ISOBUS's Past, Present and Future role in Agricultural Robotics and Automation

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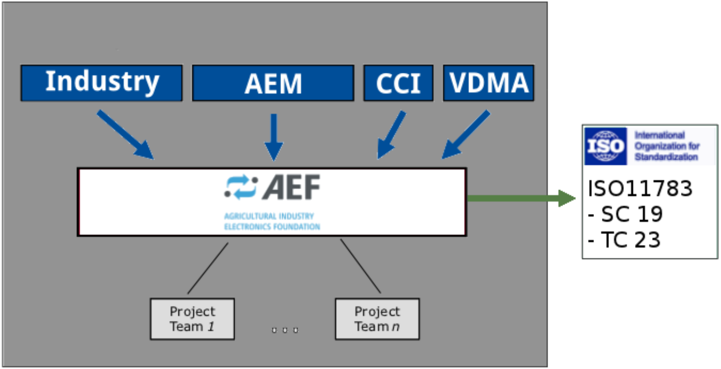
Introduction

- Hitch, Hydraulics and PTO are standardized
- ISO Norm 11783 standardizes the communications too

Figure: Connection between tractor and implement of different manufacturers

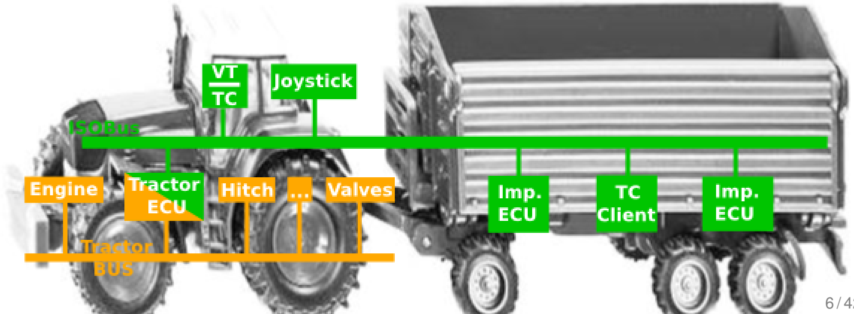
Organization

- Who is behind ISO 11783 (also called ISOBUS)



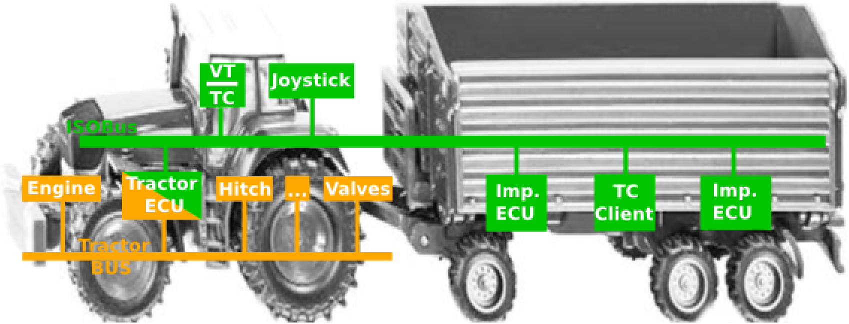
Introduction

- Serial control and communications data networks for tractors and machinery for agriculture and forestry
- Consists of 14 parts
- Based on SAE J1939 for tractor-trailer
- CAN-Based communication protocol
- Supports NMEA 2000 for positioning information



Introduction

- Plug and play
- Connection of new implements possible online
- One or many members at the same time possible
- Different topologies possible: Peer to peer, broadcast, server | client



Tractor ECU

- Class 01: Simple network-support
  - Power management
  - Speed information
  - Hitch information
  - PTO information
  - Lighting information
  - Language information
- Class 02: Total set of tractor measurement
  - Time and date
  - Speed and distance
  - Additional hitch parameter
  - Full implement lighting message set
  - Auxiliary valves
- Class 03: Accept commands from an implement
  - Hitch commands
  - PTO commands
  - Auxiliary valves commands

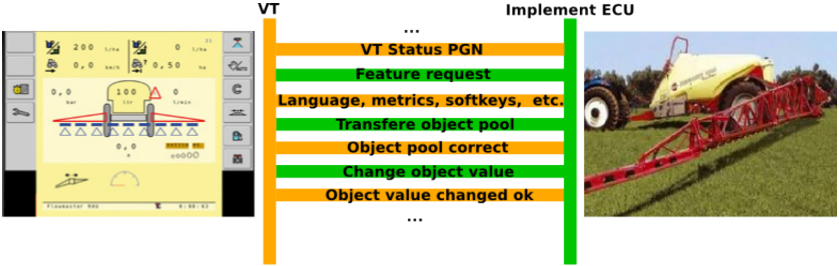
Virtual Terminal

- ECU to VT & VT to ECU
- Implement description GUI
- All GUI objects are standardized
  - Soft keys
  - Data Mask
  - Bar-graphs
  - Input and output fields
  - Graphics
  - Buttons
  - etc.
- All included in an Object Pool

Figure: Fendt Vario Terminal [14]

Virtual Terminal

- Server | Client



- Transport protocol and extended protocol allow up to 117MB of data transmission

Auxiliary inputs

- Aux-Server | Aux-Client
- Joysticks
- Control Panels
- Digital and analog inputs
- Implement's Object Pool with auxiliary functions

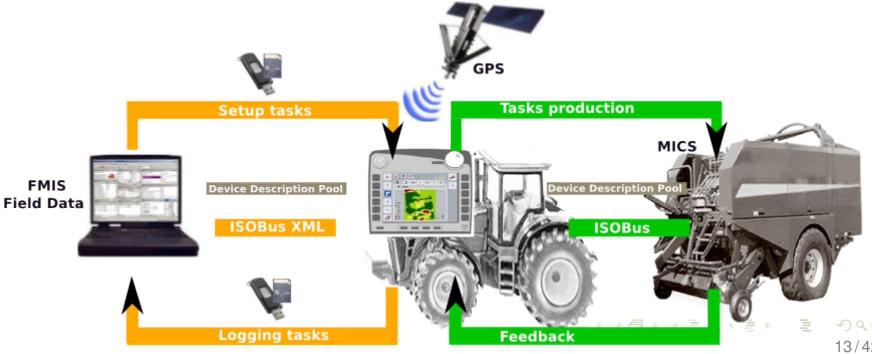
Figure: Aux-Control at CCI [3]

Auxiliary inputs

Figure: Fendt ISOBUS implement control [6]

Task Controller

- TC-Server | TC-Client
- Complete management system for agricultural tasks
- Provides commands to the implements
- Time, and position scheduled commands
- Planning done vie PC (Farm Management System)



Task Controller

- Farm Management Information System
  - Data Dictionary Identifier: working units, device clases, etc.
- Device Description Pool: Working width, number of switchable sections
- Mobile Implement Control System

Task Controller

- Task Controller Basic
- Task Controller Geo
- Task Controller Section control

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Precision Farming [1]

- New technologies (GPS, sensors, monitors and other equipment)
- Enable farmers to use electronic guidance
- Direct equipment movements more accurately
- Precise positioning for all equipment actions and chemical applications
- Analyze all of that data in association with other sources of data (agronomic, climatic, etc.)
- Precision Farming will affect the entire production function (and by extension, the management function)

Precision Farming [1]

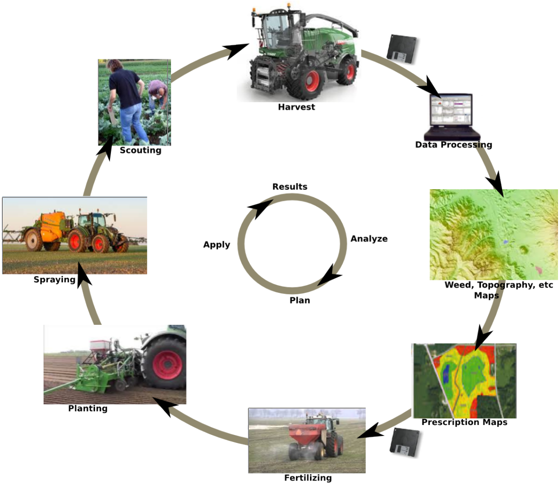

Figure: Precision farming cycle found in [1]

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Tractor-Implement Management

- Implement controls the tractor's
    - Valves
    - Steering
    - Speed
    - Hitch
    - Electronics
    - PTO
- Requires manufacturers coordination

Figure: Krone Ultima speed control TIM baler wrapper [9]

Tractor-Implement Management

- Tractor ready to accept commands?
  - Conditions not specified in ISOBUS
  - Needs cooperation between manufacturers
- Conditions fulfilled?
  - Operator in the cabin?
  - Tractor on the move?
  - Signals available with no errors (Speed etc.)
  - Safety standards?

Figure: Rauch TIM hydraulic control [12]

Tractor-Implement Management

Figure: Tractor-Implement management at Grimme [5, 4]

Figure: Tractor-Implement Automation from John Deere and Pottinger [10]

ISOBUS Conclusion

- Pros
  - Server | Client communications
  - Tractor-Implement system partially autonomous
  - Precision farming
  - Proprietary Messages
  - IsoAgLib (open source)
  - Modularity
- Cons
  - Proprietary Messages
  - Each manufacturer makes it a bit different (incompatibility issues)
  - Only for tractors?
  - ISO 11783 is open to different interpretations
  - Different generations lead to incompatibilities

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AgRA Architectures

- Detection: obstacle avoidance, image recognition, GPS, weed discrimination
- Mapping: Positioning, environment features
- Guidance: Path planing, action planning, control systems
- Action: Weed removal, seeding, harvesting, guidance, scouting

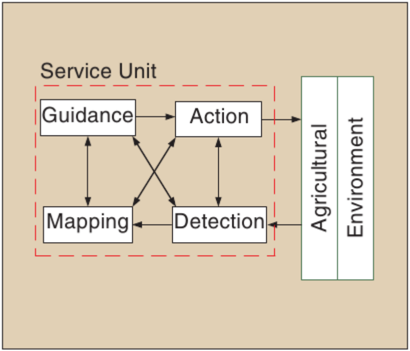

Figure: Proposed architecture for agricultural robotics [2]

AgRA Architectures

- Safety as centerpiece of the architecture
  - 1 Robotic perception, trajectory and motion planning, fault tolerance and verification of hardware and software
  - 2 Portable devices, voice and gesture, teleoperation and telesupervision, multiple vehicle coordination and cooperation.
  - 3 Safety and functionality standards

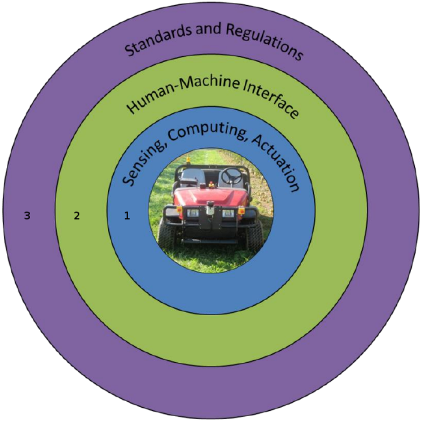

Figure: Three-layer safety architecture for autonomous agricultural vehicles [8]

AgRA Architectures

- Organization level: decision-making, task, planning, environment mapping, path planning
- Coordination level: control program, decision making, fusion algorithms
- Implementation level: control output, action execution, feedback

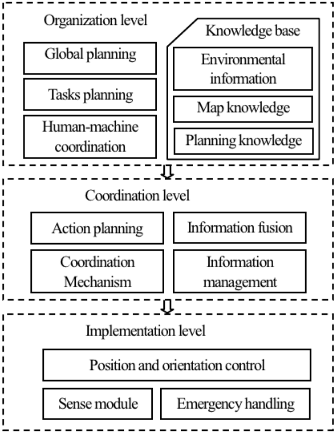

Figure: Control system architecture proposed in [7]

AgRA Requirements [7, 2, 8]

- General requirements
  - Type of vehicle: Tractors, agricultural machinery, 4WS, Articulated, etc.
  - Level of automation
  - Solve different tasks: Picking, harvesting, weeding, pruning, planting, grafting, etc.
  - Environment interaction: Detection and mapping
  - Action planning and execution
  - Safety

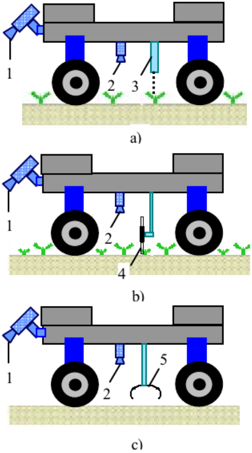

Figure: Agricultural unit from [7]

AgRA Requirements [7, 2, 8]

- Development requirements
  - Open and common architecture
  - Open design in structure system
  - Considers actuators and sensors
  - Considers control systems
  - Adaptability
  - Simple structure
  - Affordable

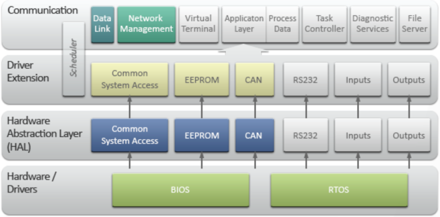

Figure: IsoAgLib [11]

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ISOBUS's Present in AgRA

- AgRA general requirements
  - Type of vehicle: ECU Tractor-like vehicles (flying vehicles?)
  - Level of automation: partially autonomous, norm still changing...
  - Solve different tasks: implements solve many but not all...
  - Modularity as big advantage...
  - Environment interaction: depends on the implement
  - Action planning and execution (TC, Section Control, TIM)
  - Human-Robot interface: VT, Auxiliary panels and joysticks
  - Safety: not included in the norm

ISOBUS's Present in AgRA

- AgRA Development requirements
  - IsoAgLib extended architecture

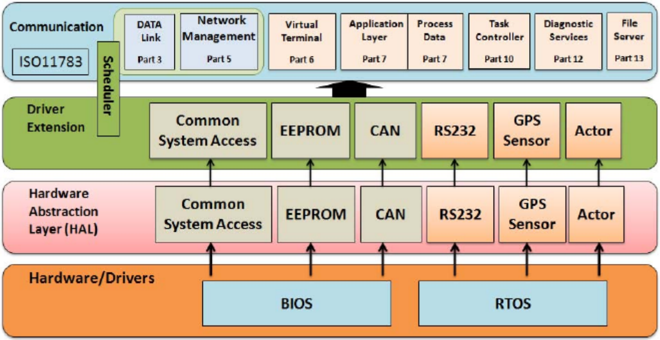

Figure: General architecture of the IsoAgLib from [13]

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ISOBUS's Future in AgRA

- Which requirements should be standardize and which stay open?
- Which requirements can be covered by ISOBUS?
- Can ISO 11783 be changed or adapted to AgRA requirements?
- Which type of vehicles should be considered (terrain 4WS, 2WS, aerial vehicles)?
- Remote access?
- Wireless communications?
- Level of automation?
- Do we want interchangeable tools?
- Only CAN based communication?

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Conclusion

• New standard proposed including:

ISOBUS parts (Physical, data link and transport layers)

- Server | Client
- Network management
- Task controller improved with new DDI
- Virtual terminal (graphical human-robot interface)
- Auxiliaries (physical HRI)

Improved application layer

- Detection (artificial vision, LiDAR, Sonar)
- Type of vehicles and their configurations (terrain, aerial)
- Levels of automation
- Wireless communications and other HRI
- Safety layer?

Questions?

Thank you!

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