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The use of telematics systems to optimize the operation of agricultural machinery

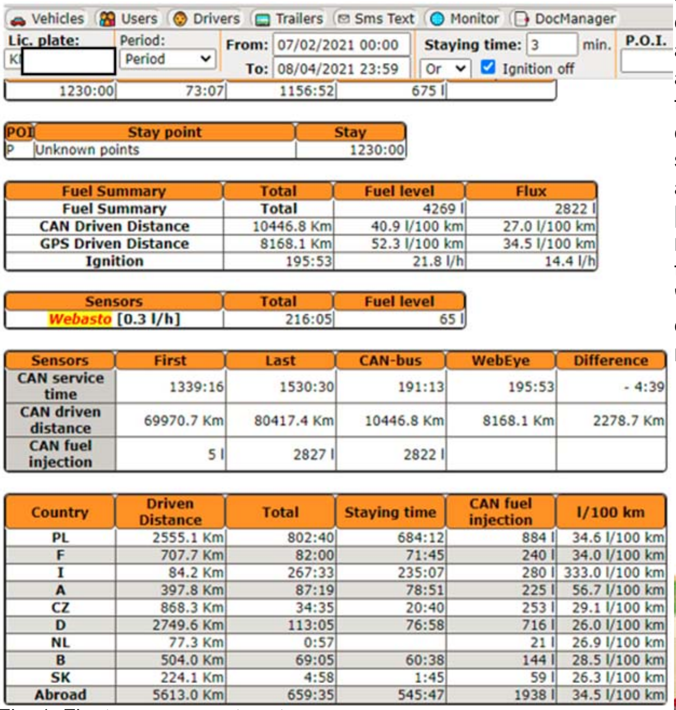
***Abstract**. The development of satellite navigation systems (GPS and GLONASS), combined with the ability to locate the position of the receiver 24/7, has contributed to the development of technology and the use of locators in various areas of life. The purpose of the research was to analyze the operation of technical means used in agriculture with the help of a recorder used to collect data from the tractor's information system in real time. The scope of the research concerned technological activities and transport activities carried out in selected production processes. The use of the system makes it possible to identify work parameters and energy input in the form of fuel consumption and to locate the aforementioned quantities in a specific place in the field. This is a prerequisite for the implementation of precision farming technology and the optimization of machinery operation is primarily concerned with the field space.*

***Streszczenie.** Rozwój systemów nawigacji satelitarnej (GPS i GLONASS), w połączeniu z możliwością lokalizacji położenia odbiornika 24/7, przyczynił się do rozwoju technologii i wykorzystania lokalizatorów w różnych dziedzinach życia. Celem badań była analiza pracy środków technicznych stosowanych w rolnictwie za pomocą rejestratora służącego do zbierania danych z systemu informatycznego ciągnika w czasie rzeczywistym. Zakres badań dotyczył czynności technologicznych oraz czynności transportowych realizowanych w wybranych procesach produkcyjnych. Zastosowanie systemu umożliwia identyfikację parametrów pracy i wkładu energetycznego w postaci zużycia paliwa oraz zlokalizowanie ww. wielkości w określonym miejscu w terenie. Jest to warunek wstępny wdrażania technologii rolnictwa precyzyjnego, a optymalizacja pracy maszyn dotyczy przede wszystkim powierzchni pola. (**Wykorzystanie systemów telematycznych do optymalizacji pracy maszyn rolniczych**)*

Keywords: precision agriculture, telematics, exploitation, information technology
Słowa kluczowe: rolnictwo precyzyjne, telematyka, eksploatacja, informatyka

Introduction

The development of GNSS (Global Navigation Satellite System) satellite navigation systems, which include GPS, GLONASS, BEIDOU and GALILEO, combined with the ability to locate the receiver's position 24/7, has contributed to the development of technology and the use of locators in various areas of life [1,2]. In addition to basic devices whose task is to determine the position and provide it to the user, devices have emerged that allow more complex functions [1].



1230:00	73:07	1156:52	675 l	

POI	Stay point	Stay
P	Unknown points	1230:00

Fuel Summary	Total	Fuel level	Flux
Fuel Summary	Total	4269 l	2822 l
CAN Driven Distance	10446.8 Km	40.9 l/100 km	27.0 l/100 km
GPS Driven Distance	8168.1 Km	52.3 l/100 km	34.5 l/100 km
Ignition	195:53	21.8 l/h	14.4 l/h

Sensors	Total	Fuel level
Webasto [0.3 l/h]	216:05	65 l

Sensors	First	Last	CAN-bus	WebEye	Difference
CAN service time	1339:16	1530:30	191:13	195:53	- 4:39
CAN driven distance	69970.7 Km	80417.4 Km	10446.8 Km	8168.1 Km	2278.7 Km
CAN fuel injection	5 l	2827 l	2822 l		

Country	Driven Distance	Total	Staying time	CAN fuel injection	l/100 km
PL	2555.1 Km	802:40	684:12	884 l	34.6 l/100 km
F	707.7 Km	82:00	71:45	240 l	34.0 l/100 km
I	84.2 Km	267:33	235:07	280 l	333.0 l/100 km
A	397.8 Km	87:19	78:51	225 l	56.7 l/100 km
CZ	868.3 Km	34:35	20:40	253 l	29.1 l/100 km
D	2749.6 Km	113:05	76:58	716 l	26.0 l/100 km
NL	77.3 Km	0:57		21 l	26.9 l/100 km
B	504.0 Km	69:05	60:38	144 l	28.5 l/100 km
SK	224.1 Km	4:58	1:45	59 l	26.3 l/100 km
Abroad	5613.0 Km	659:35	545:47	1938 l	34.5 l/100 km

Fig. 1. Fleet management system screen

The use of receivers makes it possible to record the passage of means of transport or the movement of goods and supports management during transportation, which in the case of agricultural enterprises accounts for almost half of the activities performed [3]. Precise recording of working time also makes it possible to determine the time of exposure to noise [3,4] or vibration [5], which is closely related to working parameters. Nowadays, on-board computers are used in motor vehicles and machinery to monitor and control the operation of individual components. Such systems are equipped with a number of sensors, which allows not only control, but also self-diagnosis. Enhanced recording systems are equipped with additional sensors (e.g., fuel level) or are connected to on-board computers via CAN-BUS bus and proposed as fleet management systems [6,7,8]. In such solutions, in addition to tracking position on a map and reading speed, the level of fuel in the tank and its consumption while driving can also be displayed (Figure 1). Depending on the level of sophistication, fleet management software allows various analyses to be carried out, informing the user of the result [6], and there is also the possibility of sending sms messages (Figure 1). Thanks to the integration of multiple technologies, the entire fleet forms a jointly functioning "organism" (Figure 2), which is able to communicate with each other, primarily signaling abnormal conditions requiring intervention.

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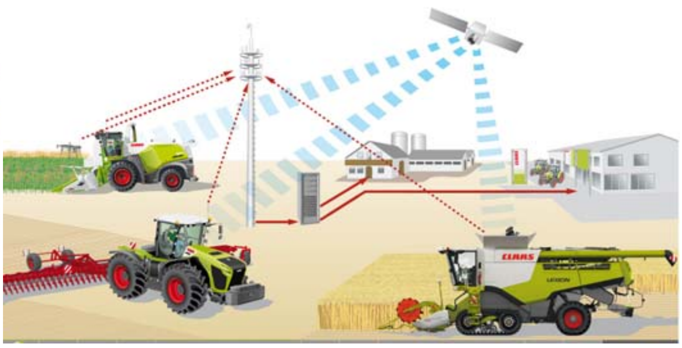


Fig. 2. Claas Telematics operating principle [9].

Material and methods

The purpose of the research was to analyze the operation of technical means used in agriculture with the help of a recorder used to collect data from the tractor information system in real time. The scope of the research concerned the technological activities carried out in selected production processes and transport activities. The research was conducted on a farm with an area of 400 hectares, while the detailed analysis covered two fields with a total area of 35 hectares located in the vicinity of Krakow (Figure 3). The time interval of information collection was adequate to the tractor's operating time and included all tractor activity. Two GPS Tracer and MyCar devices were used to collect data from the tractor's information system (Figure 4).

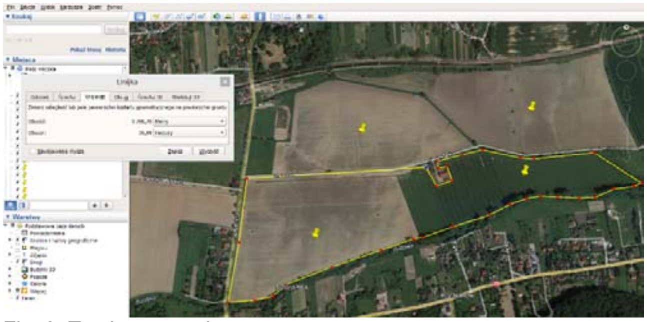
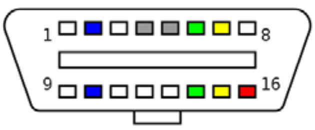


Fig. 3. Testing ground

Fig. 4 Signal transmission devices from the tractor information system



Pin	Opis
2	J1850 Bus+
4	masa nadwozia
5	masa sygnałowa (GND)
6	CAN High (J-2284)
7	ISO 9141/ISO14230 Linia K
10	J1850 Bus-
14	CAN Low (J-2284)
15	ISO 9141/ISO14230 Linia L
16	zasilanie (+)

Fig. 5. Diagram of the OBDII system connector [10].

The data was recorded by a device permanently plugged into the tractor's electrical system and sent to a server. An OBDII (On-Board Diagnostic level 2.) device equipped with a GSM modem with a SIM card is used to record tractor position data and other information downloaded from the on-board computer. The data is transmitted when the engine is started (ignition on). For communication with the on-board computer, an OBD, OBDII (Figure 5) or EDL (Electronic Data Link) system socket (Figure 6) is used, depending on the standard adopted by the machine manufacturer. For data downloading by devices made in a different standard, adapters adjusting signal pin connections are required (Figure 6,7).

The MyCar device was mainly used to record the operation of the tractor in the case of a transport trip during crop harvesting between the farm field and the farm's warehouses.

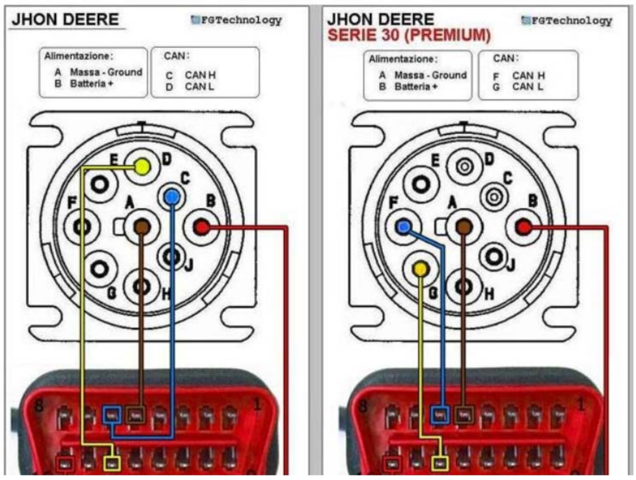


Fig. 6. Connection diagram of EDL and OBDII socket [11].

Fig. 7. Locator with adapter for John Deere tractor communication socket

TRUCKER GPS locator is used to read the geographical position of the vehicle and other data acquired through the OBDII socket. Access to the data was via the website: en.aika168.com (Figure 8), from which the information used in the study was read.

Fig. 8. System operator interface

Results

The stored data on the server allowed one to determine the exact hours of operation, the locations at a specific time and the speed at which the tractor moved. In addition, it was possible to trace the entire route taken by the tractor on a given day or assumed time interval (Figure 9). The data covered not only the transport trip from the farm (Figure 9), but also trips around the testing ground (Figure 10).

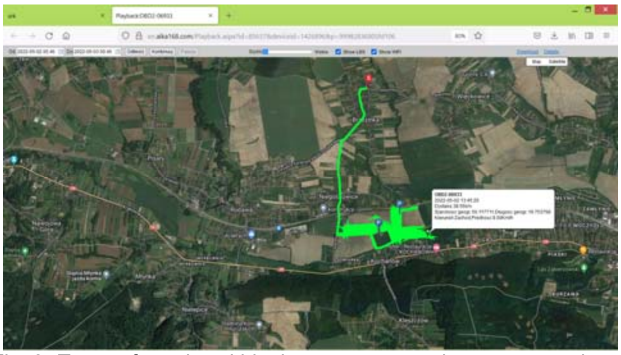


Fig. 9. Tractor footprint within the test range and transport road

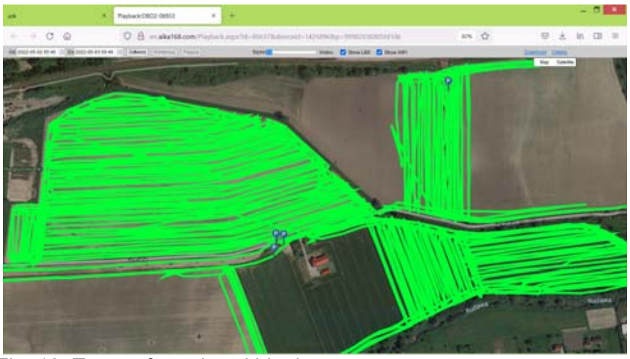


Fig. 10. Tractor footprint within the test range

With a map of the journeys and marked places of stoppage due to the need to load the seeder with seed and fertilizer, it was possible to analyze in terms of the loading location. Simulations and calculations performed showed that changing the loading location by 220 m would reduce the distance traveled by 1,760 m. This result, relative to travel over the surface of the field, gives a reduction in the distance traveled of 3%. The savings in fuel consumption with a change in the loading location would be 1.3% over the entire operation.

Information about the time, speed location and direction of the trips recorded pointwise on the map could be read directly at [12] (Figure 11). It is also possible to use the neural network as [13,14] to analyze the map obtained from the satellite.

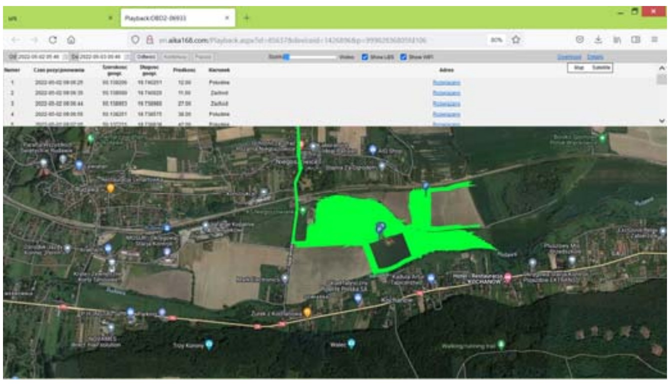
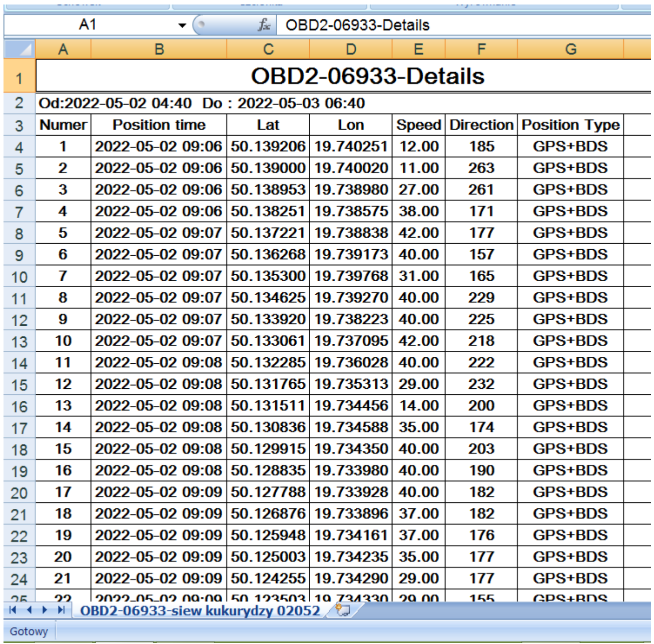


Fig. 11. Previewing the scoring data on the application page

Performing a detailed analysis required downloading the stored data from the server as a CSV file and further analysis in MS Excel software (Figure 12).



A1 OBD2-06933-Details

	A	B	C	D	E	F	G
1	OBD2-06933-Details						
2	Od:2022-05-02 04:40 Do : 2022-05-03 06:40						
3	Numer	Position time	Lat	Lon	Speed	Direction	Position Type
4	1	2022-05-02 09:06	50.139206	19.740251	12.00	185	GPS+BDS
5	2	2022-05-02 09:06	50.139000	19.740020	11.00	263	GPS+BDS
6	3	2022-05-02 09:06	50.138953	19.738980	27.00	261	GPS+BDS
7	4	2022-05-02 09:06	50.138251	19.738575	38.00	171	GPS+BDS
8	5	2022-05-02 09:07	50.137221	19.738838	42.00	177	GPS+BDS
9	6	2022-05-02 09:07	50.136268	19.739173	40.00	157	GPS+BDS
10	7	2022-05-02 09:07	50.135300	19.739768	31.00	165	GPS+BDS
11	8	2022-05-02 09:07	50.134625	19.739270	40.00	229	GPS+BDS
12	9	2022-05-02 09:07	50.133920	19.738223	40.00	225	GPS+BDS
13	10	2022-05-02 09:07	50.133061	19.737095	42.00	218	GPS+BDS
14	11	2022-05-02 09:08	50.132285	19.736028	40.00	222	GPS+BDS
15	12	2022-05-02 09:08	50.131765	19.735313	29.00	232	GPS+BDS
16	13	2022-05-02 09:08	50.131511	19.734456	14.00	200	GPS+BDS
17	14	2022-05-02 09:08	50.130836	19.734588	35.00	174	GPS+BDS
18	15	2022-05-02 09:08	50.129915	19.734350	40.00	203	GPS+BDS
19	16	2022-05-02 09:08	50.128835	19.733980	40.00	190	GPS+BDS
20	17	2022-05-02 09:09	50.127788	19.733928	40.00	182	GPS+BDS
21	18	2022-05-02 09:09	50.126876	19.733896	37.00	182	GPS+BDS
22	19	2022-05-02 09:09	50.125948	19.734161	37.00	176	GPS+BDS
23	20	2022-05-02 09:09	50.125003	19.734235	35.00	177	GPS+BDS
24	21	2022-05-02 09:09	50.124255	19.734290	29.00	177	GPS+BDS
25	22	2022-05-02 09:09	50.123503	19.734330	29.00	155	GPS+BDS

OBD2-06933-siew kukurydzy 02052

Gotowy

Fig. 12. Imported measurement data into an MS Excel spreadsheet

Analyzing passes during corn sowing, it was noted that changing the way the aggregate is guided through the field and designing a different layout of tramlines will enable a 7.4% reduction in idle passes. This will bring tangible benefits in the form of a 3.2% reduction in fuel consumption. Rerouting new tramlines will reduce fuel consumption by 5 to 8% for other treatments.

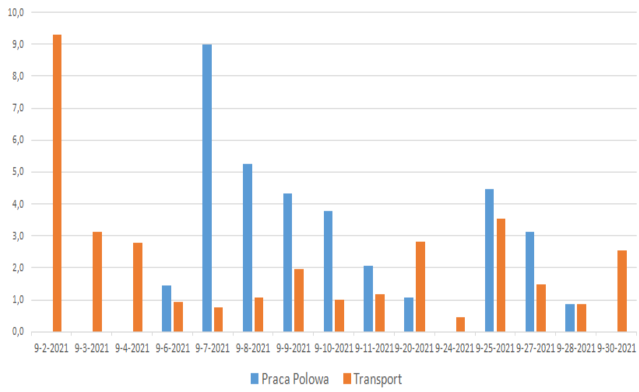


Fig. 13. Field work and transport time per day

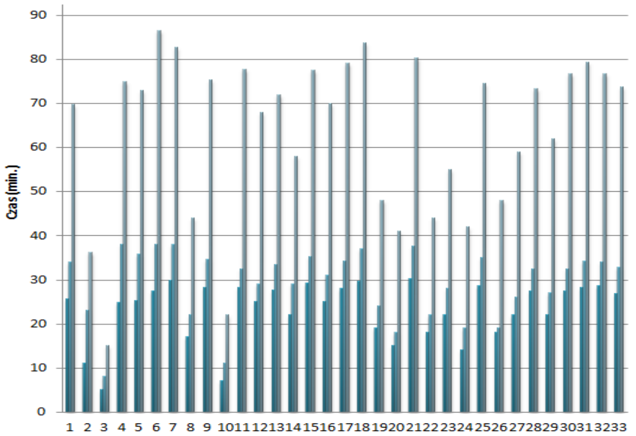


Fig. 14. Duration of transportation of agricultural crops from the study area

A compilation of information on time spent in transport and field work (Figure 13) can be the basis for changing the use of a particular tractor. When planning the replacement of the machinery fleet, this data can be taken into account when optimizing the technical parameters of a new vehicle or machine. When analyzing the time of transporting crops between the field and the farm, the information on speeds and durations (Figure 14) will be the basis for selecting the best vehicle or route during trips, which will reduce the time of performing the entire activity and downtime.

Conclusion

There was an increase in the use of the tractor, and thus in the efficiency of machinery on the analyzed experimental field in real time and subsequent treatments, the implementation of which took into account the spatial structure of the information collected in the preceding treatments. In addition, a 4.5% reduction in unit fuel consumption was recorded for seeding. In the case of some treatments, the analysis made it possible to rationalize the direction of the aggregate and the course of the tramlines, which resulted in a saving in fuel consumption of 5-8% and emission of greenhouse gases such as CO_2 what depends on the amount of consumed fuel [15].

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