (documentation)

Examples of automized data acquisition with LBS

- schematic -

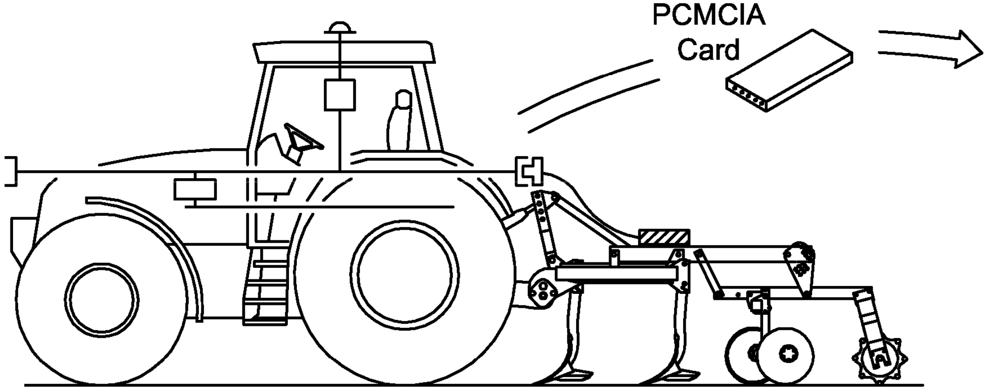


Systemconfiguration automated process data acquisition



Automated field data documentation

(Field$_{tracer}$)



Input

Pre Processing

SQL-database

Process data analysis

- referring to tasks or years -

Time Way	Used material Yield	Tractor Implement
total time part time driven way work way standing time . . .	used materials used fuel yield . . .	working depth / hight working intensity capacity . . .
Execution	**Materials**	**Maschine use**

Geo data analysis

- GIS -

Traces	Grids	Outline
tracks velocity working position standing time turning ways / pattern . . .	labour time interruptions used materials yield soil resistance . . .	labour time interruptions used materials yield soil resistance . . .
Work sequence optimisation	**Location information**	**Location evaluation**

Parameters from automated process data acquisition

Date	Start time	End time	Field	Tractor	Implement	Procedure
2001.04.30	19:45 pm	20:30 pm	TH01	MB-trac	spreader	fertilising

Time consumption in field				
total	*working*	*turning*	*standing*	*time / field*
0.59 h	61 %	23 %	16 %	0.10 h/ha

Driven distance in field			
total	*working*	*turning*	*distance / field*
4.11 km	81 %	19 %	0.71 km/ha

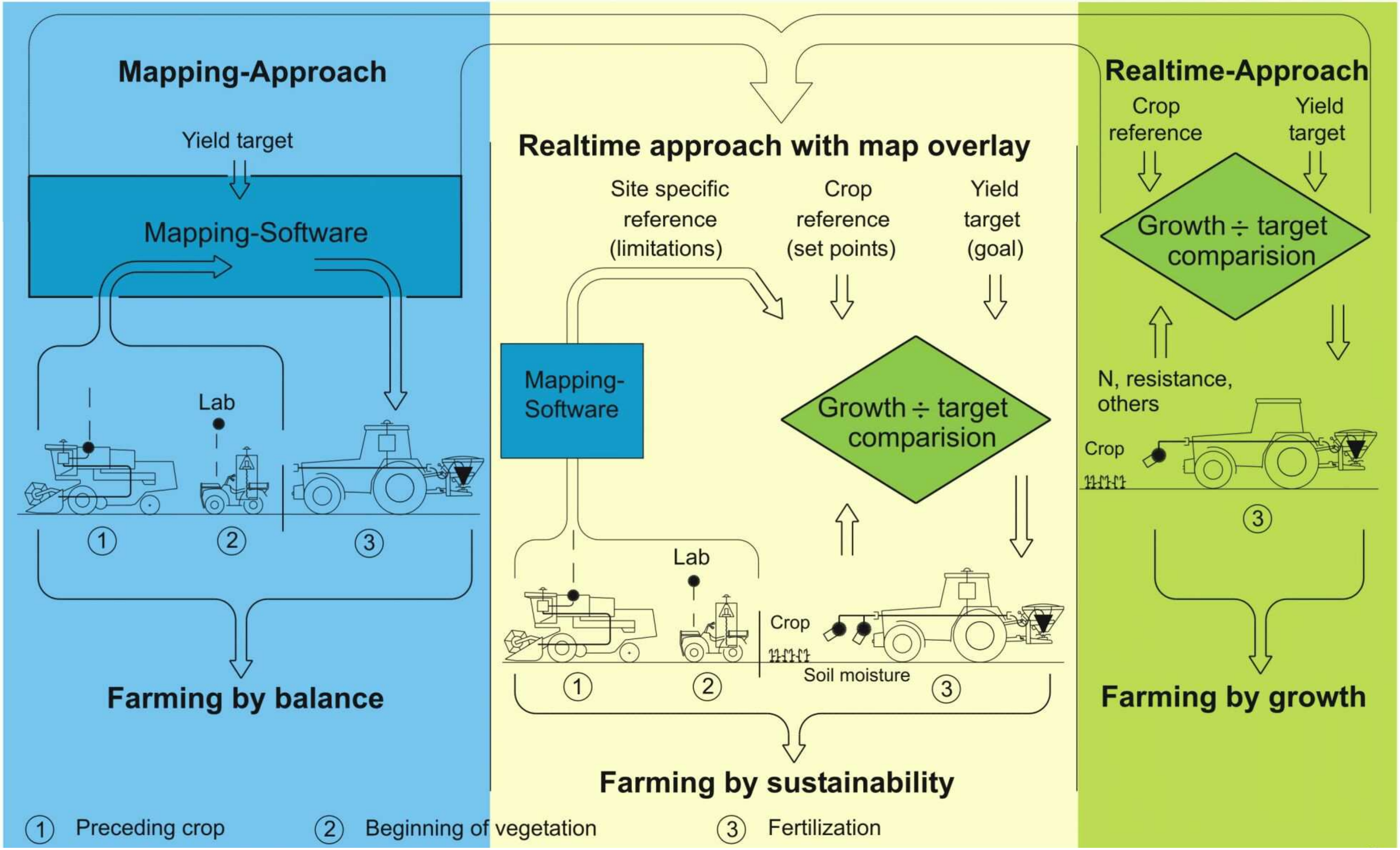
Working speed	
mean	*stddev.*
9.26 km/h	2.27 km/h

PTO speed at work	
mean	*stddev.*
450 RPM	61 RPM

Cultivated area
sum
4.75 ha

Applicated volume / weight		
sum	*mean*	*stddev*
915.6 kg	203.4 kg/ha	34.9 kg/ha

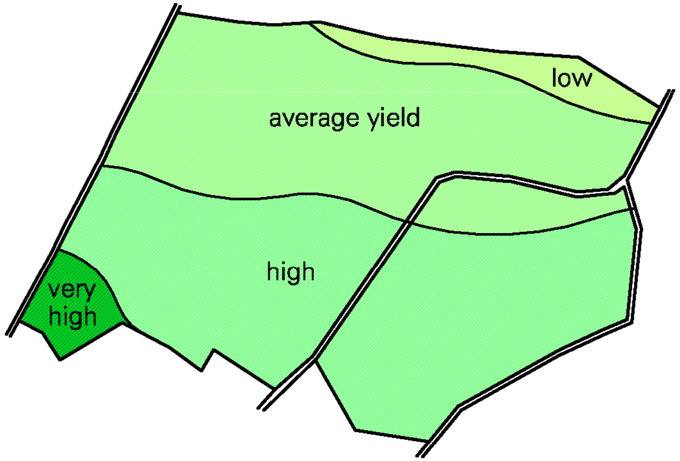
System approaches of site specific fertilization in crop production



Part field management approaches of site-specific crop management

Site-specific crop management

Large-scale farming

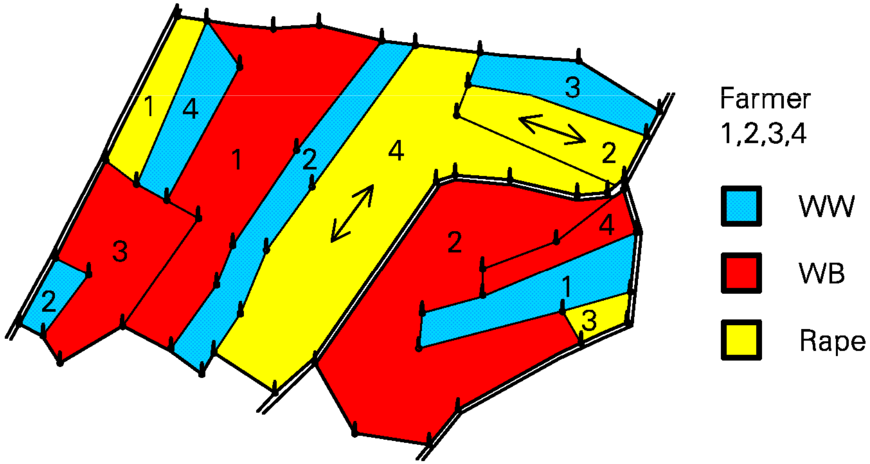


Derivation and consideration of heterogeneous part fields

- 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



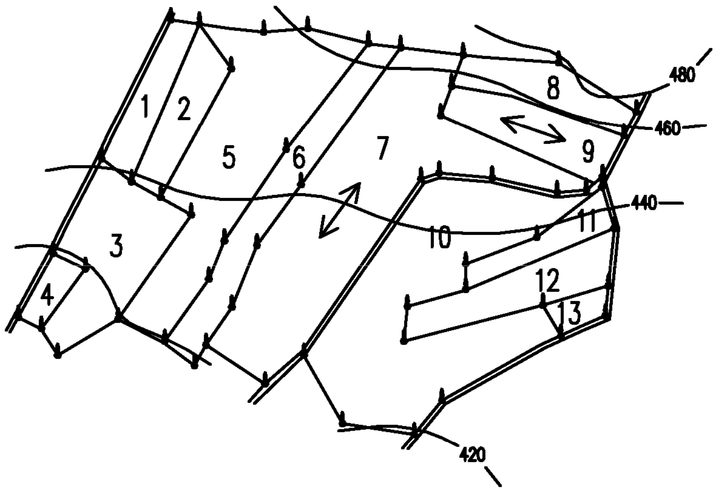
Consideration of part fields from different land lords in a transborder field

- 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

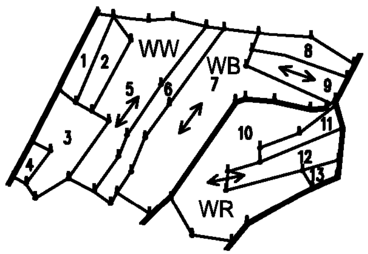
Transborder Farming Systems

Existing structure

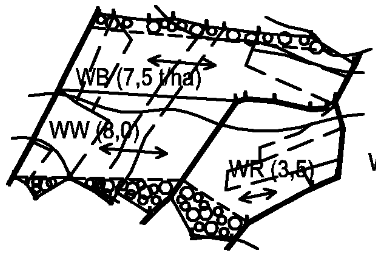


Farmer		WW	WB	WR
Farmer	A	12	5	1
"	B	4; 6	10	9
"	C	8	3	13
"	D	2	11	7

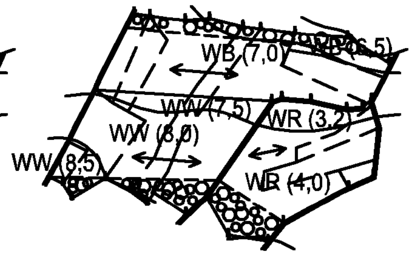
Yield orientation (economical)



by ownership

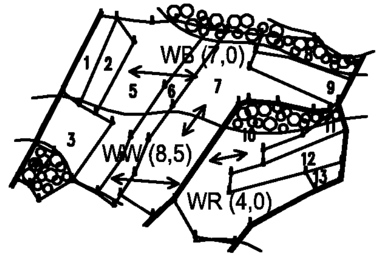


by common yield target

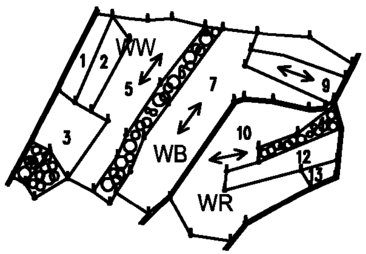


by site specific farming

Environmental orientation (ecological)

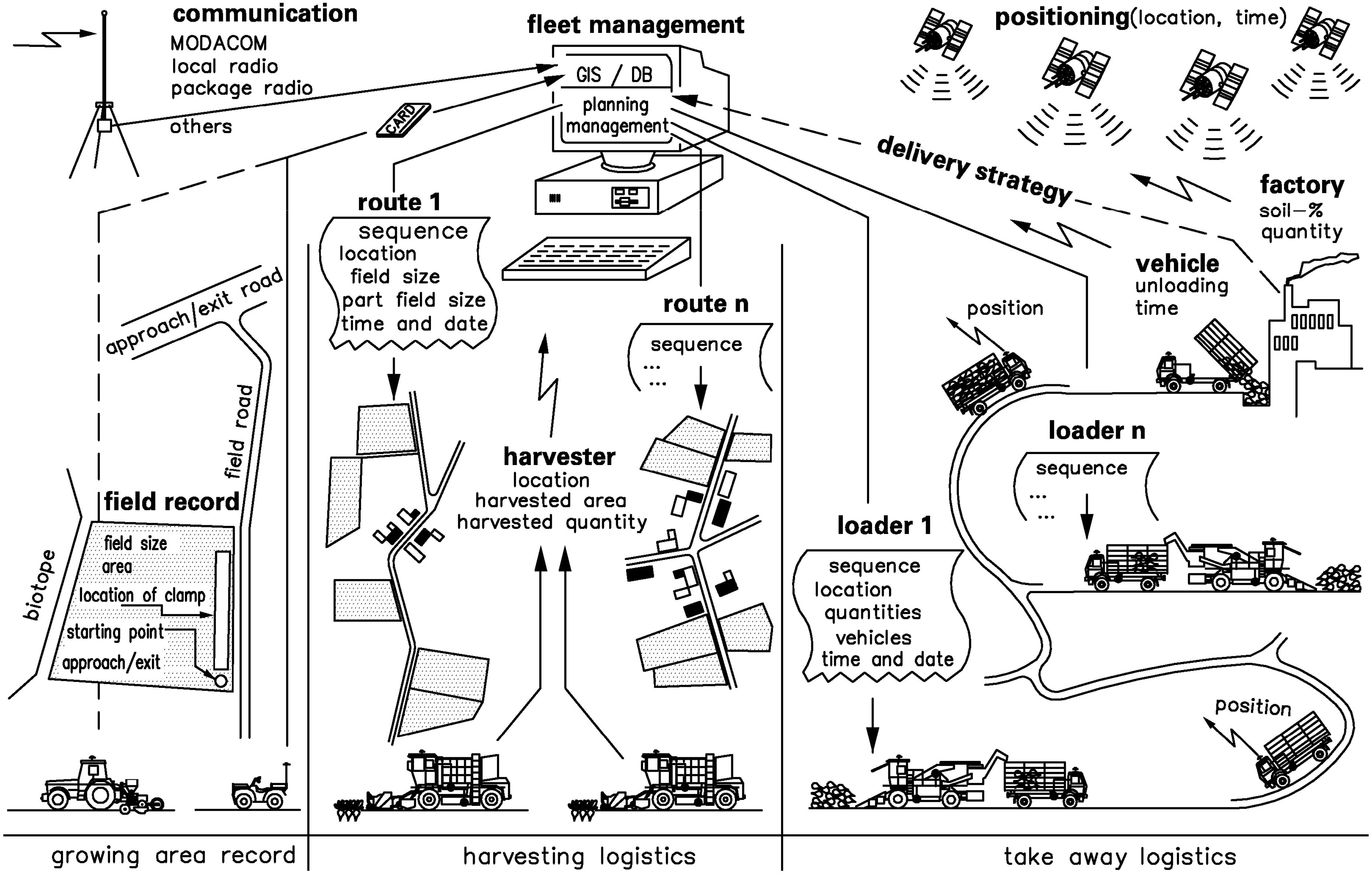


by erosion reduction

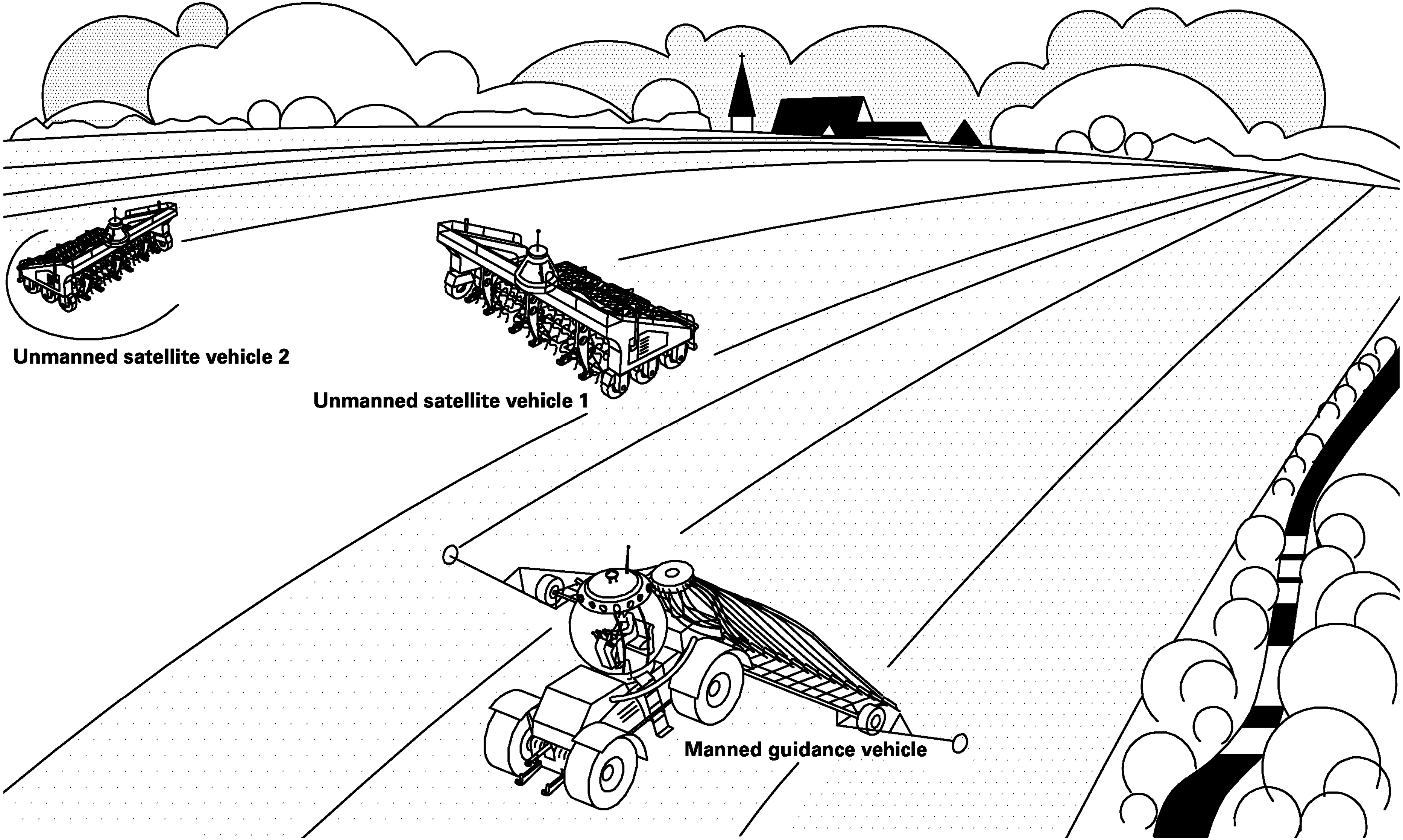


by landscape protection

Logistics of fleet management for sugar beet growing



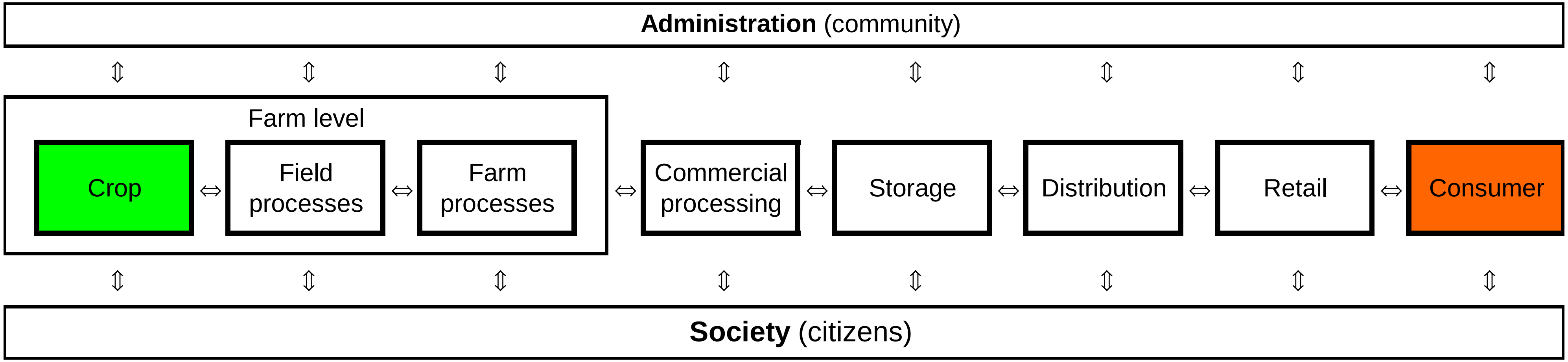
Vision of Future Agricultural Vehicles „Manned Guidance Vehicle with unmanned Satellite Vehicles“



Traceability in the production chain

There are three types of interfaces

- between processes in the chain from the crop to the consumer (field to fork)
- between processes and the administration (taxes, subsidies)
- between processes an society (confidence, believe)



→ Traceability must fulfil all requirements in the whole chain !

Information demand is still not defined

Administration

- Field location, field size, crop, treatment, yield expectation, yield
- Nutrient application, nutrient balance

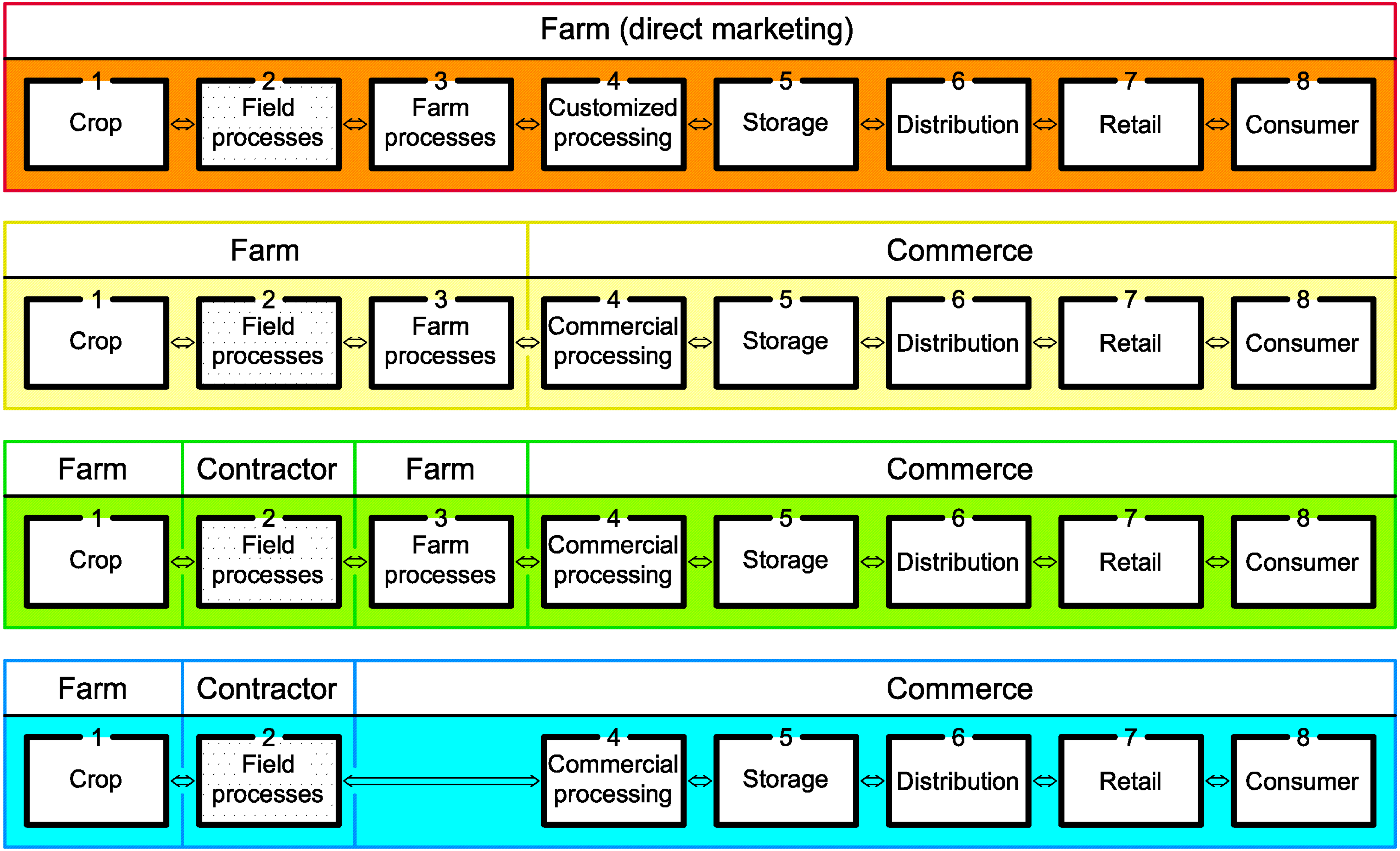
Succeeding process

- Mass/volume, origin, route of transport, time of transport, occurrence during transport
- Processes, ingredients,

Consumer

- Farming type, farmstead, region, time of production, field operations
- Applications, fuel consumption, working conditions, soil stress / working distance/ha
- Ingredients, water content, quality rate/class

Field operations in the product chain



Production information from farm level to consumer

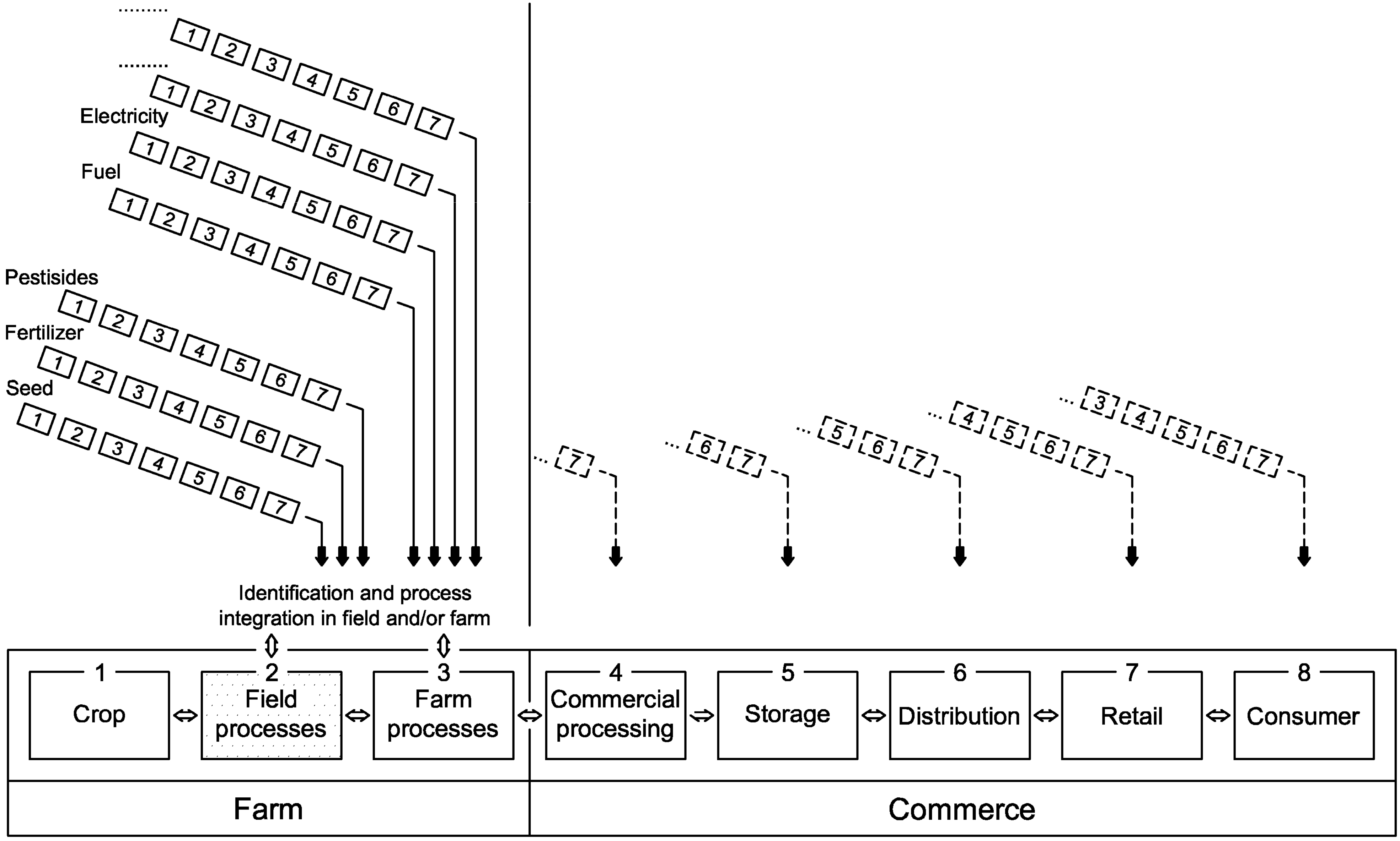
1 Farmer-only chain
- Responsibility only by the farmer
- Customized products are the demands of the consumers

2 Farmer – commerce chain
- Main responsibility by the farmer
- No influence to the end product by the farmer

3 Farmer – contactor – commerce chain
- Main responsibility by the farmer
- No influence to the end product by the farmer
- Contractor

4 Contractor – commerce chain
- Main responsibility by the farmer
- No influence to the end product by the farmer
- Contractual influence to the contractor

Product chain with supplementals in food production



Information in agricultural crop processes as part of the product chain

Farm								Out-of-farm
Information Signaling	Interaction crop, human and technology	**Information gathering** Detection	Transfer to mobile processing unit	**Information processing** Aggregation	Transfer to management	**Information integration** Management — Tracing type	Tramsfer from/to farm	**Process chain** integration
Location Environment ***Crop*** Soil Water		Sensors - manual (shape, taste, ...) - technical (mass, time, ...) Actuators (real settings) Location systems - Position - Time		Georeferenced acquisition - working person(s) (idendificaton) - intigrated technology - material (type, amount, increadients) - energie (fuel,oil,...) - time (location, work situation) - site (farm, region, country) *Memorization on-board*		Field book → **Field flow** Book keeping → **Cash flow** Quality management → **Farm flow**		**Supply** - seed - fertilyser - pesticides **Delivering** - products - by-products - other materials
Field conditions		**Field operations**				**Farm management**		**Commerce**
	↑		↑		↑		↑	
	Habit Resistance Reflectance Fluorescence		**ISOBUS** (ISO 11783) By wire Wireless Physical and syntactical standard		**ISOBUS** (ISO 11783) By wire Wireless Syntactical standards		**Paper (additional)** **Paper (by-pack)** **Bar code (on the product)** **"Bio bar code" in product** No/different standards	

Mechatronics in the farm processes

Mechatronics

- reacts on signals from crop, soil, environment
- guarantees optimised soil preparation
- adjusts defined application rates

through

- information gathering (sensor/actuator values)
- information processing (parameters)
- information integration into the farm management (quality management)
- information supply to/from the trade (commercial processing)

Mechatronics and sensors

Modern technology includes many sensors (without extra costs)

There are problems with mass and/or weight detection

- Calibration
- Robustness
- Reliability

New possibilities will be available in the detection of quality and ingredients

- NIR (near infra red reflectance)
- NIT (near infra red transmission)
- Bio bar code
- Others

Consumers would like to have additional information on

- Shape, size
- Colour
- Consistency
- Others

Mechatronics and electronic communication

Started in 1986 with LBS (DIN 9684) still no international accepted standard is available

The ISOBUS (ISO 11783) is still under definition (started in 1990) and would be able to be the standard if

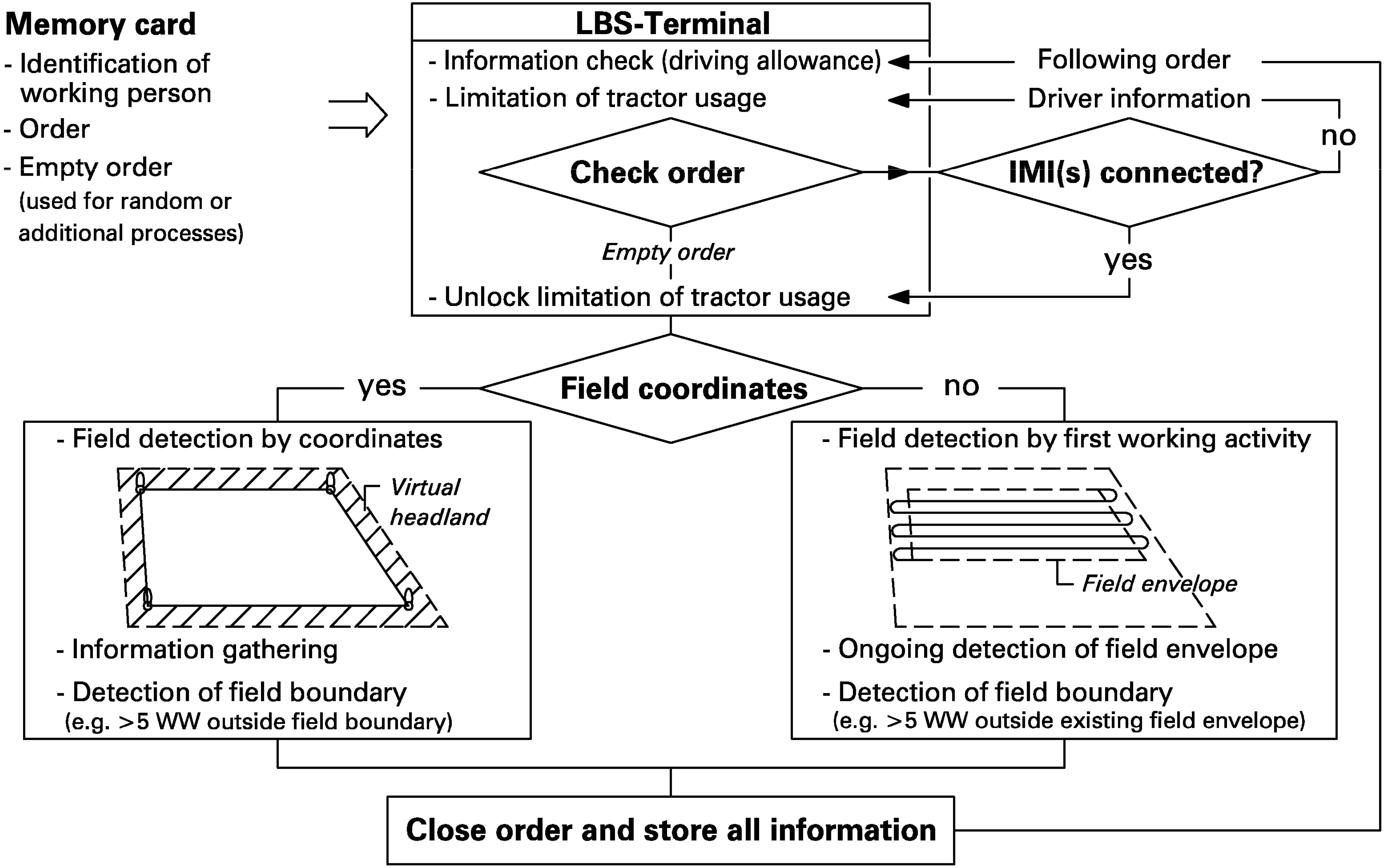
- all interfaces follow this standard
- controllers for all technologies are available
- test installations of the standards can be used.

Nevertheless incompatibilities are created by multiple programming of same procedures with different understanding and different solutions of definitions, causing

- very long development cycles
- extensive and continuing tests on conformity
- frustrated users (remaining incompatibilities with not detectable reasons in a complex system)

An "Open Source Code" would overcome all problems in a very short period of time !

Sequence of an „Automatic process data acquisition system“ with worker identification and security components



Conclusions

- Agricultural machinery is becoming more and more intelligent. Position detection with GPS (Galileo after 2008), standardised electronic communication based on LBS / ISOBUS and a high number of different sensors will become basic components.

- Precision Farming seems to be the farming strategy and practise of the future.

- Product traceability needs information gathering, processing, integration into the farm management and supply to/from the trade.

- Within mobile agricultural equipment GPS and the standardised communication by ISO 11783 opens the best possibilities for traceability.

- Sensors available today sense a wide variety of process parameters. There is a big demand for the detection of product quality, ingredients and parameters defined by the consumers.

- Traceability exceeds existing security concepts. Manual input allows manipulation. Automation may be the adequate answer.