Can we leave field trials to the machines?

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Background

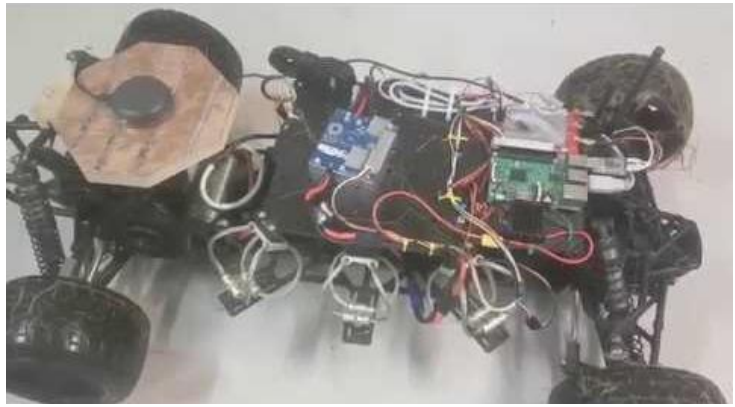
- The department has worked with renewable fuels & efficient use of machinery since 20+ years
- Late 10s increased interest in automation, first in road transport, but soon after in agriculture
- Automation can allow electrification through fewer labour hours, but more machine work hours (long hours for charging less problematic)

- Theoretical work (Electric autonomous tractors in Swedish agriculture)
- Practical tests

Our journey

- Drängen
  - Uppsala Innovation
  - Vinnova

- MacTrac
  - Stiftelsen lantbruksforskning (SLF)

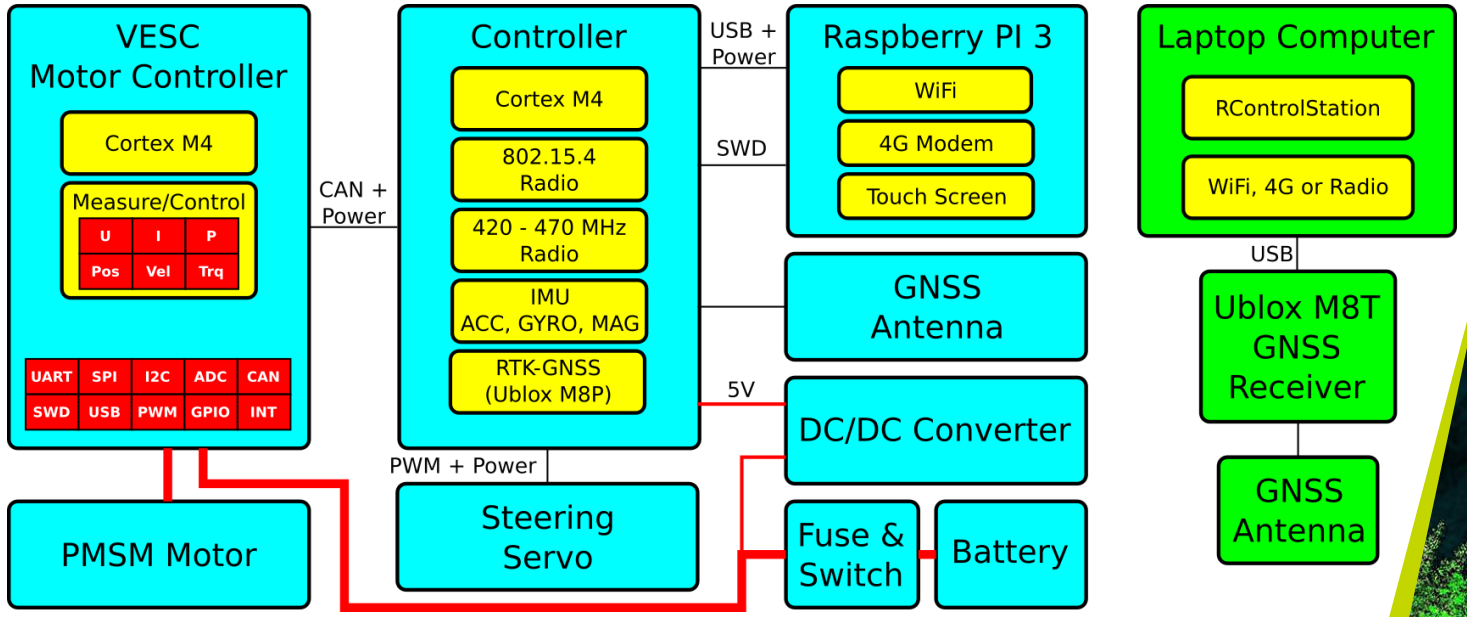


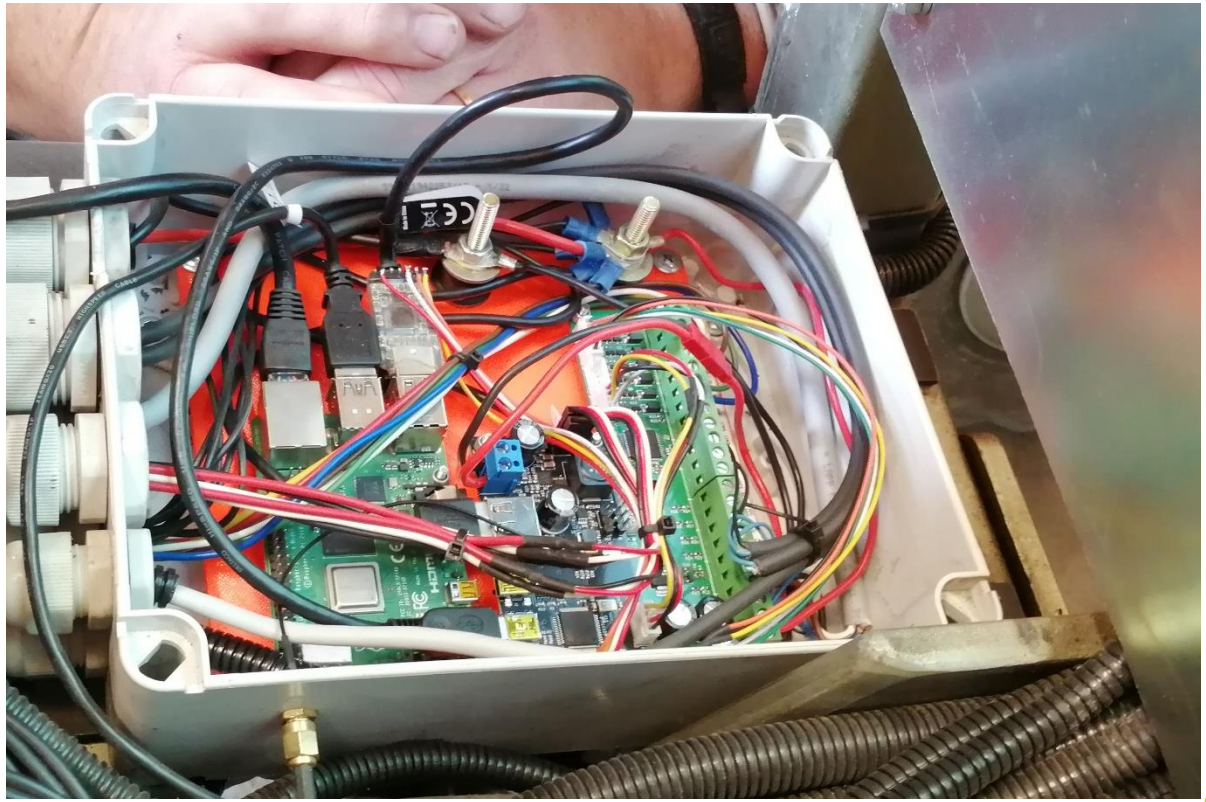
Our vehicles

- Small tractor – 30 kW, < 1 000 kg
- Combustion engine (mostly ethanol in a petrol engine)
- A-frame for implements
- Robust

Our control system

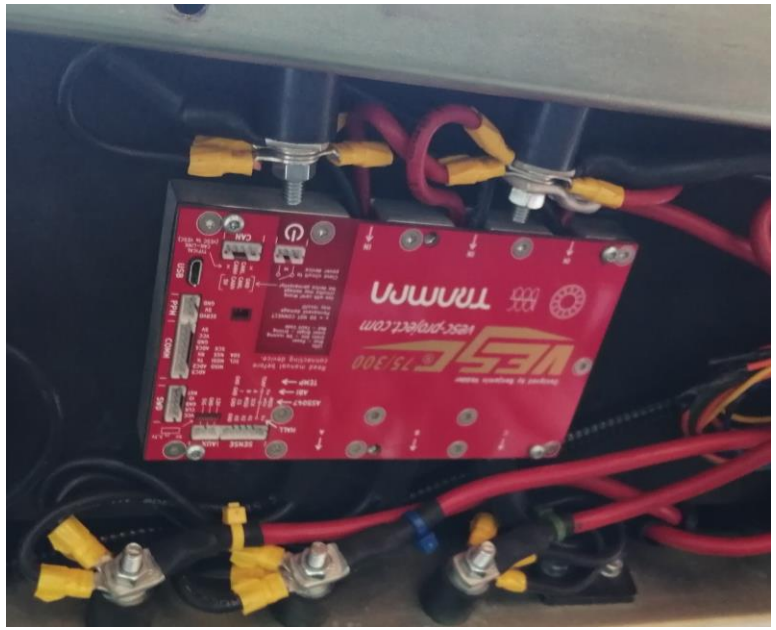
- Raspberry as onboard computer (mostly for communication, but also for some services, such as camera)
- Custom-made controller card to run code in embedded environment
- GNSS + IMU for position
- Build on open source (original, our version)





Implement control

- Implements that have moveable parts/are powered often have motors
- Use VESC (https://vesc-project.com/) to control them
  - From same developer as the control software
  - Capable
  - Sizeable community
- Have also developed communication using ROS as a communication layer in the SLF project



Safety

- Vehicle forward/backward drive turned off if no received heart beat signal in 1 sec)
- Emergency stop
- Electronic fence
- People detection (usually not activated)

Practical experiences

- Troubleshooting problematic, important to have
  - Clear information from all parts where you can have problem
  - Clear user interface (human factor..)
  - That you understand your system well (something that is not directly problematic might have indirect consequences)

- Have we started all systems? (emergency stop, controller, software at machine). After 2+ years still forget to turn on the emergency stop before we do the tests
- Do we have good connection everywhere? (wireless to the machines, power cables on the machine, information carrying cables on the machine)
- Do all components work well? (not too warm or too wet, to little electricity etc.). Can be an issue for components on the tractor as well as components used to control it (tricky to type on a computer when it rains & tricky to see the screen if too sunny)

Practical experiences (ii)

- If the tractor is programmed with the tasks it should do human labour time is mainly due to:
  1. Setting up the system, taking the vehicle to the field and back, turn off the system
  2. Make sure that it runs properly – that the vehicle stay on track and continue operation
  3. Surveillance the operation.

Over time much less 1 & 2 and mostly 3

Results / precision

- Steering based on GPS/RTK & IMU, can add tachometer in the wheels. Calculates wanted steering based on current and wanted angle + PID algorithm. Setup local RTK base station based on same hardware & software as for the machinery

- Had disks down during test → Allowed us to physically compare paths between tests
- Photo to the right shows path that has been taken 15 times or so
- Very repeatable

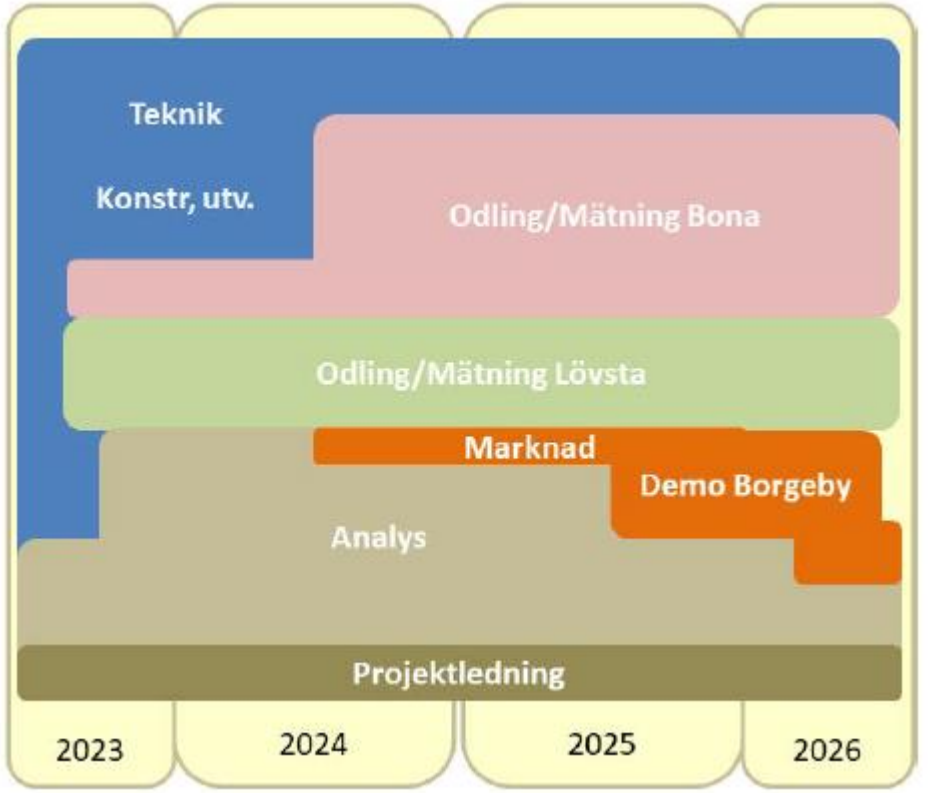
Rotational cereal with permanent bottom crops

- EIP-Agri funded project to develop equipment and know-how for a new cultivation system for **rotating cereal cultivation with permanent bottom crops**, where the work is robotized to serve in larger scale farming.
- Time frame: July 2023- September 2026
- Partners: Mapro Systems, Achaea, Bona Gård, Hushållningssällskapet, SLU
- The system is based on row cultivation and careful regulation of the amount (height) of hay for optimal contribution to the crops and regulation of weeds.

Europeiska jordbruksfonden för landsbygdsutveckling. Europa investerar i landsbygdsområden

Parts

- Machinery
  - Develop a basic machine that can autonomously process co-cultivation of grain and fodder (e.g. alfalfa)
  - Carrying five bespoke implements which handle the various stages of cultivation (seeding, mowing, milling, spraying, edging) - not harvesting.
- Cultivation/Measurement
  - confirms how a sustainable, high-yielding and resource-efficient cultivation system also contributes to energy savings, etc.
  - shows how grazing animals can be integrated into the system.
- Analysis with regards to profitability, sustainability from a life-cycle perspective & technological performance
- Market analysis.
- Project management

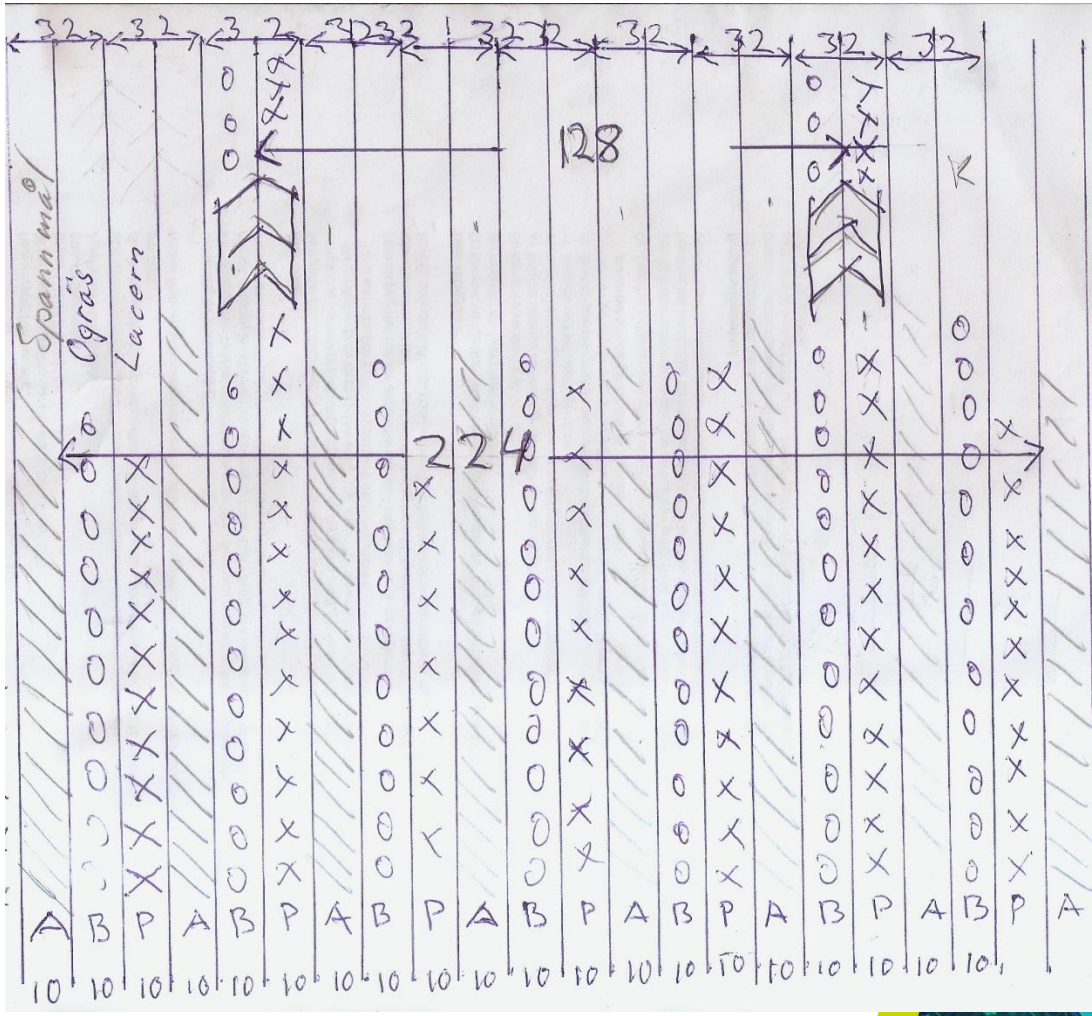


Cropping system

- Annual cereals and perennial legumes and other herbs, called ground crops or service crops, are co-grown for increased delivery of ecosystem services.
- Focus on weed control
  - Cutting the service crop
  - Edge cutting between the grain and the service crop.
- Avoid herbicides in the experiment in order to be able to more easily study the effect of other measures, but the system is supposed to work with band spraying with a full dose over the straw grain rows once in the spring and thus achieve good weed control, significantly reduce the use of herbicides and thus the risk that the weeds develop herbicide resistance .
- We will study how the nitrogen supply in winter wheat is affected by co-cultivation with the service crop and how the weed seed bank is affected by the presence of a perennial crop component all year round for three years.

Machinery

- develop, verify the function of and certify equipment with the capacity to handle the mentioned concept
- autonomous basic vehicle and a limited number of implements.
- develop and commercialize equipment with the capacity to grow cereals in permanent bottom crops in its various stages (sowing, mowing, edging, milling and band spraying)
- the whole process (except harvesting of grains and fallow, where the latter crop can harvested either mechanically or with animals) to be carried out by the equipment developed in the project.



Can we leave it to the machines?

- To be confirmed

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