Automated versus manual steering during grassland harvest operations in Western Austria

University of
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Department for
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Institute of Agricultural Engineering

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Introduction
Automated steering systems

Potential benefits of automated steering systems in agriculture:

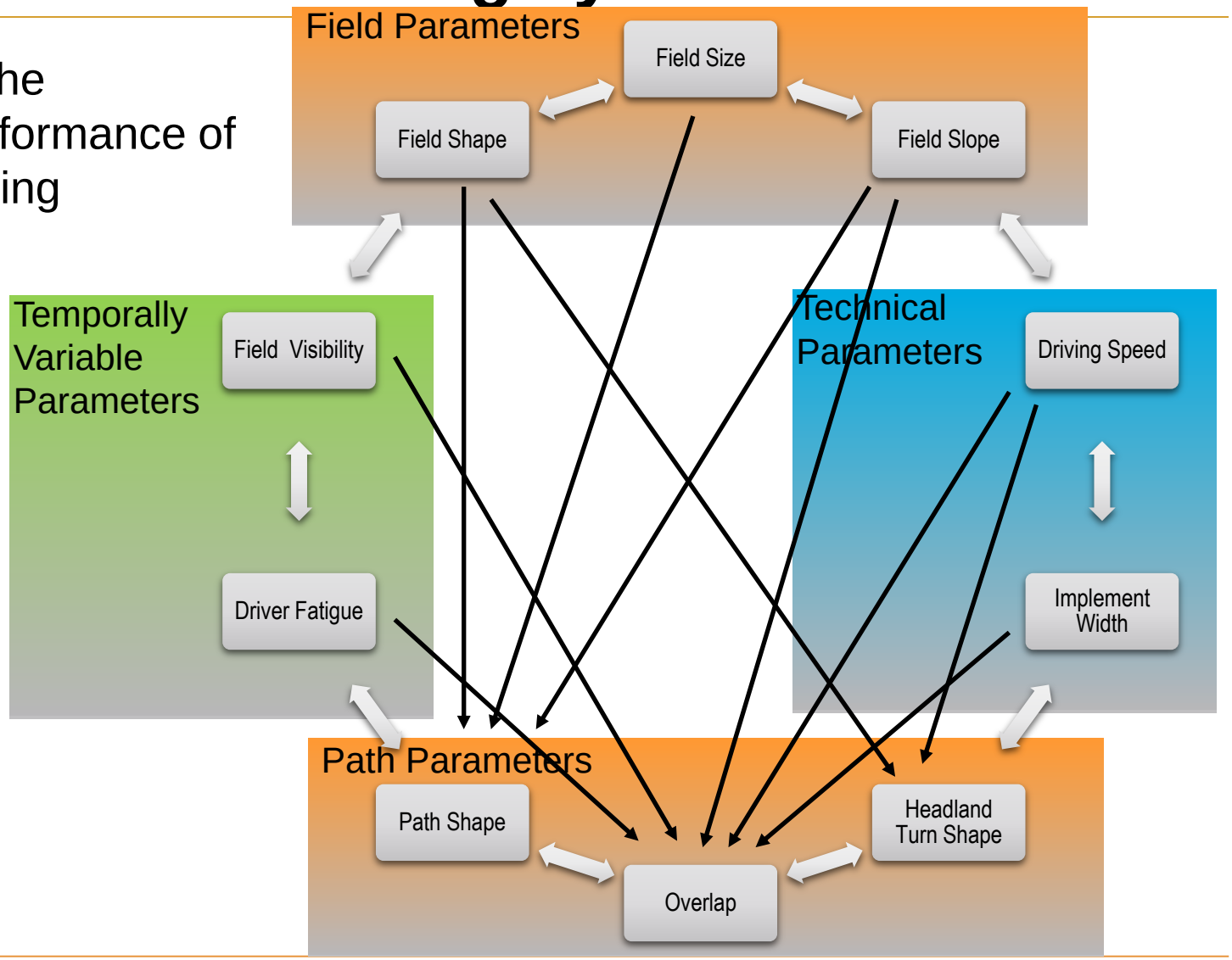
- more efficient cultivation processes through:
  - less track-to-track overlap (e.g. tedding)
  - wider headland turns by skipping neighboring tracks
  - less driver fatigue
  - field work possible even with poor visibility

Practice trials on cropland (Landerl, 2009):

- less track-to-track overlap with automated systems
- reduced labour and fuel requirements
- return on investment for cropland cultivation 70 ha -1013 ha

Introduction
Automated steering systems

Factors driving the comparative performance of automated steering systems



Objectives

On intensively managed grassland in Western Austria:

- compare automated and manual steering…
- …with regard to the parameters:
  - operating time (labour)
  - fuel consumption
  - wheel-based speed
  - track-to-track overlap
- …for the harvesting operations:
  - mowing
  - tedding
  - swathing

Methods I

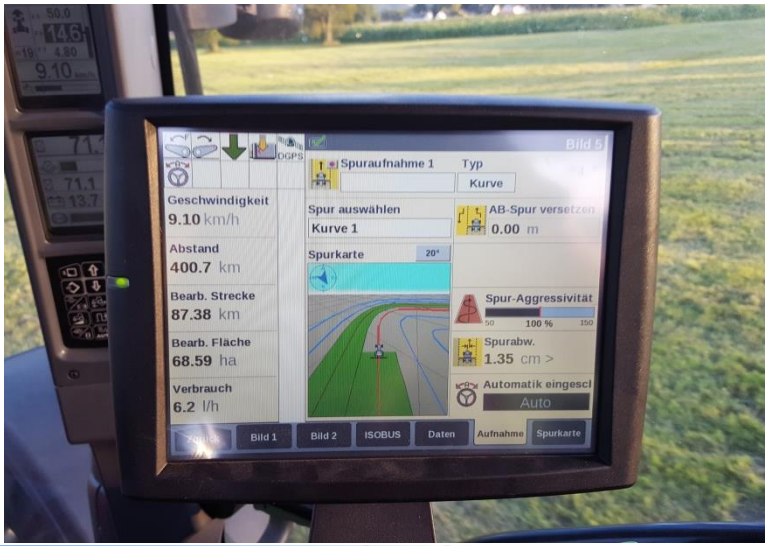
Experimental site:

- Rhine-river valley in western Austria
- Five-cut permanent grassland on dairy farm
- Six equally-sized rectangular plots, 0.79 ha each
- 3 plots (P1, P3, P6) automatically steered – straight parts only, headland turns manual
- 3 plots (P2, P4, P5) manually steered – pattern chosen by driver

Methods II

Hardware:

- Mowing:
  - 96-kW tractor (Steyr „4130 Profi“) with „S-guide“ RTK automated steering system
  - Front drum mower and rear disc mower (combined 6.1m) by Poettinger

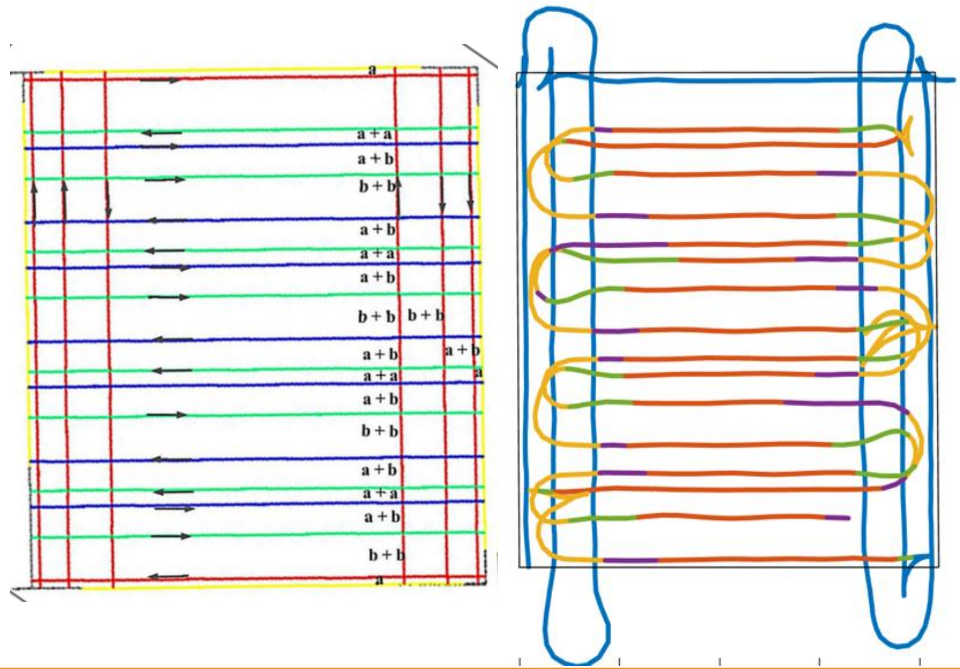


- Tedding and swathing:
  - 84-kW tractor (Steyr „4115 Multi“) with Trimble XCN 2050 RTK system
  - Six-rotor tedder (6.2m) and single-rotor swather (3.3m) by Poettinger

Methods III

Experimental features:

- Automated steering along straight, pre-programmed „multi-swath“ tracks : Farm Works software
- CAN Bus data acquired with Vector GL-3000 data logger
- headland turns were separated from straight track sections
- Statistical analyses with SAS software, one-factor ANOVA with Student-Newman-Keuls post-hoc test; significance level of p= 0.05



Preliminary Results
Whole plot efficiency I

- Mowing and tedding: automated steering requires significantly more time and (significantly for mowing) more fuel
- Swathing: automated steering requires significantly less time and insignificantly less fuel

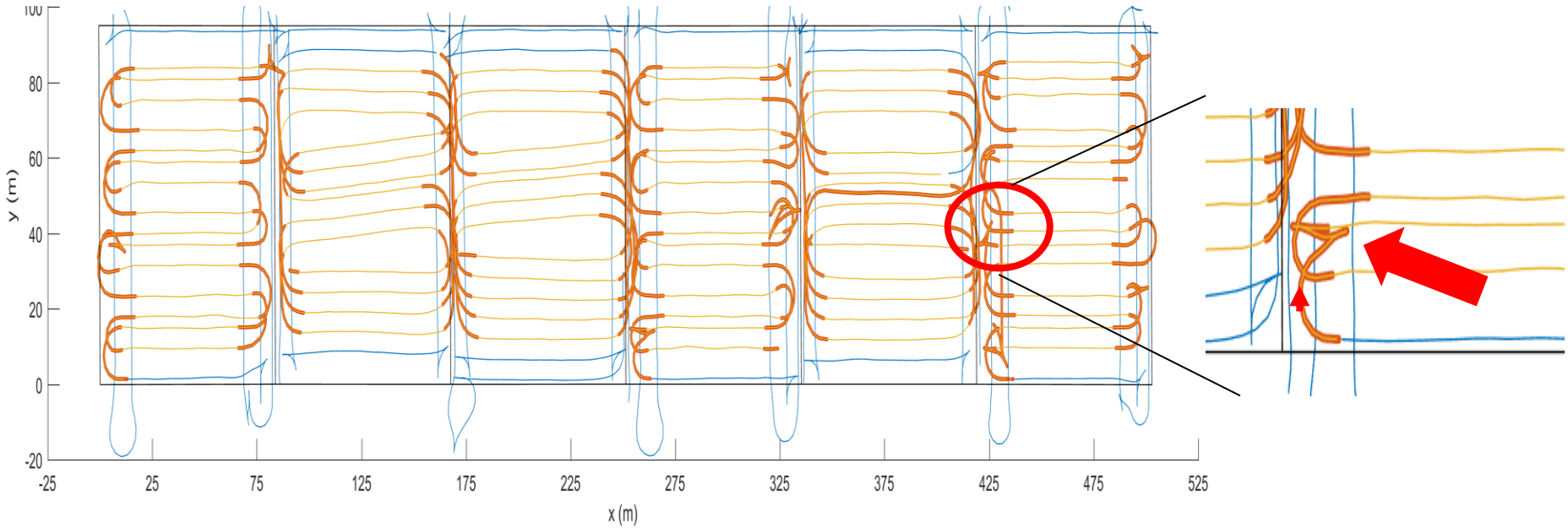
	Mowing		Tedding		Swathing	
	aL	mL	aL	mL	aL	mL
Average Operating Time [min]	15.28±3.01 a	10.72±0.41 a	11.14±0.73 c	8.57±0.50 d	22.60±2.23 e	26.76±1.26 f
Average Fuel Consumption [l/hr]	4.32±0.41 a	3.61±0.23 b	1.15±0.04 c	0.96±0.08 c	2.46±0.23 d	2.63±0.03 d

letters a,b,c,… indicate significant differences between automatic and manual steering (one-way ANOVA, p= 0.05)

Preliminary Results
Whole plot efficiency II

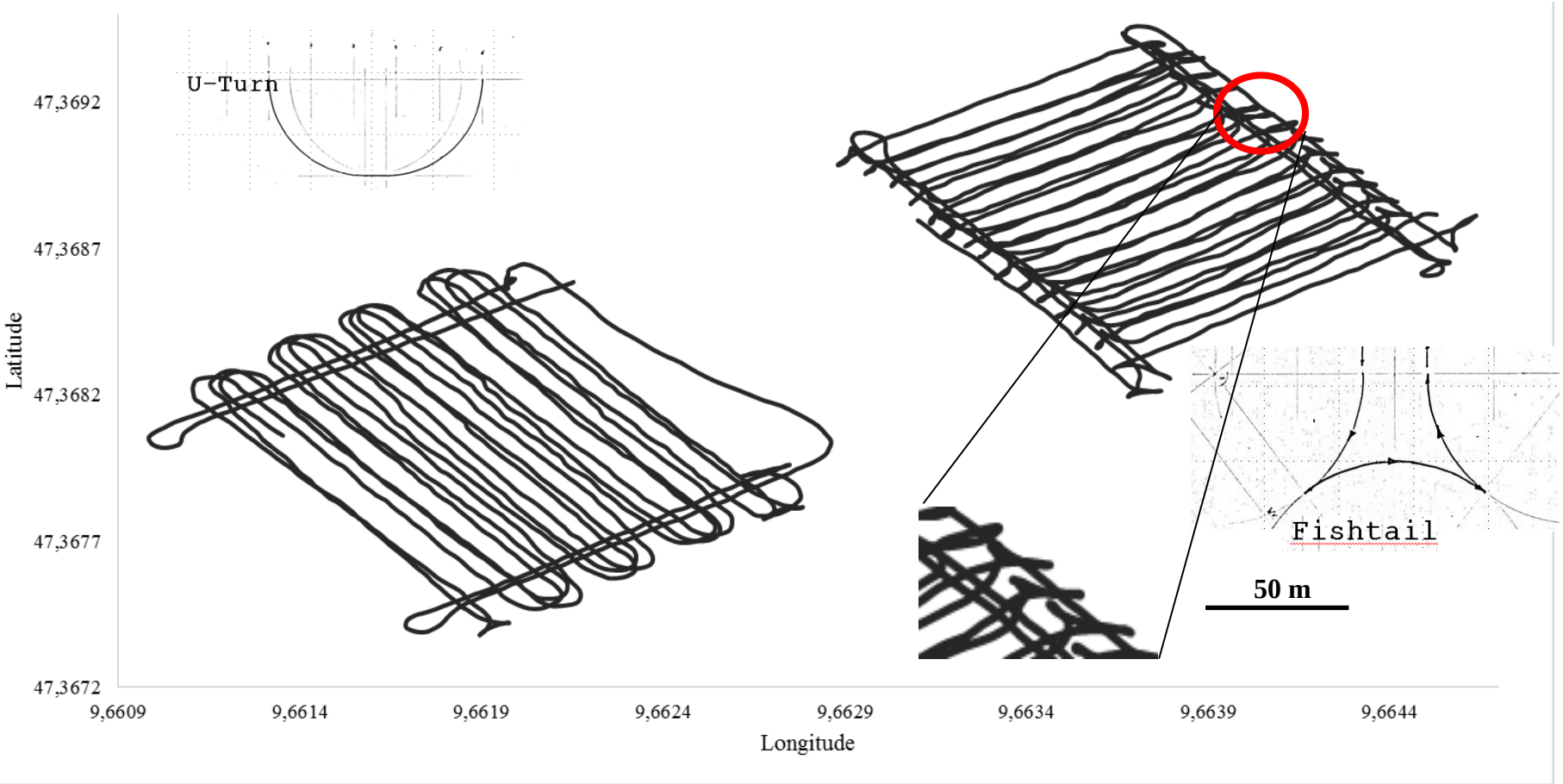
Effect of path shape – example mowing:

- automated driving: pre-planned driving pattern included a wider headland (more passes), skipped only one track (also: software problems - track-finding)
- manual driving: driving pattern skipped multiple tracks, allowing for faster headland turns



Preliminary Results
Whole plot efficiency I

Effect of Headland turn shape – example swathing:



Preliminary Results
Whole plot efficiency II

Effect of Headland turn shape – example swathing:

- manual driving: narrow swather (3.3 m) requires reversing headland turns.
- automated driving: pre-planned path allowed skipped tracks -> more efficient turns.

Preliminary Results
Track-to-track overlap

Preliminary Results
Track-to-track overlap

- both mowing and swathing can reduce overlap

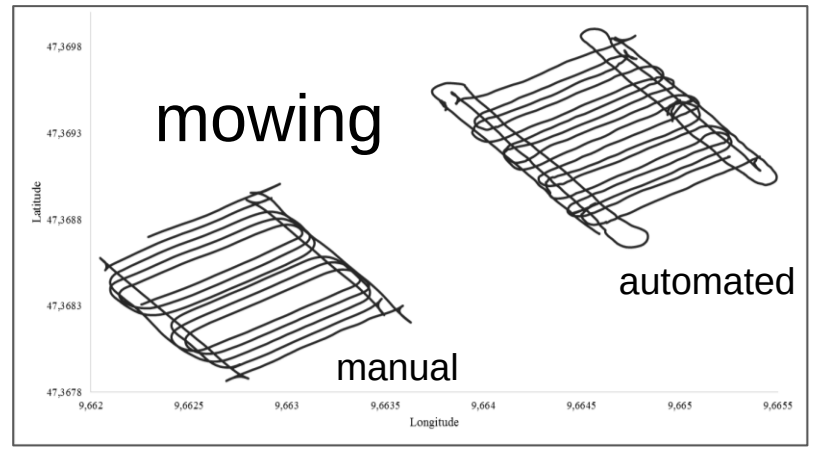
	Mowing		Swathing	
	Autom.	**Manual**	**Autom.**	**Manual**
Nominal working width [m]	6.09		4.20	
Toolbar width [m]	5.70		3.30	
Effective toolbar width [m]	5.52	5.21	3.30	3.15
"Straight line" field efficiency[1] [%]	**96.80**	**91.33**	**100**	**95.55**

1) Price (2011): Typical overlap settings for RTK in cropland: 8-10 cm. Here: Mowing: 18 cm, swathing: 0 cm

Conclusions

- automated mowing and tedding less efficient than manual mowing -
  - more efficient manual driving patterns
  - problems locking into next track
- automated swathing more efficient than manual swathing
  - narrow swather width requires reversing headland turns with manual steering, but automated steering can skip tracks

- efficiency gains through reduced track-to-track overlap (mowing and swathing)



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Thank you for your attention!

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Funding and support by:

FFG
Österreichische
Forschungsförderungsgesellschaft

STEYR
TRAKTOREN

POTTINGER

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