Land registration and cadastre in the Netherlands, and the role of cadastral boundaries:
The application of GPS technology in the survey of cadastral boundaries.

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Abstract

First of all the paper provides background-information on the system of land registration and cadastre in the Netherlands and on the Cadastre and Land Registry Agency, who since 1832 has been assigned the mandate to implement these tasks. The characteristics of cadastral boundaries are explained, and the place of the cadastral boundary survey in the procedure of the transfer of land rights. Then the paper deals with the considerations concerning the application of GPS in cadastral survey, leading finally to the decision to apply this technology widely in the survey activity. The pro's and con's of use of GPS are mentioned as they had been revealed by several pilot projects, that had been implemented during the decision making process. The impact of a conversion of co-ordinates from the 'traditional' reference system to GPS is discussed.

1 Introduction to the Netherlands

The Netherlands is a country located in Western Europe, bordering the North Sea, between Belgium and Germany. It is located at the delta of three major European rivers (Rhine, Maas, Schelde). The area of land is 33.883 km2 and of water 7.643 km2. The geographical co-ordinates are 52 30 N, and 5 45 E. The terrain consists of mostly coastal lowland and reclaimed land (polders), with some hills in the southeast. The lowest point is -7 m (Zuidplaspolder) and the highest point +322 m (Vaalserberg). It is estimated that 8 % is urban land, 58% agricultural land, 7 % forest, 3% natural reserve, and the rest is various. There are 6,6 million buildings. The population of the Netherlands is 16.067.754 people (1 July 2002). The GDP is 434 bill $, the growth rate 0.3 % (2002).The GDP by composition is 3% agriculture, 26% industry and 71% services.

In earlier times the Kingdom was a republic. The Republic of the Netherlands was formed after defeat of the Spanish occupancy in 1648, with the Peace Treaty of Münster. In 1795 the Republic was occupied by Napoleon from France, and during 1810-1813 it was annexed and became part of France. In 1815, after defeat of Napoleon in the Waterloo battle, the Kingdom of the Netherlands was formed. The territory included southern parts, now Belgium. In 1830 Belgium seceded and formed a separate kingdom. The Netherlands remained neutral during World War I, but suffered from invasion and occupation by Germany in World War II. After World War II it lost its major colony Indonesia.

The Netherlands was a founding member of NATO and EC, and participates in the EMU. The Netherlands is a constitutional monarchy and a parliamentary democracy with free elections every 4 years.

2 Institutional embedding of land registration and cadastre

In 1810 the introduction of a fiscal cadastre came to exist after the earlier mentioned annexation of the Kingdom of the Netherlands by France. The French legislation became into power. Some years before, in 1808, Napoleon Bonaparte, who needed money to finance his activities, decided to establish a system of land taxation, based on a accurate inventory of land use and land ownership,

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with precise land survey of land parcels: a fiscal cadastre. In 1811 it was decided that also in the occupied Netherlands such a system of land taxation should be introduced. As a consequence, in 1812 the work started to survey the land, and to list users and owners of the land parcels. After the fall of Napoleon, when the Netherlands became independent again, King William I adopted the system of land and building taxation based on a fiscal cadastre, and the work was continued. In 1832 (whole country; only the province Limburg was finished in 1838) the work was finally done and a country covering fiscal cadastre was ready.

Tax was levied on the value of land and buildings in terms of the revenue one could gain with it (the rental value). This rental value was assessed during the process of land surveying. The rental value was registered in the land registers and was fixed. The regulations didn't have any provisions for updating rental values. Only if land parcels were divided or joined together, the rental values were divided and joined together according to the extent of the new surface area. With this respect the cadastre always showed a more or less actual situation. New erected buildings were appraised by comparing them with similar existing buildings, so they were put on the original scale.

The amount of the tax itself was based on a so-called repartition-system. First it was decided by the national government which part of the national budget should be provided by the land and building tax (at that time this tax was a state level tax). The resulting amount was split up to the provinces, then to the municipalities and finally to the individual land parcels. It could happen that the amount of tax was different from one province to another. Anyway, at that time the rate was about 10% to 12% of the rental value.

The updating of the cadastre was based on changes in the legal situation of land and buildings. It was a major effort to have knowledge of these changes. Legal documents could be recorded at the local courts. The clerk of the court acted as a kind of land registrar. However, as another Napoleonic rule, in 1811 it was decided that these legal documents, mainly deeds of transfer and of mortgage, should be recorded at the local office of the national tax department, in order to levy transfer taxes. Such a recording became compulsory in 1824.

Thus there were some sources for investigating the changes in the legal status of land. It became much easier however, when in 1825 it was decided to join together the legal land registers and the cadastre as a special department within the national tax department, the Ministry of Finance. It was a decision by the King himself, aiming at efficiency reasons only. Actually there was quite an oppositional movement by lawyers at that time, however without result.

Here lie the roots of the Netherlands Cadastre and Land Registry Agency, in which -unlike many other countries- the land registration and the cadastre are combined in one organisation. The cadastre became a key to the public registers, even more when in 1838 a new Civil Code came into power that ordered the inclusion of the cadastral land parcel number in notarial deeds of transfer and deeds of mortgage. The fiscal cadastre also became a juridical or legal cadastre, a situation which is still a benefit at date.

A major revision of the Civil Code became in power in 1992 (symbolically called the 'new' Civil Code), together with the Cadastre Act as a specific elaboration of the parts pertaining to the system of property rights (to a thing), and its aspects of registration and cadastre. This constituted the land registers and cadastral maps as a multi purpose system aimed at providing legal security of tenure, facilitating the land market, and supporting many government activities like physical planning, development control, public acquisition of land, land taxation, management of natural resources.

3 Introduction in the system of land registration and cadastre

Land registration and cadastral mapping are tasks at national level, assigned by mandate (Civil Code and Cadastre Act) to the Cadastre and Land Registry Agency. As said earlier, this organization formed since its establishment a department of the Ministry of Finance. However, under the political expectation that land information played more and more a role in many other government activities (specially in planning and environment) the Council of Ministers decided to

shift the department to the Ministry of Housing, Physical Planning and Environment in 1974. In the same period it was decided to move the land taxation from the national to municipal level, which it still is. In 1994 the Council of Ministers decided to transfer the department into a so called independent public body, recognizing land registration and cadastre as a public task but to be executed in a business like way. The Agency was constituted by special law, the 'Cadastre Organization Act', precisely prescribing the mandate, and the division of tasks and competencies of the Agency, the Minister, Supervisory Council, and a User Board.

In this moment the Agency comprises a head office and 15 regional offices. In these offices the registers are kept, the boundaries surveyed, maps maintained and information disseminated

The Civil Code in the Netherlands provides for a closed system of real rights (rights 'in rem'). The Civil Code also prescribes the procedures for the creation, transfer and abolition of rights to a thing. Following the Roman an French traditions (our first Civil Code after Napoleon was based on the French Code Civil) the Latin notary public plays a major part in the procedures, being the private professional person appointed by the Crown to draw up authentic deeds of transfer and the like. The procedures for registration and cadastral mapping are prescribed in the Cadastre Act. Submission and recording of notarial deeds in the registers is a prerequisite to obtain legally recognized ownership. This -by consequence- constitutes a public monopoly.

The mandate to enforce the Cadastre Act is assigned to the Cadastre and Land Registry Agency. The Cadastre Organization Act provides for the regulations for this Agency, which is since 1994 a so-called independent public body, however reporting to the Minister of Housing, (Town and Country) Planning, and the Environment. Both land registers, cadastral registers and maps are included in the mandate: the Agency therefore comprises (what is called) the 'unified cadastre'. According to the law the boundary survey is performed by land surveyors of the Agency. Although there are many private commercial surveying companies in the Netherlands, a system of licensed private cadastral surveyors is not in place.

A normal procedure of a land transfer is as follows. If a buyer en seller agree on a sale (most likely guided by a real estate agent, a non compulsory party in the land market), a notary public (compulsory) will draw up a notarial deed of transfer, after verifying the right to dispose by the seller and the consensus ad idem and the like. After the signing of the deed by both parties and the notary, the notary public signs a copy as a true copy which is submitted to the Agency. The land registar of the Agency checks some formal requirements, and records the deed and provides relevant evidence for this to the notary public. As the notary public is also the intermediate for the financial arrangements, the purchase prices is kept by the notary public until the evidence of recording is received, only then the purchase price is paid to the seller. A similar procedure pertains to mortgages, which secure loans on land and buildings. In case of the transfer of a subdivided land parcel, the land surveyors of the Agency will survey the new boundaries, and assign new parcel identifiers.

In the last year 410.800 deeds of transfer were recorded, and 552.500 deeds of mortgage. Land surveyors surveyed new boundaries for 98.200 land parcels. All cadastral registers and maps are in digital format. Cadastral registers are kept in the system AKR (Automated Cadastral Registers), the maps in LKI (survey and mapping information system): two separated systems with interface connection in order to appropriately coordinate the ongoing updating of the cadastral registers and maps.

For all the services must be paid: the Agency is obliged to fully recover its costs. The total business costs in 2002 were about 207 million €. About 2200 people are employed, 600 in the head office (including the IT departments) and 15 regional offices (1600). About 250 employees thereof are active in two other tasks of the Agency: contribution to land development projects, and maintaining the national triangulation and GPS-net.

To keep good contact with the users, the Agency has a user council at national level (comprising representatives of the umbrella organizations of notaries, real estate agents, banks, municipalities,

water boards and consumers), and at regional level a system of account- and marketing management for all direct relationships with the users.

4 Role of the cadastral boundary survey in the process of land transfer

Following the French tradition of 'liberté, fraternité, et egalité' (freedom, fraternity, and equality), it is up to the parties in the land market what they want to sell or buy. It is not up to the government to direct the market in that sense. The result is that the Netherlands dos not exert a title system, but a deed registration system, within a legal framework of the causal system of land delivery, in which the validity of a land transfer might be influenced and even might be determined by the validity of a previous land transfers. A serious defect, that could make a land transfer void, is for example the lack of right to dispose by a seller. If many years later -in that case- the person who bought the property sells to another person, he might not be legally entitles to sell the property, because the property never was lawfully delivered. Of course in this system of delivery, the existence of the -so called- 'Latin notariat' guarantees that no mistakes are made with respect to all legal requirements for a legally valid delivery, and that the parties in the land market can feel secure about the validity of land transfers.

That does not mean that the government is not facilitating the land market. At the contrary, the government of the Netherlands aims at providing land owners a good deal of tenure security, both as owner of a property, and as a party in the land market. The government wants to provide secure access to land, and secure rights to land, and wants a safe security for mortgage loans. At the moment about 350 billion € of loans are secured by a mortgage, which form a substantial part of the credit system. To facilitate these major societal interests, the government exerts a land registration and cadastral system. The basic concepts for the system are that all documents concerning transactions on the land market should be eligible for public inspection (the 'publicity principle'), and that the registers and cadastral maps show exactly which persons are entitled to which object of land, and by which land right. Therefore the cadastral parcel forms a vital part of the system.

The mapping of cadastral boundaries is implemented under graphical precision, that means that the length of the half of the length-axis of the relative standard ellipse between two points should be smaller or equal to √2x20 cm in urban areas and √2x40 cm in rural areas. The accuracy of the cadastral spatial dataset depends on the type of the region, the original cadastral data are related to the scales 1:1000 (urban area) and 1:2000 (rural area). The data covers the whole country and comprises the graphical representation of about 7,7 million cadastral parcels, parcel identifiers, street addresses, house numbers, and coordinate points. A fragment of the cadastral map is shown in Figure 1 below:

Recognizing the primacy of the parties themselves in the land market, part of the system consequently is that the government does not interfere in the desire of parties to sell and buy a part of a property. It is completely up to the parties involved. No permit-system for subdivisions exists. No cadastral boundary survey is required prior to the land transfer. Different from many other countries the subdivision of a parcel does not include a permission of a planning authority. That means that in the procedure for a land transfer the transfer of the land right comes first, followed by a boundary survey later in time. So it is legally valid to be an owner of a non-surveyed parcel. The procedure then is as follows. A land transfer takes place regarding to a part of a cadastral parcel. In the deed of transfer the notary public mentions the object of transfer as a 'part of land parcel, known in the land registers as cadastral parcel with number xxx'). The verbal description of the object of transfer is legally dominant, and has priority over the cadastral description. In the land registers the parcel is preliminary divided into parts, say part A and part B, with an estimate surface area of a and b m2. Some time later, when the cadastral boundary survey takes place, the results of the survey initiate a definitive update of the registers and spatial databases. The parcel numbers 'xxx part A' and 'xxx part B' are replaced by the full numbers, and the surface areas are calculated from the co-ordinates of the newly formed cadastral parcels. The calculated surface areas (xxxA) and (xxxB) are adjusted to the surface area (xxx) of the undivided mother-parcel as

it is legally recognized (since Σ (xxxA+xxxB) = xxx). Norms are available to avoid significant differences between ‘calculated’ and ‘legal’ area’s.

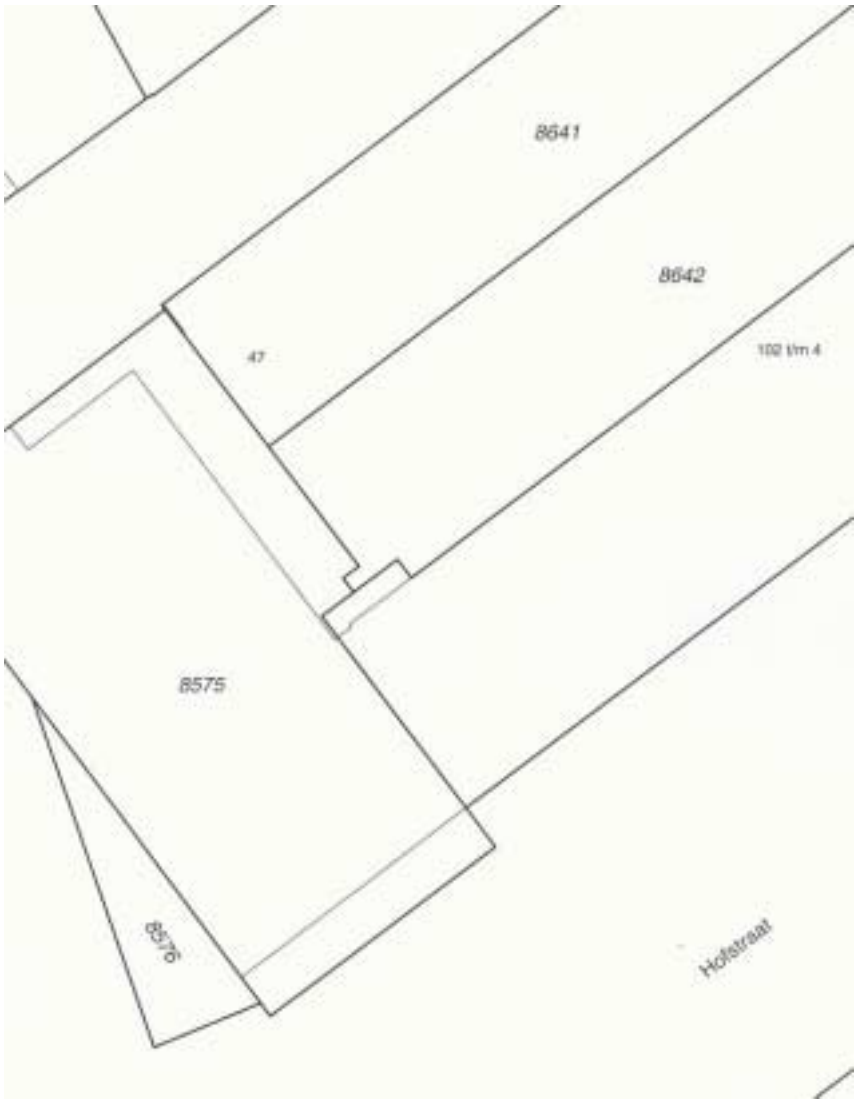

Figure 1: Fragment of the Netherlands cadastral map

The time-period between land transfer and definite updating might be some months up to one year. This is basically not interesting, as in this time between, the owners of non-surveyed parcel are fully recognized in their rights, and also financial institutions accept non-surveyed parcels as security for loans.

5 The use of GPS in cadastral boundary survey

In order to manage the information on owners, rights and parcels, the Cadastre and Land Registry Agency maintains two separate databases, as described above: a cartographic database (the surveying and mapping information system, LKI) and an administrative database (automated Cadastral Registers). The administrative database contains the essential legal and administrative information of any parcel of land. Since the introduction of the land registers and cadastre in 1832 basically all changes in the cadastral parcels are maintained on the cadastral map.

The source document for map updating is the field sketch. In case a transaction in real estate results in a change of the cadastral parcel a land surveyor of the Agency visits the site of interest and meets the selling- and buying party. When both parties agree on the location of the new boundaries the surveyor measures the new boundaries and draws up a field-sketch of the new boundaries and the relationships with topographic objects. Relevant remarks of seller and buyer of

the plot of land are laid down. The field-sketch forms a legal document and reflects the new cadastral boundaries on which all parties involved agreed at that moment. This mutual agreement is characteristic for the Netherlands legal system. The surveyor records the agreement between the parties involved in the transaction in real estate. He or she may advise when asked but will not decide on the location of the new boundaries. It is up to the parties what they buy and when. Even so, they are the ones to decide on the precise location of the new boundary. After the field survey all measurements and geometric relations will be adjusted in the back office and local coordinates are computed. A list of these local coordinates together with the sketch will be archived in hardcopy and is the untransformed source which enables any surveyor in future to reconstruct the boundaries at centimeter level, even if the local situation changed dramatically.

The field-sketch archive shows the local situation based on terrestrial surveys without distortions. The spatial cadastral database cannot be maintained without adjustments to the original terrestrial observations, resulting in local distortions. The graphical accuracy of the co-ordinates of the boundaries in the spatial database makes an adjustment of the new measurements to the map necessary. The distortion due to this adjustment-process results in a precision of the co-ordinates of boundaries which is in accordance to the earlier mentioned official requirements.

The instruments used by the surveyors in the early 19th century, chain measurements, differ from the instruments used today but not that much as one might expect. The chain is replaced by the tape and still 60% of all surveys are carried out using this tool. Also the theodolite has been used for many years and has been replaced early 1980's by total stations.

In the year 2000 real time kinematics (RTK) GPS was introduced to measure cadastral boundaries. Until that time GPS was only used to survey control networks by the department of the Agency responsible for the National Triangulation Network. This use was limited to static survey, but when Fast Static and finally Real Time surveying with high relative precision was possible, GPS became an option as an instrument for measuring cadastral boundaries. In all 15 local offices a small team of GPS 'pioneers' has been trained to use Real Time Kinematics (RTK) GPS on an experimental basis. The first year was aimed at getting experience in measuring with GPS and to develop a uniform and effective survey process; the emphasis was not so much on improving efficiency. It is known that GPS is able to measure with a certain (internal) precision but the legal aspects of cadastral survey also require repeatability en reliability. Those issues become even more complex when a GPS network of a third party is part of the survey process. The reliability issue is solved by measuring each point twice (with interrupted initialization) or three points in a line. Furthermore some additional surveys with a tape measure or total station and integrated adjustment of all those observations enables to ensure the reliability of the survey. When external GPS networks are used for cadastral survey the antennas of those networks have to be certified by the Agency. This means that the co-ordinates should fit correctly in the National Triangulation Network. As soon as the technical part of surveying with GPS was under control and all local offices were confident with the new tool an investigation was conducted in the summer of 2002 to identify all possibilities and limitations of GPS in cadastral boundary survey, including the efficiency of the GPS-method.

The investigation focused on three main elements: the technical aspects of the survey, the ergonomical aspects and economical aspects.

All local offices were asked to conduct 10 cadastral boundary surveys. The instruction has been to survey a boundary-change that could be considered as being representative for an average case and not to select on sites particular suitable for GPS. The time needed for the activities in surveying and data-processing were recorded and compared with available reference-times related to the use of conventional survey equipment. Finally a layered sample of 140 surveys has been conducted which is a reliable sample.

The conclusion was that about 25 percent of the surveys can be done more efficient using GPS, compared to the conventional approach. Efficiency is improved up to 30 percent, depending on the skills of the surveyor.

RTK-GPS is a relative technique which requires two receivers (reference and rover) connected with radio or cellular phone. The function of the reference receiver can be generated by a GPS-provider. Use of a GPS-provider with a national network will be more efficient than exploiting an own reference receiver.

Dutch law protects employees against unhealthy labor, physical as well as mental. The department of Personnel & Organization of the Agency examined the GPS work-process and with the aid of an independent consultant in ergonomics interviews were held and a survey team was visited. The interviews learned that the surveyors were pleased with the introduction of GPS because it allows to organize the survey in a more flexible way and it gives surveyors the positive feeling of working with modern technology. Interviews and practical tests gave no indication of any risk. The conclusions of this part of the inquiry were very important because the success of GPS depends much on the acceptance by the surveyor.

A study of the survey process revealed that GPS would have a positive effect on the whole process of cadastral survey. Surveyors and management would be more flexible in choice of instruments and the staffing of survey teams. When each survey is conducted with the most suitable instrument the efficiency will increase. A GPS set is slightly more expensive than a total station thus also increases investments.

6 Consequences of application of GPS for co-ordinate systems

The location of objects is fixed and represented by it's co-ordinates. Since long time, back to the 19th century the national triangulation network 'Rijksdriehoeksstelsel' (RD-system), is in use as a basis for this. Nowadays Cadastre and the section 'National Ordnance Datum' of the Survey Department of the Dutch Ministry of Transport, Public Works and Water management are maintaining the national Geometric Infrastructure. Those organizations are responsible for maintenance and publication of planimetric (x- and y- co-ordinates: the RD-system) and height information (Normaal Amsterdams Peil, the NAP-system). This infrastructure is the basis for all geodetic- and survey works in the Netherlands. As described above GPS has been used to maintain the planimetric part of this geometric infrastructure, and now normal cadastral surveys are performed using GPS. A local GPS provider supports this activity based on a nationwide GPS-RTK network.

Co-ordinates in GPS are not equal to co-ordinates in the RD-system. A smart transformation has been developed to transform co-ordinates from one system to the other. This is not just a similarity transformation, but an advanced transformation in which the inhomogeneous quality of points is included.

The cadastral spatial database contains about 200 million points represented in the RD-system. Introduction of GPS for cadastral surveys, and in general for survey activities in the Netherlands could be based on availability of this complete co-ordinate-set in GPS co-ordinates. This would require a conversion of all co-ordinates from the RD-system to GPS (ETRS, the European Terrestrial Reference System 89). This allows for a seamless workflow in the process of updating the cadastral spatial database based on GPS surveys. The impact of such a conversion operation has been investigated. The outcome was that such a transformation of all co-ordinates would not be acceptable -at least not in this moment- because of its substantial consequences:

a) History is maintained in the cadastral spatial database. Transformation of co-ordinates would result in new versions of all objects in the cadastral database with co-ordinate attributes. This would include cadastral boundaries, parcel identifiers, buildings, etc. The old versions of those represented objects still have to be managed.
b) Lower order control points have to be transformed. Those co-ordinates are listed and stored in many places.
c) Co-ordinates of house-numbers have to be transformed. Co-ordinates of house numbers are the basis for a product called 'Address Co-ordinates of the Netherlands ACN'.

d) A topology check has to be performed for the complete cadastral spatial database, mainly because it is allowed to represent 3-point arcs in this database. Transformation could result is mismatches of certain tangents.
e) Together with the transformation of the co-ordinates in the cadastral spatial database all co-ordinates of the large scale topographic database of the Netherlands have to be transformed. This high accurate large scale map has been the basis for an intensive cadastral map renovation to improve the quality of spatial cadastral data. The introduction of this transformation to those data would result in many slivers, because in some area's the topographic data are cut on the km grid because of user requirements. To slivers are complex to manage.
f) All users of cadastral spatial data, large scale topographic data, and users of ACN have to be informed on the changes in all co-ordinates they are using for their purposes. This means hundreds of municipalities, water boards, provinces, utility companies, land-consolidation projects, ministries and companies have to be informed on this on the basis of so-called update files where old and new versions of the spatial objects and related co-ordinates are delivered. A standard in this is available in the Netherlands. Those update files have to be processed by all those users in their local spatial information systems. Furthermore all spatial information which has been generated by those organizations has to be transformed. If this is not executed the system of automatic updating the spatial data of all those organizations using standardized update files will not function anymore.

Further it was observed that there will be no serious impact on surface area's. Surface area's are not only relevant for the land market, but also for all kind of EU subsidies. The impact of such conversion was too big. This means incoming GPS co-ordinates are transformed to RD-system in the cadastral updating processes. The same is valid for outgoing co-ordinates to be used in GPS environment.

7 Conclusions

Although GPS technology in land surveying has been used for quite some time, the requirements to be met in cadastral boundary surveying made in depth investigations necessary. Many cadastral boundaries concern urban area where GPS experienced difficulties in receipt of enough satellite signals. Also the requirement of survey records making it possible to setting out boundaries many years later, put some pressure on the method. After carrying out various experiments and investigations, the Netherland's Cadastre and Land Registry Agency believes that the introduction of GPS in cadastral boundary survey will enhance the effectiveness and efficiency of the process. Introduction of the new procedures and the provision of all field parties with GPS equipment has been going on since 2002. From Figure 2, you see a field party surveying a cadastral boundary in the famous lake district in the northern part of the country, Friesland. We would say: an extra-ordinary case!

Figure 2: GPS cadastral Survey in the Netherlands