Work-Economics and Financial Aspects of Parallel Guidance Systems for Tractors

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Abstract

The use of parallel guidance systems enables a savings of 3 to 6 min working time per hectare and year when growing cereal crops, and 15 to 30 min per hectare and year in the management of grassland. With cereal crops, lower requirements for seed, plant-protection products and fertiliser create additional opportunities for economising. In total, potential savings per hectar and year range between about 6.3 and 7.5 Euros (€) for winter wheat, and stand at just under € 5.6 for grassland.
In order to achieve equality of costs, parallel guidance systems with manual steering correction and short precision require a land use of about 100 ha; systems with automatic front steering and high steering precision, of about 350 ha.

Keywords: parallel guidance systems, work economics, financial aspects

Introduction

Parallel guidance systems for tractors are meant to help take some of the strain off the driver when steering and make better use of the working width of the agricultural machinery. Less overlapping means that savings can be made on working time, machine hours and resources such as fuel, plant-protection products and fertiliser (Kloepfer 2005).
Depending on intended purpose and budget, parallel guidance systems come in different specifications and performance classes. Primarily used on large arable farms, are they also worth using in small-scale operations such as in Switzerland?
The necessary land utilisation for cost-covering use of the systems is described in various sources (Keller 2005; Kloepfer 2005). In Germany, an average of 5 to 10% less overlap with corresponding economies in plant-protection products, fertiliser, fuel and working time is assumed. Depending on crop rotation and management intensity, 5 to 28 €/ha can be economised. Depending on purchase price, the necessary land utilisation for the steering system is 180 to 300 ha of utilised agricultural area. The figures vary sharply, and leave certain work-economics and financial issues unresolved.

Materials and methods

Work Economics Aspects
Using the PROOF Work-Economics Model Calculation System, the effects of the use of various parallel guidance systems in comparison with manual steering were calculated (Schick et al 2002; Schick et al 2003). Influencing factors such as working width, plot size and turning times were varied. Potential savings in terms of working time, resources and machinery costs were determined from the results (LBL 2005).

For cereal-growing, an example with no-plough tillage of winter wheat was calculated: Primary tillage with chisel, combined seedbed preparation and sowing, rolling, spreading of organic solid manure, application of mineral fertiliser and plant-protection products. All in all, a parallel guidance system has an impact on ten operations. It is only actually used in four tractor passes, however, since plant-protection products and mineral fertilisers are applied according to tractor tramlines.

Table 1: Cereal-growing variants: Three working widths, four plot sizes and three precision categories in comparison with manual steering

Theoretical working width	Deviation with manual steering	Precision with parallel guidance		
		+/- 0.3 m	+/- 0.15 m	+/- 0.05 m
3 m	+/- 0.1 m	Four plot sizes of 1 / 2 / 5 / 10 ha respectively		
4 m	+/- 0.2 m			
6 m	+/- 0.4 m			

Three working widths of three parallel guidance systems of differing precision were compared with manual steering precision on four plot sizes (Table 1). A working width of 6 m and plot size of 10 ha – both unusual in Switzerland – were chosen in order to illustrate size effects more vividly. Working widths for fertiliser and plant-protection product application – 15, 20 and 30 m – were higher by a factor of five than those for soil tillage and sowing. It was assumed that untilled land was undesirable, whilst an overlap would be tolerated. The effective working width was then obtained from the theoretical working width less the steering deviation.
For grassland management, five cuts, four applications of organic fertiliser and one of mineral fertiliser were assumed. All in all there are 28 tractor passes, for which the parallel guidance system is always required. The working widths of machines such as e.g. mowers, rotary tedder and rotary windrower are not uniform here, so combinations of machines with small, medium and large working widths were assembled (Table 2). With manual steering, a working-width utilisation of 90% was assumed; for parallel guidance systems, the same precision categories as with cereal-growing were assumed.

Table 2: Grassland variants: Three working widths, four plot sizes and three precision categories in comparison with manual steering.

Theoretical working width	Effective working width with manual steering	Precision with parallel guidance		
		+/- 0.3 m	+/- 0.15 m	+/- 0.05 m
small	90 %	Four plot sizes of 1 / 2 / 5 / 10 ha respectively		
medium	90 %			
large	90 %			

Farm Management Aspects

The anticipated overall annual costs of the parallel guidance system were calculated via absorption costing (Ammann 2005), after which the annual land utilisation necessary to cover costs was deduced from the costs and potential savings.

Results

Work Economics Aspects

In cereal-growing, 3 m theoretical working width with manual steering translates to 2.90 m effective working width; with parallel guidance with +/- 0.3 m precision, the effective working width is 2.70 m. Manual steering therefore makes better use of the working width than the parallel guidance system. With manual steering, a theoretical working width of 4 m translates to 3.80 m effective working width; with parallel guidance with +/- 0.05 m precision, the effective working width is then 3.95 m. Here, the parallel guidance system makes better use of the working width.

Table 3: Comparison of the percentage overlap between manual steering and parallel-guidance assistance. Negative values = with manual steering, there is less of an overlap than with parallel-guidance assistance; Positive values = with parallel-guidance assistance, there is less of an overlap than with manual steering.

Theoretical working width	Percentage differences in overlap between manual steering and parallel-guidance system		
	Accuracy +/- 0.3 m	Accuracy +/- 0.15 m	Accuracy +/- 0.05 m
3 m	-6.7%	-1.7%	**1.7%**
4 m	-2.5%	**1.3%**	**3.8%**
6 m	**1.7%**	**4.2%**	**5.8%**

The values appear in summary form in Table 3. Only with positive values is a parallel guidance system better than manual steering. It is precisely in the case of smaller working widths, therefore, that manual steering is superior to a parallel guidance system with a large deviation.

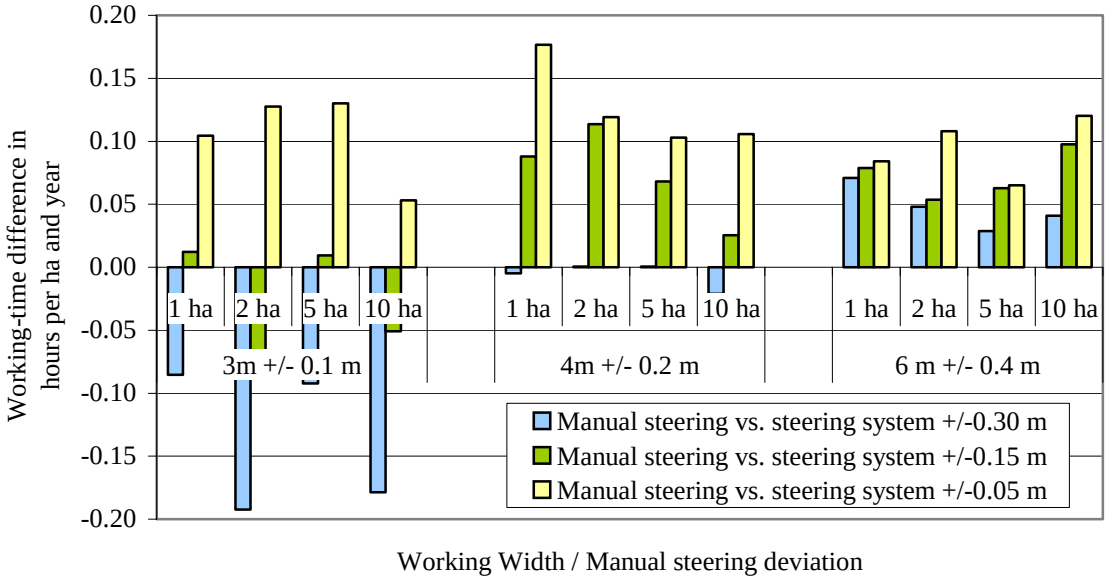

Figure 1: Working-time difference in cereal-growing comparing manual steering with a parallel guidance system, based on 10 tractor passes

This also becomes clear when calculating the working-time difference in Fig. 1. Here, it was also assumed that turning times were 15% shorter with a track guidance system.
Only with the positive values is the parallel guidance system better than manual steering. This means *inter alia* that a steering system with a precision of +/- 0.3 m only makes sense with large working widths. In total, a time savings of about 3 to 6 minutes per hectare and year may be achieved.
Unlike with cereal growing, with grassland savings in working time is achievable with a steering system in all variants (Fig. 2). Time saved per hectare and year ranges between 30 and 60 min, or about 3 to 6 min per tractor pass. This corresponds to a relative savings in working time of 1-2%.
At best, additional time savings can be achieved on grassland and with cereal growing if the average working speed can be raised by the use of a parallel guidance system.

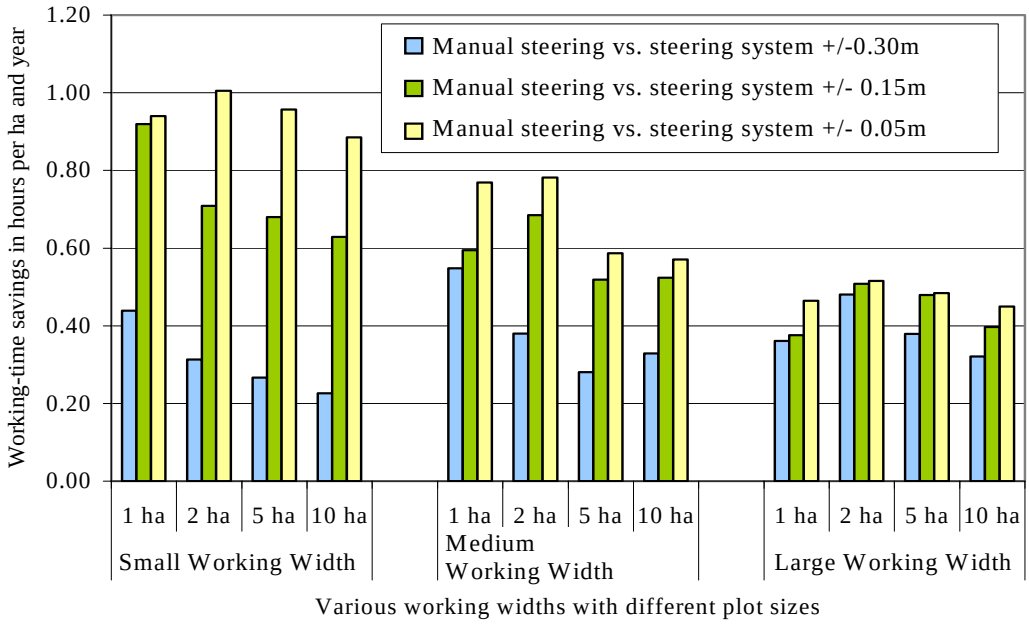

Figure 2: Working-time difference in grassland comparing manual steering with a parallel guidance system based on 28 tractor passes. Working widths: Mower, 3 m/ 6 m/8.3 m; Rotary tedder, 4.7 m/6.8 m/8.8 m; Rotary windrower, 3.3 m/4.5 m/6.5 m.

Farm Management Aspects

For an assessment from the farm management point of view, both the annual costs of the parallel guidance system and the achievable savings are of importance.
In Table 4, the annual costs of four different parallel guidance systems are calculated by way of example. The total costs per year are composed of depreciation, interest, fire insurance, repair costs and signal costs. The annual costs range from € 478 for a short-precision manual parallel guidance system up to € 5093 for a high-precision automatic steering system.
The more efficient utilisation of the working widths and reduced turning times allow a savings in working time and machine hours, both in cereal growing and in grassland. Here, it is mainly the tractor hours that are relevant; the cultivation equipment is of less consequence in terms of cost. Nor was the working time saved assessed in the

calculation. If the work force is directly remunerated or if the freed-up working time can be used lucratively, this is to be taken account of (ART estimate: € 16.25 per hour).
The cost savings for tractors follow on from the work-economics savings.

Table 4: Cost calculation for parallel guidance systems, bearing in mind 10.0% depreciation, 2.1% average interest, 0.2% fire insurance, repairs, and subscription for correction signals.

	Manual parallel guidance assistance +/- 0.30 m	Steering-assistance system +/- 0.30 m	Steering-assistance system +/- 0.10 m	Automatic steering system +/- 0.02 m
Steering correction	manual	automatic	automatic	automatic
Trace-to-trace accuracy [m]	0.10-0.30	0.10-0.30	0.10-0.20	0.02-0.05
Purchase price [€]	3125	10000	14375	31250
Amortisation period [no. of years]	10	10	10	10
Overheads [1] [€/year]	384	1230	1768	3843
Utilisation [hours/year]	300	300	400	400
Repairs [€/year]	93.75	300	575	1250
Correction-signal subscription [€/year]	0	0	938	0
Total costs [€/year]	478	1530	3280	5093

Consequently, with a reduced tillage time of about 6 min per ha and year, savings of approximately € 0.94 per ha and year can be made in cereal growing. For grassland, a savings of 18 min per ha and year brings economies of about € 5.31 per ha and year. For these savings, the parallel guidance system need only be used for four passes in the case of the grain, but must be used for all 28 passes on the grassland. Consequently, the system utilisation is correspondingly higher here.
With cereal growing, the lower overlapping of working widths also economises on seed, fertiliser and plant-protection products. The amounts of these three items required vary depending on whether the wheat is grown intensively or extensively.
Savings of up to € 6.25 per ha and year may be achieved for extensively grown winter wheat with a lower overlap of 1.7% (corresponding to a working width of four meters and a parallel guidance system with a precision of +/- 0.15 m – cf. Fig. 2); for intensively grown winter wheat, up to € 7.5 per ha and year. Savings of € 12.5 and more are only achievable with large working widths and high steering precision.
Consequently, savings in the region of € 7.2 to 8.44 per ha and year may be achieved in cereal growing along with the reduction in tractor hours.
The land utilisation necessary for the use of a steering system in the case of cost equality may be determined on the basis of the cost savings per hectare (Fig. 3). Cost equality means that the annual costs for the steering system are offset by the savings.
Simple assistance systems without automatic steering correction, well suited for use in medium-to-large working widths in grassland and saving costs of just under € 6.25 per ha and year, pays off with an area of just under 100 ha upwards. For this, however, the system must be used with all tractors concerned for all operations in which the whole of the land is tilled (e.g. for fertiliser spreading and swathing, but not for loading). A steering assistance system with a precision of +/- 0.15 m allowing for savings of just under € 9.38 per ha and year in cereal growing requires a land utilisation of 350 ha.

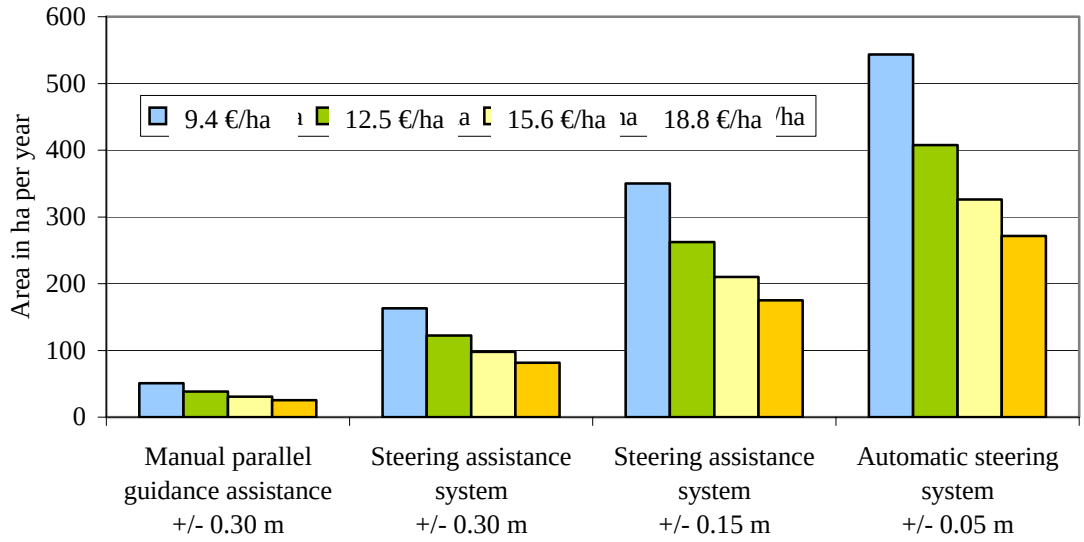

Fig. 3: Land utilisation necessary for cost-covering use as a function of costs saved per ha and year with various parallel guidance systems. Reading example: A steering assistance system with a precision of +/- 0.15 m may be employed on a cost-covering basis with a savings of € 9.4 per ha and year from 350 ha utilisation per year.

Conclusions

High precision systems are required in order to drive the working widths of up to 3 m, maximum 4 m, frequently used in small-scale operations with greater precision than by hand. Simple parallel guidance systems may be run on a cost-covering basis with low land utilisation; parallel guidance systems with automatic steering generally require a high-to-very-high land utilisation, combined with large working widths.
The use of these systems is worthwhile in crops with intensive fertilisation and plant protection, as well as on intensively managed land with a high number of tractor uses.
Moreover, it should be possible to invest the working time saved with maximum profitability in another area, or to reduce the apportionable labour costs considerably.
In terms of easing strain for the driver, the ergonomics and comfort aspect of the systems should not be underestimated, but is quite difficult to assess economically.

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