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ISOBUS

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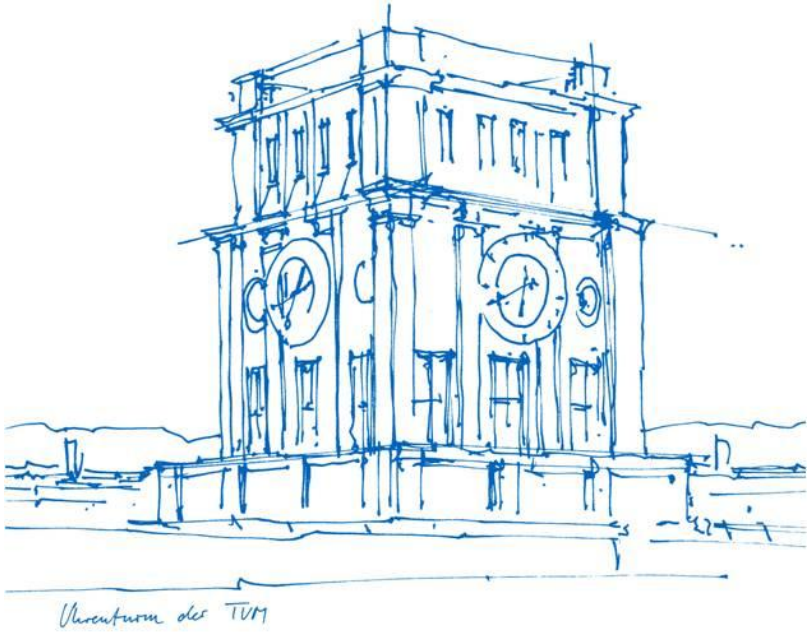
Agricultural Systems Engineering



ISOBUS in 1 Sentence

ISOBUS

is an **international standard** (*ISO 11783*)

for the

communication between tractor and implement.

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History Electronics on Tractors & Implements

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Historical challenges of AgEngineering

- **USA:**
  - Labor shortage
  - Abundance of land

  Therefore first **large scale agricultural development**

- **Europe:**
  - High-intensity farming
  - Traditions
  - Shortage of land
  - High population density

  Therefore most **innovations in AgEngineerig**

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AgEngineering development

Europe	USA
Historically grown population	Fast settlement of the land
Traditional structures	New structures based on requirements
Strong bond to ownership of land	Lesser bond to ownership of land
High population density	Low population density
Old, small roads	New road infrastructure with division of agricultural and civil use
Farming as part of society	Farming has it‘s own structures
Farmer as participant in road transport - StVZO - Fast traffic - Dense traffic	Farmer working in rounded off structures - Only crossing public roads - Speed not relevant
Restrictions in machine width	Machines better able to adapt to task

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Effects of European restrictions

- Consequent use of 3-point-hitch (front & back)
- Development of Standard- & System-Tractors (more options to mount stuff)
- Use of 4-wheel drive
- Increasing speeds (25, 40, 50, >68 kph)
- Self-propelled Machines (combines, choppers, sugar beet harvesters, sprayers) optimized for smaller structures

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Adoption of Innovations

- Small structures slow down adoption
- Many regional providers of farm machinery catering to the regional needs of farmers
- Smaller farms
- Despite globalization high differentiation in supply
  - No typical full-liner
  - Many hidden champions (relatively small farm machinery providers with strong focus on one core production process)
  - Integration yields Long-liners instead of full liners

Tractor-Implement combinations of different manufacturers are the rule, not the exception!

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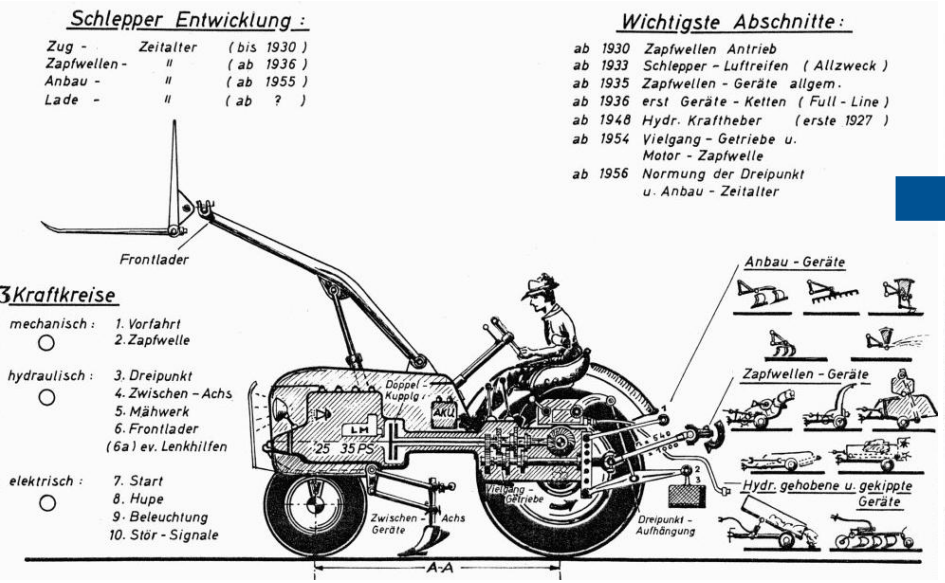
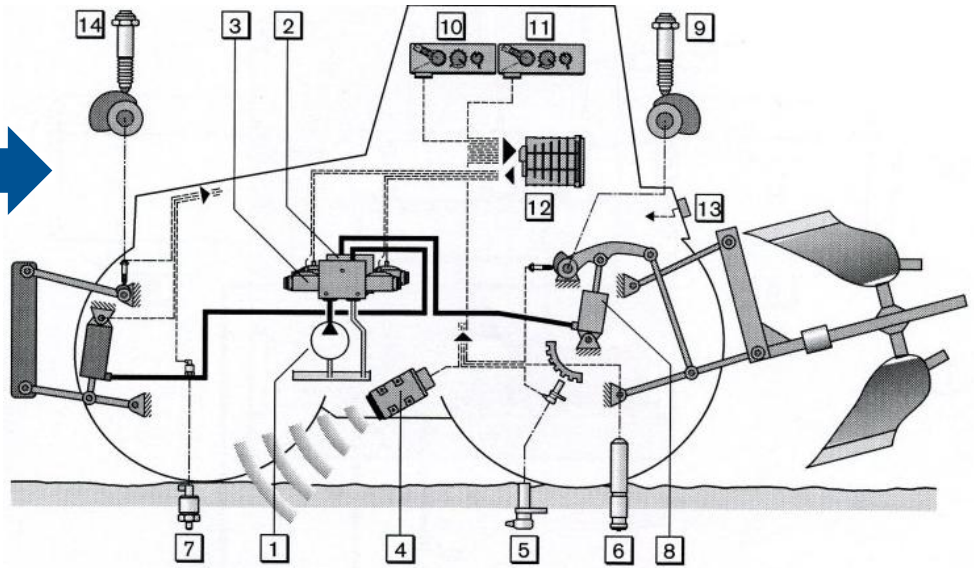
Evolution of Electronics on Tractors





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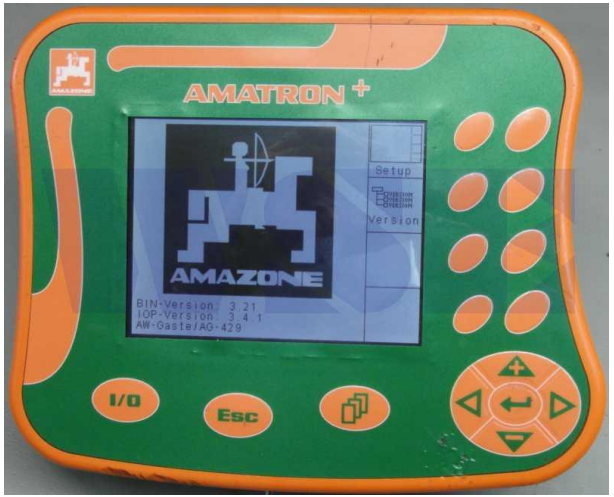
Evolution of Electronics on Implements

Field computers

Sprayer dosing computers, slip-independent dosing of chemicals/ha
Holder (1978)

Proprietary Terminals



Source: Amazone

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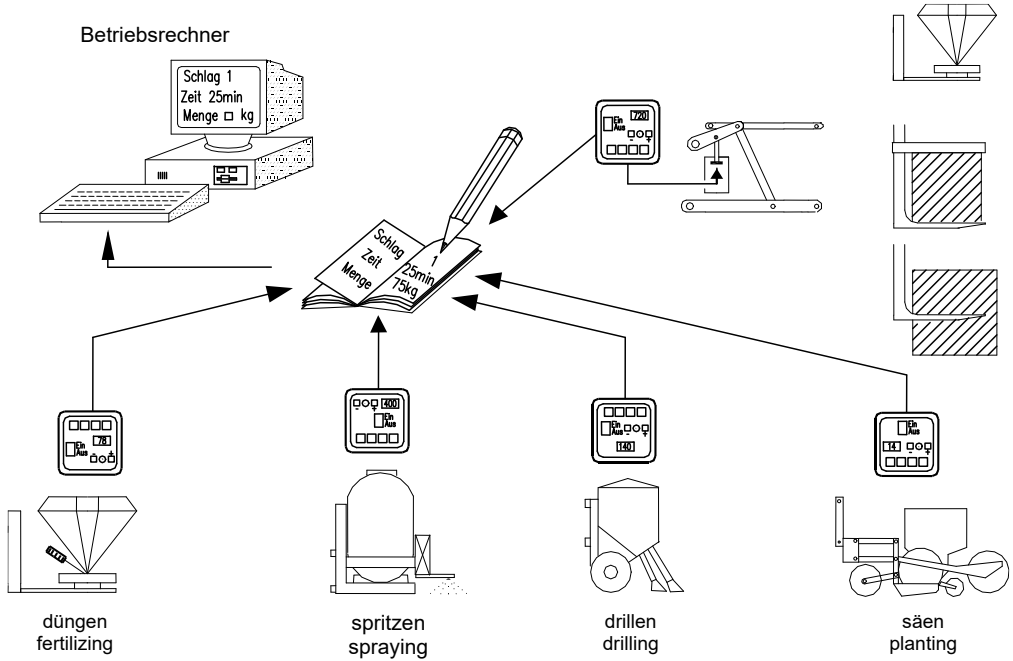
„Island“ solutions complicate management



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Benefits & shortcomings of isolated solutions

Benefits	Shortcomings
Hardware specialized for use-case	Short times of use throughout the year
Always ready	Long downtimes bad for electronics (corrosion/updates/batteries)
UI optimized for use-case	Training needed for many different UI, no universal logic for operator
Can be installed to any tractor	Must come with own sensor hardware
	No upgrades possible (high investments over the years)
	No data-transfer to external systems

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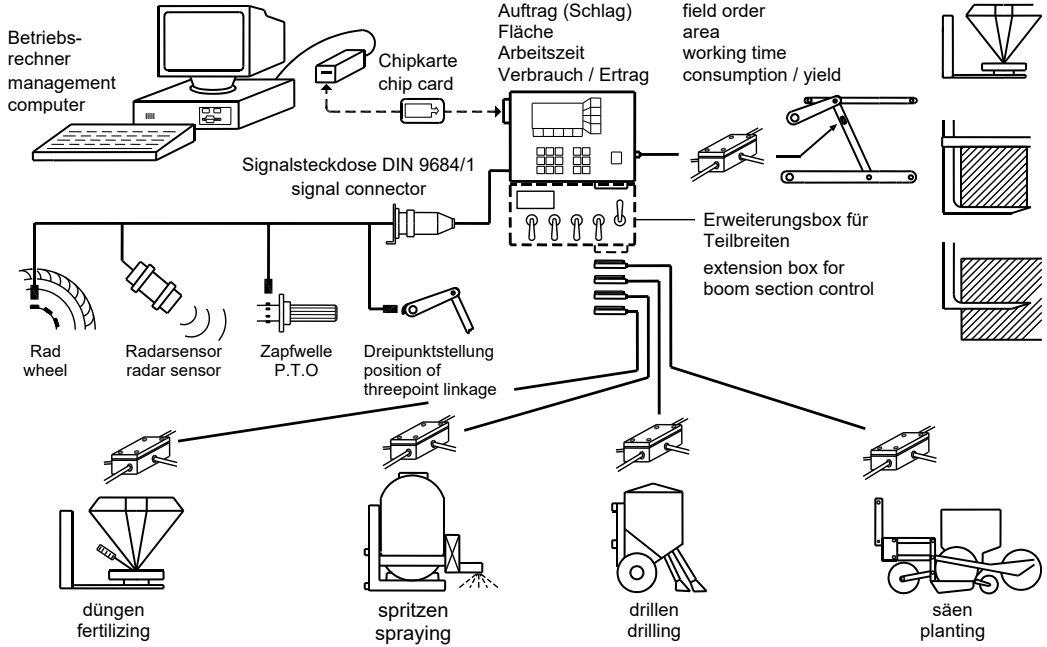
The High-time of field computers



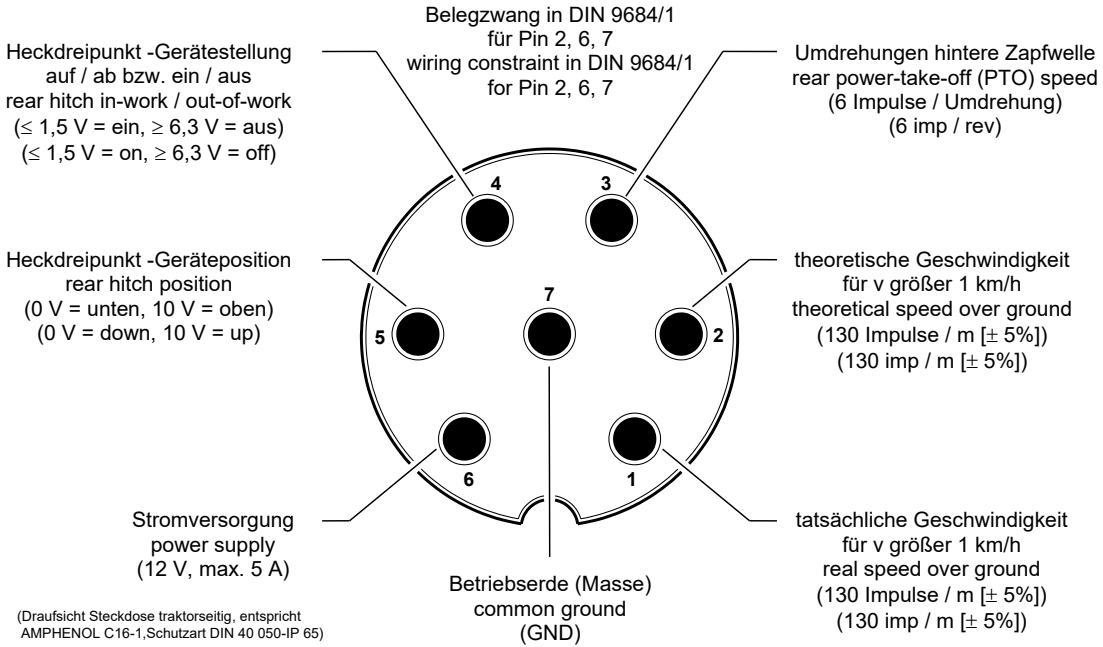
Source: Prillinger

Source: AEF

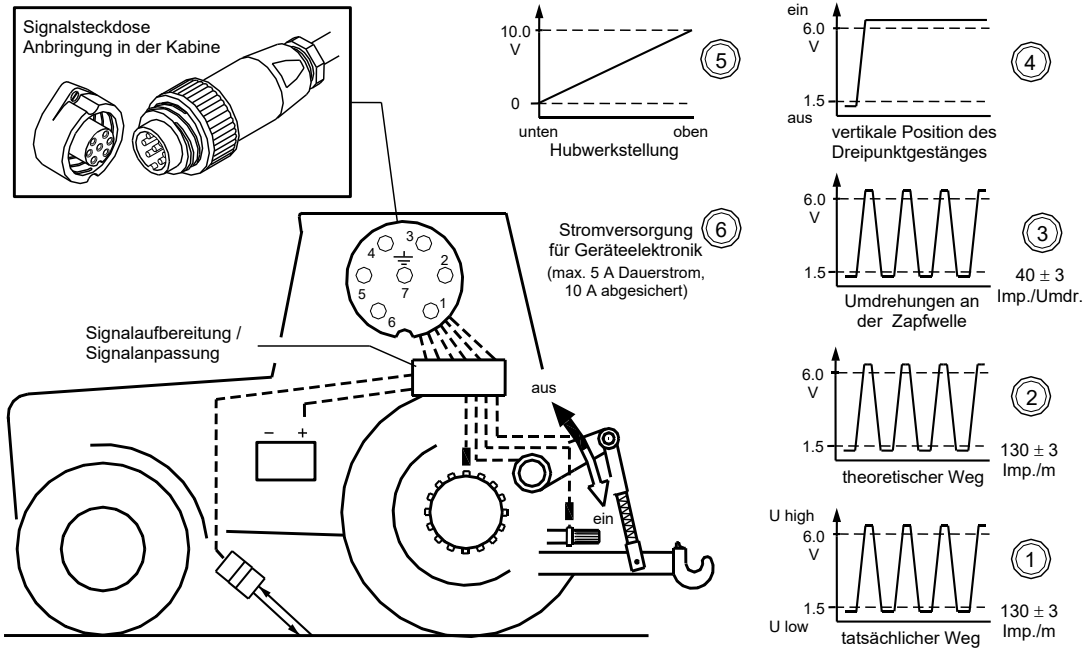
Source: STG

Source: Müller Elektronik

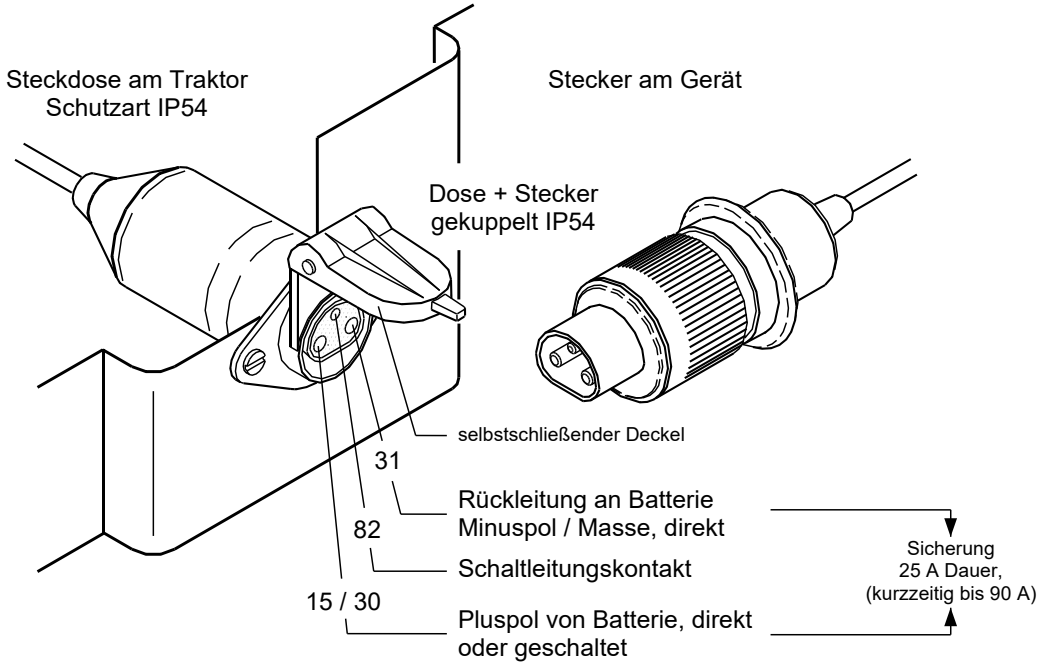
First initiatives for standards (DIN 9684/1) signal socket



First initiatives for standards (DIN 9684/1) signal socket



3-pin DIN 9680 socket



- Suggestion for Signal-socket (DIN 9684/1) included power supply to:
  - Power electronics and actuators
  - Minimize number of sockets on machine

-> Internationally not successfull (JD veto) therefore second socket (DIN 9680)

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Requirements for & emergence of

the ISOBUS Standard

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Suggested solutions to the tractor-implement problem

1. Full-Liner with **proprietary Systems** that are integrated on their machines

2. Retrofit Systems as **Universal solutions** for all manufacturers (**3rd Party** provides a „Full-Liner concept“ to all manufacturers)

3. **Standardized open system** for all Manufacturers (system with implement specific/manufacturer specific electronic but useable via standardized communication) **-> ISOBUS**

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Full-liner & proprietary Systems

Easiest & safest way to meet requirements

+ One central responsibility
+ System tests before delivery
+ Upgrades easy to adjust to existing systems
+ Differentiation from competitors
+ In-house synergies to other verticals (e.g. construction machines)

but

- User has to subordinate to a single manufacturer
- User can only use the machines in this OEMs portfolio
- Forward- and backward compatibility not a given (problem for investment decisions over long periods)

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Full-liner & proprietary systems

Full-Liner approach

- In contrast to democratic principles
- Ignores powerful middle class of machine manufacturers
- Slows down innovation / technological progress
- „buys“/integrates Innovation from small companies & centralizes markets

Full-liner-customers fully dependent

Universal Solutions as retrofit Systems

Innovations brought to the market by „Individualists“, produced by medium-sized companies

When Market is ready, big players have to offer the technology:

Either:
- Fast own development (big manufacturer behind the individualists in innovation cycle)

or:
- Agreement with individualist
  - \+ Fast innovations
  - \+ Profits from individualist‘s knowledge
  - \- Small opportunities for differentiation from competitors
  - \- Missing know-how in big companies

Big Manufacturer will then try to buy the „individualist“:

→ Becomes „Long-Liner“ or „Full-Liner“

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Standardized open System for all Manufacturers

Perfect for Europe:

- Mixed fleets of tractors & implements
- Diverse mix of regions, production schemes, crops, topografies…
- Different farm structures
- Highly diversified production

Farmer has freedom of choice:

- Best suited technology for individual farming operation
- Choice based on technology acceptance
- Choice based on relationships to machine dealers in region (service&safety)

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Prerequisites for a standardized open system

Manufacturers have to be obliged to follow standard
… prerequisite for free combination of tractors & implements

So far only Standards (DIN sockets) for

- PTO
- Hitch
- 3-point
- Light sockets
- Hydraulic couplers

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AgElectronics pre-ISOBUS vs. today

Isolated solution

History of AgElectronics

System

Way of the ISOBUS

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Technology Adoption

Not able to replace old Sockets & Machines (long life cycles of tractors 20+ years)

-> therefore evolution of systems with newer machines having the updated components available

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Requirements for the ISOBUS Standard

- Physical network of components
- Standardized communication (protocol)
- Control options for the driver
- Task Management

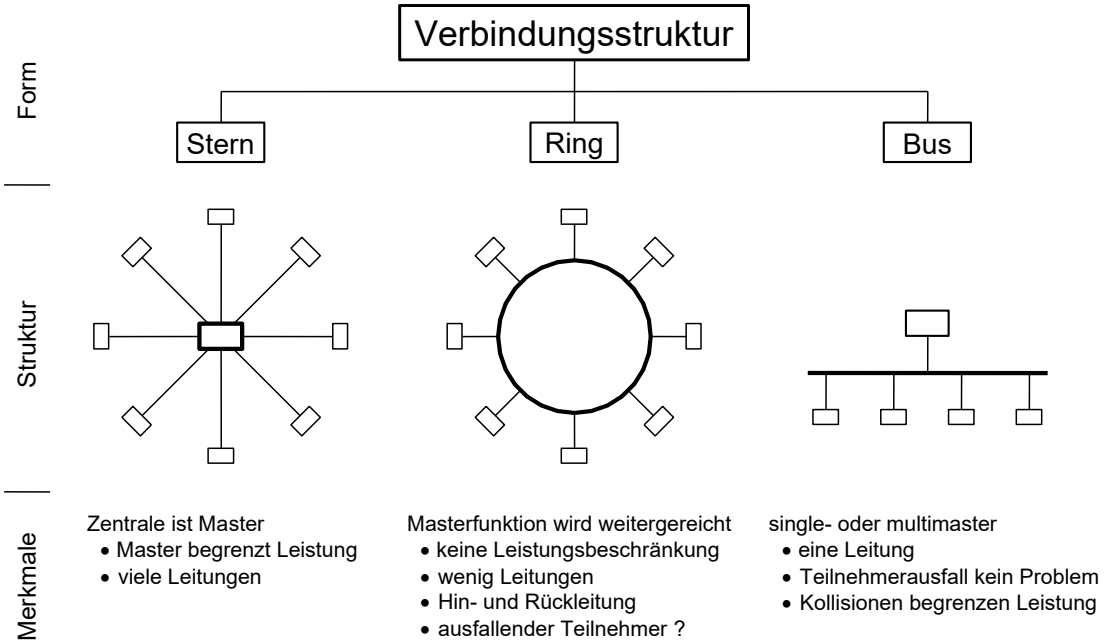
Needed Interfaces:

- Driver & Machine (Tractor or Implement)
- Operator & Farm Management (Task, documentation)
- Machine 2 Machine (Process control -> tractor2implement)

Signals:

- Basis Signals -> provide 4 everyone
- Control Signals -> provide to one or more
- Task management & documentation

Topologies -> Why BUS was chosen



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Why CAN (Controller Area Network) was chosen

Benefits of CAN Technology:

- Free configuration
- Priorisation of messages
- Multi-Master principle
- Multi-message & time synchronisation
- Data consistency throughout the system
- Error messages
- Temporary vs. Permanent error differentiation
- Short message format

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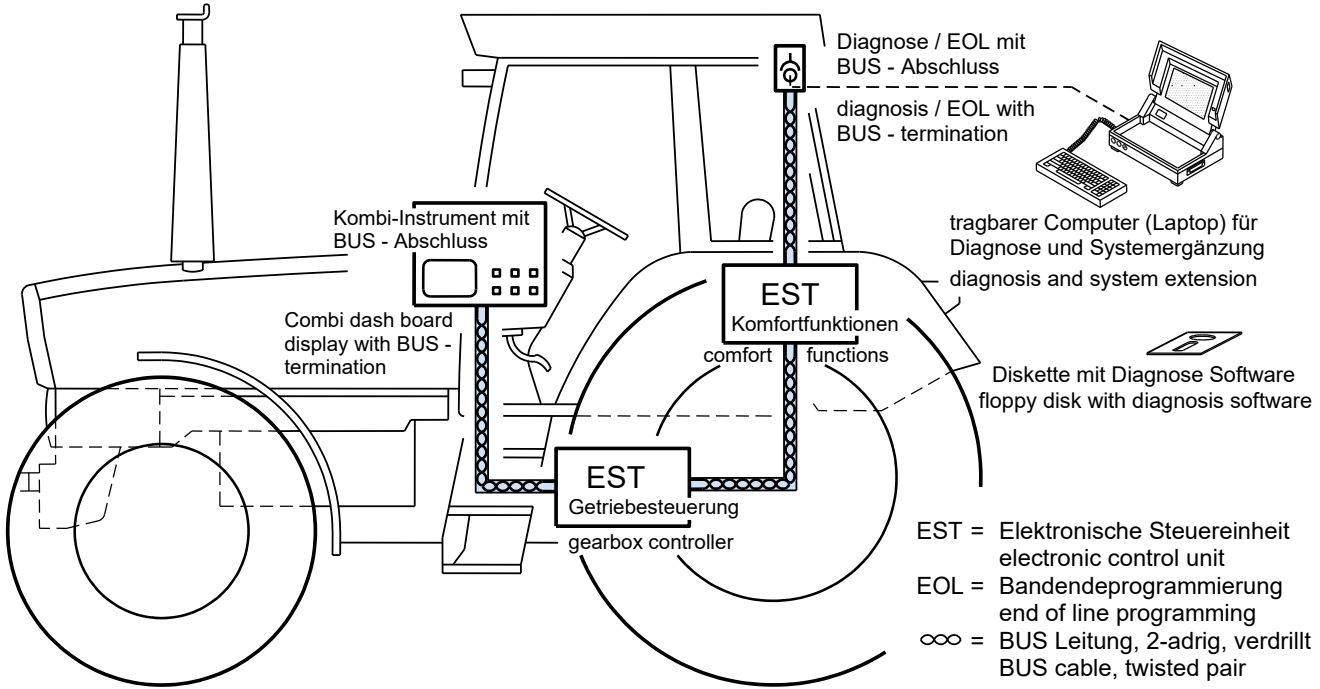
CAN (Controller Area Network) im FENDT Standardtraktor



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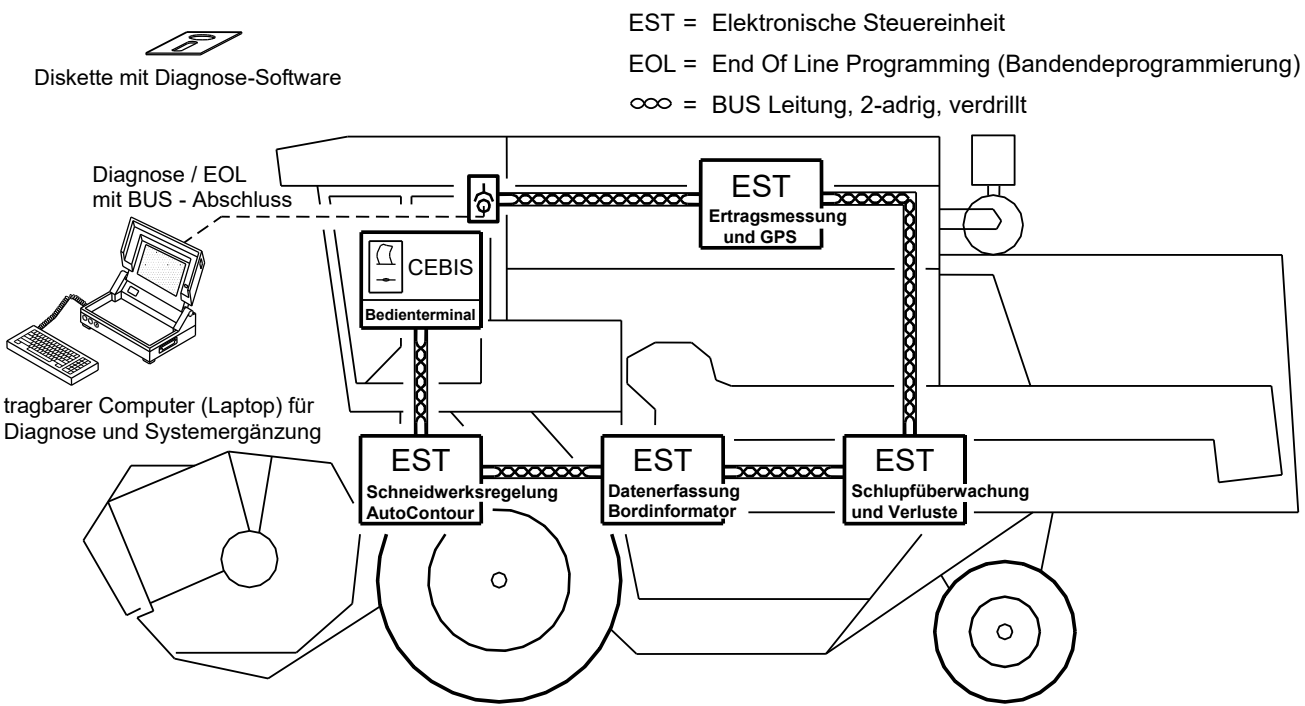
CAN (Controller Area Network) im CLAAS Mähdrescher



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Why AEF was chosen -> possible standard institutions

Market position (Market leader sets standard):

- No cost
- High technological competency
- Competitors have to follow

-> only works if there is „the“ market leader

By law

- If society/consumer interest
- Safety concerns

-> last resort

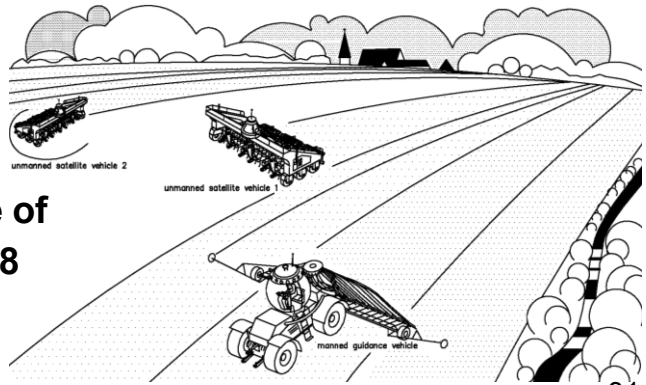
Cooperation of Stakeholders

- Search for lowest common denominator
- Long process, everyone anxious
- Technology leaders (who already have products) try to veto
- Penalty on innovation leaders

-> only way in a pluralistic market

Take Home Messages

- Electronics improve Agricultural Production Processes
- Tractor-Implement combinations from different manufacturers are the norm in Europe
- Isolated solutions have shortcomings for sustainable production
- First standard in Tractor electronics was the signal socket (DIN 9684/1)
  - ➢ Analog signals for most important tractor/implement functions
- **ISOBUS standard was formed 2001 by ISO after due diligence of the sectors requirements and is maintained by AEF since 2008**



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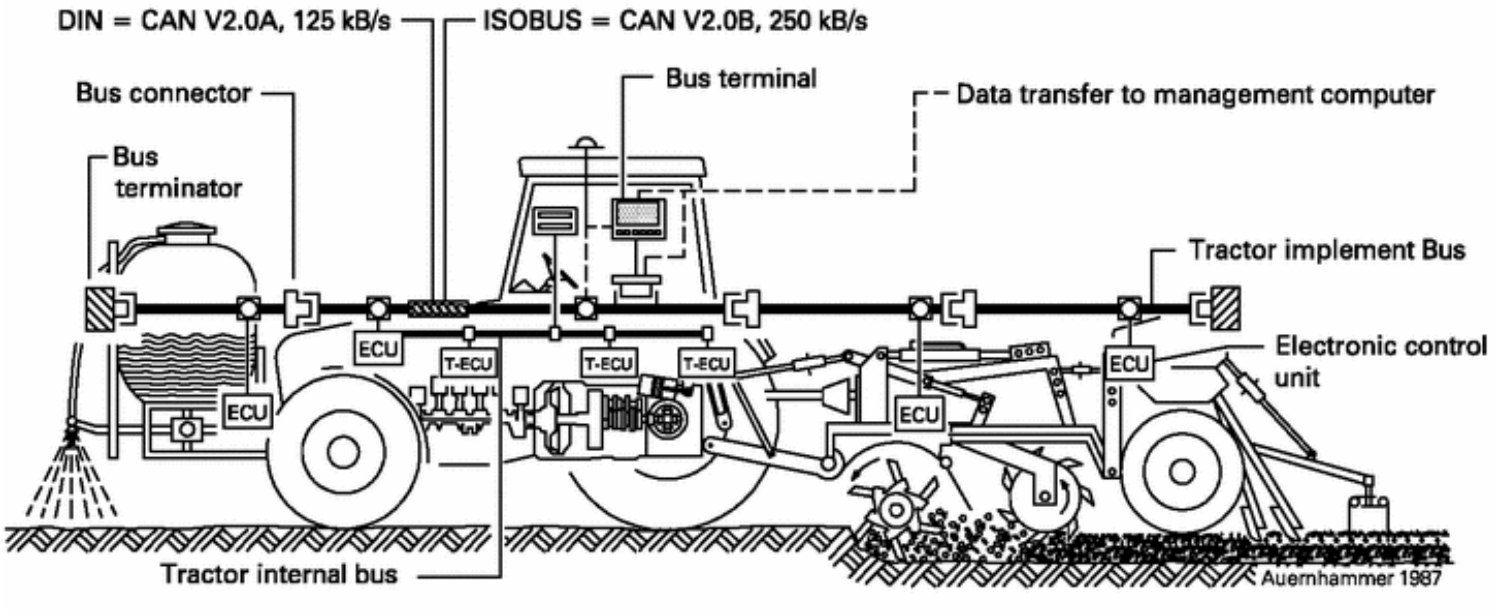
ISOBUS Today


DIN = CAN V2.0A, 125 kB/s
ISOBUS = CAN V2.0B, 250 kB/s
Bus connector
Bus terminal
Data transfer to management computer
Bus terminator
Tractor implement Bus
ECU
T-ECU
T-ECU
T-ECU
ECU
ECU
ECU
Electronic control unit
Tractor internal bus
Auernhammer 1987

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ISOBUS

- CAN with 29 Bit Identifier
- Baud-rate: 250 kBit/s (equals 1800 messages per second)
- Maximum length of CAN backbone 40 m (wiring harness)
- Structured Standard with 14 parts
- Developed as extension to J1939
- Proprietary message types are permitted (!)
- Following an ISO-OSI (Open Systems Interconnection) Layer model

Tractors and machinery for agriculture and forestry – Serial control and communications data network

Reference	Title	Status
ISO 11783-1	General standard	IS 2007-10-21; DIS 2013-05-10
ISO 11783-2	Physical layer	IS: 2012-02-24
ISO 11783-3	Data link layer	IS: 2007-10-01; DIS 2013-03-05
ISO 11783-4	Network layer	IS: 2011-11-23
ISO 11783-5	Network management	IS: 2011-03-29
ISO 11783-6	Virtual terminal	IS: 2010-10-18; DIS 2013-01-29
ISO 11783-7	Basic messages application layer	IS 2011-02-11
ISO 11783-8	Power train	compliant with SAE J1939/71
ISO 11783-9	Tractor ECU	IS: 2012-01-30
ISO 11783-10	Task controller and management information system data interchange	IS 2012-02-14
ISO 11783-11	Mobile agricultural data dictionary	IS 2011-06-29
ISO 11783-12	Diagnostic system	IS 2011-04-01; DIS 2013-03-03
ISO 11783-13	File Server	IS 2011-04-01
ISO 11783-14	Sequence control	FDIS 2013-05-23

WD: Working Draft
Standard
RS: Review Stage
Standard

DIS: Draft International
CD: Committee Draft
IS: International
TC: Technical Corrigendum

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Important ISOBUS Functionalities

Universal Terminal - UT

The capability of operating an implement with any terminal; also, the capability of using one terminal for operating different implements.

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Important ISOBUS Functionalities

AUX-N

AUX-O – Auxiliary Control “old”
AUX-N – Auxiliary Control “new”

Additional control elements that facilitate the operation of complex equipment, such as a joystick; also, the capability of controlling implement functions by means of an additional control element.
There are an “old” and a “new” auxiliary control which are not compatible. Implements and functions certified according to AUX-N cannot be operated with input devices certified according to AUX-O and vice versa.

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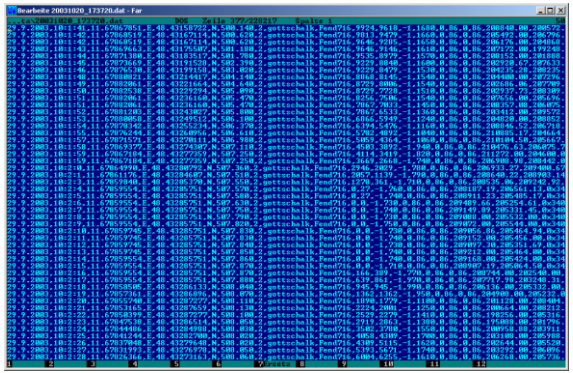
Important ISOBUS Functionalities

TC-BAS

Task-controller basic (totals)

Describes the documentation of total values that are relevant for the work performed. The implement provides the values. For the exchange of data between farm management system and Task Controller the ISO-XML data format is used. Jobs can easily be imported to the task controller and/or the finished documentation can be exported later.



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Important ISOBUS Functionalities

TC-GEO

Task-controller geo-based (variables)

Additional capability of acquiring location-based data – or planning of location-based jobs, as for example by means of application maps.

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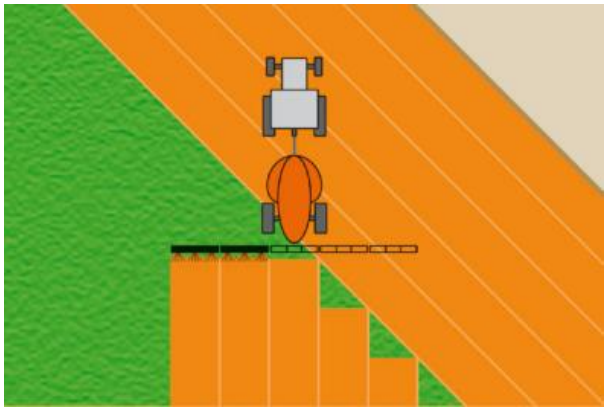
Important ISOBUS Functionalities

TC-SC

Task-controller Section Control

Automatic switching of sections, as with a plant protection sprayer, seed drill or fertilizer spreader, based on GPS position and desired degree of overlap.



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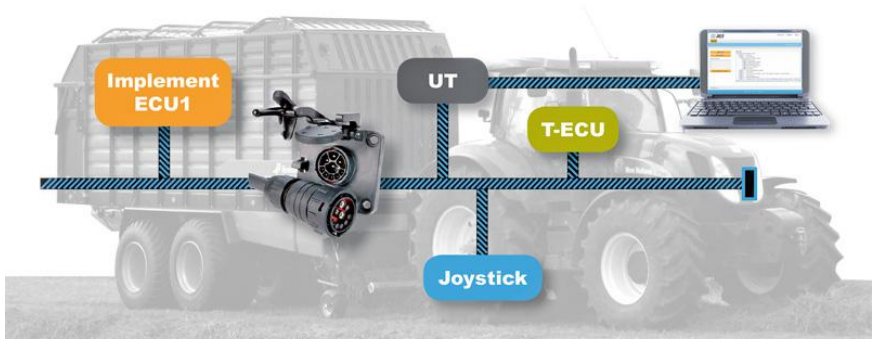
Important ISOBUS Functionalities

TECU

Basic Tractor ECU

The tractor ECU is the tractor‘s “job calculator”. This provides information, such as speed, power take-off RPM, etc. For the certification of this functionality, a connector on the back of the tractor and a terminal outlet in the cab are needed.



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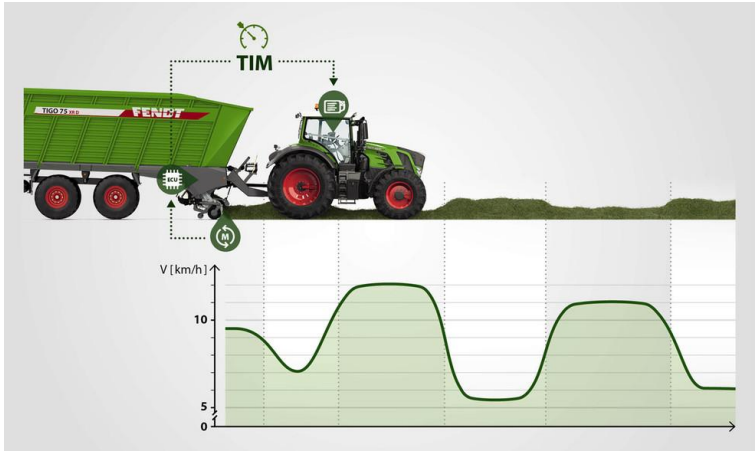
Important ISOBUS Functionalities

TIM
Under development

Tractor Implement Management

While the communication with TECU is uni-directional, i. e. the tractor provides certain information, TIM features the capability of bi-directional communication. The Tractor-Implement-Management-System (TIM) allows an implement to automatically control specific functions, such as the forward speed or the remote valves of a tractor. By letting the implement optimize its operation the overall system can achieve higher levels of productivity with less operator fatigue.”



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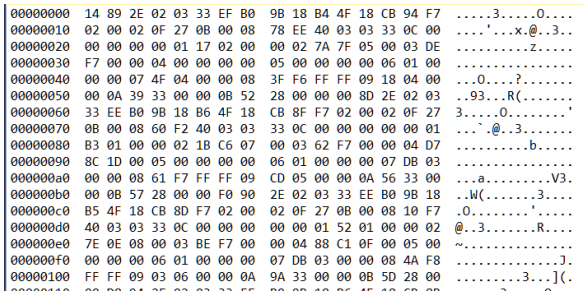
Important ISOBUS Functionalities

LOG
Under development

Logging of device values independent of the task

Describes the logging of device (tractor, implement, etc.) values that can be collected independent of a task. These values could be totals, for example total area or total harvest mass, etc. or in fact any other data which the device can send. LOG data can be exported as an ISOXML file (similar to the Task Controller data). This function can be used for products such as telematics loggers.



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Important ISOBUS Functionalities

ISB
Under development

ISOBUS Shorcut Button

ISB makes it possible to deactivate functions of an implement that were activated by means of an ISOBUS terminal. This is necessary when the implement in question is not currently in the foreground, for example when several implements are being controlled by a single ISOBUS terminal. Which functions an ISB is able to deactivate on an implement can vary widely and must be defined by the respective manufacturer.

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Automatic data documentation in ISOBUS networks

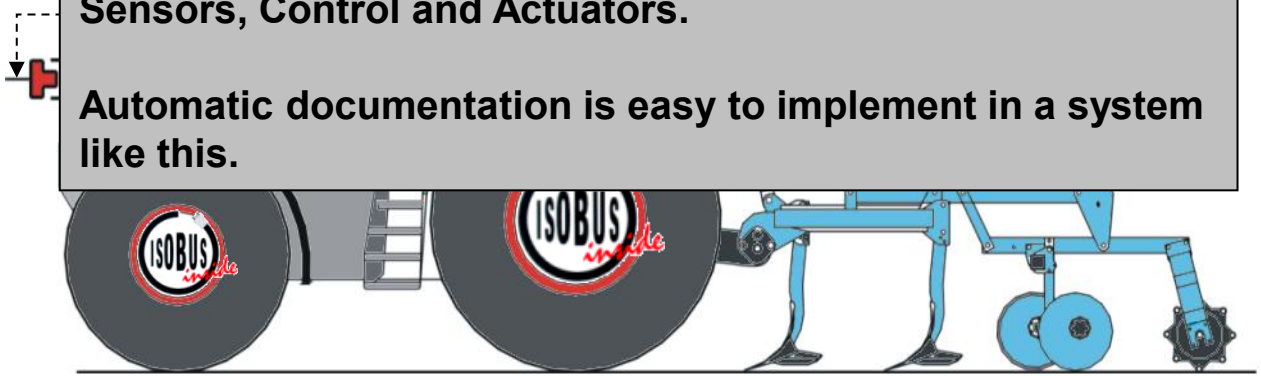
Automatic data logging in ISOBUS

ISOBUS:

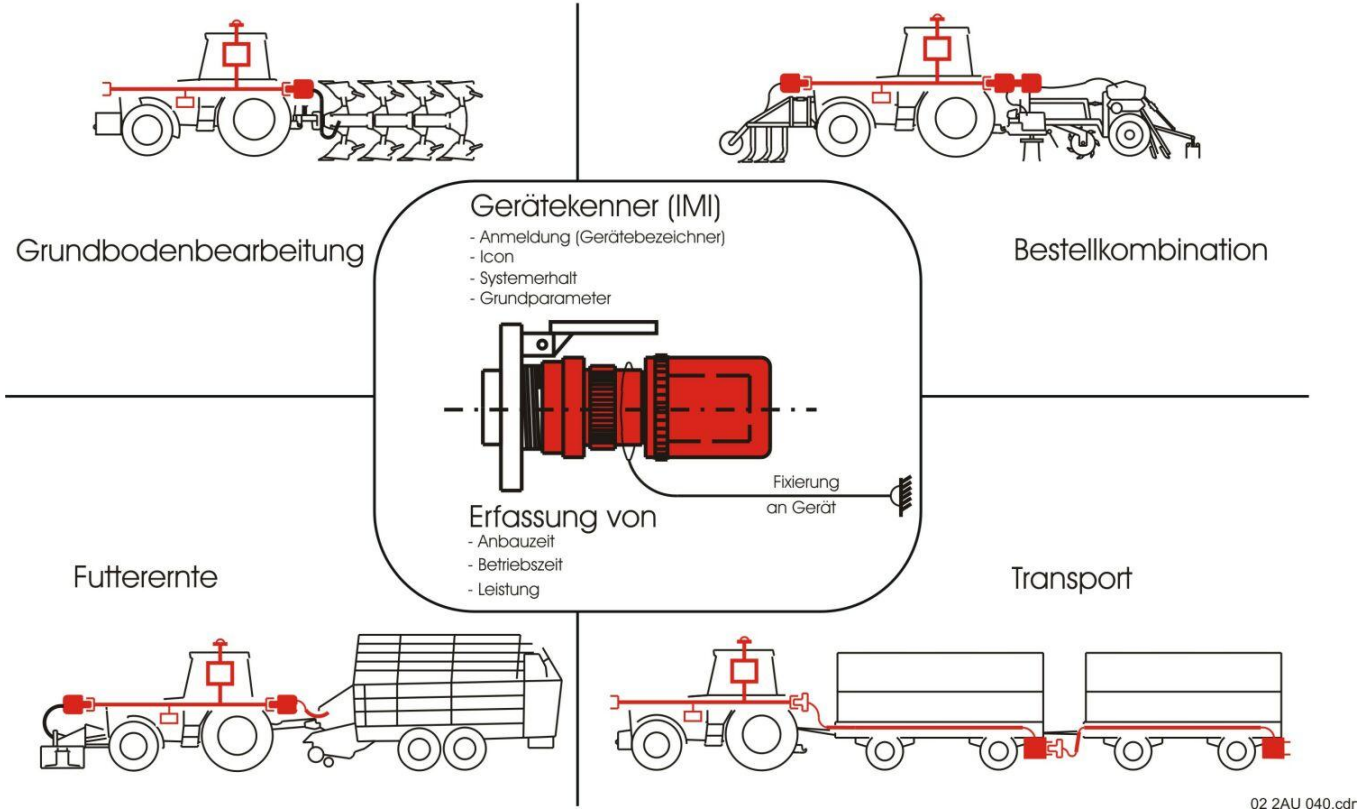
ISO 11783 standardizes communication of electronic components on farm machinery.

This enables networking of tractor and implement, e.g. Sensors, Control and Actuators.

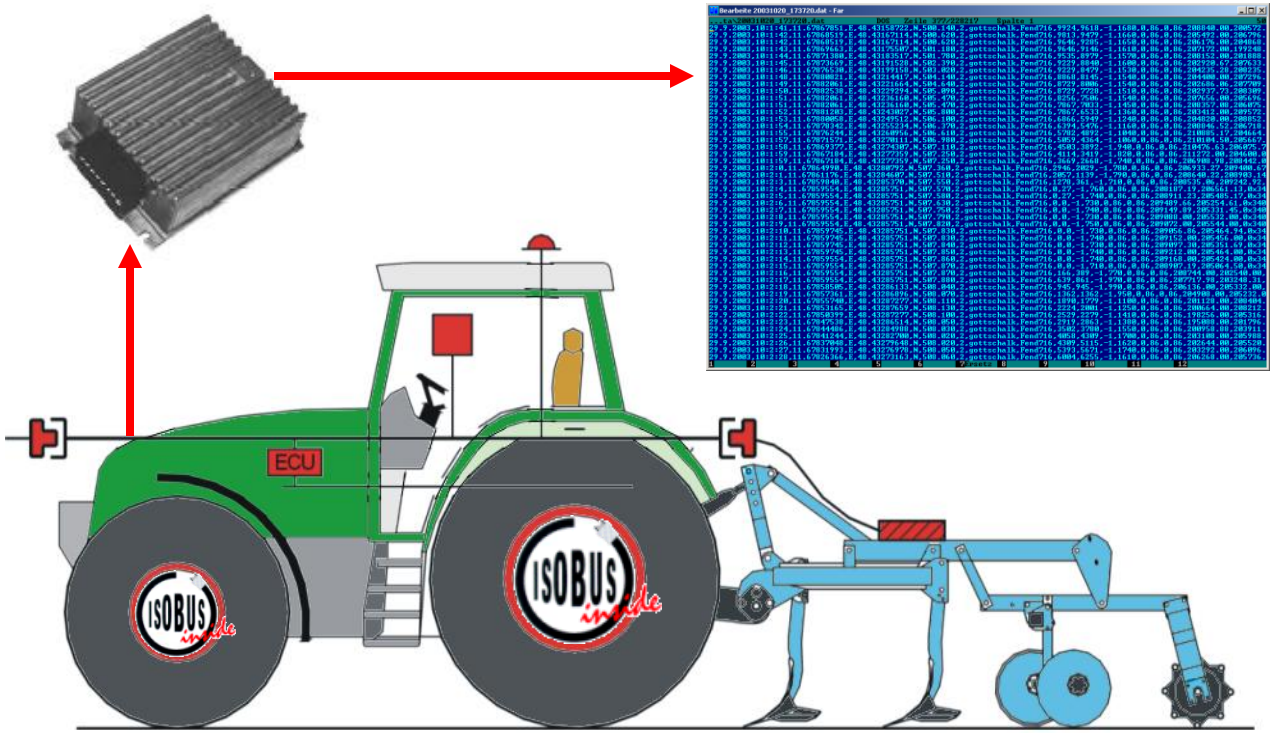
Automatic documentation is easy to implement in a system like this.



Examples for automatic process data acquisition



Automatic process data acquisition in ISOBUS networks



Raw data

Date,	Time,	Longitude,	Latitude,	Driver,	Tractor	Speed	Pos	Left,	Right,	Implement	WorkWidth
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
03.10.2001	17:34:44	10.25241661	49.89083099	w. herbert	CaCs150	1987	102	64.67	64.96	IMIgru1	3000
03.10.2001	17:34:45	10.25242329	49.89085007	w. herbert	CaCs150	1883	102	66.53	63.60	IMIgru1	3000
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
03.10.2001	17:34:49	10.25245190	49.89087296	w. herbert	CaCs150	0885	102	66.03	70.37	IMIgru1	3000
03.10.2001	17:34:50	10.25243187	49.89086151	w. herbert	CaCs150	2411	102	58.13	59.14	IMIgru1	3000
03.10.2001	17:34:51	10.25241184	49.89084244	w. herbert	CaCs150	2423	102	65.75	77.14	IMIgru1	3000
03.10.2001	17:34:52	10.25240803	49.89082336	w. herbert	CaCs150	2380	102	67.16	82.57	IMIgru1	3000
03.10.2001	17:34:53	10.25242043	49.89080048	w. herbert	CaCs150	2341	103	62.48	67.99	IMIgru1	3000
03.10.2001	17:34:54	10.25243187	49.89078140	w. herbert	CaCs150	2356	100	64.83	73.53	IMIgru1	3000
03.10.2001	17:34:55	10.25244522	49.89076233	w. herbert	CaCs150	2315	100	64.04	70.60	IMIgru1	3000
03.10.2001	17:34:56	10.25245667	49.89074707	w. herbert	CaCs150	2200	100	64.29	71.46	IMIgru1	3000
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

GPS (Ort und Zeit) | **Person** | **Traktor** | **Gerät**

Aufzeichnungsfrequenz: **1Hz**

Information content

What kind of data can be generated?

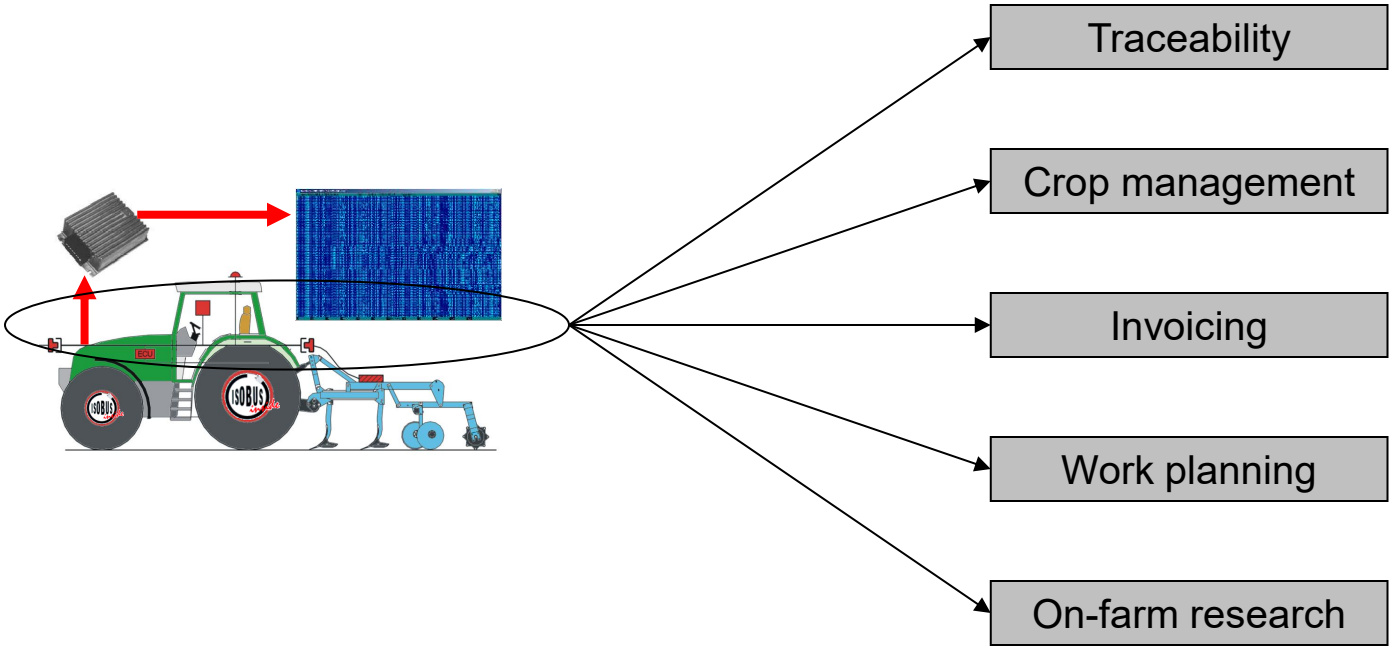
- fuel consumption
-Area covered
-Area efficiency
-Draft force
-Working speed
-Working time
-Location
-…

Information content

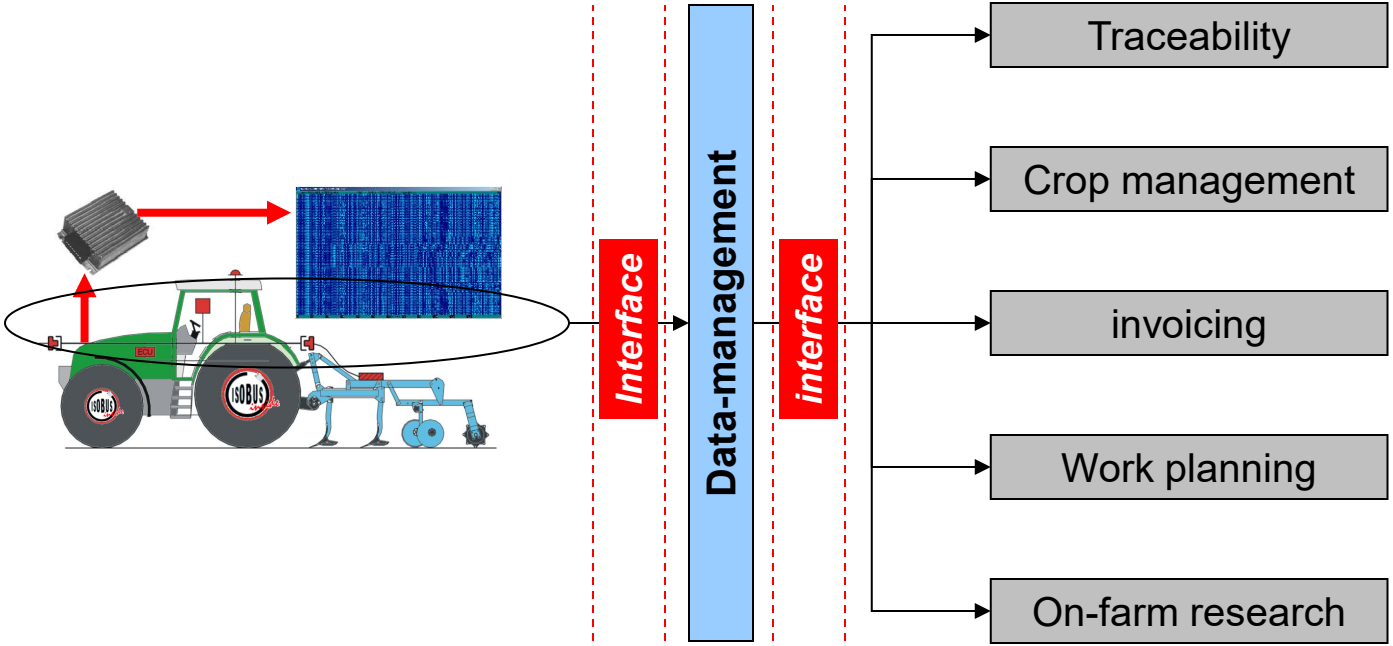
What can we do with this data?

- mapping (force, fuel, yield-maps)
-Working time analyses
-Digital field records auto-fill-in
-Automate invoicing
-Traceability of products/goods/services
-Information for site-specific farming

Data is the basis for many different use-cases



Data management between acquisition and exploitation of data values



Datenmanagementsystem als Basis für unterschiedliche Anwendungen

Interface layer

Data-management system

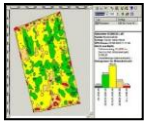
Data-processing Information-system

Database for specialised software applications

(ISO 11783 ?)

(agroXML ?)

(more ?)



Co-funded by
the European Union

Challenges & Problems with ISOBUS today

Co-funded by
the European Union

ISOBUS Limitations & ongoing work

- 20 years later, ISOBUS serves very well
- Communication performance needs to bee improved
- New advanced systems break constraints of CAN-based ISOBUS technology (limits OEMs ability to innovate)
- constrained to 250 kb/s, large and complex systems may experience CAN traffic well beyond 50% of the bus capacity
- often saturation near 100% usage

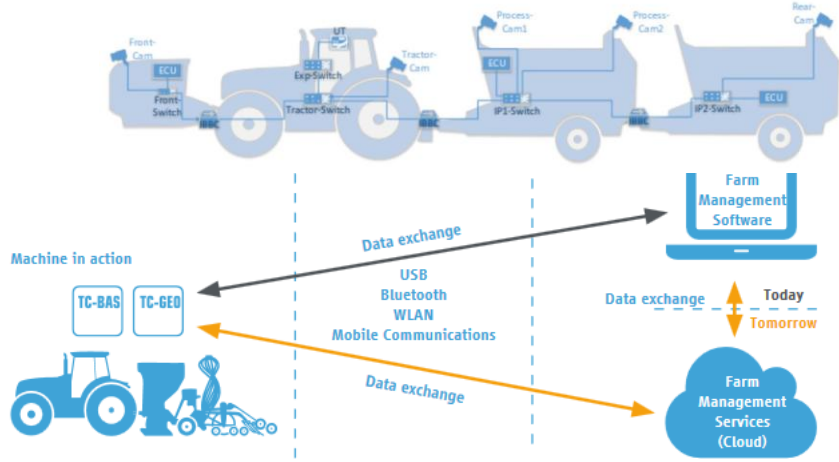
With these levels of network traffic, latencies increase significantly, even to the point where the precision of the prescription, performance of the automation, and the user experience suffer

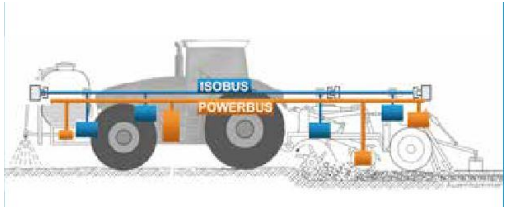
High Speed ISOBUS (HSI) will pave the way for another major step into higher performance systems.

Future Development of ISOBUS & AEF

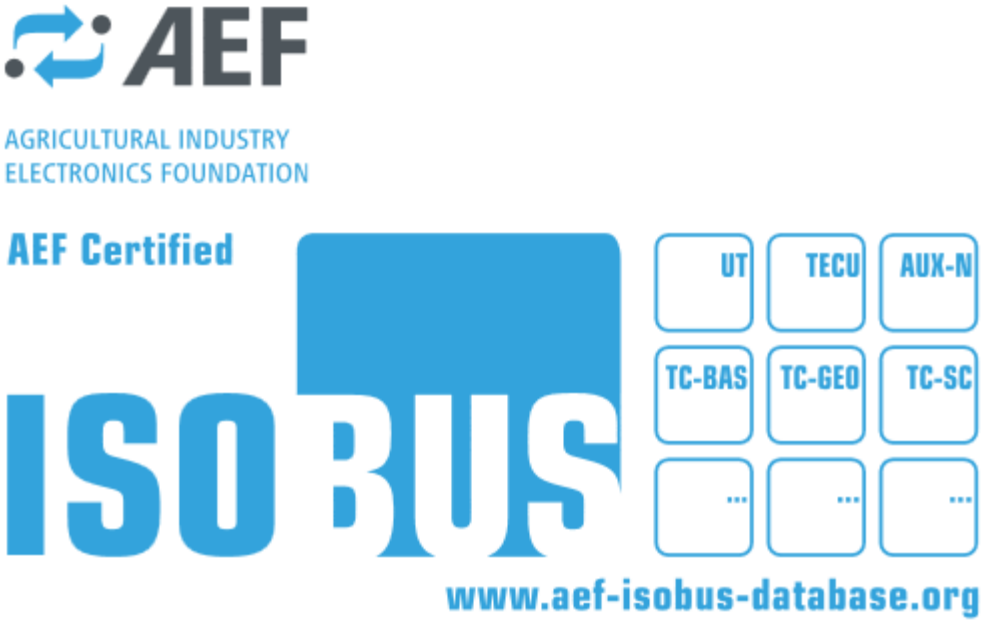
Topics include:

- HSI
- Functional Safety of electronic control systems
- FMIS
- High Voltage
- Camera Systems
- Wireless Communications





More about ISOBUS



Online Training:
https://www.aef-online.org/fileadmin/user_upload/Content/videos/AEF-webbased-training-en/story.html

Compatibility Checker:
https://www.aef-isobus-database.org/isobusdb/login.jsf

ISOBUS Data Dictionary:
https://www.isobus.net/isobus/dDEntity