GLOBAL NAVIGATION SATELLITE SYSTEM AS TECHNICAL SOLUTION ELEMENT OF FARMLAND PROCESSING IN LATVIA

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Abstract. Similarly, as it is the case in many developed countries, global navigation satellite system services in Latvia today provide not only navigation and survey works, but they are breaking into a scope as the production of agricultural products. It is most directly attributable to the involvement of agricultural land treatment technologies where satellite navigation system equipment as an integrated component appeared together with the latest agricultural equipment. This availability of the equipment expressed the desire to find solutions to the advanced technology for complete application in Latvian territory. Over the years, there has been substantial widening of satellite navigation technology availability, directly in the field of agricultural equipment use – moving from a simple and approximate precision toward high levels of accuracy and stability navigation services. In the last year perspective we can predict a continuation of the increasing demand for global navigation system services directly in farmland processing equipment and technical solutions for the user segment, especially the rapidly rising demand for agricultural machinery navigation devices with improved quality and accuracy. The article aims to confirm the assumption that for precision farming systems (including related with GNSS technologies) in farmland processing in Latvia the research preparation phase is completed and it moves to the practical implementation process. The result has a confirmation that in the last year perspective a growing demand can be identified for global navigation system services for direct farmland processing equipment and technical solutions for the user segment.

Keywords: precision agriculture, geoinformation, global position system (GPS), global navigation satellite system (GNSS), real time correction (RTK).

Introduction

At the end of the last century and the beginning of this century in the U.S. and Europe agricultural technology development which further became known as precision farming systems increasingly began to acquire more popular applications. Understanding of this effective field management technology system (EASY) is based on the four following components.

1. Tractors, harvesters and with them related management units performance optimization techniques, directly from the driver's compartment.
2. Increased productivity and efficiency of resource use.
3. Technological process control field.
4. Assistance of information technology to find the best technology and business options for holding [1].

This means that the farm maintains its own local geographic information system where the research materials of soil properties is as a basis for differentiation, based on the geographic information system (GIS) operating principles, resource saving soil processing system. The effective field management technology is provided by a global navigation system (GNSS) comprehensive application, including those belonging to global positioning system (GPS) applications family. Along with those navigation and positioning systems a variety of attached sensors systems and information technology software options are widely used. Both, GNSS systems and the possibility of merging the sensor system development and application together with information technology and software development rates significantly ahead of the thoughts and agronomic practices which is still not able to keep simultaneously track of the benefits of new technological possibilities. In Latvia (not more than in Europe and America) progress in the implementation of a significant negative impact even once limited the direct access of intellectual agro professionals to meaning [2].

On the one hand, it can be assumed that in post-Soviet territories the impact on the mentioned support timely development (failure to take place among the developed countries) left farmers' long-term inability to secrete sufficient resources for appropriate technologies and related services payment, but on the other hand, security weaknesses include the agricultural machinery specialist training for those drawbacks as non–characteristic industries – such as geodesy (the experts are competent in matters directly related to GNSS technology and technical equipment), geographic information systems, remote sensing and photogrammetric, as well as modern digital cartography. The lack of

appropriate agroservice specialist training did not contribute to the new technologies usage – even in such cases when the equipment is accessible or is offered along with the new supply of machinery for local farmers. Despite the falling behind in implementing this technology in practical use, the specialists of the Latvia University of Agriculture already in 2004 conducted research in this direction [3]. Literature indicates that in order to determine stable farming areas and accordingly convert them, they require at least five years of records, so these are not one year data and a variety of matching quality and accuracy here play an important role. In addition to the mentioned methods for the crop productivity determination the world uses remote sensing measurements in yield formation processes. Popular methods are related to the aero – photogrammetric measurements, remote sensing, including conventional digital image analysis or different light spectrum measurement using a sensor. These techniques again raised demands for specific knowledge and experience in organizing the gathering and processing of the data collected and finally matching them with the previously obtained from other systems. Here, also we must be familiar with both, GPS capabilities and conditions of use and position acquisition accuracy and positioned data matching, transformation regulations. The role of both, software compatibility between agro service providers and weather suitability for a good photo for proper extraction and processing in the shortest time and the used coordinate reference system compatibility required accuracy within and later, and it can enable agricultural specialists to understand effectively the agronomic acquired and develop further measure complexes. Regarding further measures on farms, convenient use of sensor measurements and the results of the activities were planned for immediate transfer to processing equipment resulting in potential identification of the application of proper technology, improving the status of the predictive dose fixation use according with digital mapping projects. Effective arable crop systems acquisition increases the technical unit accurate and repeatable motion in parallel rout navigation systems. Professionally properly organized GNSS – GPS use of tractors and combines with parallel driving systems is the prerequisite for resource saving technologies. When working with multiple combines or tractors in a single farm there is a need to use mutually compatible, aligned, validated navigation systems and programs (such as “GPS Pilot” and “Auto Pilot”, “agrocom Net NG” – “agrocom Map” CLAAS) [4]. Despite the short run precision farming history of Latvia in recent years such services offer a niche which is not completely empty, there are entrepreneurs who over many years undertake to develop various production processes and transport segments directly using GNSS and related facilities. In the field of agriculture there is the firm “CLAAS”, which provides the program “Telematics”, guaranteed compatibility with systems and services. The company system provides the control of machinery usage and allows arranging the logistics in large farms and partly organizes the machinery security [1]. In2013 its activities marked the specialized agricultural services company”iAgro.lv” which started to work in installation and servicing the special navigation and sensor complexes directly for agricultural field equipment.

The study goal was set to confirm the assumption that in Latvia the preparation and research phase for the use of precision farming systems linked with GNSS technology for farmland processing plants started to move into massive practical implementation, clarifying whether in recent years in Latvia agricultural processing equipment and technologies with modern GNSS solution usage demonstrate an increasing development and identify an information source which can be used to evaluate this increase. To achieve the goal of the research the following tasks were defined:

1. To find the base and offer credible sources and methods for future identification possibilities to agricultural enterprises as GNSS precise data users;
2. To use the found sources and methods to obtain information on the precise GNSS system users in Latvian agricultural holdings;
3. To identify the number of users and the change of dynamics of the used GNSS services in the last years.

During this research the acquisition is approved that the last year perspective can identify and anticipate a continuation of the growing demand for global navigation system services directly for farmland processing equipment and technical solutions for the user segment. For such approvals it is possible to find a simple but effective and easily accessible information source.

Materials and methods

In order to evaluate the situation in precision agricultural systems evaluation success in Latvia, the authors of the article offer to select the information collection and accounting positions, which continue on a regular basis and with a high degree of confidence could make it possible to determine the exact farm system users active over the figures, the quantitative and the qualitative side. Data mining position selected to relation to the use of agricultural machinery equipment which require the use of GPS system accuracy not worse than 1 meter. And the rest, according to the international literature of the criteria, do not fall to precision agricultural systems. Only civil use systems meet such precision today, which are able to use the GPS data online corrected with DGPS (differential GPScorrections) data in real time. Usually there exist two of the basic DGPS data mining capabilities – individual system (Fig. 1) and network system solutions (Fig.2). Developed countries dominate the collective of DGPS data acquisition system practices of the organization and individual systems exploiters in agriculture are not considered to be significant. In Latvia there exist network solutions DGPS – state base stations network, named as "LatPos", which now does not have serious competition. To make sure that DGPS system capability provides quality information for systems users in agricultural land processing industry a pilot study was organized and for "LatPos" system available information was collected about its users for precision farming equipment management. In user accounts service requesters and users of precision agriculture were clearly identifiable. In the information-gathering process the users were defined who ordered DGPS services to more than one unit of agricultural machinery. The obtained information was systemized by years and according to its content the thorough analysis was carried out.

Results and discussion

The Latvia University of Agriculture in 2004 conducted research in this direction [3]. Based on the precise technology field management options, the first harvest map was obtained at the Glūdaiņu field of "Vecauce" Ltd., using the crop harvester "CLAAS Lexion 420" [5; 6]. It was done by using specially equipped harvesters that simultaneously recorded a number of indicators:

1. combine location field within a meter, which is obtained by combining GPS and DGPS (differential GPS corrections) signals;
2. grain crop weight and moisture content at the grain threshing process.

To obtain such harvest map "Quantimeter" equipment, GPS navigation systems, GPS antenna and receiver, 8 MB PCMCIA data card software Lexion "Cebis" monitor and office computer were used. Entering the collected data in a PC and using the "AgroMap" software the harvest map with different intervals of productivity levels, depending on grain deluge in specific parts of the field, was obtained; which also characterized the field soil fertility levels. The harvest map relatively was able to characterize the level of income from various sections of the field [5; 7-10]. Using the analysis results, the company "CLAAS Agrosystems" computer program "AgroMap" or "AGRONET NG" in addition to the harvest map also created the field topographic map with information on terrain, soils and agro-physical properties of agro–representation etc. The cards had opportunities considered to assess the real situation in specific fields and even parts to identify the factors affecting the yield [6].

In all research activities spatial data acquiring accuracy plays an important role, which can be provided by the use of only DGPS. There exist two of the basic DGPS data mining capabilities - individual system (Fig. 1) and network system solutions (Fig. 2).

Individual systems creators, alike as it is done by Latvian researchers, usually are forced to buy additional (non–technical and sensor kit of agricultural machines) and use a special, relatively expensive, individual professional GPS permanent station kit with systems management software, data transmission equipment and count on additional expenses necessary for its regular maintenance activities, calibration and other activities associated with high–level specialists and specific services. In Latvia, like it is in developed countries, such individual equipment user's number cannot be regarded as the most important in the agricultural field. Such individual systems identification and accounting is difficult to control, so on basis the two arguments in these studies of individual systems were not considered. In the practice of developed countries the collective DGPS data acquisition system dominates, which often is created and maintained as the state exemption system. Of course, in the world there are plenty of cases where collective systems of a country territory or other greater

territory are formed and maintained by non-governmental bodies, or in parallel collaborate in multi – keepers (even competing) collective systems. The customers of vast majority systems are different surveying and geodesy, construction work specialists and accurate navigation system exploiters. Agricultural system operators in all these cases are among the many customers, the fee for the system service is acceptable enough, so there is no need to create an individual system. In some countries there are cases in which system services can also be obtained free of charge. The benefit of collective systems increases their structural characteristics – when a large area is covered with a DGPS station network which gives the guarantee of high-precision data acquisition and possible uses of on large area. In individual system cases increasing the station equipment operating distance from the DGPS stations will reduce the positioning accuracy. The first Latvian National DGPS base station network was established in 2005 –named "LatPos", which provides all the coverage of the territory with high-precision adjustment data position accuracy in real time over 1 dm. Later one more station network was created– the city of Riga "EUPOS". In recent years there is being implemented an attempt to develop precise DGPS services in the virtual network – "Trimble" representation of the company.

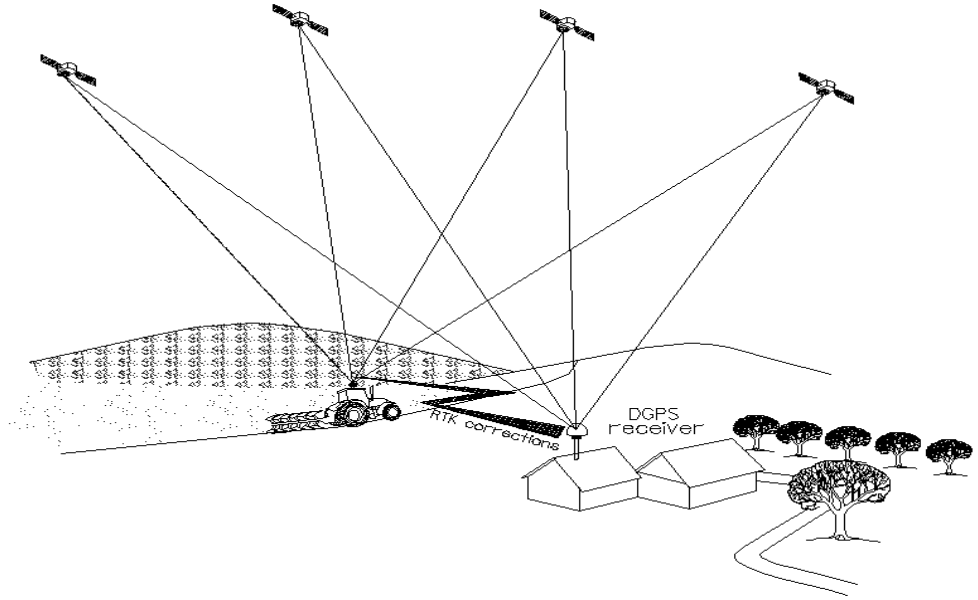

Fig. 1. **Precise DGPS data acquisition individual system**

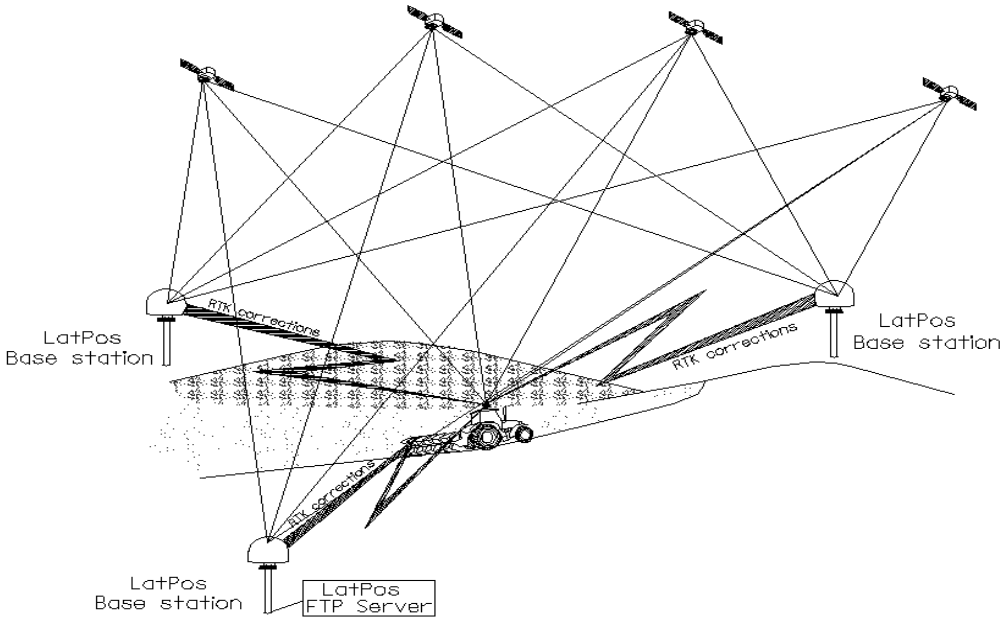

Fig. 2. **Precise DGPS data acquisition network system solutions**

Summarizing the information obtained about the opportunity to offer the availability of DGPS in Latvia and through its analysis only one comprehensive and reliable source of information in the country for users of precision farming was clearly marked. To date, for practical use of Latvian agricultural system the most appropriate is the state established and maintained by DGPS network system "LatPos" which guarantees precise data covering the whole territory (Fig. 3). The station network - the city of Riga "EUPOS" is limited to Riga and its surroundings, so the general use in agriculture is not valid. On the "Trimble" virtual network in this direction there is currently scarce information. It can be concluded that now the "LatPos" system network is not a serious alternative for use of the precision farming sector, which covers the entire territory of the country by providing real-time measurement accuracy of better than 1 meter.

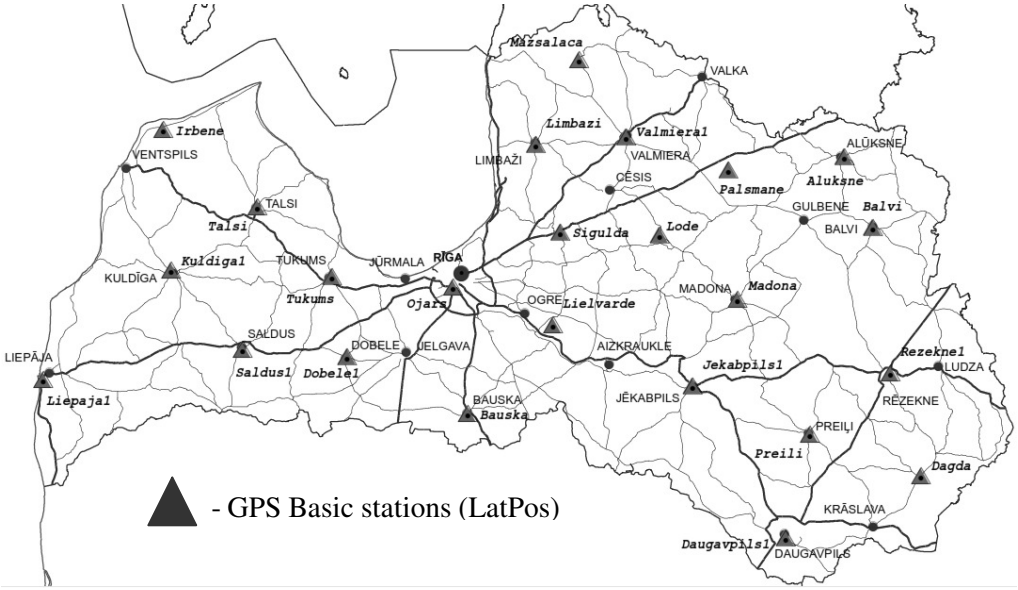

Fig. 3. **LatPos base stations situation of the year 2014**

As a research source of information, this system data about users and their activities have a great advantage – they are available in one place and according to the last day data, without the need to organize the time-consuming surveys, questionnaires, field survey, or waiting for official reports according to different standards. If in the future an alternative system will be created – it can also be used as another, equivalent research information source.

Information about the service users of precision farming systems from DGPS "LatPos" is summarized in Table 1.

Table 1

DGPS "LatPos" services for precision agriculture system users

User of system	Year			
	2014	**2013**	**2012**	**2011**
"CorsGroupAgrospeed"	5	5	5	5
"Hofer&Pautz"	2	2	2	2
"KoneKesko Riga"	1	1	1	–
"Agrikula"	2	2	2	–
Agrofirma "Tērvete"	1	1	–	–
z/s "Brasliņi"	1	1	–	–
z/s "Katlauki"	1	1	–	–
z/s "Ķauļi"	1	1	–	–
z/s "Ķiveļi"	1	1	–	–
z/s "Klagāti"	1	1	–	–
z/s "Zariņi"	2	2	–	–
Summary: users/connections	–	**11/18**	**4/10**	**2/7**

As the result of experimental operation, by analysis of the information shown in the table, the dynamics of precision farming systems users volume growth was clearly marked (Fig. 4) to the increase from 2011 doubling in the previous year. Also, it can be seen that the number of connections (Connections) is always greater than the number of registered users of the system (Agro farms). Precise farming systems in Latvia agriculture should not be considered as an exclusive phenomenon that is affordable only to large and wealthy farms in some developed and rich countries; it becomes a daily reality here as well. According to various expert calculations and comparisons with the experiences of the developed countries, the exact users of Latvia agricultural systems are considered to be about 300 agricultural entrepreneurs.

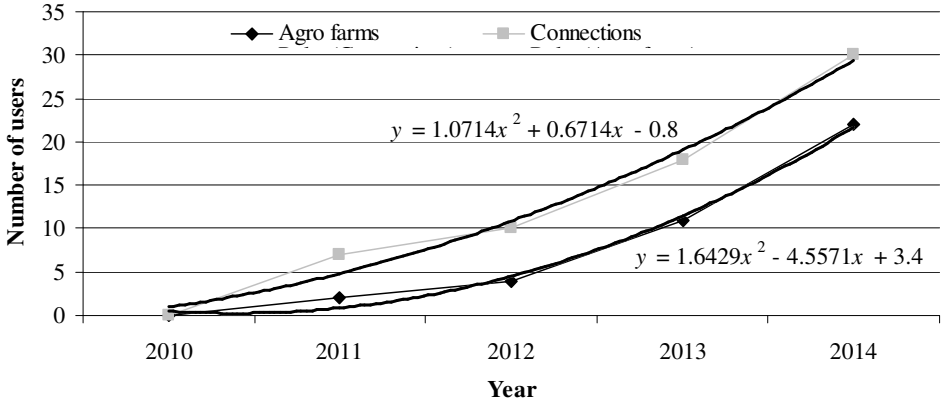

Fig. 4. **Precision farming systems users**

Further implementation of the dynamic scan has a negative effect on different levels of economic and other crises, but a common path will continue to rely heavily. First of all on the numbers and qualifications of entrepreneurs and professionals – who will be able to offer a suitable quality and scope of services to farmers.

Conclusions

The gathered information and its evaluation results with high degree of confidence allow to confirm the increase of the precise GNSS equipment use among the agricultural sector in the country. The resulting user growth dynamics suggest that Latvia has completed the initial process of preparation and studies of GNSS technology use in precision farming systems and agricultural land processing plants start the practical implementation process.

1. DGPS system itself is almost perfect and a full-fledged scientific research and statistical information source for global satellite navigation systems usage in precision farming technologies of agricultural enterprises and offers a simple, fast and up to date information data mining method.
2. The current period associated with GPS precision farming systems implementation and use in Latvia presents a systematic increasing momentum.
3. In the coming years, in Latvia agriculture significant with GPS precision agriculture technology-related increase in the number of system users is expected.

References

1. CLAAS braukšanas optimizēšana. Catalog of products, Jelgava, Latvia,2012, 47 lpp (In Latvian).
2. Blackmore S., Moore M., Remedial Correction of Yield Map Data, Precision Agriculture, No. 1, 1999, pp. 53-66.
3. Lapiņš D., Cers J., Putniece G., Efficient Crop Farming Systems, Latvia University of Agriculture, Faculty of Agriculture, materials of scientific and practical conference, Jelgava, Latvia, LLU, February 21 – 22, 2013, pp. 88-90.
4. Ess D.R., Morgan M.T., Parsons S.D. Implementing Site-Specific Management: Map-Versus Sensor-Based Variable Rate Application. Purdue Extension. Educational Materials Catalog. Knowledge to Go, 1-888-EXT INFO,2003,49, [Online][27.09.2012] Avalilable at: http://www.extension.purdue.edu/extmedia/AE/SSM-2-W.pdf.

5. Lapins D., Vilde A., Berzins A., Plume A., Dinaburga G. The choice of the differentiation criteria of soil tillage using the geographic information system (GIS). Latvian Journal of Agronomy, Jelgava, Latvia, 2008, No. 10, pp. 51-57.
6. Dinaburga G., Augsnes neviendabīguma un reljefa atšķirību ietekme uz ziemas kviešu (Triticuma estivum L.) ražu: promocijas darba kopsavilkums Dr. agr. Zinātniskā grāda iegūšanai. Latvijas Lauksaimniecības universitāte. Jelgava, Latvia, LLU, 2011, 50 lpp.
7. Moore M. An Investigation into the Accuracy of Yield Maps and Their Subsequent Use in Crop Management. Ph. D. thesis, Cranfield University, 371.1997, [online] [8.06.2012] Available at: http://www.cpf.kvl.dk/Papers/Mark_Moore_Thesis/03Abstract.pdf.
8. Dinaburga G., Lapins D., Berzins A., Plume A. Efficiency estimation of soil deep -tillage for winter wheat by using precision technologies of crop cultivation. Latvia Journal of Agronomy, No. 11, 2008, pp. 211-217.
9. Lapins D., Kopmanis J., Dinaburga G., Berzins A., Plume A., Melngalvis I., Efficacy of soil deep loosening if growing winter oil seed rape and winter wheat in conditions of uneven relief. Engineering for Rural Development, Jelgava, Latvia,2012, Vol. 11, pp. 139-144.
10. Lapins D., Kopmanis J., Plume A., Gmizo J., Effect of differences in regulated and unregulated factors in soil arable and subsoil layers on yield of winter wheat and winter oil seed rape. Engineering for Rural Development, Jelgava, Latvia,2011, Vol. 10, pp. 43-46.