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ERGONOMIC ASPECTS OF OPERATION OF IT SYSTEMS IN PRECISION AGRICULTURE

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ABSTRACT The operation of IT systems is a *sine qua non* condition in precision agriculture. In the traditional approach, professional competencies of a farmer comprise the ability to operate machines and technical equipment in production technologies for biological raw materials. Precision agriculture increases this range of professional competencies with the ability to use computer IT systems that are complex and, by their very nature, much differing in their content and scope from typical farming knowledge. The ergonomic problem can be brought down to determining whether the operation of IT systems in precision agriculture is adjusted to the predispositions, needs and skills of the farmers. Generally, in the IT system of precision agriculture, three phases can be differentiated: data collection, processing and application. To what extent should they be operated by the farmer, and to what extent by the IT specialist, is the problem that determines effective functioning of precision farming. The ergonomic assessment of some software for equipment operation, generation of harvesting maps and applications points to: (1) the need for standardisation in construction and operation of IT systems, (2) the division of the function – farmer and IT specialist (e.g. from an agriculture consulting institution) in the precision agriculture system.

Keywords: Operating specialist hardware and software, Ergonomic assessment, Need for standardisation.

INTRODUCTION Precision agriculture functions as a result of linking the (1) agro-technical and (2) IT knowledge. The intended effects of precision agriculture – such as reduced production costs, qualitative and quantitative levelling of harvest, reduction of environmental threats via local application of plant protection agents – require the ability to (a) harvest, (b) process, (c) apply the data in various IT systems. Such systems are placed on tractors, combines for harvesting, machines for application of fertilisers or chemical plant protection agents. Furthermore, input data characterising spatial differentiation of (a) harvest, (b) soil, are processed in specialist software into output data to control the operation of e.g. machines differentiating rates of the fertiliser. Traditional professional competencies of a farmer, namely the ability to operate machines and technical equipment in technologies for production of raw materials of biological origin (plants and animals), must be, therefore, extended by the abilities to operate IT systems used in such technologies. (Göhlich, 1987)

TWO METHODS FOR FARM MANAGEMENT In many regions of the world, also in the European conditions, business activity in agriculture is usually managed with one of the following methods: (1) All works, or their majority, are performed in the farm with tractors and machines owned by the farmer, (2) Almost all works are performed using outsourced tractors and machines. The earlier method principally refers to so-called family farms, or large farms owned by e.g. the State Treasury, as it is the situation in the country of the authors of this article. Plant production is usually joined here with animal production. The other method refers to farms where the owner (or leaseholder) usually deals with plant production without directly participating in such production, by outsourcing the field works from specialist companies.

There is no clear border between the two methods. We differentiate them to draw attention to two types of users of tractors and machines applied in precision agriculture:

(1) In a family farm, a farmer should individually operate IT systems, at least for data collection and their later application (after processing), (2) In a farm operating in the outsourcing system, the operation of precision agriculture IT systems can also be outsourced, just as the performance of agro-technical works. Specialisation of outsourcing companies causes that the problems with operation of precision agriculture IT systems, namely collection, processing, and application of data, can be simply solved by hiring specialists. At a family farm, the operation of IT system for agriculture is a new professional competence of a farmer to be – at least partially – learnt.

OPERATION OF HARDWARE AND SOFTWARE The fundamental aspect of ergonomic assessment of operation of electronic devices and utility software regards compatibility (Hoyos, 1974). The term "compatibility" is presently used principally in reference to computer technology and – generally means the possibility of effective information flow between the transmitter (one computer) and the receiver (another computer or a peripheral device, such as a printer). In fact, this information flow is ensured by a clear code in which the information is saved and sent between the elements of the system. Let us draw the attention, however, to the fact that in the operation of IT systems, there is always also a human being (the operator) and the problem of compatibility also refers to this element of the IT system (namely, the operator). A system cannot be referred to as "compatible" if the operator is not considered, as he is the main user of the information. Information transmitted with the agreed code (signals) should be clearly interpreted (decrypted) both by electronic devices and (understood) by the system operator. It is necessary to differentiate the operation of electronic devices (e.g. on-board computers in tractors and machines) – cf. Fig. 1 and 2 - and the operation of specialist software for data processing (e.g. Agro-Map) – cf. Fig. 3. The operation must take into account the following fundamental ergonomic recommendation: *elements of the system, distributed in various places, must be operated in the same manner* (namely according to the same sequence of control actions for the same functions). Let us also add to this recommendation that learning to operate compatible systems, namely considering human mental predisposition, is easier, and the risk of making a mistake is lower. Naturally, for elderly operators this is of special importance.

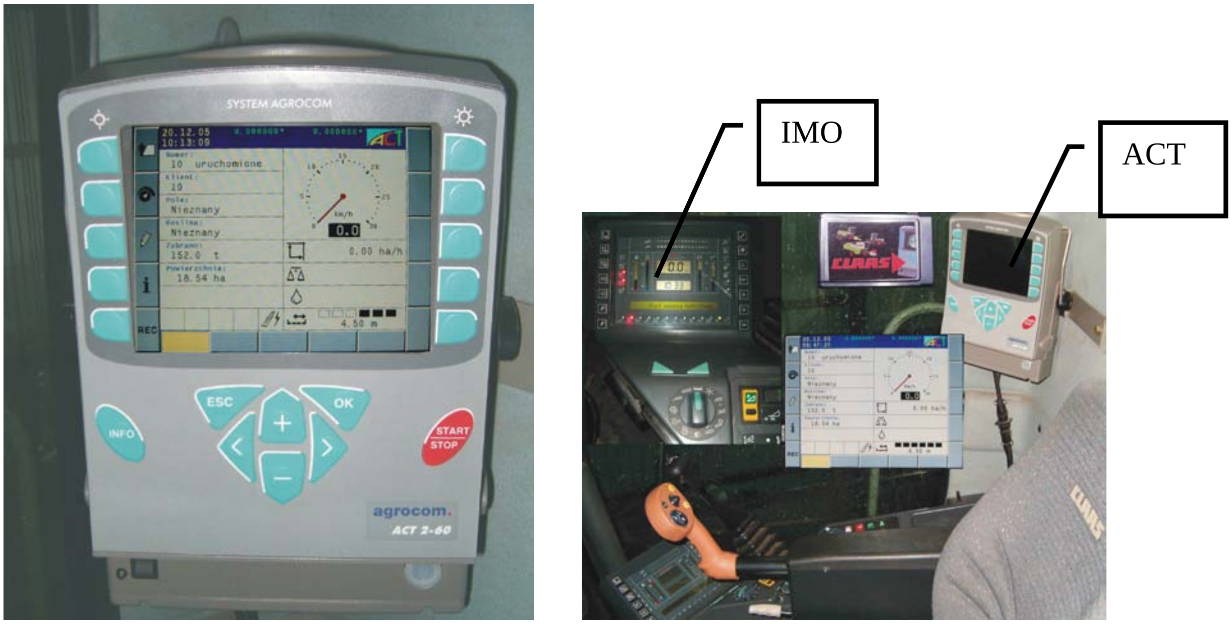

Figure 1. Control panel of an on-board computer for harvest registration in the Claas Lexion 480 combine.

Figure 2. Control panel for computer to control the operation of the fertiliser distributor.

Operation of electronic devices is, in fact, a strictly defined sequence of control activities, usually comprising the pressing of one or more keys on a keyboard or symbols on a touchscreen. The number of functions of an on-board computer varies, and so does the number of control actions to launch such functions. And so, the first use of the Claas type combine with optical harvest registration by Agrocom, at the beginning of the season, will require the performance of at least 15 functions – together on on-board computers of the system and the combine (Fig. 1), comprising 47 actions (Table 1). The aforementioned two computers are “functionally connected”, and presently the company begins to replace this configuration with a single device. In the case of controlling a variable application for mineral fertilisers, the situation may be as presented in Table 2, where the number of actions reaches 58. In the case of using the same machine, the encoding of parameters will not be necessary, and then the number will drop down by 36 (9x4) (Table 2).

Table 1. The number of functions and actions related to operation of an on-board ACT computer cooperating with on-board IMO computer of the combine, during harvest registration with optical monitoring system by Agrocom.

No. of func.	Functions usually performed once per season		Functions related exclusively to the harvest registration		
	Type	Number of actions	No. of func.	Type	Number of actions
1	Setting the date and time	4	1	Entrance of a chip card with the request to the computer	1
2	Language selection	4	2	Checking the correctness of GPS status	2
3	Resetting of combine slant sensor	5	3	Selection of the request to process	2
4	Setting the zero point for harvest measurement	5	4	Starting the request (start)	1
5	Calibration of speedometer	5	5	Input of data on volume weight	3
6			6	Switching to the harvest parameter screen	1
7			7	Adjustment of humidity during operation	3
8			8	Adjustment of volume weight during operation	3
9			9	Value adjustment on the collected harvest weight during operation	5
10			10	Closure after the completion of the request	3
Total number of functions		5		Total number of functions	10
Total number of actions		23		Total number of actions	24
Number of functions for operation of an exemplary set		15			
Number of actions for operation of an exemplary set		47			

Table 2. The number of functions and actions related to the performance of spatially varied fertilisation using the system: on-board computer LH 5000 GPS + PDA with SiteMate VRA software.

LH 5000 GPS				PDA with SiteMate VRA software		
No. of func.	Functions		Number of actions	No. of func.	Functions	Number of actions
1	Selection of	action	2	1	Launch of the SM software	2
2		machine	2	2	VRA selection	1
3		model	2	3	Display of application map	1
4	Encoding machine parameters	Operating width	4	4	Selection of dosing parameter (optional)	1
5		Selection of fertiliser dose	4	5	Selection of file name for background save (optional)	1
6		Selection of speed sensor	4	6	Setting the operating parameters	9
7		Operating field area	4	7	start	1
8		Quantity of fertiliser in the tank	4			
9		Selection of operating time sensor	4			
10		Selection of passage length sensor	4			
11		Setting PTO shaft sensor (once per season)	4			
12		Setting possible percentage dose change (optional)	4			
Total number of functions 12 Total number of actions 42				Total number of functions 7 Total number of actions 16		
Number of functions for operation of an exemplary set 19 Number of actions for operation of an exemplary set 58						

Let us draw attention here, apart from differences in the appearance of the on-board computers and their operating procedures, to the specificity of using agricultural machines, namely: (1) relative short operating time during the year (seasonal, sometimes just 100-200 hours per year), (2) need to operate various machines (and on-board computers) by the same operator (Juliszewski, 2006; Juliszewski, 2009).

During data collection about the harvest and its moisture, with the frequency of – 0.2 Hz for harvest (one measurement per 5 s), moisture – up to 20 s per measurement depending on the size of the harvest, at a field of 20 ha, approximately 4500 numbers are collected (considering only yield data). These will later allow for development of application maps – unless the operator has made a mistake while launching the harvest registration system. Let us draw the attention to the fact that both data collection in the on-board computers of the combines (tractors), and the use of application maps for fertilisation or herbicide dosing, occurs without (visual) control of the user (driver) who is convinced that the electronically controlled system functions correctly. The requirement for control cannot be, by its nature, formulated against the operator, as this clearly exceeds the capabilities of his visual perception (e.g. the observation of the variable dose of the fertiliser or herbicide). The only requirement to be formulated is that the procedures for on-board computer operation be performed correctly (faultlessly).The operation of software for processing of the data characterising the harvest and soil at the field requires specialist knowledge and skills. It also, certainly, requires having a costly computer software. The basic menu of Agro-Map software, which forms an integral part of the monitoring system described in this article, comprises 6 tabs (Fig. 3) with a varied number of functions, the more complex of which require several actions to achieve the intended goal. The performance of application maps for fertilisation, starting from development of harvest map, through creation of the plan for soil sampling for richness, performance of richness maps and the maps for fertiliser demand - this requires, by estimate, over 100 actions.

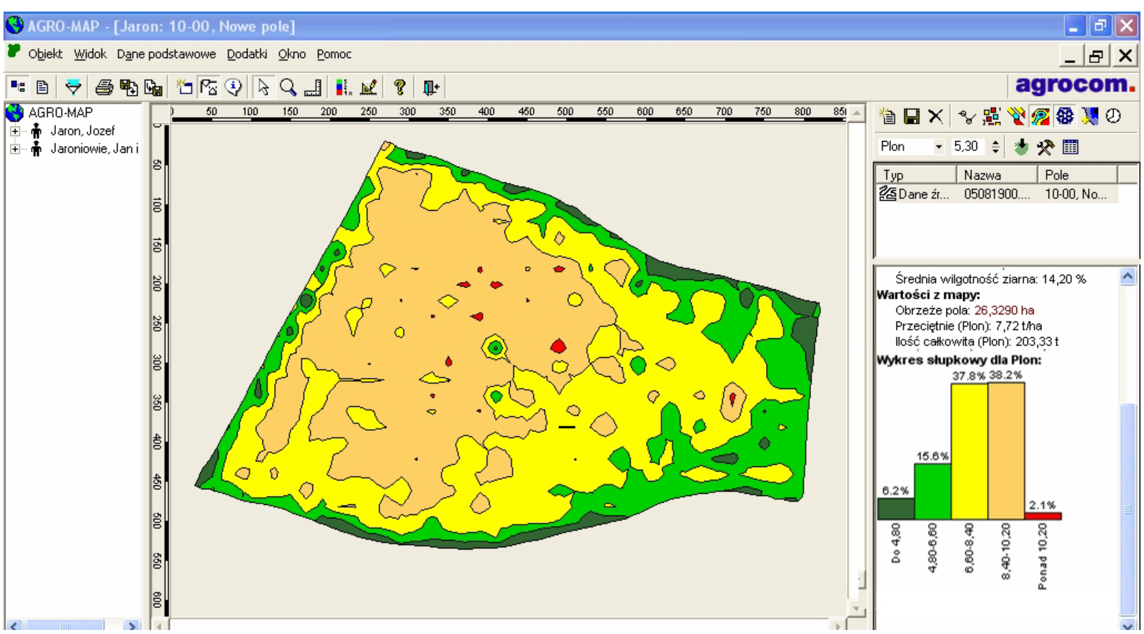

Figure 3. Example of Agro-Map data processing software by Agrocom

CONCLUSION The operation of the entire IT system in precision agriculture – from data collection, via data processing, to practical application – exceeds traditional competencies of a farmer. There is, however, rationale for acquiring such skills. The operation of the entire IT system must meet the following ergonomic requirements: (1) Control panels and the procedures for operation of such control panels occurring in various parts of the IT system (in various machines) must be similar to one another as much as possible; (2) Operating procedures should be simplified so that the most important functions ("Record data", "Save data", "Apply data from file", etc.) can be launched with one button on the control panel (particularly important for elderly farmers); (3) Standardisation of procedures for data transfer from the farmer to the company processing such data – and the other way round – would facilitate their mutual cooperation. The fact that manufacturers of electronic equipment for tractors, combines and farming machines used in precision agriculture about the need of their ergonomic adjustment to operator needs is one of the reasons limiting the industry's development. According to the survey performed in Germany regarding the perspectives for application of precision agriculture in their country, among the greatest difficulties, most respondents included "the need of long time to learn equipment operation," "lack of compatibility," and "unreliable software" (Reichardt and Jürgens, 2007).

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