# Some aspects of using modern GNSS-RTK type technology in agriculture

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**Abstract.** Geodetic space techniques, especially the appearance of global navigation satellite systems (GNSS type) have revolutionized the field of positioning and navigation, in all areas, by improving quality and access to a geodetic reference system, which would remain compatible with new technologies and the opportunities they bring. Today, a global, stable NAVSTAR-GPS or GNSS type system, ensures a precision of centimeters, which can be easily obtained.

Using GNSS-RTK technology in agriculture and works on this subject is auspicious because together with geographic information systems (GIS), they can lead to a fair and expeditious resolution of all issues, especially in Romania. Currently, a program is underway in Romania, with the support of the European Community through the Agency for Payments and Intervention in Agriculture (APIA), to identify parcels and physical blocks that belong to different owners.

Using GNSS-RTK technology in agriculture and works on an important issue affecting certain works in agriculture, namely soil erosion, together with geographic information systems (GIS), photogrammetry and terrain laser scanning methods for studied areas leads to solving all the problems in Romania quickly and accurately.

This program covers the financial aid to be granted to farmers and land owners, and in this context, the land of each owner must be determined. This is possible through ground measurements using GNSS-RTK technology, through aerial photogrammetric methods, and for some problems, e.g. the study of soil erosion in land reclamation works, it can be done using GNSS-RTK technology, terrestrial laser scanning, photogrammetric and classical methods.

This paper presents the use of GNSS-RTK technology, its undeniable advantages in comparison with other techniques, as well as certain aspects of the technology.

**Keywords:** ROMPOS, GNSS, GIS, GNSS-RTK , acquisition of data, agriculture.

## 1. Introduction.

Traditionally, a reference network consisted of a network of ground control points, called geodesy points and the coordinates of the other points that were connected and which are based on these points. Since the introduction of space geodetic technologies this paradigm has changed in a fast and efficient way, in terms of time spent for execution of works, and so has the accuracy and ease of use of positioning equipment using GNSS technology and GNSS-RTK technology in particular. Currently, the ability to collect geo-referenced data in order to choose the geospatial variant with the information layer that has the highest accuracy and the ability to establish spatial relationships and extract related information has been and is being improved and is increasingly a part of business in many companies at central and local level. With regard to our ability to associate the coordinates of objects in our physical environment, our techniques and precision have improved, and so has the efficient access to an accurate reference frame which must be provided and maintained each time. If a relationship must be established between objects, independent of their spatial separation or the date of observation, a reference network is consistent, has a sufficient density and is forced to identify and analyze the spatial and temporal processes of interest. Failure to maintain these capabilities and issues could lead to a reference network that cannot fulfill its primary purpose.

This paper summarizes the development of spatial measurements in recent years and describes the improved measurement techniques that have led to the creation of networks of geodetic control, how they evolved and moved from "ground in space", but also the use of these networks and measurement methods in agriculture, for measurements, vehicles and geographical information systems used in this field. The global satellite positioning and navigation technology, i.e. the NAVSTAR-GPS technology, as a global satellite constellation, occurred in the early 1980s.

While NAVSTAR-GPS technology has been limited by the accuracy of transmission of its orbit, it seems to have other advantages on its side in that it needs no inter-visibility between ground stations, facilitating logistics operations for topographic measurements, thus allowing the stationing of checkpoints in physically accessible locations that were conveniently filled by the user.

In order to provide precise GPS orbits in which basic products are continuous in a consistent global reference system, IGS stimulated the development of a global distribution for tracking network stations and creation of regional and global data centers (DCS) for public access.

Currently, there is a safe way for GNSS users to connect directly to the global reference system by using GNSS data, which they gather from a single receiver from any point on Earth. This new opportunity has efficiently changed the activity of modern GNSS users.

## 2. The virtual references stations (VRS) concept used in Romania through the position determination system (ROMPOS).

The concept of VRS, as an approach, is a derivative of multiple reference stations, but differs in that GNSS reference receivers are used to determine the dual frequency code and to send GNSS data from a virtual base station which is located near the user's receiver. Data from the GNSS user and the virtual station data are then processed in single core mode in order to determine the coordinates of the user's receiver. This can be done almost in real-time mode (similar to RTK) or post-processing, but the calculation of near real time requires a broadband between reference stations (if data are calculated virtually through GNSS).

The concept of VRS enables the user to access data from a virtual GNSS reference station, in any location that is close to the actual GNSS determined reference station in the GNSS network. Also, the VRS approach is more flexible, allowing users to use their existing handsets and software without involving any special software or communications equipment, in order to simultaneously manage data from all reference stations.

With VRS, users in the network of permanent stations can operate at greater distances than with those in conventional RTK or faster than static mode GPS (typically, 10 and 20 km) without low precision. Under ideal conditions, the VRS approach can provide a single coordinate point with precision of a few centimeters for a network of reference stations separated by distances of 45-120 km. Such is the case of the National GNSS Network and ROMPOS (class A reference stations, around 70 km between them). Regarding our problem, i.e. the specific demand for short distance positioning, it should be noted that the concept of VRS was originally created for quick / static users or RTK working with relatively short distances (less than 9-12 km) from the area of interest.

Therefore, using the VRS method proposed by Wanninger (2002), the length of the action range for GNSS kinematic applications post-processing is changed. During this method VRS will be modified, VRS is mentioned in a fixed position to the rover and its initial approximate position, and trajectory corrections are applied to the Rover for its position at a given time. When the current approximate position of the rover is more than 12 km from its original position, a new Virtual (VRS) reference station is created. This process continues whenever the distance of 12 km is reached. In reality, the virtual reference station is created depending on the area of interest.

## 3. Adoption and use of GNSS-RTK type systems in agriculture.

The interest of farmers for very precise GNSS-RTK systems has increased in recent years at a rate that has taken many experts by surprise. Today modern agriculture cannot exist without the implementation of the GNSS positioning system and in this case GNSS-RTK. A reliable use in agriculture indicates that, for surfaces larger than 50 ha, Romania should use GPS or GNSS-RTK equipment. Such a rapid large-scale growth for precision of + / - 3.2 cm for GNSS-RTK is the result of several converging factors - economic, social and technological. Some of these factors have encouraged farmers to adopt, for their agricultural activities, vehicles that require a precision of 5-7 cm, available with OmniSTAR, VBS, WAAS and EGNOS for corrections. Another system that is gaining ground in Romania is the ROMPOS Position Determination System, widely being used for terrain measurements and in other fields such as agriculture, forestry, where land and vegetation allow. The low prices of new technology, especially electronics, resulted in a low cost of GPS and GNSS systems. For example, a Trimble AgGPS Autopilot with automated steering system and GNSS-RTK base station, for a farm, cost around 60,000 EUR in 2003-2004, a relatively high price and one that was difficult to turn into profit with a small farm. Once the new concepts, namely constructive integration (installed hardware and hydraulic equipment), appeared on agricultural vehicles and harvesters, together with RTK networks and base stations, the cost of a similar GNSS-RTK system in mid 2008 reached 35 to 40,000 EUR. Today it is 15,000 to 20,000 EUR.

While the positions held by farmers and those which function as a basis are still effective, both technically and operationally, their cost was still a barrier for many farmers interested in GNSS-RTK technology. This quickly became obvious to progressive farmers in many regions, giving rise to yet another concept: GNSS-RTK with base stations located in areas of interest. Such networks may charge a modest annual tax for users, about 10% of the cost of an RTK base station installed at the farm near the area of interest. This makes the acquisition of a GNSS-RTK rover or vehicle systems to be more attractive and more accessible to thousands of manufacturers, both globally and in Romania.

Fig.1 Connected Farm and Farm Works Information Management

It is very important to remember that all GNSS-RTK systems must provide two different solutions, so as to provide reliability, and these should be around + / - 2-3 cm accuracy. GNSS-RTK solutions in terms of correction signals for distances from base stations, in order to increase the accuracy of the Rover type receptor should not present major differences in GNSS-RTK precision. This is true for cases when there are two or more repetitions of measurements, especially for control and increased accuracy, but also when comparing different systems made by different companies. By using various algorithms that are more precise, GNSS-RTK systems are more effective than others, and therefore, they

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may represent different solutions in terms of positioning accuracy.
For a base station to really get an accurate of + / - 2 cm, it must have a relay transmission for the RTK correction signal through a reliable radio. For a mobile receiver (Rover) accuracy is ensured and the transmission system is able to operate at a distance of 5-10 km, because at greater distances one needs special permission from the secret services, at least in Romania. Despite optimistic expectations, not all GPS manufacturers have developed effective and reliable transmission solutions for corrections via radio waves in order to solve this crucial aspect of GNSS-RTK technology. Therefore it is important, before buying such a system, to gather information about its characteristics, range and, last not least, the precision it offers.

## 4. The RTCM data transmission network via Internet Protocol (NTRIP).

As interest in wireless Internet and the expansion of communication increases, alternative means of GNSS-RTK and corrections' distribution are being developed at an accelerated pace every year. A recently adopted standard, known as transmission network for RTCM via Internet Protocol (NTRIP), now facilitates transfer of GNSS data and products via the Internet [Weber, 2004]. This protocol takes advantage of existing communications services for mobile Internet users, especially in populated or industrial areas, roads and highways. It also enables GNSS-RTK correction service providers to serve Internet users, instead of having to implement and support costly dedicated channels, in order to transmit the desired products (GNSS measurements).
Currently, the most important is the NTRIP protocol, which was adopted mainly by users of the Real-Time-Kinematic (RTK) GNSS measurement method with real-time applications. Using NTRIP, correction service providers have the means to control user access and monitor usage time and cost recovery based on the time used. In areas covered by the mobile network, users access the GNSS-RTK and the corrections flow created by the reference stations, several hundred miles from the place where the activity takes place, for a relative positioning accuracy of a few centimeters. This technique respond to geo-spatial data requests which, in many applications, are possible in cities or near cities and roads, but in agricultural areas that are far away there are common problems that can be solved by using permanent or individual stations as local reference stations.

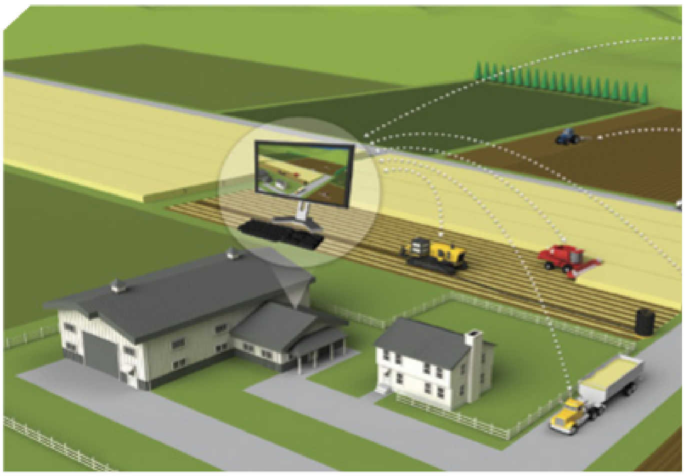

Fig.2. Connected Farm™ allows you to connect your software and hardware across the entire farm to improve efficiency and decision-making.

In agriculture, a number of activities are changing dramatically because of the ability to control a vehicle in a margin of precision of 2-3 cm.
In the near future, the U.S. Defense Department will launch the next generation of NAVSTAR-GPS satellites that will provide enhanced services to public users, including those in agriculture.
Other global positioning systems such as GLONASS, GALILEO and COMPASS, are partially or fully functional. These systems launch modern satellites every year which, in addition to those of the NAVSTAR-GPS system, bring more precision.
Companies working in this field, such as Trimble, have released three GPS receivers with new double frequencies that possess Trimble R-Track™ technology. This comes to help the new L2C signal that is completely

updated. Their transmission has already started.
The NAVSTAR-GPS system was the only one Trimble R7, at one point, which had a length of L2C, ready to be field tested, in order to test the satellite signal coming from the Joint Program Office (JPO) which manages the NAVSTAR GPS system. The Trimble R7 technology, compatible with GNSS satellites today, and the future L2C signals, successfully demonstrate that Block IIR-M satellites transmit data that can be collected, tracked and authenticated. The American company Trimble invented and successfully developed the GPS-GNSS Real-Time Kinematic (RTK) method of measurement, a technology that allowed precisions of + / - 2-3 cm in terms of checkpoints for agricultural vehicles. In time it proved to be economically viable and at the same time practically functional.

## 5. Some aspects regarding the future of farming by using the GNSS-RTK positioning system

At present, accuracy for fast and heavy agricultural vehicles is a daily practice in many farms around the world, while in Romania these issues are still in their infancy, although constantly developing. This rapid implementation raises two logical questions:

- What is the likely future of vehicle control technologies?
- How much is additional accuracy and precision useful to farmers so that it can be economically justified?

A part of further developments in the use and application of GNSS-RTK installed on steering systems already exist or are expected to help vehicle drivers avoid driving on slopes or steep paths, take rapid and fair decisions simultaneously in different areas of activity and especially in agriculture. In agriculture it is imperative that in areas with soil erosion, the use of various tools be rational and have a higher precision in correcting and successfully mapping agricultural areas. This helps in keeping such instruments on cultivated land and ensures that chemical fertilizers and products are properly deployed throughout the area, thus preventing product loss, improving fuel efficiency and extending the life expectancy of agricultural vehicles.
Another important aspect is the monitoring of machines and the people that operate them, namely the time spent executing a certain work in agriculture.
At present, there are robotic agricultural vehicles, harvesters and other machines that are being tested and implemented, which are equipped with GNSS-RTK applications. A number of those who implemented the new technology will undoubtedly purchase the latest technology being used by these pieces of equipment. Taking all this into account, it takes time to determine how GNSS technology will not increase costs but improve profit for agricultural activities, which ultimately is the most important thing.

## Conclusions

This is the result of a number of factors, including the ever changing needs of farmers and the availability of GPS-GNSS equipment, especially from Trimble, which is the first in creating equipment for agricultural vehicles and developing RTK and base stations. Recently, other companies that manufacture GNSS equipment have introduced GNSS-RTK systems and base stations into production. Their cost is lower but their performance is still not as outstanding compared to the equipment manufactured by Trimble .

Trimble GNSS-RTK and the networks using base stations offer correction signals for more than 65% of agricultural land in the U.S., but also for many other nations around the world that have a modern agriculture. GNSS-RTK technology, as an agricultural method of measuring, will continue to evolve together with that of field measurements, mining and construction measurements, and measurements for railway communication and other important industries. The future indicates that Trimble will continue its role as a global forerunner in GNSS technology with its measurement and control systems and will continue to show farmers around the world

(Romania also) that they are of the best quality. The use of GNSS positioning systems - especially those of GNSS-RTK type - in agriculture is very current and will continue to grow in intensity as it will become an essential element of profit growth. GPS-GNSS positioning systems and geographic information systems represent the future in all fields, especially in agriculture.

In order to use GNSS-RTK positioning systems in agriculture, in monitoring and using various machines and systems, this system for determining position and measurement can be used for a prediction of atmospheric factors and as weather stations. Base stations used by this equipment and the permanent stations located in a county on in a city are equipped or can be equipped with high precision sensors, compared to some local meteorological stations.

In conclusion, we can unequivocally declare that GNSS technology - especially GNSS-RTK - brings an increase of precision to agricultural works and increased economic efficiency for surfaces larger than 50 hectares.

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