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Bc. Zdeněk Eberl

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Zdeněk Eberl

Technology and Environmental Engineering

Thesis title

Assessment of real-time farm machinery management systems

Objectives of thesis

Analysis of real-time farm machinery management systems on the market from the viewpoint of hardware and software design and of information efficiency, demonstrated by employment analysis of chosen farm machinery.

Methodology

Methods of current state analysis. Methods of individual systems comparison according to selected criteria. Methods of statistical data analysis.

The proposed extent of the thesis

cca 55 pages

Keywords

real-time management, telematic system, farm machinery, GPS, workrate analysis

Recommended information sources

Company Brochures.
HUNT, D. Farm Power and Machinery Management. Iowa State Press, 2001, 384 pp. ISBN 978-0813817569.
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The Diploma Thesis Supervisor

doc. Ing. Petr Šařec, Ph.D.

Electronic approval: 16. 1. 2013
doc. Ing. Petr Šařec, Ph.D.
Head of department

Electronic approval: 4. 2. 2013
prof. Ing. Vladimír Jurča, CSc.
Dean

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Declaration

I declare that this thesis was developed independently under the supervision of Mr. doc. Ing. Petr Šařec, (PhD)., and was used only the sources cited in the attached list. I further declare that the electronic form is identical for both prints and do not object to rent or disclosure of my thesis or parts therewith the approval of the department.

In Prague on

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Zdeněk Eberl

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Assesment of real-time machinery management systems

Key words: real-time management, telematic systém,farm machinery, GPS, workrate analysis

Abstract::

This work aims to analyse tractor operational data related with works on the field. Evaluation was based on information acquired from the telematics system, which was installed in the machine. Function of the system that relates to this topic is also introduced, and its potentials are described. The work should provide an overview of telematics possibilities and of its practical use.

Abstrakt:

Cílem této diplomové práce je vyhodnocení provozních dat traktoru při pracovních operacích na poli. Hodnocení proběhlo na základě informací získaných ze systému telematiky, který byl naistalován na stroji. S tím souvisí i seznámení s funkcí těchto systémů a popis jejich současných možností. Práce by měla poskytnout představu o možnostech telematiky a jejím praktickém využití.

Content

1. Introduction

Agriculture is a broad field that focuses on plant cultivation and livestock breeding. The continuous increase in population have resulted in growing requirements on agriculture.Although agriculture placed greater demands, so it significantly decreased the number of workers. Therefore, efforts to combinate all operationsin order to save time, finances and labor. In crop production, soil is constantly enriched with nutrients and adjusted to achieve the highest possible return with the required quality. All machines in the plant production process requires greater demand, such as accuracy, reliability, adjustability and maneuverability. Also connecting the machine, without which the plant production certainly did not go, they must be constantly upgraded to meet the ever increasing demands of the customer.

Constant pressure to reduce costs and improve operational efficiency of agricultural machinery leads to the need of finding other sources of savings. To discover the potential savings in operating the machine can serve telematics systems currently penetrate into agriculture.

Agriculture are under increasingly growing demands.Need to make quick and correct decisions, often under difficult circumstances, is of great importance for the profitability of production. There is also increasing interest in the possibility of monitoring machines at work without having to go to the field. These requirements are imposed only on the time demands and the lowest possible impact on the environment, but also to minimize the operating costs and time. Therefore, the operations hat arestate of the art are starting to include components that meet specific conditions and traffic to a specific farm. With the precision guidance system to obtain information on the operation of the machine in conjunction with a specific location. This information can then be used, for example, in the application of fertilizers, sprays, seeds in order to distribute them to places where they are needed.As a result this greatly optimizes your productivity and income.

The concept of telematics can be defined as a system of engineering discipline concerned with the creation and efficient use of information environment for homeostatic processes (the compensation of intrusiveness to maintain strong processes according to defined criteria such. Comfort, economy, etc.) territorial units to a global network industries.

Throughout the years we have witnessed a marriage of informatics and telecommunications to create telematics. We have witnessed telematics accomplish everything from improving health care quality to reducing the environmental impact of vehicles. It has revolutionized many aspects of our world, such as changing the way hospital patients are diagnosed, and lowering ordinary peoples insurance premiums. As in many other fields, as well as in agriculture is very effective use of information technology. Basically, it is about getting the necessary data, transfer, processing and use.

Telematics systems are now able to pinpoint the exact location of the vehicle and based connection to car control unit to determine its current operating and technical status and in cooperation with the digital tachograph to evaluate the driving style of the vehicle and driver.

The current position of each vehicle can always see the satellite. Transferring data from vehicle. The vehicle runs using modern mobile radio technology. This means that wherever there is a service, there is also a connection to tracked vehicles. These systems allow anyone who has relevant information to monitor the entire fleet and keep track of all important 24 hours a day. Using vehicle tracking systems can be achieved by reducing fuel consumption vehicles, maintenance costs and CO_2 emissions, transport automation processes, reduce or records of working hours for drivers. Acquisition of these systems is to transport company cheaply and therefore should be carefully considered when using systems economically advantageous.

Evaluation of operational data tractor was based on information from telematics systems. The contribution of this work contributes to the fact that this is a prime example of how to use telematics system to identify potential opportunities to increase operational efficiency.

2. Scientific hypothesis and objectives of work

This section set sout the objectives and hypotheses of paper.

2.1 Objectives

Analysis of real-time machinery management systems on the market from the view point of hardware and software design and of informatic efficiency, demonstrated by employment analysis of chosen machinery.

Specifically, the work aims to evaluace data about agricultrue processes obtained from telematics system. As data are obtained from telematic system and data are further evaluated. The work should show how it is possible to workwith these systems in practice and what informations the system can provide.Part of the work is a description of telematics systems in general, in terms of the principle of operation and description of selected specific systems of different companies.

2.2 Hypothesis

Each telematics system is in something different. These differences are very specific, so when choosing a system by each potential user should be aware of what is expected from the system.As soon as realize this, then there is no problem to find which system is the best for required criteria. Some systems are more focused just on fuel consumption monitoring and general needs such as location. Other systems monitor more variables at the same time.

3. Literature search

3.1 Management of production processes in real time

Manufacturing companies are increasingly forced to optimize their production processes and increase productivity. So that officials could correct choices, as they need good quality information at the corrrect time. In a production environmentthere is a huge amount of information. Information is necessary to collect, process, store and evaluate for the most rapid response to various states in production or process. In the modern company, the demands and requirements to work with production data are constantly rising. This implies not only increase the efficiency of the production process itself, but also the efficiency of data processing. The main objective is to manage the operations in real-time without there being a gab.[3]

3.1.1 Real time management

RTM is implementation of production processesto achieve the stated goals. At the same time cycle adapted to the rhythm that requires a controlled process.The implementation phase is done according to production standards that are included in the production protocol, from that an operational plan is formed, and an operational record.RTM in telematics works like comprehensive system of highly specialized professionals to manage fleets of agricultural technology in medium and large farms.However the application finds thatutilization in smaller companies and family farms.Usage is also possible in other areas such as cars, trucks, construction equipment, container transport and more.[51]

Collecting data in real time for optimized production management

In todays fast paced world it is necessary to obtain a complete overview of the life cycle of a product or service. Management of production processes requires access to production data in real time. Collection of operational data in real time is required to measure the fulfillment of a plan and to improve current methods. In larger farms it is used in the harvest process of each cell in the process. The flow work is working from harvest to store and do not begin downtimes in process.[51]

RTM managed by human or in „open loop“

Rhythm of management is an hour or less or a day and inning.In open loop work people like coordinators of the process. They work in periods and require supervision over the implementation of the work plan process. If something is wrong and it does not take place according to plan, so try to correct it as soon as possible, preferably immediately. They have responsibility for the results of each shift. The mostly used type of open look is a dispatching system.[51]

In practice realization open loop means:

1. Creating a standard model => short operational termor period plan(ploughing,tillage)
2. Creating an information system = information is in right time at right place => evidence it in real time
3. Make a decision during production process in real time

   a) preparation of decisions = releases production orders, respectively. production orders over short-term operational plan, workflows and quantity. In shortcut - creates resource requirements by sophisticates rough schedule => soft scheduling,
   b) implement decision,
   c) monitoring and control during production process or orders and fulfillment of production tasks, technological and quality parameters,
   d) correction of deviation from standard production,
   e) coordinates worker’s activities,
   f) collateral material and energy,
   g) ensure machine utilization and their serviceability
   h) coordination and use of interoperable services.

Dispetching system of RTM

Dispetching system (DS)is used together with soft centralized scheduling (coordinators out of field) and main significance lies in the institutionalization of man by clearly delegated powers and activities. DS isused when is desired coordination activities.

Stages of DS

1. Standard dispatching - his task is to collect informations of identification character and ensure connection with the required section
2. Dispatcher service – the same as #1. + quantitative monitoring of compliance rough or fine schedule and coordination of selected activities
3. Dispatching system – the same as #2 + creation of standard and rough schedule, preparation of decision - soft schedule, implementation of decisions, removal deviations and failures

In a dispatching system,the dispatcher in this case becomes responsiblefor management of personnel to perform the tasks. These are arising from operating of a period plan or to detect correction of approved manufacturing standards. Dispatcher in this system can also coordinate the groups and workplaces controlled by the supervisor. It can also generate feedback directly to guide the creation of planning documents and standards. Dispatcher of the third stage of development must also correspond to dispatch documentation used for management and technical support.

Dispatching documentation includes

1. Operative and period plan, fine scheduling
2. Dispatching instructions – the operating instructions, dispatcher's operating instructions, regulations
3. Procedures of making decision - the deployment of technical resources and people, business situation
4. Operating Regulations => Rules => timetable for action

Technical section

1. Appropriations for transmission and visualization of information linked to GPS and GSM (location of machines in the field and their performances, the position of vehicles in the area)
2. Appropriations for objectification input information - filtering (logic controls) false or irrelevant information from the informations needed for decision-making
3. Means for processing and visualization of information - computer programs viewing and control model, the variance, fine scheduling, evaluating the progress of work in the field.[51]

3.2 Precision agriculture

One of the most important directions of development agricultural production in recent years is in the developed countries undoubtedly farming system on land-called precision agriculture or locally targeted management. Its essence lies in the fact that a given property, as a basic unit of management in crop production are already not treated as a whole. During the cultivation of the local differences that within it can be and how it appears also generally tend.The term precision agriculture appears on the professional press for several decades.

The introduction of precision agriculture technologies into common farm activities has provided farmers the opportunity to cope with in-field variability and to be able to handle and manage efficiently a vast amount of available information. In HGCA's (English office for growing cekals) Precision Farming Glossary , the description of Precision Farming includes "whether crops are growing at maximum efficiency". Others suggest it as "a method of crop management by which areas of land/crop within a field may be managed with different levels of input depending upon the yield potential of the crop in that particular area". Benefits of PF include reduced costs of production and less risk of environmental pollution through application of chemicals over and above crop need.

This modern approach is enabled by the development of satellite technology, allowing to determine with relatively good accuracy the actual position anywhere on the Earth's surface. So it is possible to determine for example the actual position of vehicles during their journey, the actual position of people in their movement, position of a boat while sailing and also the position of agricultural machinery in their work on the land.

If the information about the location of land on Earth joins some additional information as may be for example in agriculture,information on soil types, soil type, soil nutrient, soil moisture, soil conductivity, color, vegetation, slope of the land etc.

You can create an extensive database of information that is useful for subsequent reference cultivation of the land. Modern technology allows all land to cultivate so that it responds to local differences within it. Simply speaking, that precision farming is the application of modern information technologies in crop production.[5][7][9]

3.2.1 History of precision agriculture

The idea of precision agriculture is not entirely new. Earlier attentive farmers knew that the land on which farmers do not completely uniform evenly across the land area performed the same operation with the same care. Already in earlier times its known that at different locations the same land shows fluctuating income. These finding were only possible because every farmers had only a small area of land. With increasing size of individual fields, while a farmer or agronomist aware that conditions (soil, humidity etc.) in a large field are not the same, but had very limited options is somehow that identify and present. Used machines and tools were not more variable and did not allow intervention in one field.

The development of the necessary technology began to allow detailed monitoring and resulted in the the interventions that can be variable on a particular parcel. Only the development of relevant technologies allow detailed tracking and then variable treatment of landapproached simple chart the historical development of technology that lies at the root of precision agriculture.

The first companies engaged in precision agriculture originated in the USA, Denmark and Great Britain at the beginning of the nineties in the 20th century. It soon became apparent that the development of machinery, electronics and software needs to be carried out to meet the needs of precision agriculture as a complex system, which is not within the power of one manufacturer. Based on this fact and the creation several systems providing a complete service from collection and processing soil samples, determination of sampling strategies according to the type of landscape and land, creating maps physical properties of soil available nutrient content, soil pH and organic matter content in the soil or soil moisture over the yield maps, processing of data using GIS to different information layers agronomic interpretation of these data and theresulting fertilizer application maps (maps of soil properties and plant fields that are designed for variable application of fertilizer), pesticide use, and different options agronomical measures to prepare the ground . Geoinformatics takes place at all stages of the production processes within precision agriculture input data can be in the form of position information from GPS (global positioning system) and harvest, as aerial or satellite images or in the form of models which simulate the processes of the surveyed land. After processing of the input data in a PC the information is applicable to the appropriate action on the property (yield maps, application maps, soil-supply of nutrients etc.).[15][16][42]

3.2.2 Principle of precision agriculture

Simply speaking, precision agriculture is based on monitoring real-time weather data, condition and the composition of the soil,until the crop reaches maturity, the use of specific machines to specific cases, monitoring labor costs and availability of labor. Then should do some predictive decisions that looks at planting, fertilizing and harvesting crops. These decisions should serve to maximize crop production, reduced environmental impact and reduce the cost of work performed.

Precision agriculture supports variable application of fertilizers and sprays. It is closely associated with the use of Global Position System (GPS). The decision should be given the time of selection, so that from the beginning has been to a particular location suitable seed that uses weather conditions at the site. Then, on the basis of data on weather decides how the fertilized and how the crop will further care. At the end of this procedure to decide on harvesting and transportation to the distribution centers where it is possible to re-use traffic data to avoid unnecessary loss of time and temperature.

The information age brings the ability of integration between the technological advances into precision agriculture.Precision agriculture aids are low inputs, high efficiency and sustainability of this standards in agriculture. The approach of the system is mainly benefits the emergence and convergence of several technologies, including the GPS, geographic information system (GIS), miniaturized computer components, automatic control, in-field and remotesensing,mobilecomputing,advancedinformation processing, and telecommunications [15][16][25][33]

3.2.3 Significance of precision agriculture

This system consists of exactly localized agro interventions on farmed land. As the field is not homogeneous, various parts of the field are different andit is therefore necessary to align all agrotechnical interventions, particularly fertilizers, chemical treatment of crops etc.

However, to localize the places safely it is necessary to use yield maps, maps on soil or a combination of both. These data can be supplemented by aerial and satellite remote sensing. For these interventions is required necessary information ploze machines in the field at the precise moment. To determine the position of the GPS system is used, based on the action of satellites. Creating yield maps of land, which are based on data obtained from the onboard computer to the combine harvester equipped with a probe yield, moisture and system for determining the exact position of the machine via GPS.[6]

Identified sites with different characteristics (lower fertility, different moisture content, soil of another kind, but also crop attacked by disease or pests) on one property are recorded and used as a basis for further agronomic intervention (chemical treatment only this place, applications larger or smaller doses fertilizers etc.) results not only in a significant reduction in production costs (savings of chemicals, fertilizers, fuels, saving reduced wear of machines), but also environmental protection, which is not burdened with excessive doses of chemicals.The use of these systemsin agriculture supports Natural Resources Conservation Service (NRCS).[15][16]

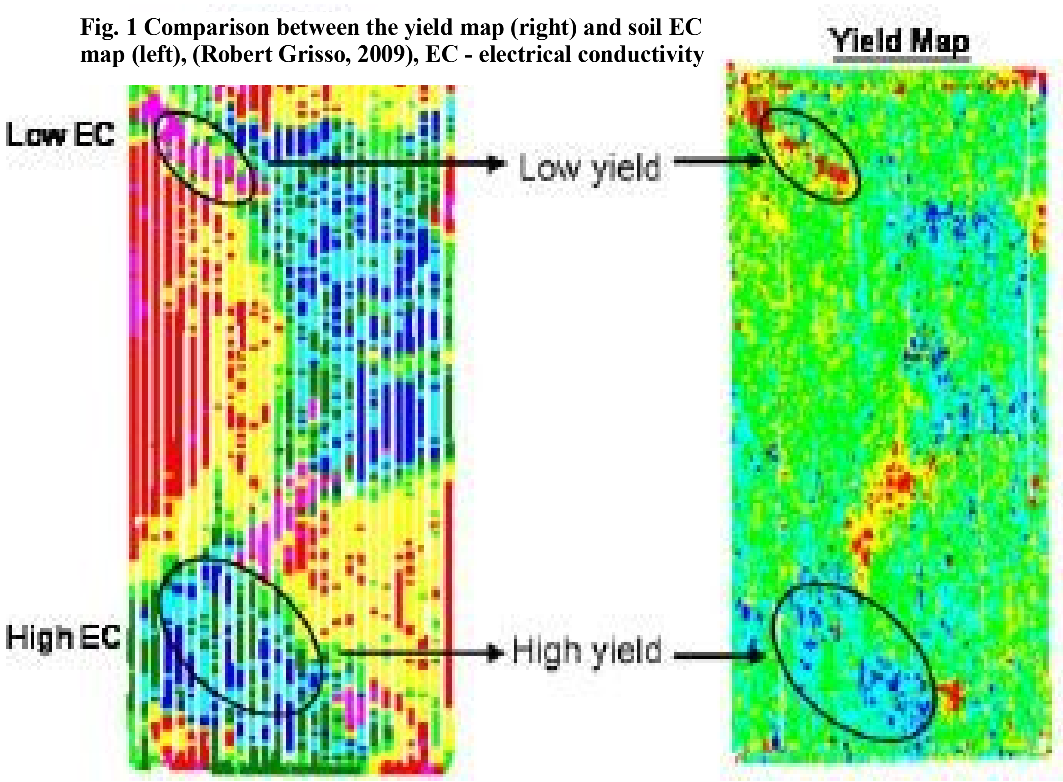


Fig. 1 Comparison between the yield map (right) and soil EC map (left), (Robert Grisso, 2009), EC - electrical conductivity

3.3 Telematics

Extension of the European Union caused a significant increase in traffic of people and goods. On the other hand, it also raised isscussions in relation to transportation, such as congestion on the road network, the delays in public transport, the problem of traffic accidents and safety in general. To solve and fix these problems the European Commission supports the implementation of Intelligent transport systems and services (ITS) across all modes of transport to increase its effectiveness and safety.Compute science of processing data for storage and retrieval; information science".

Telematics is all about being able to get information on vehicles. Everything from fuel performance to driving speed can be tracked with telematics. The beginning of telematics could be said to have started with a tachnograph over 60 years a go. To understand telematics you have to understand GPS.

Telematics is the result of convergence and subsequent phase synthesis of telecommunications technology and informaticssupport for managerial economics and mathematical methods for the creation and management of complex systems. Telematics effects are based on the synergism of all default fields. Advanced telematics is in their applications one of the important conditions of emergence of the knowledge society, since it constitutes for intelligent environments and enables based on the information obtained to extract knowledge descriptions of complex systems. [4] [6]

Telematics can be operated either passively (access to information via the web), as well as actively, ie. including notifications depending on the position of the machine, the reports of error messages and / or operating conditions. The advantages of the system include establishing better contact management tools with drivers, regardless of distance and fewer trips services, which are held only in truly necessary. Furthermore, telematics allows better organization of activity of entire fleets of machines, thus, for example, harvesting chains. Managers can create a timetable for the work of individual machines and sets, and then check its compliance in real time, or to make corrections operations. This allows for better synchronization operations, while optimized control inputs. Other advantages will be better intelligence, intuitive operation and interconnection of machines and data at a better level. Data on the machines in digital form can be integrated into farm management and agronomic systems. They serve well for detailed analysis and performance evaluation. [31] [32]

The technological innovations of on-board tractor performance monitoring systems and the recent advances in tractor technology, enables the acquisition of tractor and implement status data through the ISOBUS (International Organization for Standardization), and provide useful information to optimize the overall operations and field productivity. Combined with the Differential Global Positioning System (DGPS), the system could be used for spatial mapping of tractor-implement field performances. Such technologies emerge as standard features on contemporary tractors with the aim to provide enhanced farm and operations management through the use of extensive databases as the basis for decision support and control actions. Additionally, on-the-go sensors mounted on agricultural machinery provide site-specific analytical information of soil and crop conditions. Moreover, the development of autonomous vehicles adopted to field tasks will gradually change the role of the tractor operator toward monitoring and strategic management as this development will require an explicit management information system capable of managing interactive information flows and provide useful guidelines in real-time for operations execution. The interconnection between the ISOBUS and precision agriculture innovations will meet the farm manager's demands by the opening up of wealth of information for improved management of crop production.Mechanization is one factor that has had a significant effect on TFP since the beginning of modern agriculture. Mechanized harvesting, for example, was a key factor in increasing cotton production in the last century. In the future, mechanization will also have to contribute to better management of inputs, which will be critical to increasing TFP in global production systems that vary widely among crop types and regional economic status.[33][34][43][28][29][30]

3.3.1 Explanation of telematics

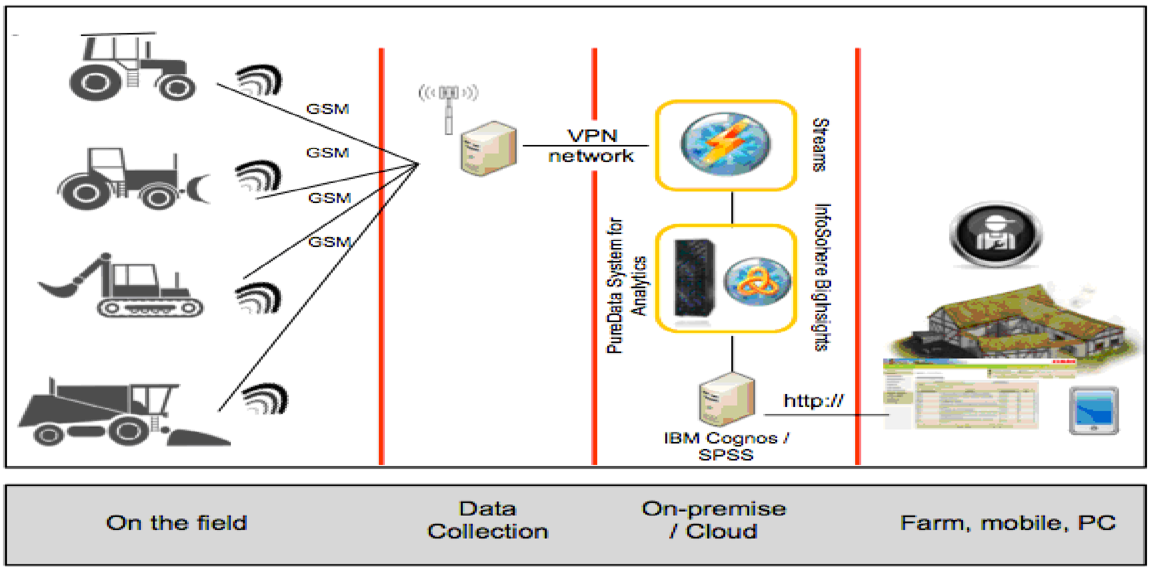
The term telematics isdefined as remotely control of the position and status of machines, while there are two explanations for the origin of the name. The first option talks about the origin of the term as the combination of the words telecommunications and informatics. The second explanation is that the term originated from the Greek "tele" (distant) and "Matos" (a derivation from the word "machinary" - machine). The second definition would therefore rather fit because of the formation of the system. The issue is often called the term telemetry. Telemetry derives from the words "tele" (distant) and "metron" (gauge). It is therefore a remote measurement and that of the label cannot be considered totally wrong, but this term is used more in the measurement of physical quantities. More correct designation issue tracking and remote operating vehicles quantities thus seems to be the term telematics.

Telematics is a system used for online vehicle tracking, monitoring operational data, performance parameters and machine diagnostics. This information is then sent over the cellular network to the central server.[11][14]

From there, the data is displayed, for example, at the web portal, accessible to anyone who has the appropriate access data from their home computer. Because everything happens in real time, so we see this device can help to improve the organization of the fleet, reduce fuel consumption and also because it can ensure compliance with maintenance intervals. Although this system may seem advantageous only for large farms, its advantages saving time and human resources even for the smallest agricultural operations.Telematics service also allows a specialist to check important performance parameters and send directly to the terminal driver in the cab appropriate recommendations to increase efficiency. Telematics is also capable of checking on the progress of field work, which place high demands on precision.

The last benefit of the implementation of systems and services in terms of social benefits is in increasing of traffic safety and operations. Telematics can also help in theft machine if it stays connected all the time, so it within a few minutes, the affected company to find out.[25] [26][27]

Fig. 2 Structure of telematics (Ralf Goetz, 2014)



3.3.2 History of telematics

History of the word telematicsis increasingly inflected in the literature, it is necessary to look at times about 30 years ago. At that time theword Telemechanics was often used which had importance of remote monitoring and control processes. This meant that the remote control was necessary for the telecommunications environment that mediated transfer instructions from the kontrol elements. Telematics was later remotely extension of surveillance and control elements.

Remote controls entire information systems or processes purposeful focus. It not yet telematics context of today's sense of the term. Currently on telematics laid integrating task and so it is possible to imagine a telematics system distributed information system, where each information subsystems are connected intelligent telecommunications environment. The term information subsystem are understood to existing dedicated information systems used for the collection and processing one type of data.

The resulting telematics concept leads to the possible use in any defined location and at any defined time all the necessary information required for proper operation of the application. Telematics system himself this information barches and he guarantees their transfer to a place where there is envisaged applications.

The concept of telematics system includes also optimal design of telecommunications environment to meet the requirements of speed, security and availability of information in each relevant place where the application. The definition of these parameters is related to definitions of partial information interface subsystems, which also have an impact on speed and safety information retrieval. While ensuring telematics system with required information is securely obtained even in real time according to the requirements of the application program, telematics becomes important branch of the current basic and applied research. [4][29]

3.3.3 The essence of telematics

In many ITS applications are satellite navigation systems tkey component, because positional information from these systems is integrated into the ITS applications. The main benefit of the deployment of systems and services in terms of social benefits is to increase safety and reliability of transport.

Furthermore, telematics allows better organization of activity of entire fleets of machines, thus, for example, harvesting chains. Managers can create the work schedule of individual machines and sets and check compliance in real time or to make corrections of activities. This allows for better synchronization of all operations and optimized control of inputs. Other advantages will be better intelligence, intuitive operation and interconnection of machines and data at a better level. Data on the machines in digital form can be integrated into farm management and agronomic systems. They serve well for detailed analysis and performance evaluation.

Telematic systems operate on a similar principle, and therefore we can say that it consists of similar parts. These systems are based on the collection of data on the machine, where each manufacturer uses a different frequency. These data are then transferred via GSM (GPRS) network and is transmitted to the server company that provides this service. The user then logs in with the credentials to the site of the company, or through a special software, which is directed to the server automatically. The computer needs to be connect into network. Under certain conditions, the control unit itself sends back instructions (or the order is sent manually by the operator). This action activates the equipment for process control (eg, a set of equipment designed for traffic control, such as symbols of variable traffic signs, signal characteristics of the light-signaling devices, etc.).

Each machine that wants to take advantage of telematics systems must be equipped with GSM / GPS antenna, if not using telematics systems connected via navigation. Module with integrated chip or card, which is predefined in specific settings of the machine, such as tilt sensors. This module is connected to the antenna, and to supply to the CAN-BUS. If the system consists simultaneously from other measuring devices are also connected to it. This happens mostly when the machine is not equipped with on-board CAN-BUS network and is necessary to determine the values of various operating parameters, or if we need to collect data, which includes on-board network.[43] [28] [29] [30] [12][11][31]

3.3.4 Measurement of consumption

Consumption measurements can be done in three ways. Each of these methods have advantages and disadvantages. One of the easiest and cheapest method of getting information from the CAN-BUS. This method is also less expensive. Another possible way is to flowmeter and sensor in the tank. The advantage of the values of the CAN-BUS versus sensor and flowmeter is easy to obtain data, low cost and do not need to assamble additional sensor.The biggest disadvantage is the measurement accuracy and measurement variability. Accuracy is always based on type of work. If the motor is constant load, it will operate at higher rpm, accuracy of measurements will be adequate. However, when the machine to operate at low rpm, thus will have lower consumption and consumption data will be less accurate.

The last two methods of measuring consumption is based on assemble the measuring device. But as already indicated above, these methods are expensive and the price rises with quality of measuring device that is used. However, if it is necessary to measure the consumption as accurately as possible, nothing else gone and these systems must be installed. The disadvantage of these sensors in the tanks may occur when working on slopes. Advantage may be taken at any point of removal of fuel when the machine is not used.

3.3.5 Time cracking

Telematics systems are added to the machine for monitoring fuel consumption, as well as use of time. Each operation takes different times and these systems also help monitor individual operations. Among the most important of tracking time along with own work activity downtime, transportation machinery to the place, turning at the headland.

As a stimulus for determining the time either speed signal sequence of the machine status, or sequence of states in combination with the distance traveled. Speed is usually the easiest way to determine the activity. Every process the machine does results in another interval velocity. This method is very general, but for monitoring the normal operationit is sufficient. The signal sequence is predefined for most activities. The most important aspect by which one may determine the working status of the selection signal. It may be the position of the linkage or turn on or off the PTO. Greater accuracy is achieved if one takes into account the distance traveled. Timing runs from information available from the CAN-BUS machines.

3.3.6 Development of telematics in agriculture

Telematics experienced in recent years in the Czech Republicshowed rapid development in businesses in this area. It is still sorely missing the idea of the state of the further development of ITS systems. At this moment there is no government-approved document that can describe how telematics will develop in the medium term. But this document should increase development of these system across all branches.

In recent years, progressively more manufacturers have begun to address the development and integration of telematics systems into their machines. This step was absolutely necessary to streamline agricultural production. This development is necessary but this is also due to other factors such as, Farming many years had not introduced a new principle functioning machines, there is only a zooming performance and dimensions of contemporary machines and also integrating more and more electronics into machines.

This new technology was developed in response to the development of navigation systems and precision agriculture. It was necessary to use these systems more and thus began to expand and integrate telematics in agricultural operations. This system began to use the data and processes that have already been obtained, but with them also did not work.

As an added incentive, which can be used to assist the development of telematics in agriculture and aloowed for telematics systems to be integration into other sectors that use mobile devices.The biggest boom of those systems were mainly in transport. Especially in this sector it was necessary to invest in the development of systems and also making more of the development of these systems in other sectors much cheaper and thus more accessible.

In agriculture, these systems were very welcomed news, because in agriculture there should be monitored quantities that have a greater amount than is necessary for automobile traffic mainly because it was necessary to draw relevant conclusions. Another impetus for pursuing their machines could lead to the problems in human resources companies, for whom it is a issue to find a responsible and qualified operators and their machines so they want to keep tabs on their machines.

The first brand that focused on the production of these systems in the agricultural sector was John Deere in 2002 with their system JDLink Machine Massenger. However, this system was considered a pioneer of telematics systems in agriculture. With less price performance and the great demand for these systems in 2008-2009 new companies that offer these systems. Most of these systems has its foundation in the construction industry, primarily because they were applied in these facilities.[24][25][29][30][31]

3.4 Itineris

Itineris is a comprehensive professional highly specialized system for managing fleets of agricultural technology in medium and large farms.Usage is possible in other areas such as passenger cars and trucks, construction equipment, container transport andmore. This robust system is characterized by its universality independently of brand, age of equipment and electronic equipment. With this universality, it can also provideall relevant and detailed information about machines and employees that are moving around the grounds.

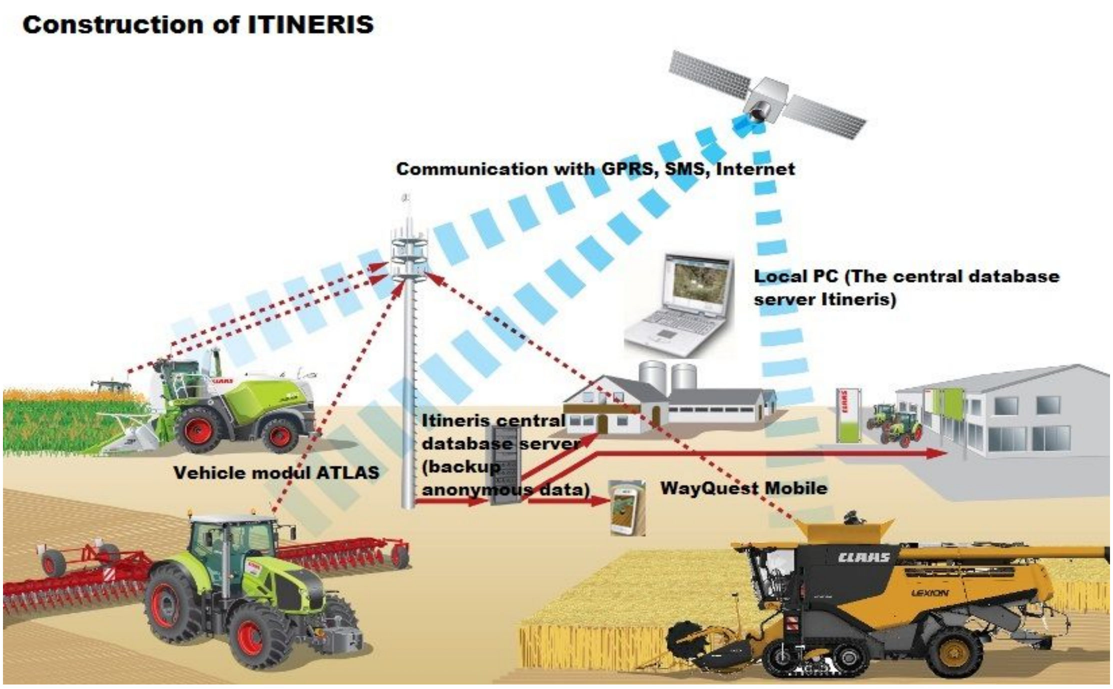
Itineris allows detailed monitoring the machine position via GPS, driver identification, workflows, consistency with soil blocks and crops, fuel consumption and more. It also provides detailed information about machine and employees and their movement around the fields and paths. The system would watch over the position of the machine based on documents from the system LPIS.

Company Itineris in collaboration with some companies also involved in the autopilot in machines where the machine is guided through the navigation monitor with accuracy up to 2.5 cm. These devices can be set up and monitors the weather in a given location or an overview of the sprays on the land.[11]

3.4.1 Construction of Itineris

Construction of Itineris is classically divided into hardware and software parts. Hardware parts includes vehicle modul, used for communicating of vehicle with the network (GPRS,GSM,Internet). From these network data are sent to a central data network (central database server) of Itineris. At the Itineris, data are processed in anonymity and allocated to the appropriate account of individuals or companies that have unique login data. Server sends data over the Internet or GSM into customer devices (computer, mobile phone, tablet etc.). At device they need special programs (WayQuest and WayQuest mobile).[11] [22][23]

Fig. 3 Construction of ITINERIS (CLASS brochure – edited by author)



3.4.2 Instalattion and application

Installation is possible on any vehicle, which has a voltage of 12-24 V. If the system is connected to the CAN - BUS, as it is necessary to assess the machine on which the system will be connected.It is not difficult to put the system into the vehicle, theefore customer do not need to have perfect knowledge and are capable installation by themselves. But the company has included professional installation for customers, who bought or ordered the system.

The modeRoute preview, which is dynamically linked to maps with graphs, it is possible to analyze in detail the very large number of situations.When working the sprayer or spreader, it is possible to find out, if driver covered the entire plot area and if driver has complied good working speed.In preparing the the soil and seeding this can easily display multiple work operations at the same time and easily be checked if there were complied working angles between individual operations.The system recognizes the individual connecting machines, various operations and counts actual worked hectares. In the tabular sectionit is possible to generate interesting reports.If it is necessary to bring other seeds, water or diesel on the current land or on the next land. The telematic system can inform agronomist immediately about these situations.As a last much used function is the history of the specific land, where are recorded all activities with specific implements on the land for a period that is set (usually a year).[11]

3.4.3 Accuracy of Itineris in the Czech Republic

The system uses GPS and GLONASS satellites and RTK correction signal. The great advantage of this system is that is isthe most accurate for high precision work, while long-term static accuracy. The correction signal is available in the machine immediately after switching on, there is no need to wait for clarification.

This accuracy can be utilized in a Controlled Traffic Farming, machine control during seeding, tillage, spraying, fertilizer spreading, turn off sections, harvest forage or measurement yields.[11][21]

Methods for obtain the RTK Correction

There are three ways to obtain correction of the stations. In the first case, the machine is equipped with a GPRS modem that receives corrections from the reference station network, which is based on technology from Leica Geosystems. Navigation solutions firm Itineris are connected to the network and are fully compatible. Leica network is currently the most extensive network RTK of reference station in the Czech Republicwith more than 50 physical transmitters.

Fig. 4 Leica transmitters in the Czech Republic (AGRI-PRECISION brochure)

In the second case, it's RTK corrections from the Net with its own reference station. The machine is equipped with a GPRS modem that receives compensation from the company's own station. Own reference station can be installed anywhere in a suitable place within the farm. It is not necessary to take into account the line of sight between the machine and the station. This solution provides a very high range correction (50 km from the station) and is suitable for operating multiple machines within the farm.

In the third case, it's RTK corrections from Radio with its own reference station. The machine is equipped with a radio receiver that receives compensation from the company's own station. Own reference station can be installed anywhere in a suitable place within the farm. It is necessary to take into account the direct line of sight and terrain conditions. This solution provides a very stable range correction to a distance of 5-10 km (Using a higher radio modem for longer distances). When using this device depends on the choice of a receiver for the machine, because each unit is working with different accuracy.

Fig. 5 Navigation Raven (AGRI-PRECISION brochure)

The most accurate results has GS – Satelite with navigation Raven. The accuracy of system is +- 5 cm. The system uses GPS and GLONASS satellites and the correction signal GS-Satelite. The correction signal is transmitted geostationary satellite and uses a dual frequency transmission correction, correction of both GPS and GLONASS technology and PPP (postprocessing data). It is characterized by high stability and high long-term accuracy.Itineris system has an accuracy of + - 1 mA is therefore used for monitoring machines.The system uses GPS satellites, EGNOS correction and own patented algorithm to refine the position. Despite the use of very small "patch" antenna is achieved very high accuracy for the purposes of monitoring vehicles on land blocks.[11] [21][22]

3.5 John Deere

John Deere pioneered telematics in agriculture when it was introduced JDLink Machine Messenger in 2002. This system was capable of displaying the current position of the machine, information about the state of the engine, determining different times of routes, downtime and labor in connection with a speed and a lot of other alerts, such a deviation in the engine.This system was $ 2,495 and the annual fee is $ 495th The activity of this system was subsequently terminated due to termination of analogue transmission of mobile networks and the transition to digital. For user feedback indicating that it is unfilled in the market and that the interest in the products of this kind was, but due to the price they expect more features.

In 2009, the company replaced Machine Messenger with two products: JDLink Select and JDLink Ultimate. JDLink is John Deere's telematics system designed for customers and managers who desire to take their operation to the next level of productivity and efficiency without leaving the office. Whether it is receiving an e-mail or text message, users can manage the operation in real-time without being in the cab. Using the power of JDLink can optimize your productivty, increase your uptime, and boost profits with JDLink information all from a laptop, desktop, or mobile device.

With JDLink, is possible:

- Monitor machine health
- Extend life through preventative maintenance
- Simplify maintenance scheduling and documentation
- Increase uptime through alerts of potential downtime
- Document machine and operator productivity
- Recover stolen machines through GPS tracking

JDLink works by combining a controller (MTG) that includes cellular communication and GPS antennas. Machine data is collected by the controller and wirelessly transferred to a secure data center, where it's made available via the JDLink website. An optional satellite mode is available for areas where cellular signals are not availabe or reliable. JDLink will still connect via cellular connection unless a connection cannot be established. Then JDLink will switch over to satellite mode.

There is a mobile app for iOS and Andoid devices. When you download the free JDLink mobile app, monitoring and managing your machines from outside the office is easy. If you already have a JDLink account, simply log in and check your machines.[20][52]

3.5.1 Instalattion and application

This device in the set has following parts antenna for GPS and GSM signal, Satellite Module, Modular Telematics Gateway Controller and SIM plug. The installation of this device by the manufacturer can be done yourself, but most companies for the use of these devices let you perform the installation from the manufacturer. Data obtained from the system CAN-BUS via GSM or GPS (not work in buildings) will be sent to the server where the user can check via mobile phone or computer. On the Internet are already available applications running on GSM-based, which can be used on mobile devices. John Deere system integrates advanced communication technologies, such as CAN, Cellular, Satellite, and GPS, into a sophisticated network that meets your specialized needs.

The John Deere Electronic Solutions Modular Gateway offers mobile communications and processing that integrates GPS, GPRS data, and on-board machine communications via CAN, RS 232, or Ethernet.

Remote Access

Remote Display Access gives the ability to view an operator's screen remotely, if that person has a permission. This will save a trip to the field to help an inexperienced operator, getting them back to work faster.

Remote Display access requires:

- GreenStar 3 2630 Display
- JDLink Activation
- MTG/JDLink-equipped machine
- Ethernet cable

Service advisors can help reduce downtime by reading diagnostic trouble codes remotely, as well as recording performance readings. And if a technician discovers through Service Advisor Remote that parts are needed in order to fix the problem, he can send the right ones out the first time. With service advisor, machine can also also receive wireless software udpdates, avoiding a technician trip to the field with laptop in hand.[20][52]

3.5.2 JDLink versions

JDLink Select helps optimise machine logistics. It shows the exact location of every machine on detailed, full-colour Google maps.

It's an all-makes solution, including older John Deere and non-John Deere equipment. Itprovides 24/7/365 machine hour, location and maintenance tracking. It is possible to set the allowable operating times and days using the curfew feature. Easily draw a geofence around a machine so everybody can be alerted should the machine travel outside its virtual boundary. JDLink Select is available as a field-installed option.

JDLink Ultimate can measure the amount of time spent doing different tasks and cut it down on non-productive engine hours such as idling. Systems shows how the machines are being utilised with analysis of engine load for better working efficiency. Owner can set own alerts on individual machines so he'll know if fuel consumption goes above a certain level, fuel is running low or he is not performing the task as fast as he had expected you would.

So it does everything like Select does, plus provides a comprehensive view of engine diagnostics, and adds monitoring of fuel consumption, gear selections, component pressure and temperature, and full-featured diagnostic information retrieval. JDLink ultimate monitors service status and advises of schedules maintenance.[20][52]

3.6 AGCO

AgCommand® offers management of individual assets and complete fleet management with machine performance reports, wireless communication, a web based application for easy access to data, and theft recovery. AgCommand provide a higher level of understanding about the efficiency, performance and logistics of entire operation from a computer or mobile device – putting fleet and asset information at fingertips and enabling to make big-picture decisions about your operation. The AgCommand mobile app enables total fleet and asset management from anywhere with an Internet connection.

Acquisition and transfer of operating variables is similar to that of other manufacturers. Therefore, data obtained from the network CAN-BUS, together with data on the position of the GPS are sent via the mobile operator (GSM network) on servers where users log in through the website. [19]

3.6.1 AGCOMMAND versions

AGCOMMAND is available in two versions Standard and Advanced plus, while the hardware is the same for both versions. Change from Standard to Advanced plus can be done without physical intervention on the vehicle. The difference between the versions is in amount of recevering data, frequency of recording, and also a method of obtaining data. Standard version plus the data are stored after 60 seconds and sent once every 15 minutes. For version Advanced data are stored every 10 seconds and sent after 10 minutes.Version Standard Plus displays the following information engine running, working status, speed and machine hours. It is available for all brands, even without CAN-BUS system. On the Advanced version is monitored more data from CAN-BUS from the engine speed to the temperature of the content.[19]

3.6.2 AGCOMMAND functions

The system refers to the status of machines and givesreports that indicate the operational efficiency. The system has a predefined kits and it is up to the user to choose the variant. Examples of the reports include run time of the engine, the area (field, region, centers), work efficiency and the data assemblies. Furthermore, the predefined report in relation to the service, which displays the status of maintenance and expected time until the next maintenance. At that time it is possible to set the reminders.

Run Time Engine graphically shows what part of the day was the engine is running, or you can monitor several machines at once and compare them. Working efficiency tells us how it used working time, using the defined machine states, either by time or distance traveled. In this report includes the activity of the machine, there is presented proportional representation, but each is assigned a status of either time or distance traveled.Report by field filters the data only for specific areas and others disregarded. In the Overview tab, the system displays all the machines fleets, and in what condition it is.History tab provides the ability to track the movement of the machine. Bookmark administration used for compiling fleets, adding machines, setting reporting service, determine the boundaries and various alarms. For information on maintenance and the actual position of the machine are displayed and retailers, in order to better service scheduling, nothing but the seller can not see. If the customer decides serviced the machine itself, then you may cancel this function (Administration tab). A good idea is also that if the system uses the company engaged the services may share some information with the customer. The system should also manage remote transmission of orders and application maps to machines and back. Export of data is possible in PDF or CSV. [19]

3.7 Case IH

Case Company is the market represented by AFS Connect 2.0. This system company offers in two versions BASIC and ADVENCED. The system has big advantage in full monitoring of CAN BUS data in every minute. The BASIC system is available for all brands of machines (tractors, combine harvesters, forage harvesters).[12][13][14]

AFS Connect 2.0 is based on a hardware and a new web based interface to provide the ultimate user experience. This offering will allow customers to set vehicle parameters, manage their fleet, remote monitor, and give them a real-time dashboard. Furthermore, AFS Connect 2.0 provides an opportunity to customize maintenance plans for customers.

AFS Connect has a major advantage over competitors in response, which is every minute.Next in what would be better than competitors is intuitive system for simple operations.
The machine can help a person automatically due partly intelligence, all system functions are integrated so that they become part of the machine. The last advantage is that data can be shared with the public. So developers can watch online diagnostics tractor and thus react more quickly to problems.

Tab. 1 Types of machines that are fully compatible with AFS Advenced (CASE brochure)

Model Family	BASIC Features	ADVANCED Features
Puma 130-160 Tractor (T4A engine)	X	X
Puma 170-230 Tractor (T4A engine)	X	X
Magnum 235-370 Tractor (T4A engine)	X	X
Magnum 250-380 Tractor (T4B engine)	X	X
Steiger 350-600 Tractor (T4A engine)	X	X
Steiger 450-600 Quadtrac (T4A engine)	X	X
Steiger 370-620 Tractor (T4B engine)	X	X
Steiger 470-620 Quadtrac (T4B engine)	X	X
Axial-Flow 5140, 6140, 7140 Combine (T2)	X	X
Axial-Flow 5140, 6140, 7140 Combine (T4B)	X	X
Axial-Flow 7230, 8230, 9230 Combine (T4A)	X	X
Austoft 8000,8800, 8800MR Sugar Cane Harvester	X	X
Other	X	

3.7.1 Application and installing

The product hardware and the subscription services are only available via the case parts and service distribution channel.The hardware is installed on the machine and once installed operates independently from the operator. This device is included in the installation package the following things. Mobile dishes that receive GSM and GPS signals. Cable harness in one solution includes basic services only due to no CAN interface and has specific platform which provide custom harnessing for specific machine platforms, can support both basic and advanced services when it has a CAN interface

The software is the internet browser which the customer uses to retrieve the information. This is where the customer interaction is and where our focus should be.Active cellular data plan is included in the service and it has not extra data charges.

The telematics unit already comes with a global roaming SIM card installed. This SIM card is geared to work with multiple GSM provider per country to utilize optimum Network coverage. No SIM card or data plan needs to be provided by the dealer or customer.

Advanced subscriprions require “fully supported” models with an AFS Pro 700 display installed. The price of all subscriptions include and “all in” data plan which works with the SIM card in the telematics unit. No additional charges for data transfer will occur.

The dealer access to the AFS Connect portal enables dealers to create customer accounts. The customer will receive an email with his login details and is able to start using the service. For additional details about ordering and activation, dealers can consult their Precision Farming Specialist (PFS) or their Parts & Service Sales Manager (PSSM).[12][13][14]

3.7.2 AFS CONNECT versions

Basic level is targeted at customers running legacy Case IH equipment and competitive machines. A machine dashboard allows to read basic engine information according to the J1939 communication standard. Any data messages from the machine CAN BUS are supported.The main advantages of the system are the following fastest update rate, machine monitoring, overview for fleet management, machine monitoring, automatic maintenance remind and machine status.

The system has the fastest update rate on the market, the rate of system is only one minute. A fine resolution of positions allows precise tracking of travel routes or in field passes. The system allows you to instantly see the position of machines. The system also allows you to track the history of the machine position and change of position in 1 minute intervals and this gives the fleet management overview of machines.If the machine puts the area where you want to move. The system automatically generates alerts when the machine leaves the area or starts against the original plan. The user can also use the system so that it can set the time when to intervene with the machine, so if there is an unauthorized use, alerts immediately is sent to the owner. The system monitors itself planned maintenance. Just set an engine hour limit in AFS Connect and have an automatic email sent to you or your dealer. The dealer can already start to order required parts or schedule a technician. One caninstantly see the current status of machines. The system automatically displays the current status of the machine (built on the site, idling or running), because it can determine the efficiency and possibly make some improvements. When it detects excessive idle time, for example, in logistics or other activities, so they can then be optimized. This graphical representation of working hours will allow easy comparisons of the machines. See Engine parameters like hours, Key ON / OFF, Idle, Idle Long, Working, High workload and traveling. On dashboard is graphical representation of the key vehicle parameters (on machines with J1939 availability): Engine speed, Engine oil temperature, Hydraulic oil temperature, Engine coolant temperature, Engine oil pressure, Hydraulic oil pressure, Engine coolant level, Fuel level, Battery voltage, DEF level. Analogue inputs are available to see the status of an implement or attachment. With two analogue inputs on the telematics unit that is easy to do: Just hardware switch or sensor inputs to the telematics unit and you are able to see the actual status and draw reports of historic switch status.

Advanced level is targeted at customers running newer CASE IH machines. Fully supported machines need to have an AFS Pro 700 screen to utilize all advanced features. Advanced features include full access to the machine CAN BUS (SES) which allows remote performance optimization and operator coaching. ADVANCED Level includes all BASIC features.

Instantly see the current status of your machines. Knowing in an instant if the machine is stopped, idling, or working will pinpoint efficiency gains.

The system has available following statuses: Key ON, Idle, Lond Idle, Working, High workload and travelling and following processes: Moving, Working, Working & Moving, Unloading, Moving & Unloading, Unloading & Working, Unloading & Moving.

With the advanced status it is possible to highlight the efficiencies which can be gained in the field in a very detailed way. Easily find out which one machine spends more time unloading than others or those who unload more while moving. This can gain you harvesting hours.

In Advance level CANBUS plays an important role in this version you can choose from 40 parameters that follow, of course is that you can watch all 40 parameters simultaneously.

Quicker response time enhances the clarity of data and thus can be optimized processes.

- operate the machine in a certain way and the technician or machine expert is able to see the impacts by looking at the dashboard and the CAN parameters live
- Watching the losses from a combine while operating or the effects on higher speed on thresher speed are interesting for tuning the combine harvester.
- Watching the tractor performance when different loads or gears are selected enable the machine to be optimized by an expert, remotely.
  [12][13][14]

3.8 Global Navigation Satellite Systems (GNSS)

Applications using GNSS signals are applied not only to road, rail, air and maritime transport but also in other areas such as telecommunications, geodesy, agriculture, mineral prospecting and mining or environmental Earth observation. Important is real time prediction of possible critical situations and natural disasters. Furthermore it is connected with civil security at all levels of a society. The use of GNSS applications brings a strong impact for both economic and industrial development of every country. The market with these products and services.is growing at an annual rate of 25%. It is expected that in 2020 it will be operating for about 3 billion satellite navigation receivers. Satellite navigation is becoming an important part of everyday life, not just in cars and mobile phones, but also in energy distribution networks or time and banking services and many other fields.

This modern approach is enabled by the development of satellite technology, allowing to determine with relatively good accuracy the actual position anywhere on the Earth's surface. So it is possible to determine for example the actual position of vehicles during their journey, the actual position of people in their movement, the actual position boat while sailing or also the position of agricultural machinery during their work on the land. If the information about the location of land on Earth joins some additional information as may be for example in agriculture, information on soil types, soil type, soil nutrient, soil moisture, soil conductivity, color, vegetation, slope of the land etc. You can create an extensive database of information that is useful for subsequent reference cultivation of the land. Modern technology allows following all land to cultivate so that responds to local differences within it. Simply speaking, that precision farming is the application of modern information technologies in crop production.

The abbreviation GNSS are called global navigation satellite systems for autonomous positioning by using orbiting satellites in orbit are ableto target object position anywhere on Earth. Focusing capable of performing an accuracy of several tens of meters, and in special cases up to centimeters. High accuracy is primarily intended for special applications in certain sectors of the civil sector, or for the military sector.Around the turn of the 21st century, GNSS technology had become so precise and accurate that it had outpaced the requirement for the early phases of precision farming and become commercially viable for enabling a number of automatic-guidance applications. Advances in GNSS technologies include decimeter to centimeter accuracy by using signals from a geospatially known reference point to correct satellite signals. One premium example is a real-time kine-matic global positioning system (RTK-GPS) technology that reduces fatigue and lowers the skill level required to achieve high-performance accuracy in field operations.[18][17][6]

3.8.1 GPS

US military GPS navigation system is currently the most widespread global navigation system. Without GPS there would not be the telematics we know today. GPS is a system that was designed for navigation and positioning. It was developed by the US defence department which knew of the importance of exact data on the positions of its assets. It was developed to fulfil the pressing need to have increased communication and exact data on the battlefield. It used the satellite network in cohesion with ground communication.GPS that exists today is still under the control of the US military.It has become an indispensable tool for services all around the world. GPS basically works through a network of satellites that cross reference your signals location on the ground to the satellites location in space. By trilateration these positions and accounting for the difference in time for the signals to be sent back and forth, you can get an exact position of your location. You use at least three satellites to determine your GPS location. Trilateration works by calculating the relative location of different satellites by using known reference points to calculate the position of an unknown reference point.

Today is already used in many farms in Bohemia and Moravia day that are convinced that the use of GPS navigation systems from manual till automatic pilots for significant savings in the economy crop production. However, this is only the beginning. Use of GPS systems offers unprecedented possibilities of the new management of the entire crop production. Therefore it may be farmers in the Czech Republic are proud that it is one of the first in Europe, who got the chance to use the network RTK VRS enabling agricultural machinery ride with accuracy + -2 to 5 cm. The network has built a Leading Farmers CZ, a.s. Everyone in agriculture is now looking for opportunities where still take another cost provisions. Travel inaccuracies machines definitely belongs here, because inefficient driving increases fuel consumption and machine wear overall.[4][10][18][48]

Structure of GPS system

The GPS system consists of three basic segments:

Space segment

This system consists of GPS system of satellites that orbit in nearly circular orbits in high orbit MEO (Medium Earth Orbit) at a distance of 20,200 kilometers from the Earth's surface. Orbits a total of 6-shifted 60SE inclination to the equator 55˚. Originally 24 satellites, including 21 active and 3 spare, thus every track should be regularly spaced 4 satellites. But the reality is that on the runways is irregularly spaced 5-6 satellites. All the satellites orbiting the earth at a constant speed 3.8 km / s wih time circling 11h 58min.

Groundsegment

Ground or control segment is used to monitor and control the entire space segment. Uses the navigation messages broadcast by the satellites is coordinated maneuvers of satellites and corrects time variations of atomic clocks.

Users segment

The structure of each user segment consists of GPS receivers that are able to capture and then process the signals from different satellites. From these signals must then provide information about their position and time. Receivers operate so. Passively. This means that signals only receive and do not transmit. With this passive way of communication satellites receivers with GPS systems can serve an unlimited number of users. [48][47][49]

3.8.2 GLONASS

GLONASS is the Russian satellite navigation system similar to the American GPS. It was developed by the army of the Soviet Union and is now operated by the Russian army. Currently, the orbit operation of 24 satellites and the basic structure of the system is complete.

<u>The structure of the system GLONASS</u>

The GLONASS system consists, like the GPS of three segments:

Space segment

Space segment consists of 24 satellites orbiting MEO orbit, like it was originally designed GPS system. Of the 21 active satellites and three reserve. However, unlike GPS satellites GLONASS orbit in only three planes mutually offset by 120˚. The satellites are in one plane from each shifted by 45˚, which revolve in circular orbits at an altitude of 19,100 km above the Earth and inclination to the equator 64,8˚. The orbital period is 11 hours and 15 min.

The structure of the space segment guarantees continuous visibility of at least 4 satellites in 97% of the Earth's surface using 21 satellites. In case of using all 24 satellites guarantees continuous visibility of at least 5 satellites at 99% of the earth's surface. Technical parameters of satellite antennas and the overall composition of the system ensures the usability of the navigation signals up to 2000 km above the Earth's surface.

Ground segment

Land management and control of the Russian segment of the global navigation system GLONASS only extends throughout the territory of the Russian Federation. This gives him a considerable time limitation for the monitoring and management of the space segment to the US GPS system. Ground complex task is to monitor the space segment via radio signals from all visible satellites and to perform these functions.

User segment

User segment of the GLONASS system is similar to the GPS system. It is thus made up of individual receivers that passively processed signals transmitted from satellites. On the basis of data received subsequently provide information about their position and time. Also in this system it is possible to simultaneously operate an unlimited number of users.

Unfortunately, due to very well developing economic situation in Russia and the constant delays start full operation of the GLONASS system, the user is often considerably more backward compared to GPS. This was mainly influenced by a small number of manufactured reception facilities for the civilian sector. User part is thus far consists mainly among surveyors and researchers.[47][49]

3.8.3 GALILEO

GALILEO is the European satellite navigation system developed and funded by the Member States of the European Union. Unlike previous navigation systems GLONASS and GPS is designed from the outset for civilian users. Their capabilities should be significantly better in terms of accuracy, reliability, availability and quantity of services offered than any other existing navigation system.

The Galileo system has the greatest potential, especially in transport (air, road, rail, sea and river, city, etc.), but offers a wide range of uses in other areas where increased security, accuracy and comfort (energy industry, banking, agriculture, civil protection, environment, construction, etc.).

Structure of GALILEO

Since GALILEO system is developed and operated within the same country, but through several Member States of the European Union, and its structure is more complicated.

Global part

Global component forms the most important part of the system. It is formed as with previous systems space and terrestrial segment.

Regional part

The regional component is made up of several External Region Integrity Systems called ERIS. Their task is to provide reports on the integrity of the system independently of the reports from the Galileo system. This step is designed to provide legal guarantees for guarantee of individual states and entities. ERIS systems will be operated by private companies eventually states or groups of states outside the EU.

Local part

Local Folders will be operated by private companies and will serve to increase the availability and quality of the signal in bad connectable areas.

Space segment

Upon completion of the Galileo system should its space segment consist of a total of 30 satellites orbiting at an altitude of 23,222 km above the earth's surface. Of the 27 active satellites and three backup. The satellites are located on the three circular orbital planes inclined to the equator 56˚. On each orbit is a total of 9 active and one backup satellite. Satellites are mutually shifted by 120˚. Orbital period of each satellite around the Earth is 14 hours. All the satellites constellation attract the same position every ten days, and during those days orbiting the Earth, a total of seventeen.

Ground segment

The essential parts of the ground segment Galileo are its two main control centers GCC (Ground Control Center). Each of these centers is used for its activities, one of two special road systems:

Ground Control Segment

GCS system is responsible for the control and management of the space segment. Its main task is to maintain control of satellite constellation, discharge planning new satellites and recovery after failures with maximum elimination of negative impacts on services. The control system uses the global satellite TT & C, through which it communicates with the individual satellites. Using these maneuvers are performed satellites and any downtime during servicing.

Ground Mission Segment

GMS system is used to control navigation signals. The information is used to synchronize the time, determining the parameters of the orbits and integrity checking. It uses a global network of GSS (Galileo Sensor Station), through which real-time monitors signals from the satellites and thus implements the functions necessary for the services provided. Data are then transmitted navigation message via ULS stations via satellite communications back to the control centers and users. Stations are required to implement the service SAR. In the future it is planned to GSS 40 stations equipped with atomic clocks.

User segment

Since Galileo project is still in development and testing phase, and receivers are manufactured so far only for test purposes. Manufacturers, however, promise much greater performance and lower consumption of the receiver based on the newly developed chips. Receivers also be able mutual compatibility between GALILEO navigation systems, GPS and GLONASS. This will guarantee a much greater availability of services, while the navigational accuracy. It will move with the precision of 1 meter and in special applications, particularly paid to a few centimeters.[45][46][47][49]

4. Materials and methods

This section describes the methodology.

4.1 Methodology

First, it was necessary to get enough material for studying. Data are obtained from companies brochures, scientific articles, articles in newspapers, agriculture books and from the manufacturers of systems.

Because telematics systems are used mainly for informational purposes. For processing data from Itineris the programme MS Excel, 2010 was used.In MS Excel this calculated the avarage values of sorted data.

4.2 Chosen company

The location of study is the Senagro a.s. farm. Farm is located near Senožaty village in the disctrict Pelhřimov. Senagro farms on twelve cadastral territory of the plain at an altitude of 400 - 600 m above sea level. Farms approximately 2 000 hectares of agricultural land,of which 1 700 ha of arable land and 300 hectares of meadows. The company is engaged in both traditional agricultural production, ie crop production (cereals, potatoes and rape) and livestock production, as well as road transport, agricultural machinery repairs and electricity production in the biogas plant which produces 600 kW/year.

Fig. 6Location of Senagro a.s. (mapy.cz)

4.2.1 Processing of data from the system

The data that was exported from the system. Specifically make a document in format * .xlsx, whereis table with data each work process specified number plate machine, start date, start time, end date, end time, the driver interval, the working mechanization, the first start of engine, the last time of engine operating time, the total time of engine running, driving away first, last move, working hours, total travel time, downtime, travel distance, AVG speed (km / h), MAX speed (km / h) Theoretical area (ha), fuel consumption (l) .The data could then be used in other calculations, without having to use any special steps to modify them or acquisition..

4.2.2 Used formulas

This section provides formulas for calculations. Calculations about time are not presented, because i tis obvious how to calculate these values formulas do not have positive influence on clarity and simplicity of work. Calculations about ecnomomy are in the text or are obvious.

<u>The weighted arithmetic average [-]:</u>

This formula has been used in various calculations.Here is just a general formula. The exact values which were used or based, are indicated in the text.

$$\overline{x} = \frac{{}_{i=1}^{n} w_i \times x_i}{{}_{i=1}^{n} w_i} \quad (1)$$

where,

[-] values

w [-] weight of values

Fuel consumption rate [l.ha-1]:

This parameter used to know how many liters of fuel are consumed for manage one hectare. It can be calculated using the following equation.

$$Q_a = \frac{Q}{A} \tag{2}$$

Qa [l.ha^{-1}]	fuel consumption rate
Q [l]	fuel consumption
A [h]	managed area

Fuel consumption rate in [l.h^{-1}]:

This parameter used to know how many liters of fuelare consumed in one hour.
It can be calculated using the following equation

$$Q_i = \frac{Q}{Tw} \tag{3}$$

where,

Qi [l.hod^{-1}]	fuel consumption rate
Q [l]	fuel consumption
Tw [h]	working time.

4.2.3 Used normalized values

Light conditions

The flat terrain with slope 4 °, light soil (sandy and loamy),optimum moisture and soil conditions, a regular big land (over 20 ha),high yield of harvested crops, positive driving conditions (eg. Public road),tractors work with rated power about 20%. [35]

Medium conditions

Slightly sloping terrain (above 4 ° and 10 °), medium heavy soil (sandy loam, loam), slightly compacted soil, larger irregular parcels (over 5 ha), medium yield of harvested crops, less favorable driving conditions (eg. a paved country road, field during harvesting grain or forage, etc.), tractors work with rated power about 50% (eg. the application of industrial fertilizers, mechanical treatment of vegetation, etc.). [35]

Hard conditions

Very sloping terrain (above 10°), heavy soil (clay-loam, clay), compacted soil, small rugged land (up to 5 ha), low yield of harvested crops, baddriving conditions(uneven and unpaved dirt roads, fields during harvesting root crops, etc.), tractors work with rated power about 80 %, (eg. plowing, spreading manure, tillage by rotary cultivator, etc.). [35]

Tab. 2 Normalized values ([35] edited by author)

The working process				
		Easy conditions	Medium conditions	Hard conditions
Ordinal number	Unit of measure	Diesel [l.unit of measure $^{-1}$]	Diesel [l.unit of measure $^{-1}$]	Diesel [l.unit of measure $^{-1}$]
1	Stubble breaking (the disc cultivator)			
	ha	4,90	5,80	6,70
2	Medium plowing with a modification of furrow			
	ha	17,00	21,00	28,00
3	Deeper soil tillage			
	ha	16,50	20,00	31,50
4	Seedbed cultivating			
	ha	1,90	3,00	4,50
5	Seeding by seeding system			
	ha	8,50	10,50	12,50

5. Results

This chapter explains what can be carried out now to watch (agriculturist) via telematics systems even though he had not left the officeor is not present on the property. Reading these data was performed WayQuest Itineris system, which is described in chapter 3, subsection 3.4.

Chapter also displayed and processed data from common operations in the field, which the company conducted annually. That is why the work is focused on these operations. Specifically, its about the following plowing manure by plow, plowing manure by ripper, stubble cultivation by cultivator, seedbed cultivation by seedbed cultivator and seeding by pneumatic seed drill. n the following operations are used following implements and tractor. For these machines are displayed basic iformations and parameters. Data are measured on different fields. Data are from the years 2013/2014. Since the data are obtained from the theoretical value, so the average efficiency is taken only as an optimistic result. For accurate calculations would need to know the exact field where was measurements done.

The work focuses on fuel consumption monitoring with different connections mechanization, which is necessary in each company.The choice of these operations is convenient. Without these operations in place it would not be possible to have the current agriculture status present. Who is engaged in agriculture, wants to keep tabs on their fuel costs, time consumption and the status of their fleet, during these operations.Selected tractor is John Deere 8230, tractor belongs to the leading categories tractors, if we evaluate the performance and comfort. Tractors are very strong and are used in big farms. Brand John Deere is very popular in agriculture because it is taken as a a very reliable brand and not expensive.

5.1 Evaluation of systems

In this subsection are assessed telematics systems which are listed in sections 3.4, 3.5,3.6 and 3.7. Three systems have two versions, namely basic and advanced. Itineris has only one version. Itineris version has simile attributes,such as advanced versions of other systems, so here is evaluation only of the advanced versions and Itineris. Basic versions are fully compatible with all machines, only AGCO system is compatible with machinery of group

AGCO. Basic versions do not have many features as advanced version. Advanced versions have more functions and the possibilities of using. Advanced systems have improved functions than the basic version, but they are not fully compatible with all brands and types of machines.

JDLink Ultimate system has a very sophisticated to monitoring of service repairs on machine. System can alert on these corrections.Its disadvantage is very long update rate, so that the controller can not respond immediately to situations which arose at work. The system AgCommand® Advenced Plus has a very sophisticated control of drive, the system can recognize if machine goes or turns on the headland, thanks to this function the system can better calculate distances and areas which were worked. AgCommand® has well-elaborated of monitoring tools in the field, but its update rate is 10 minutes and compatibility only with machinery from group AGCO. These properities make system not suitable for the current requirements of agriculture. Itineris system has not improved version. Its advantage consists in the compactness of almost all agricultural machinery. Another advantage is the update rate. This system provides informations about the machines every minute. The most comprehensive of desribed systems is AFS Connect 2.0 Advanced, this system has all properities from above, so that they appear as the best option for selection. AFS Connect 2.0 Advenced also allows service specialist to check important performance parameters and send directly to the terminal driver in the cab suitable recommendations to increase efficiency. Telematics also possible to check on the progress of field work, which place high demands on precision. But this system is compatible only with the machines mentioned in Tab.1.

Tab. 3 Comparison of telematics systems (Case brochure - edited by author)

FUNCTION	AGCO Your Agriculture Company	JOHN DEERE	AFS CONNECT	
UPDATE RATE	10 MINUTES	1 HOUR	1 MINUTE	1 MINUTE
MACHINE SPECIFIC CAN DATA				
MACHINE DASHBOARD				
MAINTENANCE SCHEDULING				
ADVANCED STATUS				
MACHINE COMPARISON				
MACHINE ALERTS				

5.2 Information about machines

This chapter provides a basic description of the machine, which observation relates.

5.2.1 John Deere 8230

Everywhere in observations is appearing tractor John Deere 8230 as a replacement for John Deere 8220. Tractor began production in 2006. It can be manufactured as row-crop tractor and crawled tractor.

The tractor is equipped with a variable geometry turbocharged diesel engine with 9 l displacement (with 118 mm bore and 136 mm stroke).This engine is a liquid-cooled inline. Inside enginehides 6-cylinder with 24-valve.Rated power of the tractor is 245 hp (182.7 kW) as a maximum power is listed 265 hp (197.6 kW) by EC 97/98. Rated RPM during which the tractor reaches the rated power is 2 100 min^{-1}. Maximum torque is 1 340 Nm. Turbocharging in engine operates on the basis turbo with variable turbine blues

Full power shift transmission operated with right-hand control lever. Transmission defaults to gear 7-forward and 2-reverse on startup, although this may be re-programmed. Automatic PowerShift (APS) enables automatic shifting to maintain engine load. Maximum speed is 40 km/h. Both axles are driving, but the front drive is detachable. Weight of machine is 10 771 kg.[41]

5.2.2 Opall Agri EUROPA 180

Semi-mounted plow Europa II consists of the hinge, chassis, swivel head, suport, frame, axles, wheel, holders of plow bodies and traffic signs.The total width of the plow is 245 cm. Number of working bodies is 7, working width at one blade is 35 cm, so the working width of the plough is 2,45 m. Spacing plow units is 100 cm. The weight of the plow is 3 700 kg. All plowing in the company proceeded to a depth of 20 cm. [40]

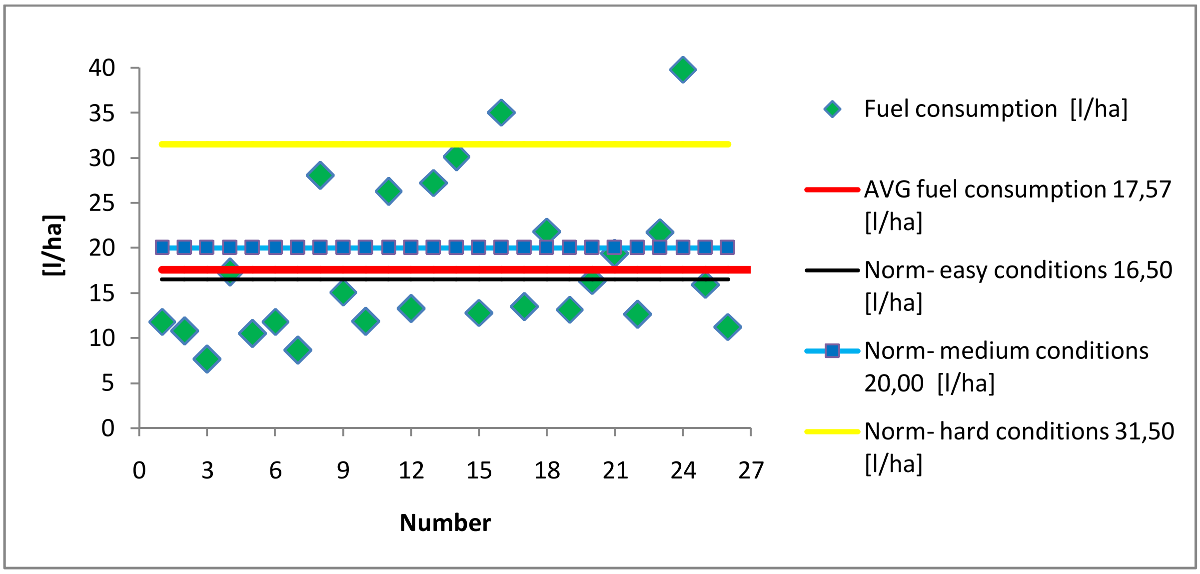
Tab. 4 Operational data of Opall Agri EUROPA 180 (author)

No.	Date	AVG velocity [km/h]	Distance [km]	Theor.area [ha]	Feul Consum. [l]	Working time [hr]	Downtime [hr]	Fuel consum. [l/ha]	Fuel consum. [l/hr]
1	13.8.2013	6	15,631	4,38	51,7	2:33	0:04	11,80	15,51
2	14.8.2013	8	9,546	2,67	72,7	3:38	2:21	10,79	21,81
3	15.8.2013	11	10,151	2,84	74,6	1:16	0:08	7,65	31,97
4	20.8.2013	7	37,151	10,40	79,6	6:05	0:42	17,33	15,26
5	21.8.2013	7	30,381	8,51	114,8	6:15	1:55	10,47	22,01

6	25.8.2013	9	32,587	9,12	115,2	4:44	1:02	11,80	20,69
7	26.8.2013	8	38,494	10,78	116,3	6:08	1:20	8,64	17,67
8	27.8.2013	8	33,397	9,35	119,7	4:33	0:17	28,07	18,18
9	28.8.2013	11	44,489	12,46	130,5	4:20	0:30	15,08	20,88
10	1.9.2013	11	44,489	12,46	130,5	4:20	0:30	11,85	24,94
11	2.9.2013	10	12,334	3,45	137,4	1:20	0:04	26,27	26,25
12	3.9.2013	7	44,092	12,35	138,9	7:10	0:43	13,25	22,34
13	4.9.2013	8	16,955	4,75	143	3:20	1:20	27,23	23,00
14	5.9.2013	6	28,484	7,98	154,7	6:13	1:48	30,11	16,88
15	8.9.2013	8	45,045	12,61	166	6:35	0:49	12,80	41,50
16	9.9.2013	8	17,305	4,85	170	2:32	0:16	35,05	22,82
17	10.9.2013	8	38,975	10,91	178,6	5:13	0:27	13,49	23,97
18	11.9.2013	7	42,372	11,86	178,9	7:08	1:21	21,84	26,97
19	15.9.2013	12	41,169	11,53	183,7	4:00	0:37	13,16	42,39
20	16.9.2013	10	55,47	15,53	184	6:27	1:08	16,37	30,00
21	17.9.2013	11	81,422	22,8	197,1	9:10	1:46	19,39	32,14
22	29.9.2013	8	40,924	11,46	198,6	5:34	0:39	12,63	32,65
23	30.9.2013	8	36,392	10,19	217,1	5:05	0:04	21,77	30,43
24	31.9.2013	8	38,812	10,87	237,4	5:14	0:25	39,83	33,28
25	3.10.2013	13	69,959	19,59	259,5	6:38	0:52	15,93	42,54
26	4.10.2013	8	45,185	12,65	275,4	6:06	0:23	11,25	45,15
27	5.10.2013	7	36,409	10,19	286	5:29	0:28	10,47	52,16

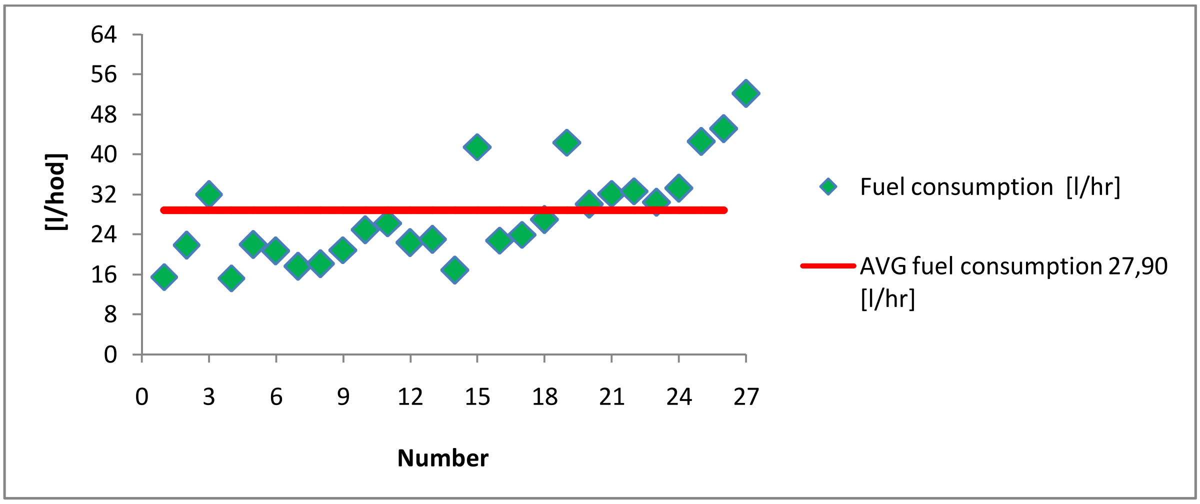
During the ploughing, 27 records were measured. Records are dated in the autumn of 2013. From the data it is possible to calculate average area of plowing per hour by simple calculation. This average is 1,97 ha/hr. Plowing was performed to a depth of 20 cm.

Fig. 6 Comparison of fuel consumption per hectar of ploughing with Opall Agri EUROPA 180 (author)



The Tab.4 and the Fig. 7 show that the consumption is generally just below the minimum expected value. It is due to the fact that the tractor drove by low velocities. The measurements, which occurs higher average consumption can be noticed higher velocity or these measurements are influenced by the composition of the soils and weather conditions. According to the normative can be also seen that the tractor does not use rated power to the full.At a given plowing depth, it is only 60%.

Fig. 7 Fuel consumbtion of ploughing with Opall Agri EUROPA 180 (author)



From the Fig.8 and Tab.4 it is apparent that the fuel consumption per hour is directly dependent on the movement and velocity of the tractor. Most other values are close to average, if not, then it is probably due to the weather and soil type.

In plowing by Opall Agri EUROPA 180, the average fuel consumption is 17.57 $l.ha^{-1}$, which according to the standards indicates light conditions, but plowing should belong to the heavier conditions, if the time hasto be effective. AVG Fuel consumption per hour is 27,90 $l.hr^{-1}$.

5.2.3 STROM Terraland TD 3000

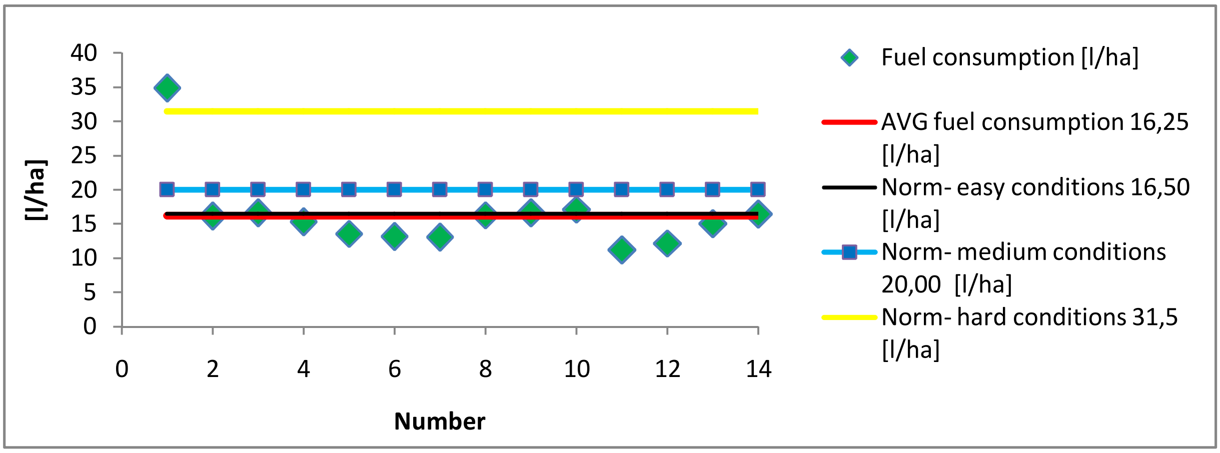
STROM Terraland TD is a machine allowing more than ploughing, the overall concept of the machine allows adequate replacement of the classic ploughing while the day performance increases (speed of operation 6-10$km.hr^{-1}$). It is a semi-mounted chisel plow with working width of 3 m. Total machine weight is 2 510 kg. The machine has 7 working bodies.This machine processed stubble to a depth of 20-30 cm.Working width of the implement is 6 m.

Tab. 5 The operational data of STROM Terraland TD 3000 (author)

No.	Date	AVG velocity [km/h]	Distance traveled [km]	Theoretical area [ha]	Feul Consumption [l]	The working time [hr]	Downtime [hr]	Fuel consum. [l/ha]	Fuel consum. [l/hr]
1	4.8.2013	6	3,859	1,03	35,9	0:37	0:23	34,85	58,22
2	8.8.2013	10	8,614	2,58	41,7	0:57	0:34	16,16	43,89
3	13.8.2013	16	9,802	3,28	54,4	1:40	0:26	16,59	32,64
4	15.8.2013	10	22,472	5,98	91,5	2:31	0:00	15,3	36,36
5	9.10.2013	8	23,689	7,11	96,5	3:10	0:13	13,57	30,47
6	15.10.2013	9	27,686	8,31	109,3	2:31	0:21	13,15	43,43
7	20.10.2013	10	29,291	8,4	109,7	2:26	0:36	13,06	45,08
8	23.10.2013	8	23,826	7,15	116,5	4:51	0:11	16,29	24,02
9	26.10.2013	8	23,548	7,06	117,2	4:33	1:37	16,6	25,76
10	28.10.2013	8	23,778	7,13	122	4:12	1:26	17,11	29,05
11	1.11.2013	11	46,071	13,82	154,2	4:57	0:36	11,16	31,15
12	3.11.2013	9	53,45	16,04	195,3	7:19	1:36	12,18	26,69
13	7.11.2013	10	55,752	16,73	251,2	7:00	1:19	15,01	35,89
14	10.11.2013	11	62,294	18,69	307,1	7:22	1:31	16,43	41,69

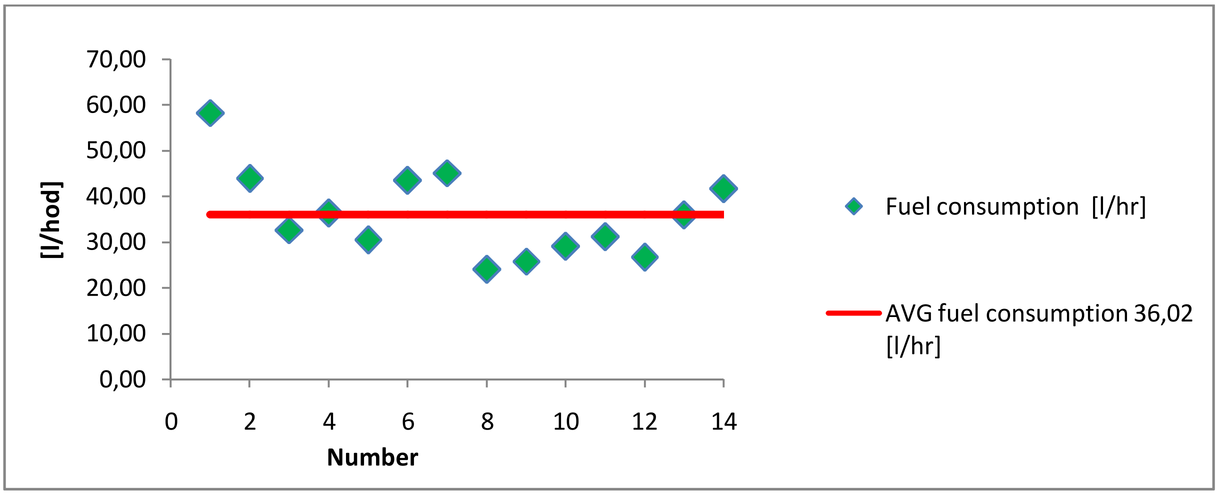
14 records were measured during ploughing of manure. Records are dated in the autumn of 2013. From the data is possible to calculate average area of plowing per hour by simple calculation. This average is 2,34 $ha.hr^{-1}$. Plowing was performed to a depth of 20-30 cm.

Fig. 8 Comparison of fuel consumption per hectar of ploughing by STORM Terraland TD (author)



The Tab.5 and the Fig. 9show that the consumption is generally just below the minimum expected value. It is due to the fact that the tractor rode in low velocities due to the connected implement. According to the normative can be also seen that the tractor do not use its rated power even at 60%.

Fig. 9 Fuel consumption of ploughing with STORM Terraland TD (author)



The Tab. 5 and the Fig. 10 show that the fuel consumption per hour is directly dependent on the way of driving and velocity. The first measurement probably was not successful and so it is wrong. The cause may be a short working time or weather conditions and soil type.

During procedure, the average fuel consumption is 16.25 $l.ha^{-1}$, which according to the standards indicates light conditions, however ploughing of manure should belong to hard conditions, if the time to be effective. Therefore, to increase efficiency and time savings should be aggregated implement with bigger working width or current implement should be aggregated into a tractor with lower performance. The tractor is luxuriously powerful for this implement and depth. Fuel consumption per hour is 36.02 $l.hr^{-1}$.

5.2.4 STROM SwifterSO 6000 F

The SWIFTER SO_F is a seedbed cultivator. Simple and lightweight it combines all working operations (up to 7) for seedbed preparation in a single pass. The machine can be used for conventional farming as well as minimum tillage systems. The machine facilitates easy exchange of an internal working sections. Implement type is semi-mounted seedbed cultivator. [37]

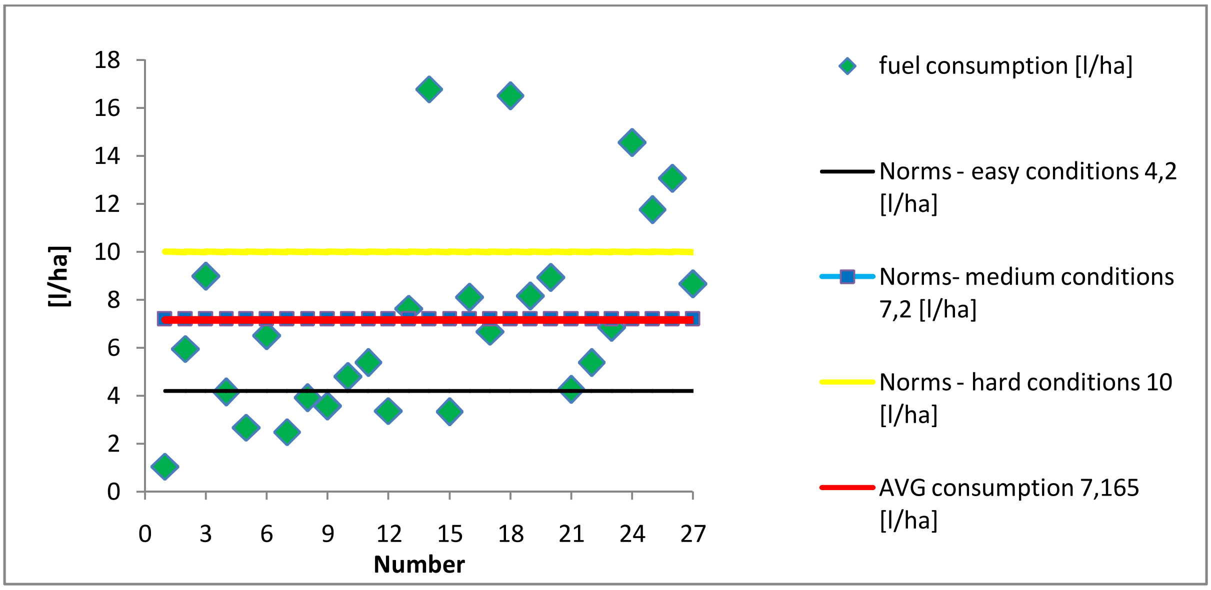
Tab. 6 The operational data of STROM Swifter SO 6000 F (author)

No.	Date	Avarage velocity [km/h]	Distance traveled [km]	Theoretical area [ha]	Feul Consumption [l]	The working time [hr]	Downtime [hr]	Fuel consum. [l/ha]	Fuel consum . [l/hr]
1	2.4.2013	13	24,555	14,73	15,4	2:04	0:12	1,05	7,45
2	3.4.2013	16	4,729	2,84	16,9	0:21	0:07	5,95	48,29
3	4.4.2013	9	4,603	2,76	24,8	0:53	0:21	8,99	28,08
4	5.4.2013	8	12,251	7,35	30,5	1:46	0:16	4,15	17,26
5	6.4.2013	13	19,51	11,71	31,3	1:31	0:03	2,67	20,64
6	8.4.2013	8	10,076	6,05	39,3	1:55	0:20	6,50	20,50
7	9.4.2013	9	27,553	16,53	41,0	4:26	1:13	2,48	9,25
8	15.4.2013	11	20,137	12,08	47,3	2:16	0:23	3,92	20,87
9	20.4.2013	12	40,018	24,01	85,5	3:44	0:23	3,56	22,90
10	21.4.2013	9	34,861	20,92	100,3	4:44	0:52	4,79	21,19
11	22.4.2013	10	32,015	19,21	103,2	4:34	1:23	5,37	22,60
12	23.4.2013	12	53,499	32,10	108,0	5:30	1:03	3,36	19,64
13	24.4.2013	10	23,641	14,18	108,2	2:28	0:09	7,63	43,86
14	28.4.2013	9	11,994	7,20	120,9	1:20	0:00	16,79	90,68
15	29.4.2013	11	60,911	36,55	121,6	6:29	0:49	3,33	18,76
16	30.4.2013	8	28,194	16,92	137,1	4:31	0:47	8,10	30,35
17	1.5.2013	11	35,762	21,46	143,2	4:27	0:56	6,67	32,18
18	2.5.2013	11	14,492	8,70	143,6	3:21	1:45	16,51	42,87
19	7.5.2013	10	30,555	18,33	149,6	3:27	0:24	8,16	43,36
20	8.5.2013	11	28,273	16,96	151,3	2:46	0:14	8,92	54,69
21	9.5.2013	12	59,405	35,64	151,8	5:59	0:46	4,26	25,37
22	10.5.2013	10	50,407	30,24	162,9	6:00	1:02	5,39	27,15
23	11.5.2013	12	52,342	31,41	215,3	5:56	1:03	6,85	36,29
24	12.5.2013	10	24,801	14,88	216,7	3:00	0:39	14,56	72,23
25	13.5.2013	9	30,972	18,58	218,5	4:37	1:02	11,76	47,33

26	15.5.2013	10	33,977	20,39	266,4	4:24	0:48	13,07	60,55
27	16.5.2013	11	60,469	36,28	314,4	6:24	1:06	8,67	49,13

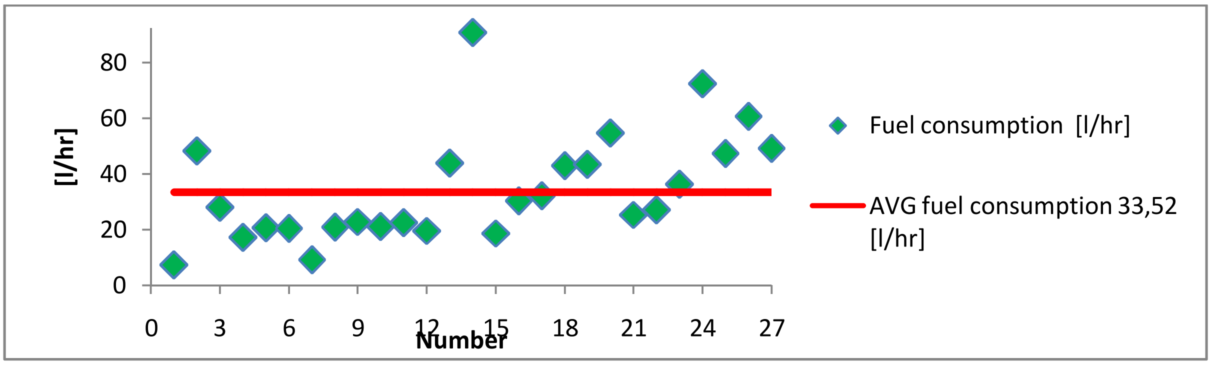
Data from seedbed cultivating in years 2013/2014 is given in Tab.5. This data have been selected from telematic system. From the data is possible to calculate average area of cultivating per hour by simple calculation. This average is 5,03 $ha.hr^{-1}$.

Fig. 10 Comparison of fuel consumption per hectar of seedbed cultivating with STROM Swifter SO 6000 F (author)



Based on the results indicate that seedbed cultivating held by the majority of assumptions and measurements were around average, some even came out in table values.Measurements that are above average have a higher average velocity.The first measurement is probably an error in the amount of fuel consumption. The error could be caused, because at the time of measurement, tractor was not in a horizontal position, then the float in the fuel tank gave bad value.

Fig. 11 Fuel combustion of seedbed cultivating with STROM Swifter SO 6000 F (author)



As the Tab.6 and Fig.12 show, the measured values have two bigger deviations, the first one is caused by incorrect measurements, however, this error has no significant impact on objectivity, thus it does not need to be removed. The second is caused by a high average velocity of implement at work.

Average fuel consumption is 7,165 $l.ha^{-1}$, because tabulated value for secondary conditions is 7.2 $l.ha^{-1}$, so we can say about the measurements that were conducted in accordance table values. Deviations in consumption are caused by higher average velocity of implement for measurement or by wrong reading. This mistake could be caused by poor position of the float in the tank when the readings. Average fuel consumption of cultivatingis 33.52 $l.hr^{-1}$. Values are generally simile than the average. Two deviations are caused by the aforementioned bad position of the float in the tank. The performance of implement is 5,04 $ha.hod^{-1}$.

5.2.5 LEMKEN Solitair 9 + Heliodor

Pneumatic seed drill Solitair + disc harrow heliodor from company LEMKEN makes the exact distribution and depth of seed placement are secured by structure. The working width of the drill is 6 m. Machine weight without fulfillment is 1 540 kg + 3 550 kg. The number of lines on the machine is 48 with a pitch of 125 mm. Hopper capacity is 1 850 liters.The drill has Solitronic board computer that has a compatible control module with GPS. [39]

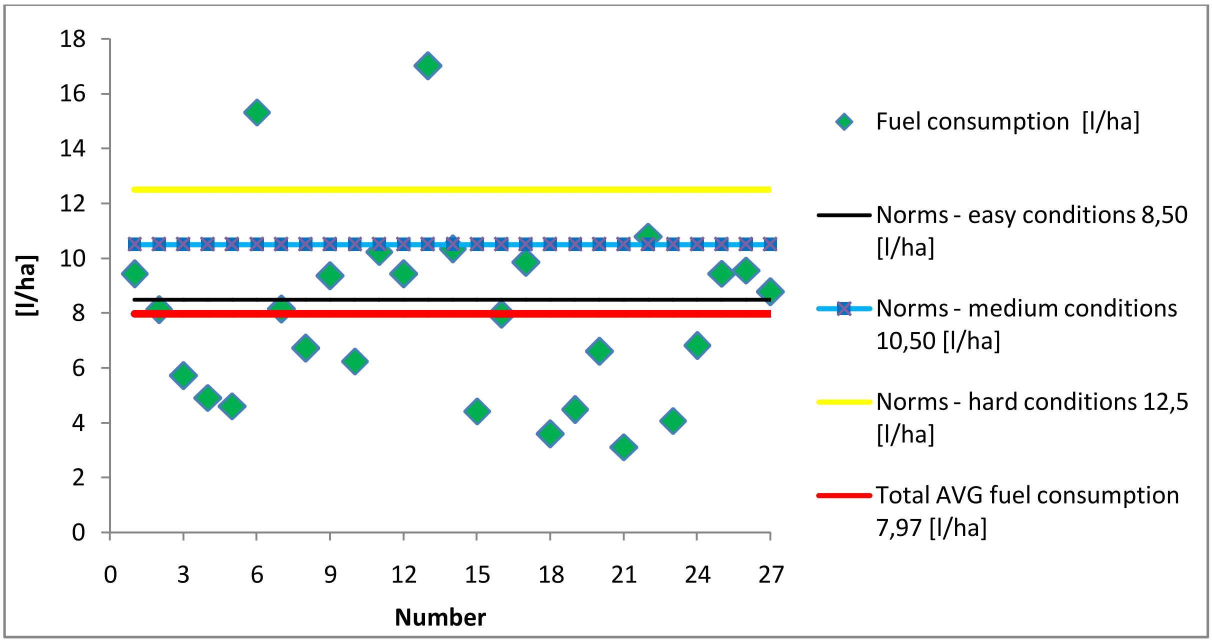
Tab. 7 The operational data of Lemken Solitair 9 (author)

No.	Date	Avarage velocity [km/h]	Distance traveled [km]	Theoretical area [ha]	Feul consum. [l]	The working time [hr]	Downtime [hr]	Fuel consum.n [l/ha]	Fuel consum . [l/hr]
1	16.4.2013	11	15,35	9,21	86,9	1:43	0:18	9,44	50,62
2	17.4.2013	10	53,25	31,95	259,6	6:56	1:52	8,13	37,44
3	18.4.2013	12	48,27	28,96	165,6	5:10	1:05	5,72	32,05
4	19.4.2013	12	74,38	44,63	219,4	8:27	2:12	4,92	25,96
5	23.4.2013	12	44,51	26,70	123,2	5:27	1:33	4,61	22,61
6	24.4.2013	9	25,96	15,58	238,8	4:02	0:59	15,33	59,21
7	28.4.2013	13	4,67	2,80	22,8	0:32	0:11	8,14	42,75
8	29.4.2013	10	49,79	29,87	200,8	6:59	2:06	6,72	28,75
9	30.4.2013	9	39,82	23,89	223,6	6:31	1:46	9,36	34,31
10	31.8.2013	11	35,75	21,45	134,0	4:06	0:58	6,25	32,68
11	1.9.2013	14	22,57	13,54	138,6	3:01	1:34	10,24	27,63
12	2.9.2013	11	59,73	35,84	338,1	7:30	2:06	9,43	45,08

13	3.9.2013	11	35,42	21,25	361,6	5:26	2:06	17,02	66,55
14	4.9.2013	10	34,99	21,00	217,2	4:27	1:17	10,34	48,81
15	5.9.2013	12	73,07	43,84	193,9	8:02	1:39	4,42	24,14
16	10.9.2013	28	22,49	13,49	107,4	0:55	0:10	7,96	117,16
17	15.9.2013	8	14,14	8,48	83,6	2:00	0:10	9,86	41,80
18	16.9.2013	12	19,31	11,59	41,7	1:45	0:09	3,60	23,83
19	17.9.2013	12	82,296	49,38	221,5	8:36	1:25	4,49	25,76
20	18.9.2013	11	58,486	35,09	232,1	6:53	1:18	6,61	26,13
21	19.9.2013	13	28,735	17,24	53,7	2:52	0:45	3,11	18,73
22	21.9.2013	11	35,282	21,17	228,5	3:52	0:45	10,79	59,09
23	22.9.2013	12	35,483	21,29	86,7	3:12	0:16	4,07	27,09
24	23.9.2013	12	48,472	29,08	198,2	5:42	1:45	6,82	53,57
25	24.9.2013	12	59,547	35,73	337,4	7:12	2:03	9,44	46,86
26	25.9.2013	12	44,216	26,53	253,7	4:59	1:35	9,56	50,91
27	28.9.2013	12	48,635	29,18	256,2	4:14	0:23	8,78	60,52

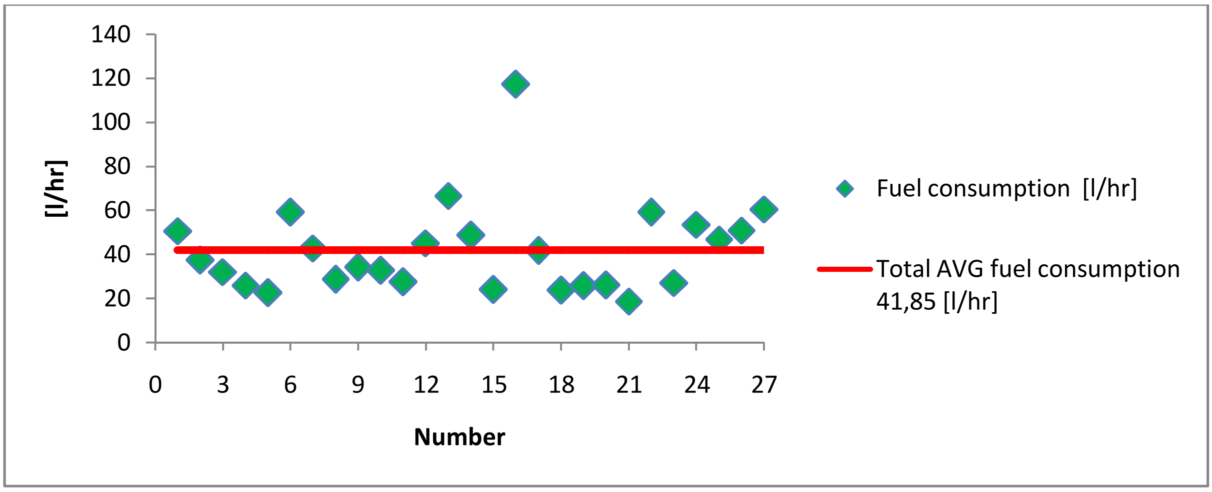
During the working process of seeding crops were selected 27 records from year 2013.From the data is easy to take the average performance of implement. The AVG performance of implement is 5, 12 $ha.hr^{-1}$.

Fig. 12 Comparison of fuel consumption per hectar of seeding with Lemken Solitair 9 (author)



Of sorted datain the Tab.7 was calculated fuel consumption (l) per hectare (ha), which are plotted in the Fig.13.According to the graph, it is evident that the some measurements areidentical with tabulated values.That means that the working process is carried out according to the table values.However, much of the ride has a lower average fuel consumption than easy conditions, this is caused by seedingsystém, that is used in conditions where there implement Heliodor does not needed, but company used it for better preparation of the seedbed.

Fig. 13 Fuel consumption of seeding with LEMKEN Solitair 9 (author)



The Tab.7 and Fig. 14 show that most of the fuel consumption measurement was approximately identical. Only one measuring of fuel consumption is higher. That is caused by the high average velocity.

According to the Fig.13, it is evident that the average consumption is 7.97 $l.ha^{-1}$. The Fig.14shows that the average fuel consumption per hour is similar for all measurements except for measurement, where the average speed is 28 $km.h^{-1}$. This speed caused a large deviation from the other values in fuel consumption. At this speed, the driver consumed 107, 4 liters of fuel on the theoretical area of 13.49 hectares. However, the area was planted in 55 minutes. AVG fuel consumption per hour is 41,85 $l.hr^{-1}$.

5.2.6 Simba X-Press

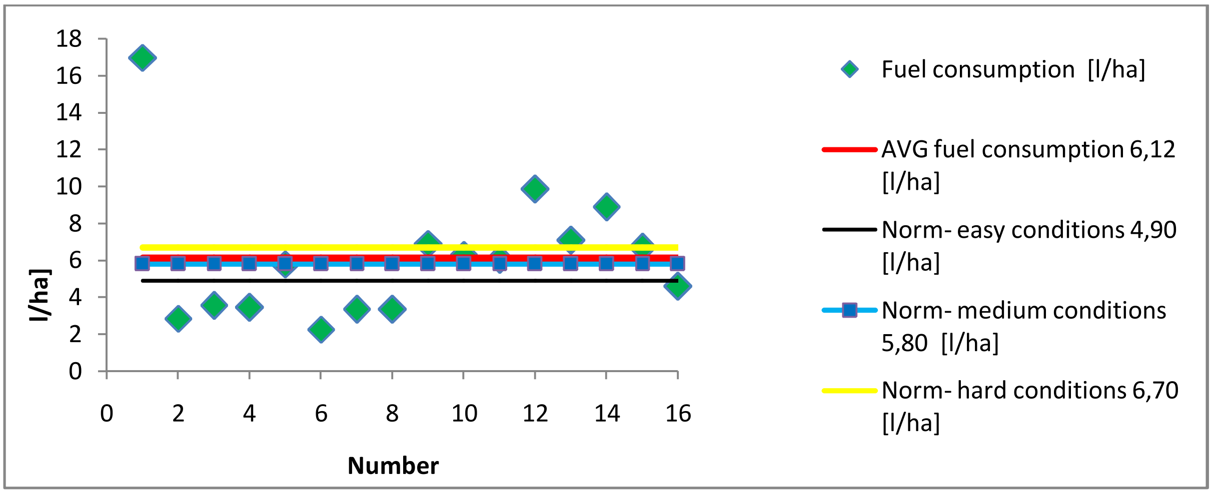
X-Press is very versatile a disc cultivator. This implement is using for high-quality crop stubble after harvest or seedbed preparation.Individually imposed the toothed plates with a diameter of 510 mm are in two rows, hung on robust frame spring steel.Depth of stubble by this machine is up to 25 cm. Working width of the implement is 5,5 m. Simba X-Press works with 44 discs. The total weight of the semi-mounted machine 6 350 kg. This machine processed stubble to a depth of 5-10 cm. [38]

Tab. 8The operational data of Simba X-press (author)

No.	Date	Avarage velocity [km/h]	Distance traveled [km]	Theoretical area [ha]	Feul Consumption [l]	The working time [hr]	Downtime [hr]	Fuel consum. [l/ha]	Fuel consum. [l/hr]
1	2.4.2014	11	3,724	2,05	34,8	0:28	0:08	16,98	74,57
2	3.4.2014	12	22,892	12,59	35,8	2:10	0:11	2,84	16,52
3	4.4.2014	13	28,551	15,70	55,7	2:42	0:29	3,55	20,63
4	5.4.2014	15	32,063	17,63	60,7	2:16	0:08	3,44	26,78
5	6.4.2014	12	19,287	10,61	61,4	3:24	1:50	5,79	18,06
6	7.4.2014	10	54,191	29,81	67,0	5:58	0:56	2,25	11,23
7	28.4.2014	11	49,921	27,46	91,5	5:48	1:13	3,33	15,78
8	15.5.2014	16	56,226	30,92	103,5	5:47	2:06	3,35	17,90
9	16.5.2014	26	33,28	18,30	126,2	1:40	0:24	6,90	75,72
10	28.5.2014	9	45,02	24,76	156,0	5:30	0:29	6,30	28,36
11	15.6.2014	11	50,841	27,96	168,7	5:14	0:40	6,03	32,24
12	30.6.2014	10	35,677	19,62	193,4	4:01	0:32	9,86	48,15
13	17.7.2014	13	50,899	27,99	198,5	4:12	0:05	7,09	47,26
14	18.7.2014	13	45,116	24,81	220,4	4:42	0:58	8,88	46,89
15	19.7.2014	10	61,552	33,85	227,0	6:43	0:44	6,71	33,80
16	15.8.2014	10	122,698	67,48	309,1	13:37	1:39	4,58	22,70

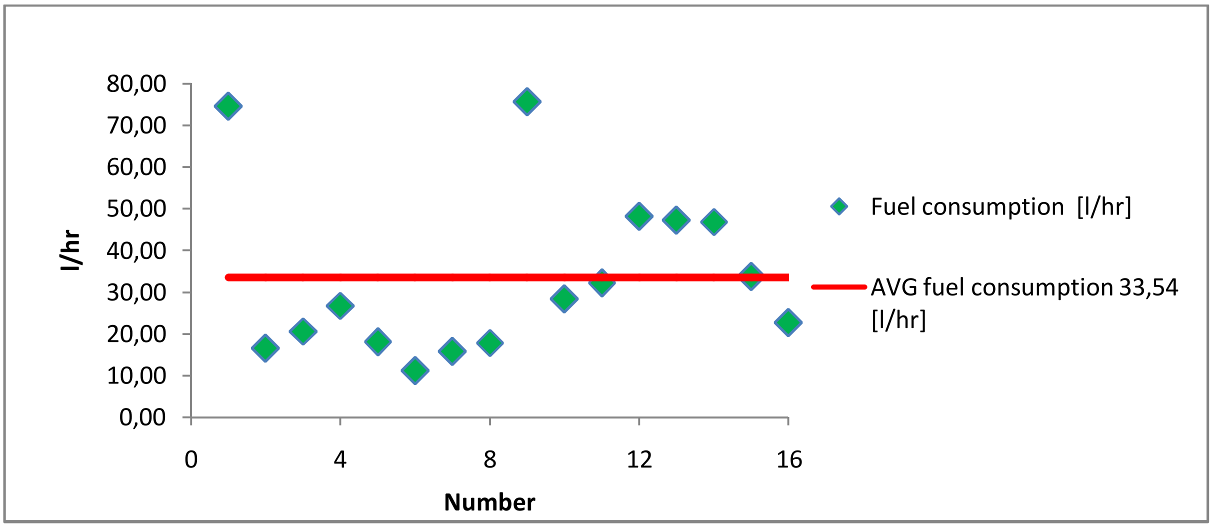
This implementis used in the company on the field with worse conditions for preparation of sowing soil. All data are from 2014. The performance of the machine is 5.28 ha.hr^{-1}.

Fig. 14 Comparison of fuel consumption of stubble breaking with Simba X-press (author)



The Fig.15 shows that the average consumption per hectare based on the appropriate standards. This means that the working process is carried out according to the table values.

Fig. 15 Fuel consumption of Simba X-press (author)



As the Tab. 8 and the Fig. 16 show two significant deviations are caused in the first case by a short period of working operation and in the second case by a high average of the velocity and thereby also an increased engine speed, which is positive for the implement work, but not for fuel consumption.

The Fig. 15 shows that the average fuel consumption per hectare is 6.12 $l.ha^{-1}$, the assumed value was of the medium 5,80 $l.ha^{-1}$. Most of the values corresponds with range of 2-10 $l.ha^{-1}$.This is caused by different soil conditions or weather.The first measurement is not aligned to given standards, but also was measured only 28 minutes, so that the result can not be evaluated as relevant. Average fuel consumption per hour at stubble breaking by cultivator Simba X-press is 33.54 $l.hr^{-1}$.The performance of implement is 5,28 $ha.hod^{-1}$.

Tab. 9 Implements overview (author)

	Working width (m)	Depth of process (cm)	Weight of implement (kg)	Performance (ha/hr)	Fuel consumption (l/ha)
Simba X-press	5,5	10	6 350	5,28	6,12
LEMKEN Solitair 9 + Heliodor	6	x	5090	5,12	7,97
STROM Swifter SO 6000 F	6	10	4400	5,03	7,165
STROM Terraland TD 3000	3	20	2 510	2,34	16,25
Opall Agri EUROPA 180	2,45	20	3 700	1,97	17,57

Tab.9 briefly covered all implements, which were monitored. The table shows the working width, working depth, weight, performance and fuel consumption.

6. Discussion and conclusion

The main objective of this work was to evaluate the operational data of the tractor on the basis of information on the operation of its telematics system, which used data from worksheets and made notes on the operation possible.The telematics system allows the monitoring of fuel consumption of individual rides and the wearing down of various parts of the tractor

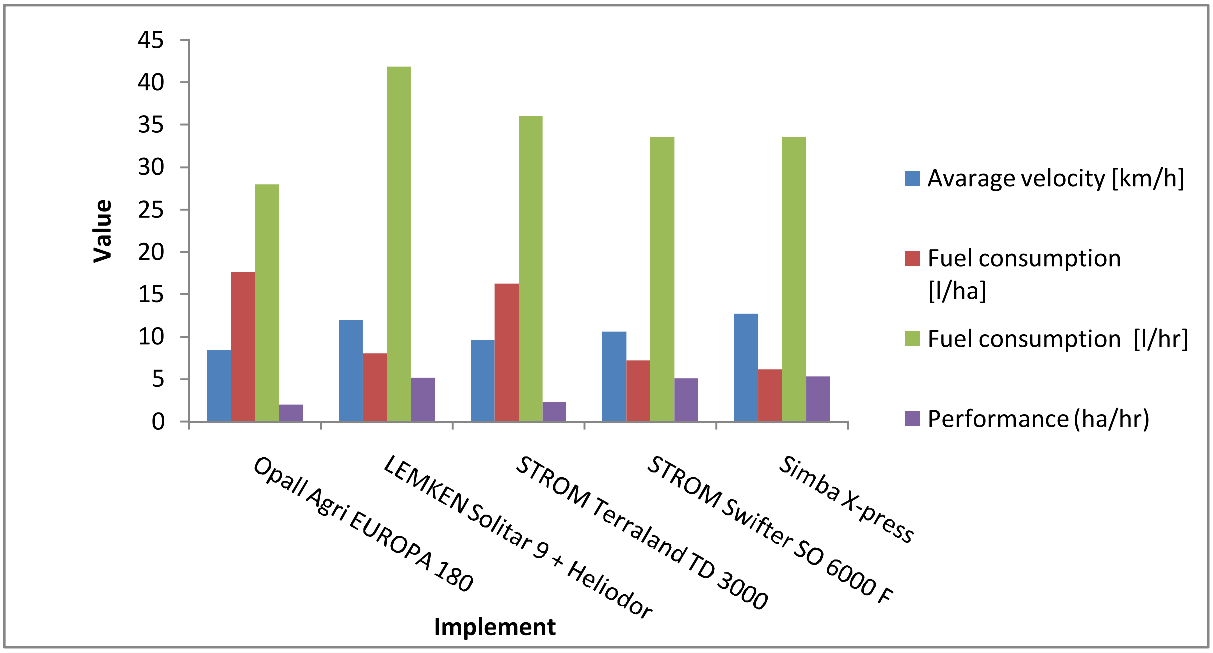
From the work,the ways in which data can be used to improve processes in fields with implements and how to manage the farm by matching the suitable tractor with the selected implements is obvious.

The telematics system can only bring small savings that result from facilitating and streamlining work by an agronomist or another authorized person. The biggest savings result from the measures that are introduced into the processes through which data from the system is detected throughthe lack of aggregation by the tractor which is stronger than is needed to be for implement. The system thus mainly controlled by the operator can check the entire fleet of machines. Also, thanks to the system the servicing of maintenance machines can be planned. Therefore, if the measures are in place, based on the information, they need to be respected and checked continuously. Only in this way can the telematics system acquire a desired economic effect (saving the operation technology outweighs the cost of acquiring and maintaining technology).

According to the norms, it was found that the tractor JD 8230 is in aggregation with plow Opall Agri EUROPA 180 more than sufficiently. For this tractor could be aggregated implement with a larger working width. The same applies for the implement STROM Terraland TD 3000.

The aggregation with JD 8230 showed that the plowing implement STROM Terraland TD 3000 is better than a plow Opall Agri EUROPA 180. Although it has a higher average consumption of 36.02 $l.hr^{-1}$, due to an average fuel consumption per hectare 16.25 $l.ha^{-1}$ and performance is 2.34 $ha.hr^{-1}$, this implement is better for soil preparation. Plow consumes 17.57 $l.ha^{-1}$. The performance of plough is only 1.97 $ha.hr^{-1}$. This aggregation has only one advantage in the fuel consumption. The fuel consumption is 27.90 $l.hr^{-1}$.

Fig. 16 Comparison of resulting values (author)



Implement Opall Agri EUROPA 180 has following results. The avarage velocity is 8,36 km.hr^{-1}. Performence of the implement is 1,97 ha.hr^{-1}. The fuel consumption is 27,90 l.hr^{-1}. These free values are lowest from the observed machines. The avarage fuel consumption per hectar is 17,57 l.ha^{-1}.

Results of implement LEMKEN Solitar 9 + Heliodor are following. The avarage velocity is 11,93 km.hr^{-1}. The fuel consumption is 41,85 l.hr^{-1}, this value is the biggest of fuel consumptions per hour. Performence of implement is 5,12 ha.hr^{-1} and fuel consumption per hectar is 7,97 l.ha^{-1}.

The avarage velocity of STROM Terraland TD 3000 is 9,57 km.h^{-1}. The performance of implement is 2,27 ha.hr^{-1}. Fuel consumption per hectar is 16,25 l.ha^{-1} and fuel consumption per hour is 36,02 l.hr^{-1}.

Results of implement Simba X-press are following. The avarage velocity is 12,65 km.hr^{-1}. Performence of implement is 5,12 ha.hr^{-1}. These two values are the biggest from measurements. The fuel consumption is 33,54 l.hr^{-1} and fuel consumption per hectar is 6,12 l.ha^{-1}. The fuel consumption per hectar is the lowest from measurements.

The avarage velocity of STROM Swifter SO 6000 F is 10,56 km.h^{-1}. The performance of implement is 5,04 ha.hr^{-1}. Fuel consumption per hectar is 7,17 l.ha^{-1} and fuel consumption per hour is 33,52 l.hr^{-1}.

The measurement shows that work with implements at higher velocity cause higher fuel consumptions and thus higher input costs. But with the higher velocity of the implements, company will get more time for operations which follow.This time provides reserves in the manufacturing process for unexpected situations, such as bad weather conditions or machine failure. The system also clearly records operations every day and this creates a better overview of the use of the machines. From this clarity,necessary breaks for services such as oil changes and other reasons can be schedule.

Due to the bigger purchase and operating costs this system pays off only in larger companies with several employees, because agronomist has an overview of everything that is going on without needing to leave the office. This creates a higher work efficiency and time savings for individual processes.

The improvement of telematics systems will lead to a reduction of the impacts on the environment. I recommend the development of a tool which refines the measurement of fuel in the tank. Furthermore, it should record the weather from eachoperating day, and the soil structure of the land. These factors have a strong influence on the measurement accuracy.

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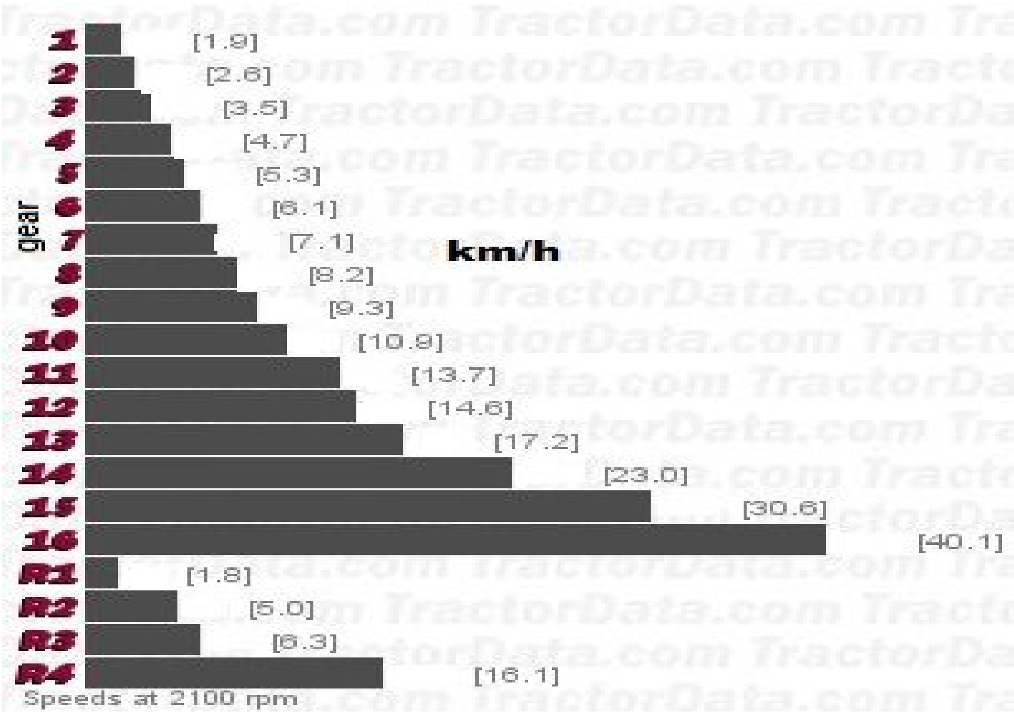
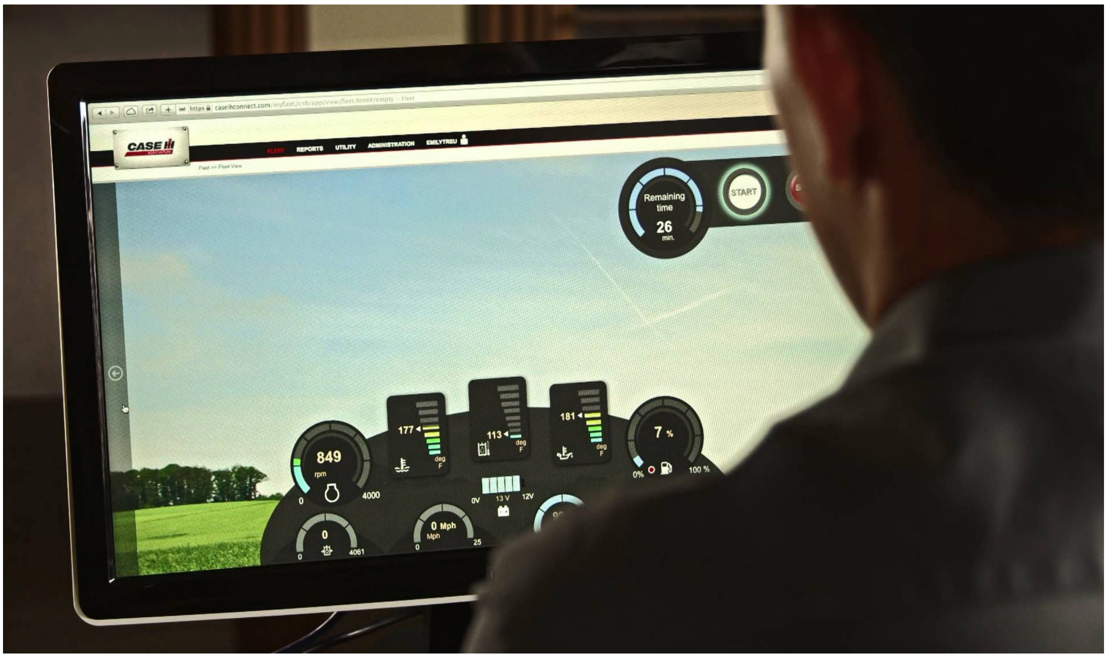
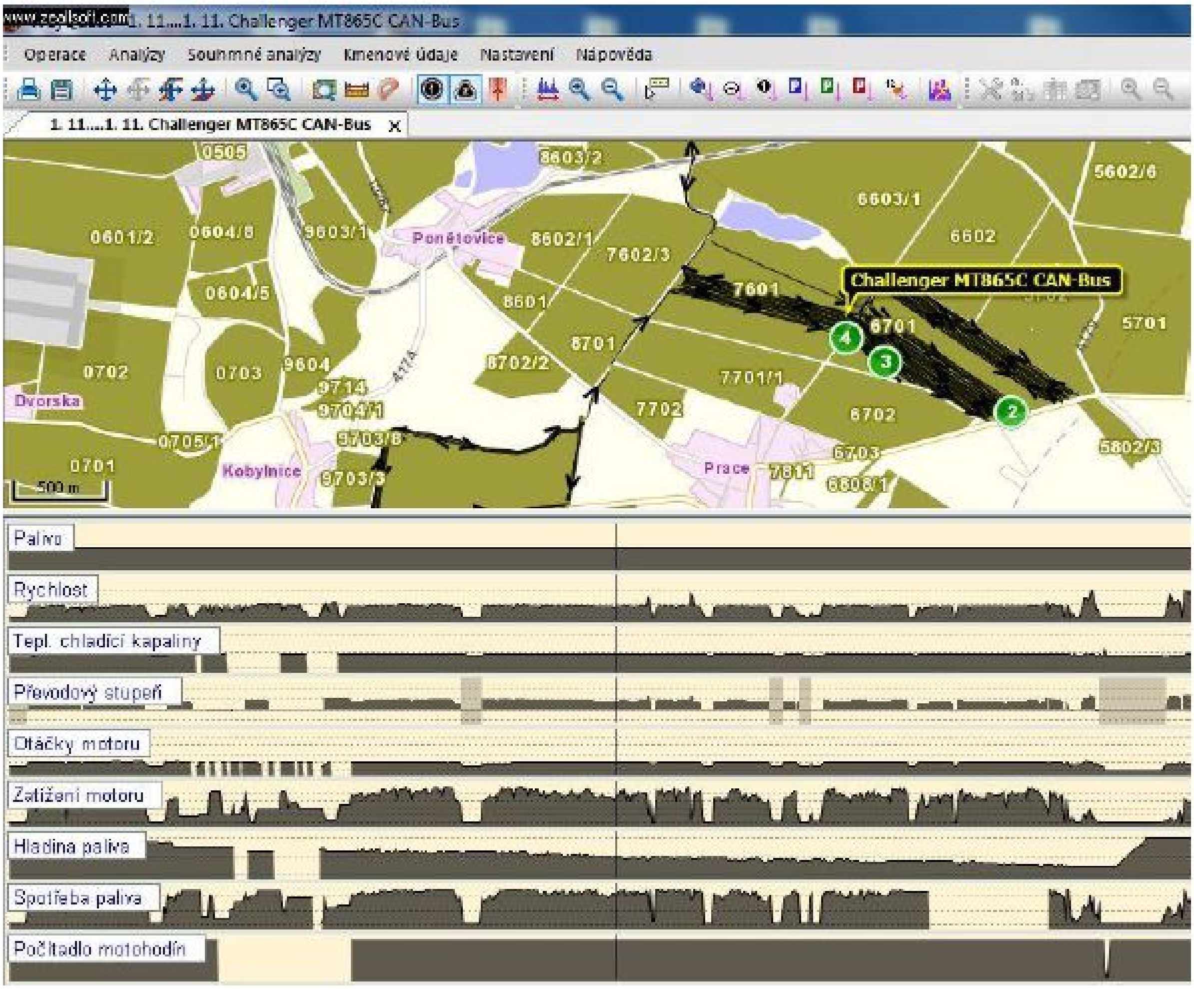


App 1. The dependence of speed on gear JD 8230 (www.Tractordata.com)

App 2 Dependence of fuel consumption on performance -JD 8230 (www.TractorData.com)



App 3 Dashboard AFS 2.0 Connect (Case brochure)



App 4 CAN BUS monitoring by system Itineris (Itineris brochure)

Místo události: 5001_1
Plocha [ha]: 23.975

Řidič	Pracovní proces	Počáteční čas	Konečný čas	SPZ	Čas strávený na parcele	Pracovní mechanizace	Celková doba motoru v chodu	Celkový čas jízdy	Prostoj	Ujetá vzdálenost [km]	Průměrná rychlost [km/h]	Max. rychlost [km/h]	Obrobená plocha [ha]	Odhadovaná plocha [ha]
Urbášek Petr	Podmítka Quadro	23.8.2012 16:54:44	17:49:59	F933	0:54:47	Kockerling Quadro	0:54:47	0:47:06	0:07:41	9.555	12.17	16	3.68	5.45
Urbášek Petr	Podmítka Quadro	24.8.2012 10:48:47	14:17:48	F933	2:54:07	Kockerling Quadro	2:44:10	2:34:10	0:19:57	30.269	11.78	24	11.81	17.25
Urbášek Petr	Podmítka Quadro	27.8.2012 13:04:57	13:44:04	F933	0:38:52	Kockerling Quadro	0:38:52	0:29:34	0:09:18	5.047	10.24	16	2.06	2.88
Vymazal Roman	Podmítka Besson	24.8.2012 10:38:35	11:59:15	F924	1:20:31	Gregoire Besson	1:20:31	1:08:31	0:12:00	12.438	10.89	14	5.16	5.60
?	Setí Vaderstad	27.8.2012 13:23:41	16:59:40	F930	3:34:46	Vaderstad Rapid A 600s	3:34:46	3:09:24	0:25:22	52.132	16.51	27	23.79	31.28
Celkem					**9:23:03**		**9:13:06**	**8:08:45**	**1:14:18**	**109.441**	**13.44**	**27**	**46.50**	**62.45**

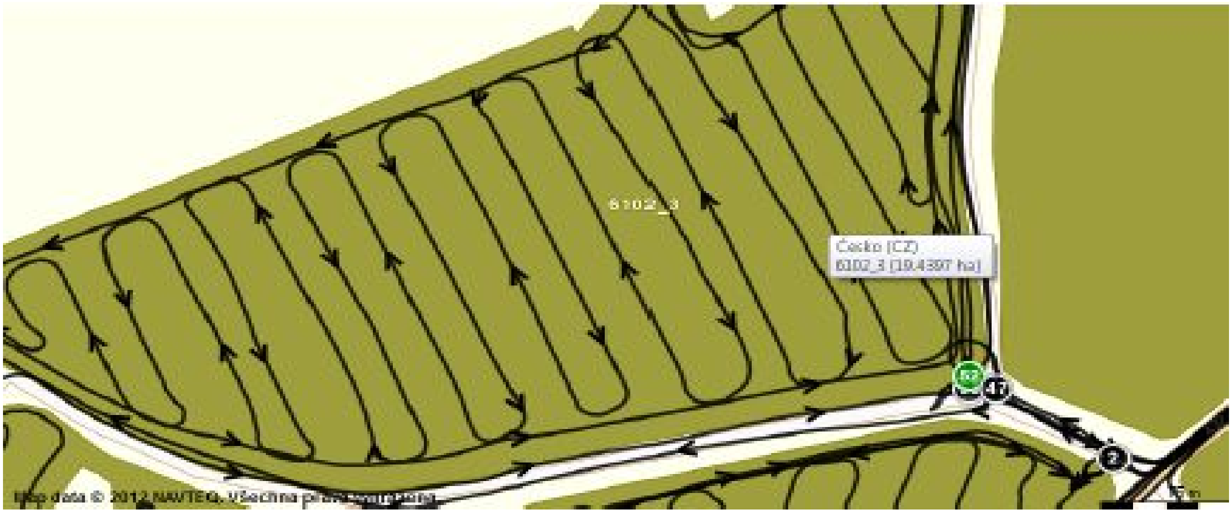
App 5 The book of operations - sorting by plots (Itineris brochure)

Řidič: Pochop Aleš
Datum: 26. března 2012

Termín odjezdu	Doba příjezdu	SPZ	Doba jízdy	Ujetá vzdálenost [km]	Místo odjezdu	Místo příjezdu	Kategorie lokality	Doba čekání	Průměrná rychlost [km/h]	Max. rychlost [km/h]
7:40:20	7:41:57	MT575B	0:01:37	0.062	Středisko Mělkovice (Žďár nad Sázavou)	Středisko Mělkovice (Žďár nad Sázavou)	Údržba	0:39:26	2.30	6
8:21:23	8:21:39	MT575B	0:00:16	0.018	Středisko Mělkovice (Žďár nad Sázavou)	Středisko Mělkovice (Žďár nad Sázavou)	Údržba	0:26:14	4.05	25
9:33:33	10:59:34	MT575B	1:26:01	34.580	Středisko Mělkovice (Žďár nad Sázavou)	...Herálec fekál plnění č.1 [40 m] (Herálec)	Fekál plnění	0:13:44	24.12	56
11:37:05	11:39:13	MT575B	0:02:08	0.412	...Herálec fekál plnění č.1 [39 m] (Herálec)	Herálec fekál plnění č.2 (Herálec)	Fekál plnění	0:10:25	11.59	20
11:49:38	12:26:53	MT575B	0:37:15	12.552	Herálec fekál plnění č.2 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:37	20.22	54
12:37:30	13:15:02	MT575B	0:37:32	12.681	Herálec fekál plnění č.1 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:06	20.27	56
13:25:08	14:00:59	MT575B	0:35:51	12.371	Herálec fekál plnění č.1 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:04	20.70	54
14:11:03	14:49:03	MT575B	0:38:00	12.735	Herálec fekál plnění č.1 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:35	20.11	54
14:59:38	15:40:04	MT575B	0:40:26	12.345	Herálec fekál plnění č.1 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:09	18.32	57
15:50:13	16:28:44	MT575B	0:38:31	12.983	Herálec fekál plnění č.1 (Herálec)	Herálec fekál plnění č.1 (Herálec)	Fekál plnění	0:10:10	20.22	59
16:38:54	16:40:45	MT575B	0:01:51	0.413	Herálec fekál plnění č.1 (Herálec)	...Herálec fekál plnění č.1 [40 m] (Herálec)	Fekál plnění	0:11:02	13.39	21
Celkem			**5:19:28**	**111.152**				**2:42:32**	**20.88**	**59**

App 6 Logbook (Itineris brochure)

App 7 Itineris mobile application - Android compability (Itineris brochure)



App 8 The record of track (Itineris system)

App 9 John Deere 8230 (www.JohnDeere.com)

App 10 STROM Terraland TD 3000 (www.bednar-machinery.com)

App 11 STROM Swifter SO 6000 F (www.bednar-machinery.com)

App 12 Opall Agri EUROPA 180 (www.opall-agri.cz)

App 13 LEMKEN Solitair 9 + Heliodor (www.profiagrar.com)

App 14 Simba X-press (www.amacoint.com)