Telemetry and Farm Fleet Management

Area **2** – **Technologies**

Lesson **9** – **Communications**

Sequence ID – **30**

UPM

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DISCLAIMER

A2.L9.T2 Telemetry and farm fleet management

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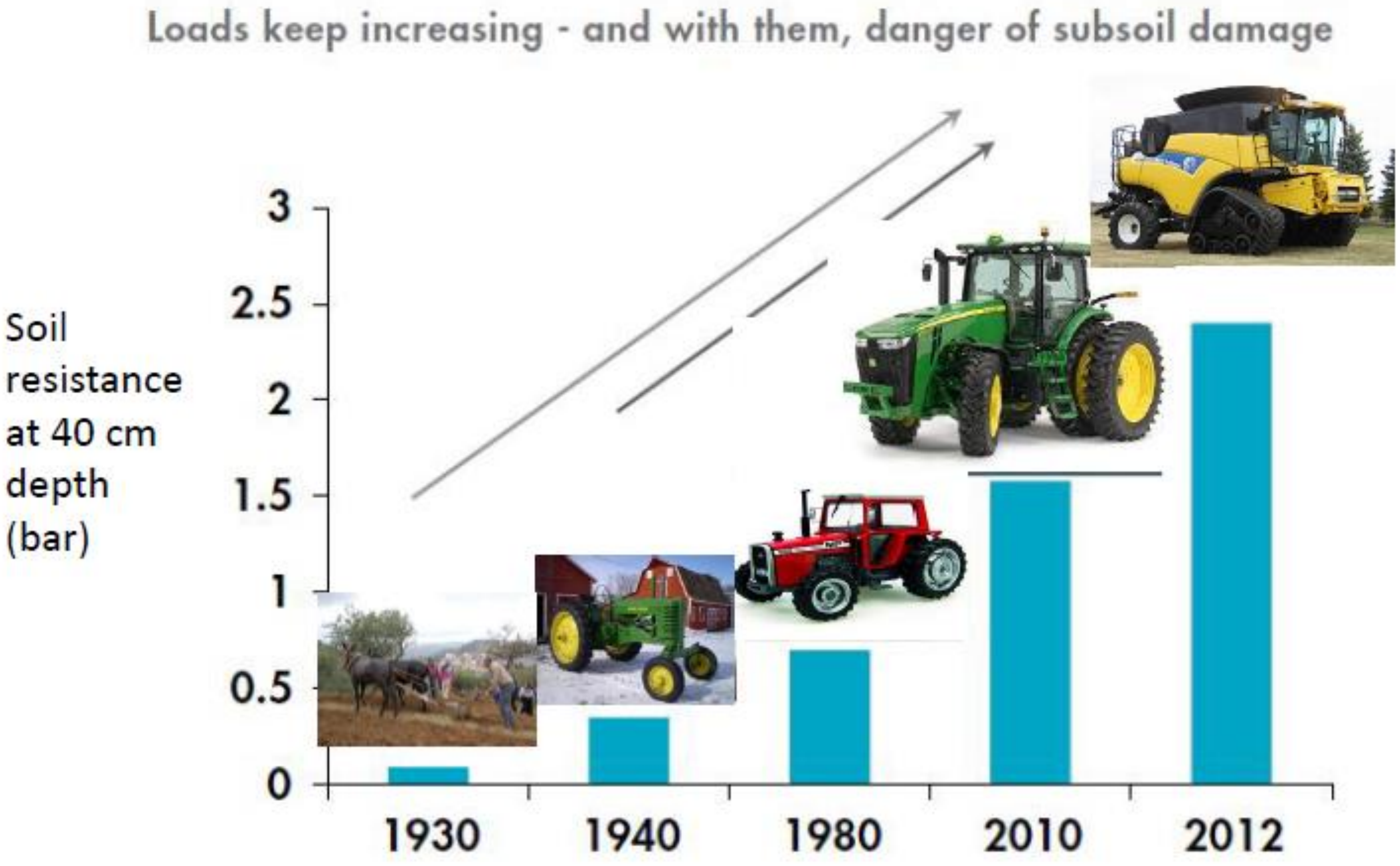
Is cropping turning subsoils into roadbase?



Is cropping turning subsoils into roadbase?

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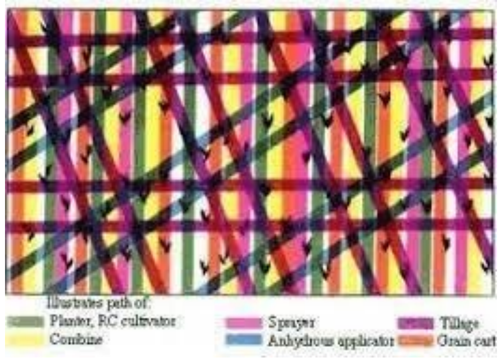
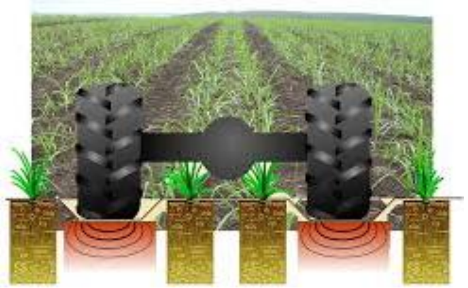


Uncontrolled Traffic → Crop & Wheels without differentiating → Slow Root Growth & Waterlogging

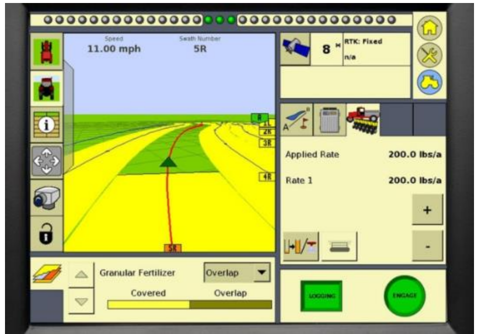
Controlled Traffic Farming (CTF) → Differentiation: Crop Only, Wheels Only → Easy Root Growth & Drainage, Low Rolling Resistance

Control Traffic Farming

- It confines tire and track induced soil compaction to permanent tramlines by controlling traffic. This produces softer crop zones and allows easy access into the crop for row cropping, relay planting or raised bed techniques.

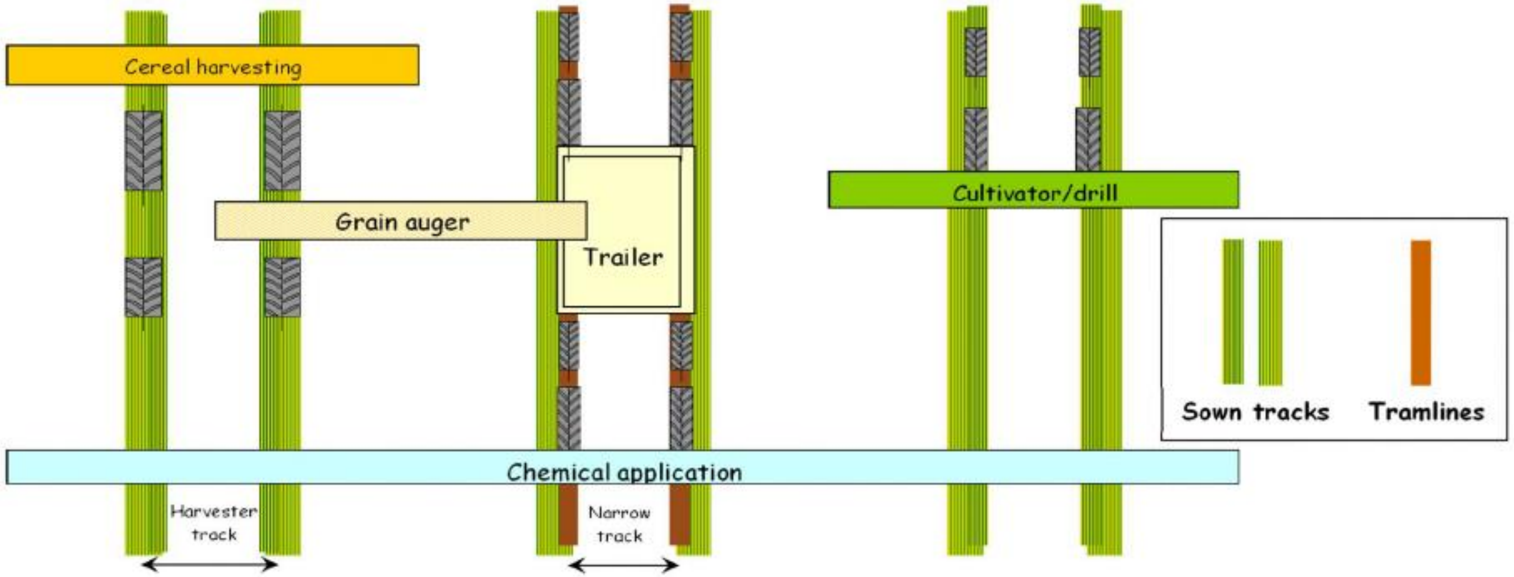


- It uses a guidance system for more accurate driving to minimize overlap and to set up and maintain tramlines.



Control Traffic Farming

- CTF solves most of the negative effects on soils through the use of precise positioning systems, corrected by RTK, by self-guiding the traffic of the machines along the same streets year after year.



Tramline design

Bare tramline

Fuzzy tramline

Sown tramline

Source: Westen Australian Agriculture Authority

Tramline Direction

- In the CTF the rule that the driving direction parallel to the longest field edge is the optimal one does not apply.
- The cost decreased by 9% considering a conventional spraying system.

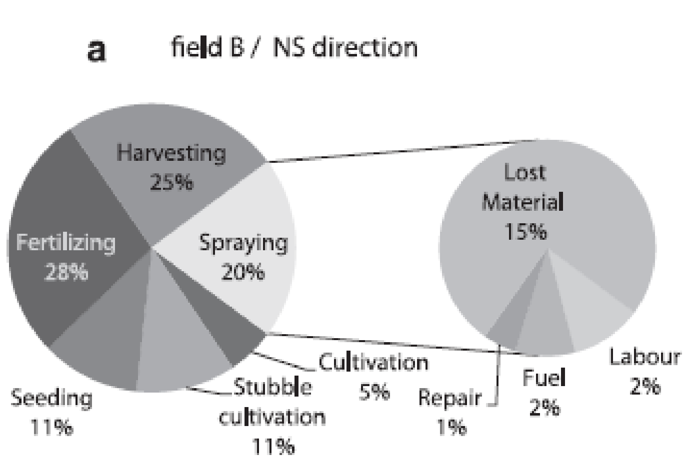


Fig. 7 – Cost distribution in the case of field B for the a) NS and b) EW directions of the tramlines.

Source: Bochtis et al., 2010

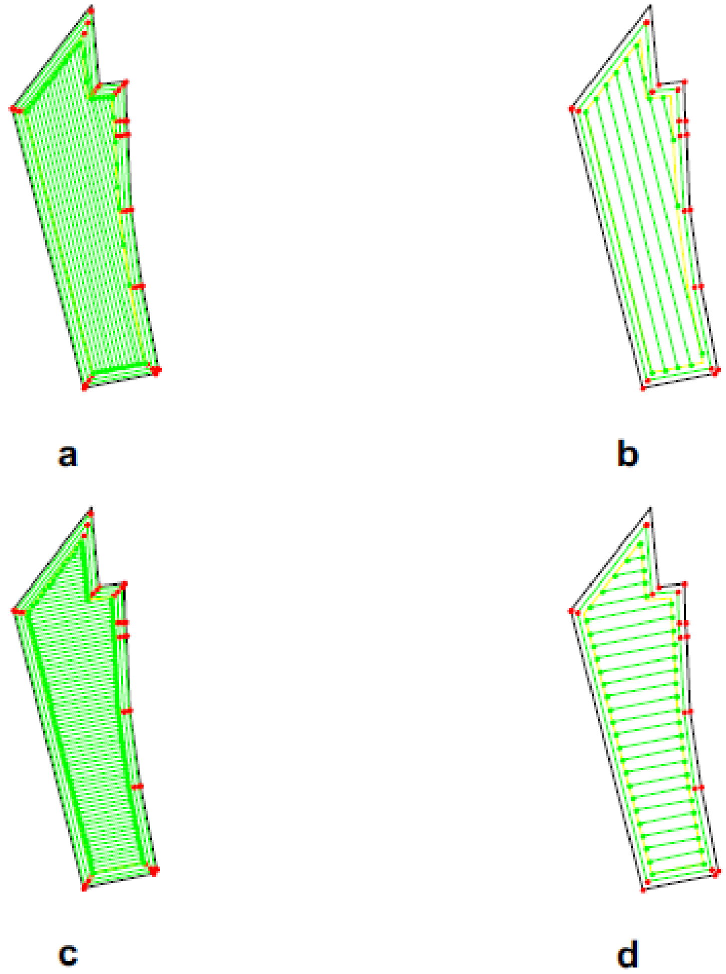


Fig. 6 – Tramlines in Field B for operating widths 9 m (a and c) and 27 m (b and d), and driving directions North–South (a and b) and East–West (c and d).

Tramline Direction

- The choice of the NS direction becomes more cost-effective, in terms of the annual cost, when a sprayer with more than 3 automatic controlled sectors is considered.

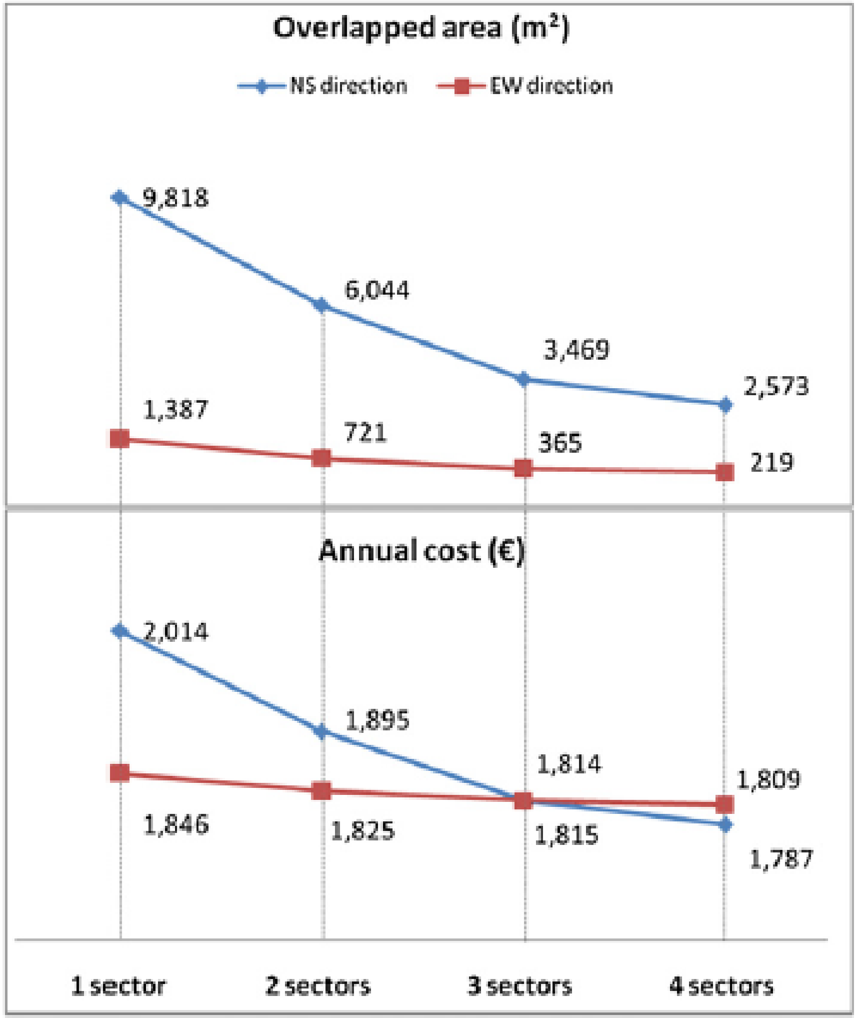


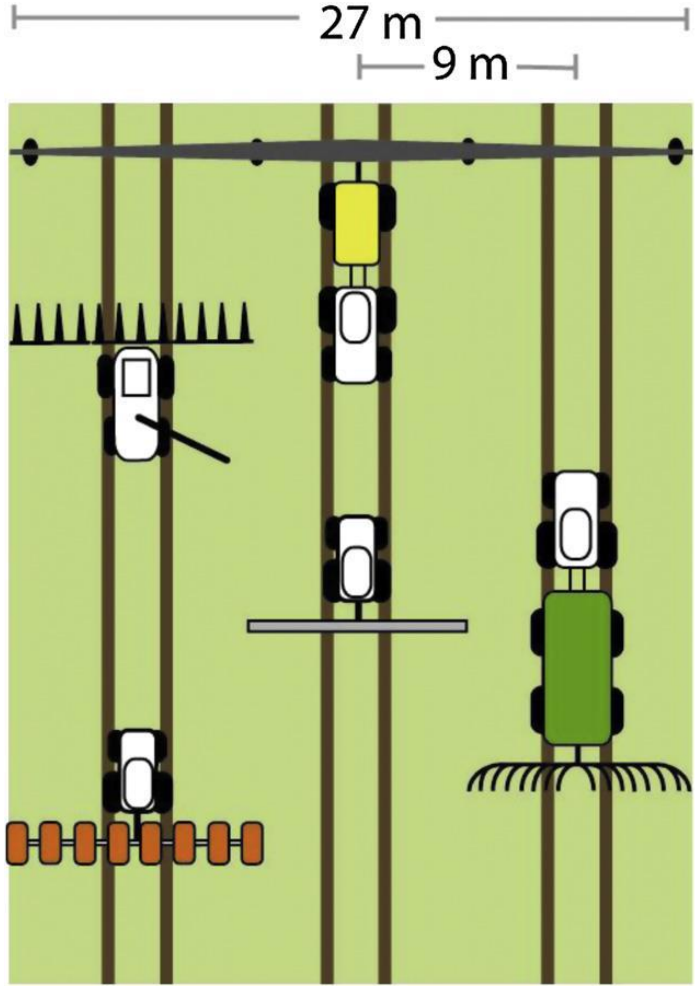
Fig. 8 – The overlapped area (upper diagram) and the total annual cost (lower diagram) for field B for different number of automatic controlled sectors of the spraying system.

Source: Bochtis et al., 2010

Matching Machinery Widths and Tracks

- Ideally, all machinery tracks and widths should match but large grain harvesters with wide wheel tracks, offset harvester fronts and large air seeder bars greater than 12 meters can make matching difficult.

- As soil is compacted most in moist conditions, spraying and seeding equipment is the most important machinery to match.



Source: Bochtis et al., 2010

Matching Machinery Widths and Tracks

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- Most existing machinery does not have matching widths or wheel tracks so changing cropping machinery and wheel track width is essential to win the most benefit from tramline farming systems.

Source: Westen Australian Agriculture Authority

Benefits of CTF

- **Better efficiency:**
  - ➢Reduced input costs of 3 to 10 per cent from less overlap through more accurate driving.
  - ➢Easier driving from using a guidance system, which reduces fatigue.
  - ➢Earlier access for operations such as seeding, spreading and spraying on the compacted tramlines in wet conditions.
  - ➢A tramline farming system is estimated to reduce fuel use by up to 25 per cent.

Benefits of CTF

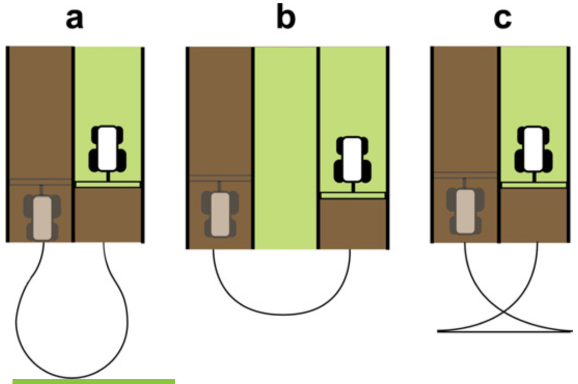
➢ Highly interconnected tasks executed by the cooperation of heterogeneous agricultural machines

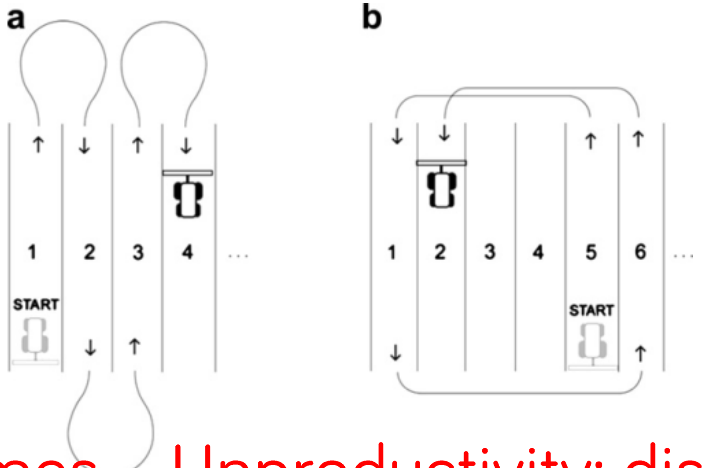
New technologies offers:

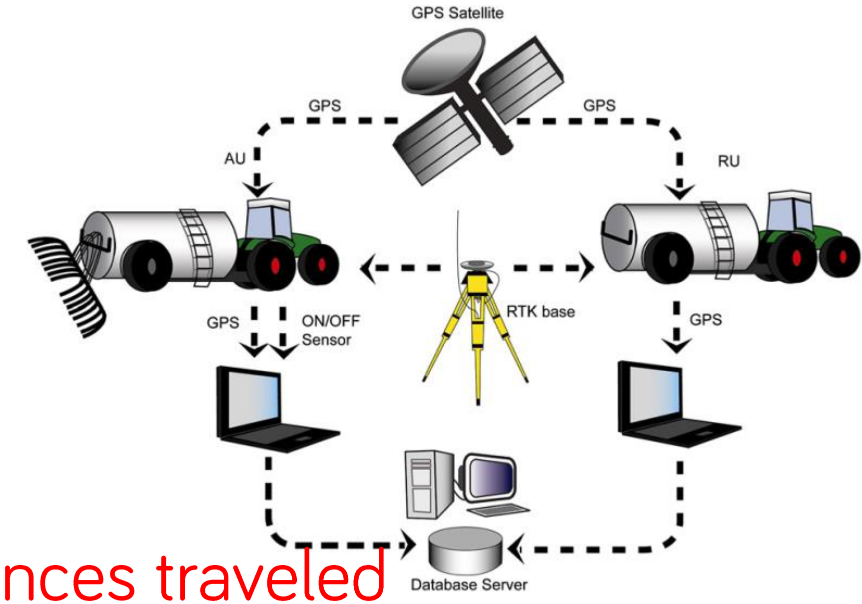
➢Greater freedom of movement.

➢Possibility of coordinating more than one tractor.

➢Meeting points with the recharging unit.







Min. the dead times = Unproductivity; distances traveled

Benefits of CTF

- **Better yield and value:**
  - ➢Less crop damage and soil compaction.
  - ➢Crop yield by 5–15 per cent, depending on soil type, the degree of track matching and the duration of the system.
  - ➢Grain quality: for example, fewer screenings in cereals and more oil in canola by improved soil characteristics and plant root access to water.

Benefits of CTF

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- **More agronomic opportunities:**
  - ➢Relay of summer crops before grain legume is harvested, using relay planting.
  - ➢Better fertilizer use by placement near row, deep ripping and placement on alternate inter-rows.
  - ➢Banding of post-emergent fungicides and inter-row shielded spraying;
  - ➢Better stubble handling by running tines between rows of the previous crop.
  - ➢Sowing back into old furrows or pre-made furrows after early rains or wet harvests.

Task Synchronization

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Decoupled (Sequential)

- Typically, successive operations: tillage, sowing, fertilizing …
- They can be combined or not in time:
  - ➢Packing and loading are combined in time without being coupled
  - ➢Field stacking and loading can be combined or not

Task Synchronization

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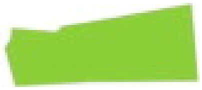
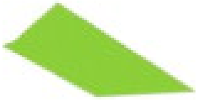
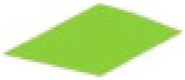
Coupled (Synchronized)

- The machines remain united at some point in the operation
- The working capacity of the cycle is determined by the machine with a longer cycle time
- It can be optimized in time or cost
- Aspects to consider:
  - ➢Number of machines involved
  - ➢Way of working in the field
  - ➢Possibility of (un) coupling the trailer

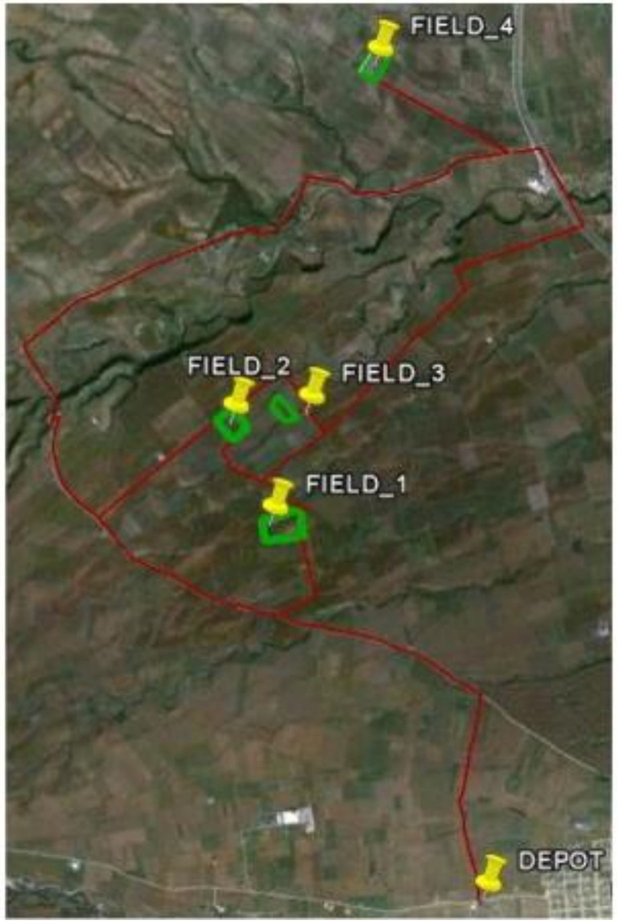
Task Synchronization

Task Synchronization

- Finding a permutation schedule for a number of geographically dispersed fields where bio-mass handling operations have to be carried out involving a number of sequential tasks

Field ID	Field shape	Area (m^2)	Task times (s)		No. of bales
			Baler	Loader	
1		51,140	5106	2150	17
2		28,280	3840	1800	11
3		14,526	2490	2740	11
4		33,000	5865	7545	30

Source: Bochtis et al., 2013



Task Synchronization

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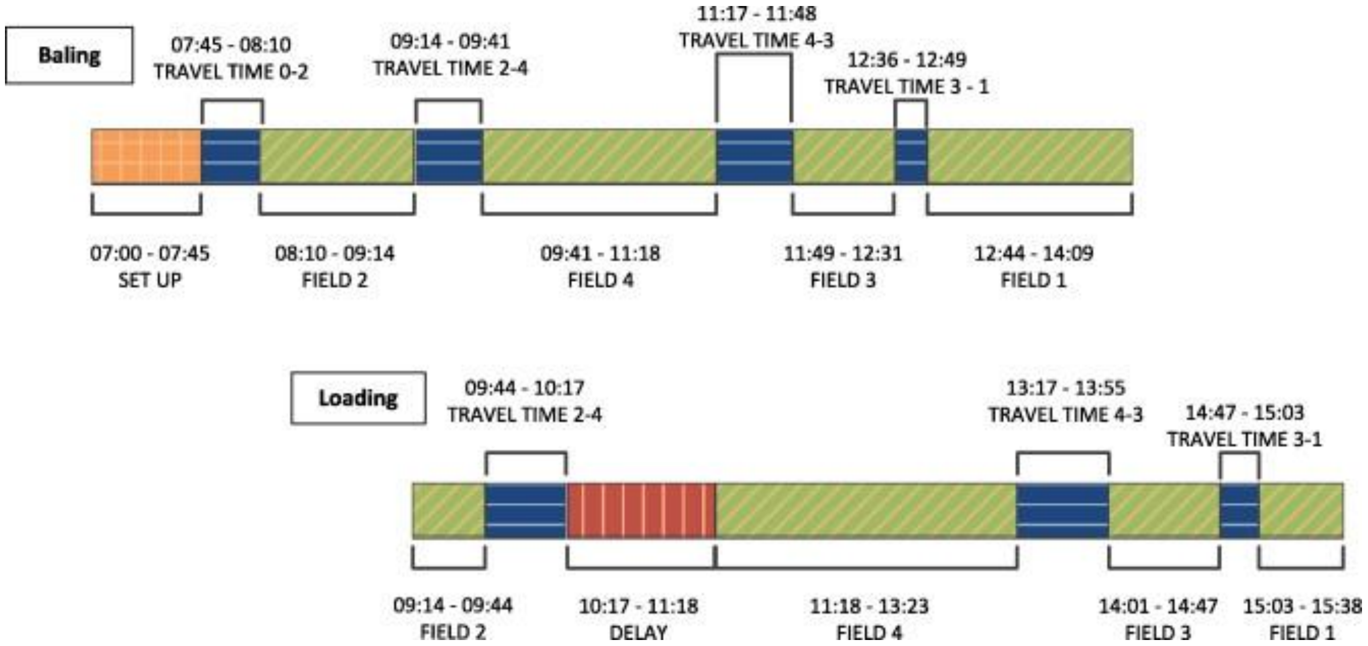
The executed schedule

- The schedule as it has been planned and executed by the contractor. The duration of the total operation was 8 h and 38 min (starting time: 07:00, makespan time: 15:38)

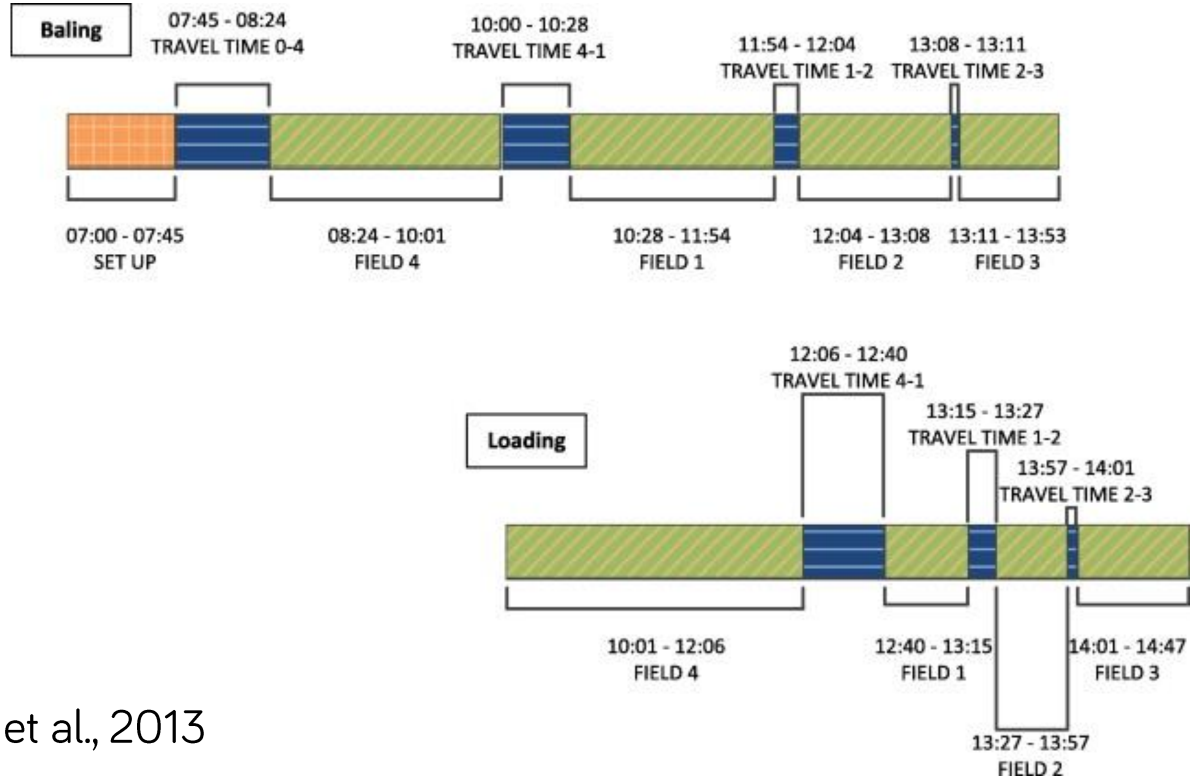


Source: Bochtis et al., 2013

Task Synchronization

Optimal schedule

- Travelling times between each physical location and for each machinery type and the task time for each operation are required as input
- According to the optimal solution, it is reduced the total operation time with 51 min which amounts to a **9.8% reduction of the total time**



Source: Bochtis et al., 2013

Task Synchronization

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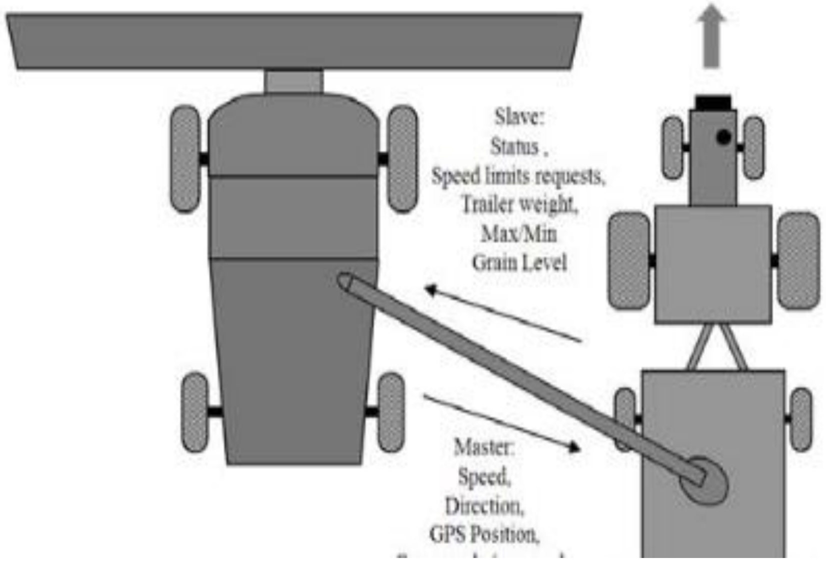
- The synchronization of tasks is to optimize the working capabilities of the machines.
- Unforeseen events are a frequent cause of the occurrence of downtime.
- Real-time re-planning procedures are basic for the optimization of large machinery parks.
- The service can be community in the way that the costs are shared.

Task Synchronization

- Short range wireless communication systems for machine synchronization
- Long range wireless communication for fleet management, and for production and task control in real time.
- ISOBUS protocol allows real time control in machines connected through mechanical, hydraulic, electrical and electronic connections.



Task Synchronization

- The communication system between machines must provide a real time communication, in order to activate a distributed control task, ensuring that machines are hooked during the programmed operation.
- The protocol needed by short range communication for machine synchronization purpose has requirements related to real time and safety of communication, due to the need for information reliability and for controlled maximum delay.

Task Synchronization

Fendt GuideConnect

- Two tractors are connected through a positioning system and a wireless communication system to form a unit, where one of the two vehicles is unmanned and performs the same work procedure as the vehicle manned.
- It need to be defined the following and lateral distance between the two tractors.

https://www.youtube.com/watch?v=qJ4gbT3z5dE

Task Synchronization

John Deere Machine Sync

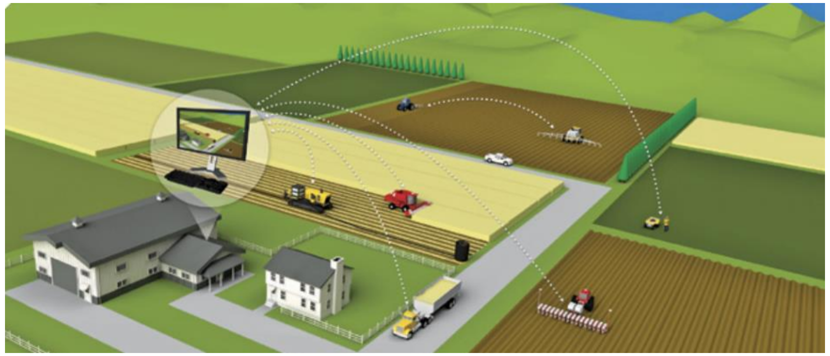
- Two machines can work simultaneously with each operator having immediate access to coverage maps and guidance lines to ensure complete field coverage.
- Automated communication and logistics for combines and grain carts, by allowing the combine operator to automatically control the location of the tractor and grain cart while unloading on-the-go.

https://www.youtube.com/watch?v=7iDKx7kbHqs

Information Management

- Fleet management functions, tracking the location of the machine and an overview of the operating status.
- The security functions and the anti-theft protection and against incorrect use alerts include the geofencing and the management of time restriction work.
- Fuel consumption, speed, working time… in real time.

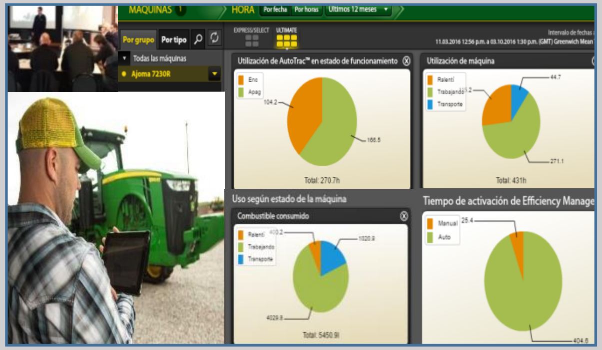
Where are my machines? How long do they need for specific work? How profitably are we using our machines?



Telemetry: Geo-referential or Parametric?

Satellite-based (GNNS)

Geolocation
Electronic barriers



Based on SCADA

Diagnosis
Characterization

Approaches to Parametric Telemetry

Diagnosis

- Digitized signals with a high frequency of tens of hertz (tens of times per second)
- Spatial information is not relevant
- The visualization of data is fundamental

Characterization

- Lower acquisition frequency
- It has several uses
  - ➢Work planning in the field
  - ➢Analysis of the quality of the tasks and state of the machine
- Automatic data analysis is basic

Types of Fleet Management Systems

Multi-brand

- They only access generic CANBUS data
- Beware of temporal and data resolution

Owner

- Access to all engine data but not attachments
- High data resolution and temporary low

Uses of Telemetry in Agriculture

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- Make recommendations that improve energy efficiency
- Establish improvements in the conditions of use of machinery
- Potentially identify maintenance issues.

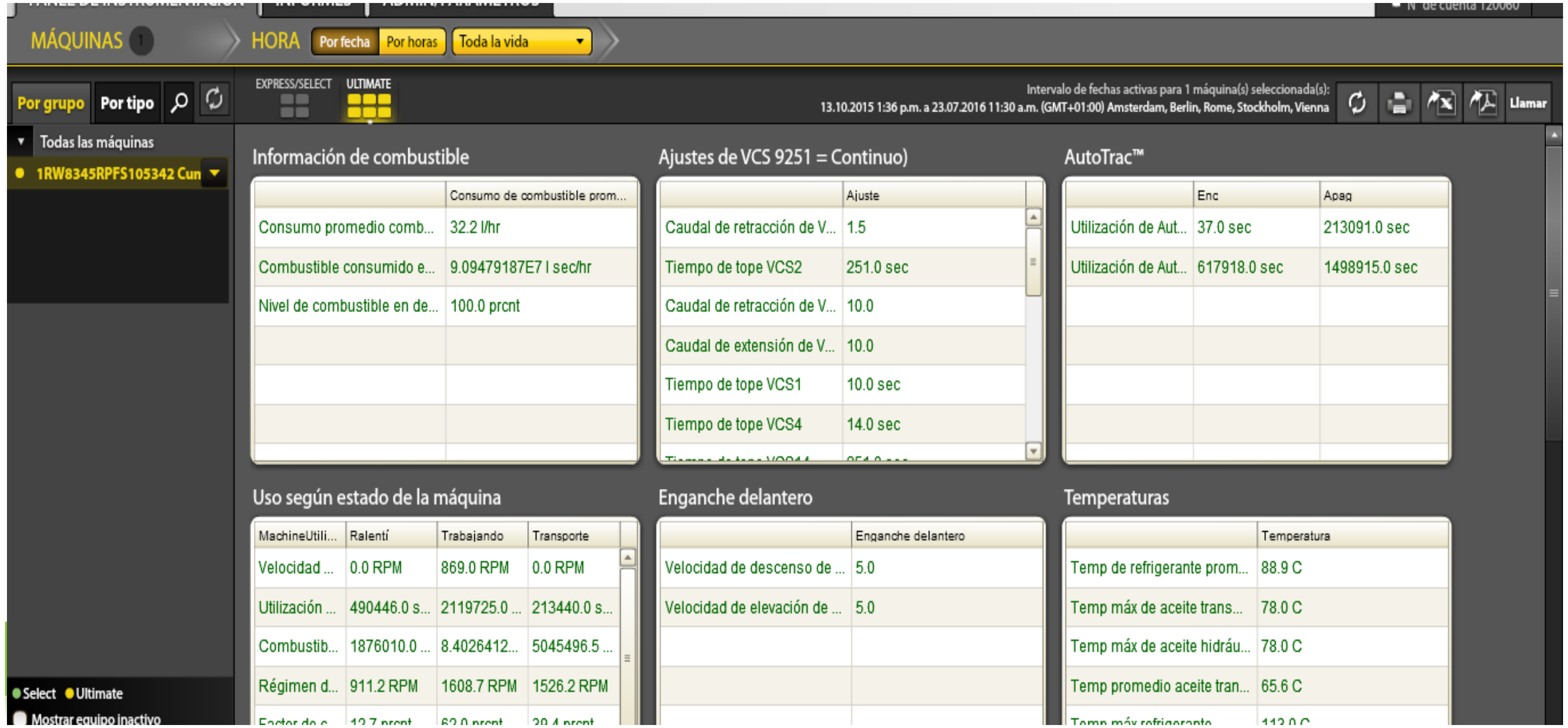
Do you own several tractors and would you like to know where they are at each moment?

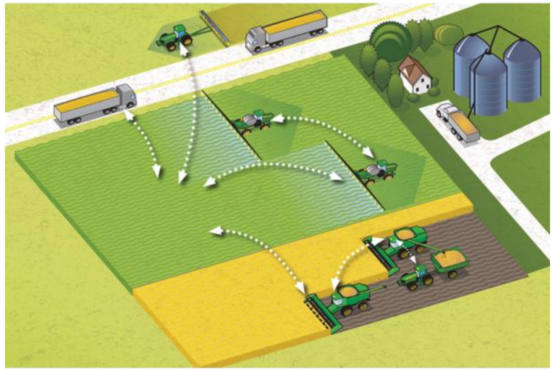
Would you like to know data about the work they do and about the quality of said work

What about a possible breakdown, the dealer can know the service code (remote fault diagnosis) before moving to the machine, to prepare the necessary parts?

JD Link Telemetry

- Download engine data (more than fifty variables) in periods established by use (engine hours) or by date; in both cases the resolution (minimum period of time considered, up to 1 h of use or 1 working day)





JD Link Data Analysis

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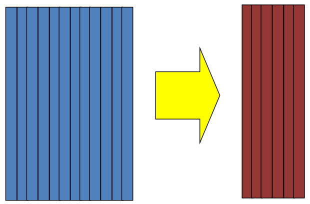
PCA

Unsupervised

Dimension reduction

- [scores,loads,ssq,res,reslm,tsqlm,tsq] = pca(data,plots,scl,lvs);



Cluster

Unsupervised

Data grouping (pattern recognition)

Discriminante

Supervised

Projection that maximizes differences

JD Link Data Analysis: Variables downloaded

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Category	Subcategory	Acronym	Description
Motor	Work	RW	Regime (rev min-1)
		LW	Load (%)
		cW	Hourly consumption (l h^{-1})
		CW	Total consumption (l)
		T_TBJO	Assigned time (%)
		v_TBJO	Speed (km h^{-1})
	Transport	RT	Regime (rev min-1)
		LT	Load (%)
		cT	Hourly consumption (l h^{-1})
		CT	Total consumption (l)
		T_TPTE	Assigned time (%)
		v_TPTE	Speed (km h^{-1})
	Iddle	RR	Regime (rev min-1)
		LR	Load (%)
		cR	Hourly consumption (l h^{-1})
		CR	Total consumption (l)
	Management	T_IPM	Intelligent management time (%)

JD Link Data Analysis: Variables downloaded

Category	Subcategory	Acronym	Description
Maintenance		TmR	Tª average temperature (ºC)
		TMT	Tª max transmission (ºC)
		TMH	Tª max hydraulic (ºC)
		TmT	Tª average transmission (ºC)
		TMR	Tª max cooling (ºC)
		TmH	Tª average hydraulic (ºC)
		V	Average voltage (V)
		N1	Number of interrupted cleanings of exhaust filter
		N2	Number of exhaust filter cleanings completed
		NN	Fuel level (%)

JD Link Data Analysis: Variables downloaded

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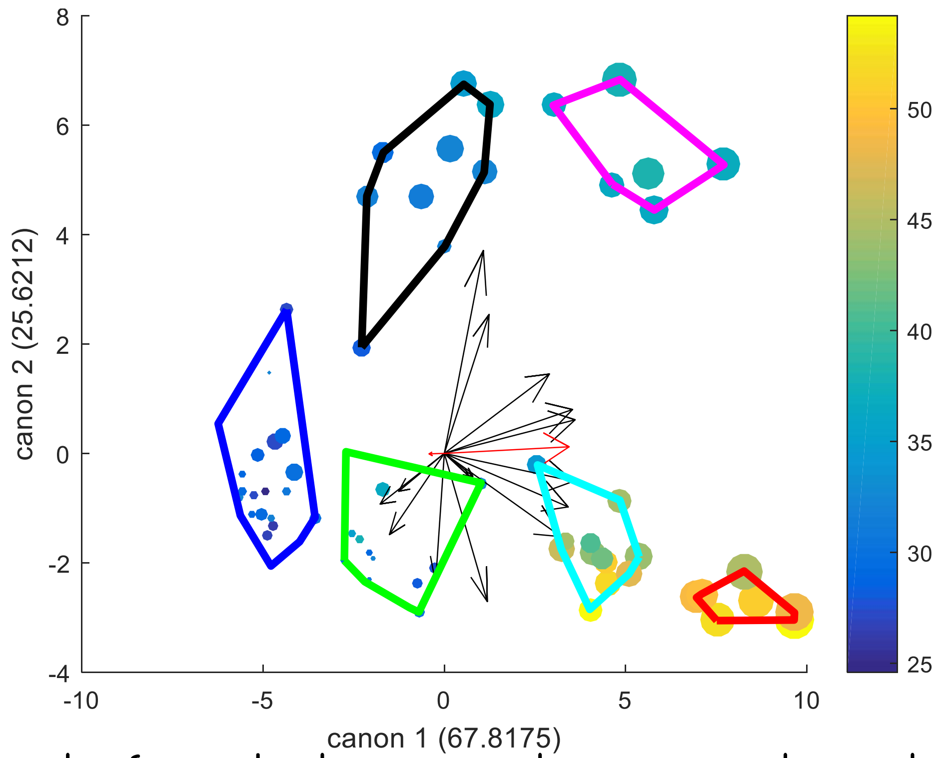
Category	Subcategory	Acronym	Description
Tasks	Traction and drive	Slip P1 a p9	Ranges in figure (%)
		T_TDF	PTO time (%)
		T_IDM	Time front-wheel drive (%)
	Auxiliaries	H1	Flow vcs 1
		H2	Flowvcs 2
		H3	Flow vcs 3
		H4	Flow vcs 4
		H5	Flow vcs 5
		Elevator	Position

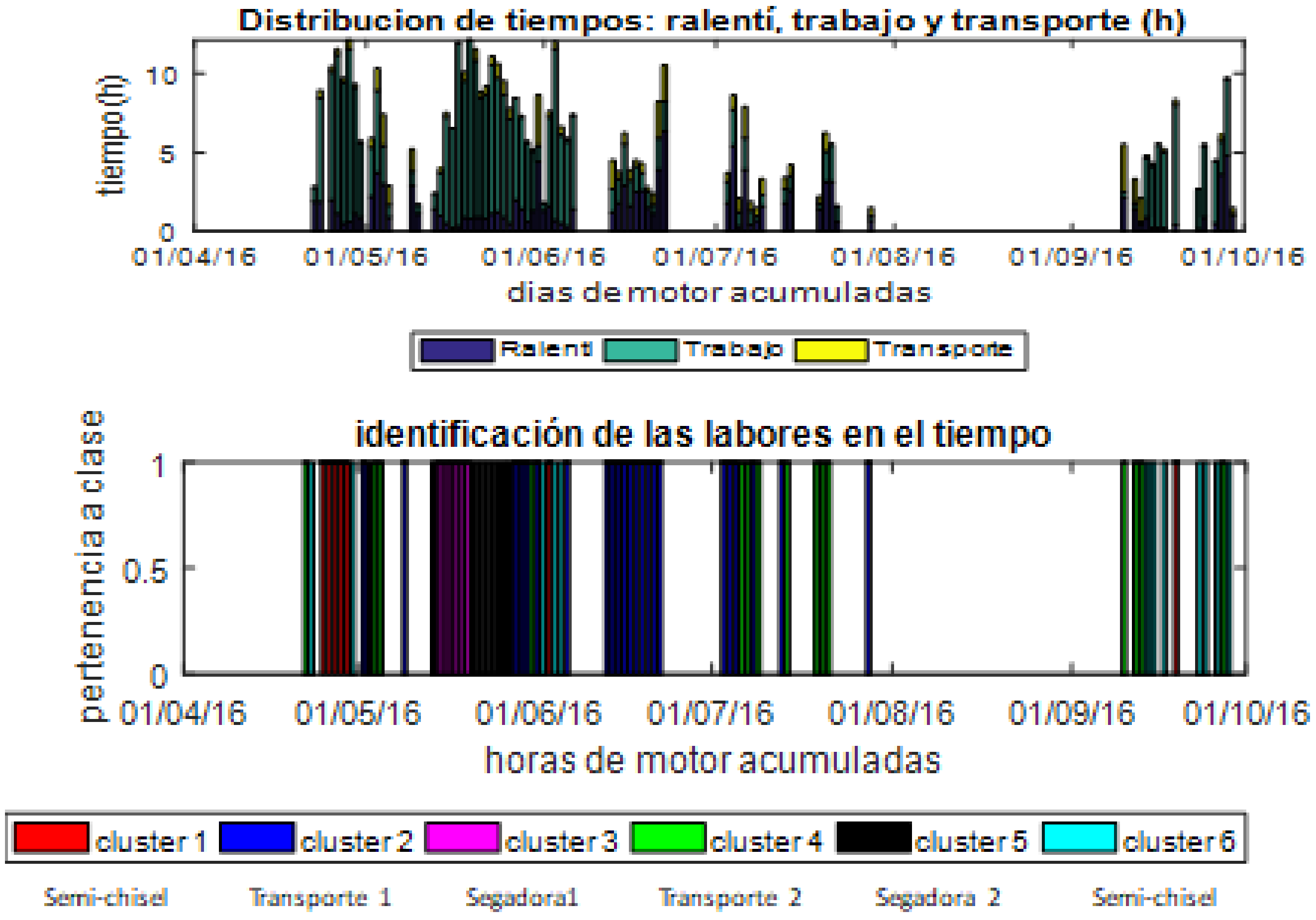
JD Link Data Analysis: Unsupervised Procedure

- The use of the automated procedure has led to the isolation of six different patterns as identifiable tasks: heavy and light traction activities, heavy and light PTO tasks, and heavy and light hauling.
- With this information and a slight feedback to the farmer (equipment list in use and actual width) it was possible to make a unique match between equipment and task.



Results from the k-means clusters: marker color refers to the engine load under working conditions; marker size indicates fuel consumption (l h^{-1}) and; line color identify the tasks segregated with the unsupervised procedure.

JD Link Data Analysis: Characteristic Features



Task distribution along the season

JD Link Data Analysis: Characteristic Features

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	Transport at harvest (red)	Light hauling with mouldboard (blue)	Heavy hauling with mouldboard (magenta)	Light hauling with chisel (green)	PTO activated (black)	Heavy hauling with chisel (cyan)
RW(rev min-1)	1786.11	1252.91	1695.17	1338.10	1560.28	1736.77
LW (%)	49.79	28.79	37.00	31.63	31.94	45.19
cW (l h^{-1})	21.36	9.08	15.35	10.87	12.47	19.02
CW (l)	196.23	17.54	140.38	12.57	86.68	88.11
TW (%)	87.88	39.52	91.39	25.10	77.19	81.66
IPM (%)	0.68	4.21	0.53	8.37	1.40	0.33
TDM (%)	91.70	6.56	68.10	63.23	13.28	92.86
TDF (%)	0.00	1.12	86.00	1.09	60.21	2.22
RT (rev min-1)	1773.94	1681.32	1677.10	1734.47	1719.11	1690.17
LT (%)	52.29	46.55	48.27	50.77	49.14	48.03
cT (l h^{-1})	23.99	20.38	20.88	22.71	21.94	21.12

JD Link Data Analysis: Recommendations

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Action plan I

- ✓ 1) Reducing the idling time in hauling tasks to half the current value (50%), that is to say, 200 haul hours, 100 h are idling and reduced to 50 h (given that the average consumption at idle is 3.84 l h^{-1}, in 50 hours you would save about 200 l of diesel fuel).
- ✓ 2) To teach the farmer how to properly use the electronic engine management during task, which according to the available technical studies could lead to a 20% reduction in fuel consumption at work; in this case amounting to 8 l h-1 (for 10% reduction) in 400 hours of mouldboard and chisel, that is, 3200 l of fuel that could be saved for tractor 8345R during a season.

JD Link Data Analysis: Recommendations

Action plan I

- ✓ 3) Improving the traction conditions so that the median slippage (50% of the time) is between 6 and 8% and its variability is reduced (this means studying the counterbalance with the concession and learning how to use the differential lock reasonably).
- ✓ 4) To carry out a second round of indirect estimates, such as areas worked to see if they fit with the farm's data as a validation test for the proposed procedure.

JD Link Data Analysis: Recommendations

Action plan II

- ✓ 1) the improvement in terms of consumption does not seem very relevant (on average it is around 5 l ha^{-1}) since the tractor is being used at low-medium power levels: always <55% load and <1800 rev min-1).
- ✓ 2) It is necessary to reconsider the ballasting procedures and the use of the front traction due to inadequate slippage values.

JD Link Data Analysis: Recommendations

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Action plan II

- ✓ 3) Mowing without front traction has shown the least consumption compared to the activated front traction: 2.5 l ha^{-1} compared to 3.5 l ha^{-1}.
- ✓ 4) May and June are the months of maximum activity (> 10 h daily), therefore the use of optimization procedures for task sequence seems a promising tool to improve efficiency.