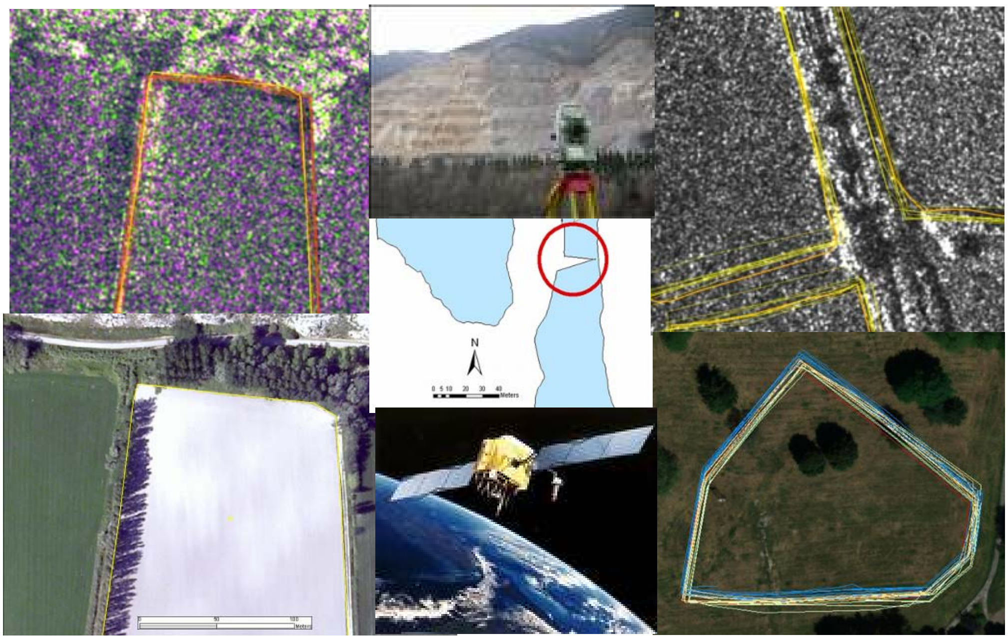
JRC Technical Notes

Area measurement validation scheme

Simon Kay, Aleksandra Sima



EUROPEAN COMMISSION

Institute for the Protection and Security of the Citizen

The mission of the JRC-IPSC is to provide research results and to support EU policy-makers in their effort towards global security and towards protection of European citizens from accidents, deliberate attacks, fraud and illegal actions against EU policies.

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Address: via Fermi, 2749, 21027 Ispra, Italy
E-mail: simon.kay@jrc.it
Tel.: +39 0332 78 9702
Fax: +39 0332 78 5162

http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

JRC 51300

ISBN 978-92-79-08714-1
Catalogue number: LB-80-08-274-EN-C
DOI: 10.2788/77728

Luxembourg: Office for Official Publications of the European Communities

Content:

1. Introduction

1.1. Purpose of this document

1.1.1. The purpose of this document is to define an approach for the validation of area measurement methods for agricultural parcels, using mainstream forms of equipment (GNSS, remote sensing, or in general geomatics based survey tools).

1.1.2. The aim of this validation approach is to provide a standardized way for the **estimation of the performance** of tools for area measurement, which can objectively be shown to perform correctly under specific conditions, and considered therefore fit for the purpose of measurements made in the context of field checks noted in Commission Regulation 796/04, Article 30.

1.2. Motivation

1.2.1. The basic requirement for measurements may be defined as follows:

- Measurements with an agreed accuracy, which are **reproducible** and can be used as proof of evidence in court:
  - independent of who is generating the data, (farmer, member state, auditor)
  - obtained with the use of equipment which fulfils objective criteria, and at the same time is reliable and robust, preventing errors due to wrong usage

1.2.2. The availability of different equipment and techniques for rapid area measurements has become diverse in recent years. Tools can range from relatively cheap (€ 100) up to considerable investment (more than €10 000 for a dual frequency GNSS receiver, even more for satellite based imaging systems). However, all stakeholders – the Commission, Member States and farmers – need assurance that the tools on offer are able to perform to acceptable standards.

- **To achieve this, a standardised approach needs to be designed for the validation of performance claims by providers and manufacturers of these measurement systems.**

1.2.3. Since the beginning of 2008 Members States are obliged by article 30(1) of Commission Regulation (EC) No 796/2004 to determine the areas of agricultural parcels "by any means proven to assure measurement of quality at least equivalent to that required by applicable technical standard, as drawn up at Community level." That means that a proof of quality of the area measurements systems used for on-the-spot checks should be present. A standardised validation test of these systems would deliver that proof.

1.2.4. A further motivation for this, in Member States where such legislation might be considered pertinent, is compliance with EU Directive 2004/22/EC on measuring instruments. As is noted in the pre-amble (2) of this text:

> *Correct and traceable measuring instruments can be used for a variety of measurement tasks. Those responding to reasons of public interest, public health, safety and order, protection of the environment and the consumer, of levying taxes and duties and of fair trading, which directly and indirectly affect the daily life of citizens in many ways, may require the use of legally controlled measuring instruments.*

1.2.5. Therefore, depending upon the transposition of this Directive into national law, there may be a specific legislative need to fulfil such obligations when using measurement tools in the context of subsidy management and control. Once more, a standardised approach to validate performance claims by manufacturers of area measurement systems would support such a need.

2. Introduction to measurement method validation

2.1. Background

2.1.1. Equipment used for analytical tasks may be certified to provide a guarantee of performance. This certification should ensure that the equipment use provides:

- A clear definition of accuracy or performance to be expected of the system
- Results within defined statistically predictable limits
- Reproducible measurements by all parties
- Reliable results, usable in court
- A consequent benefit in terms of legal liability

2.1.2. A pre-requisite of certification is the determination of system performance; this step is termed here as "system validation", and is just **one step** of the certification process. A typical overview of the certification process is outlined in Figure 1, below.

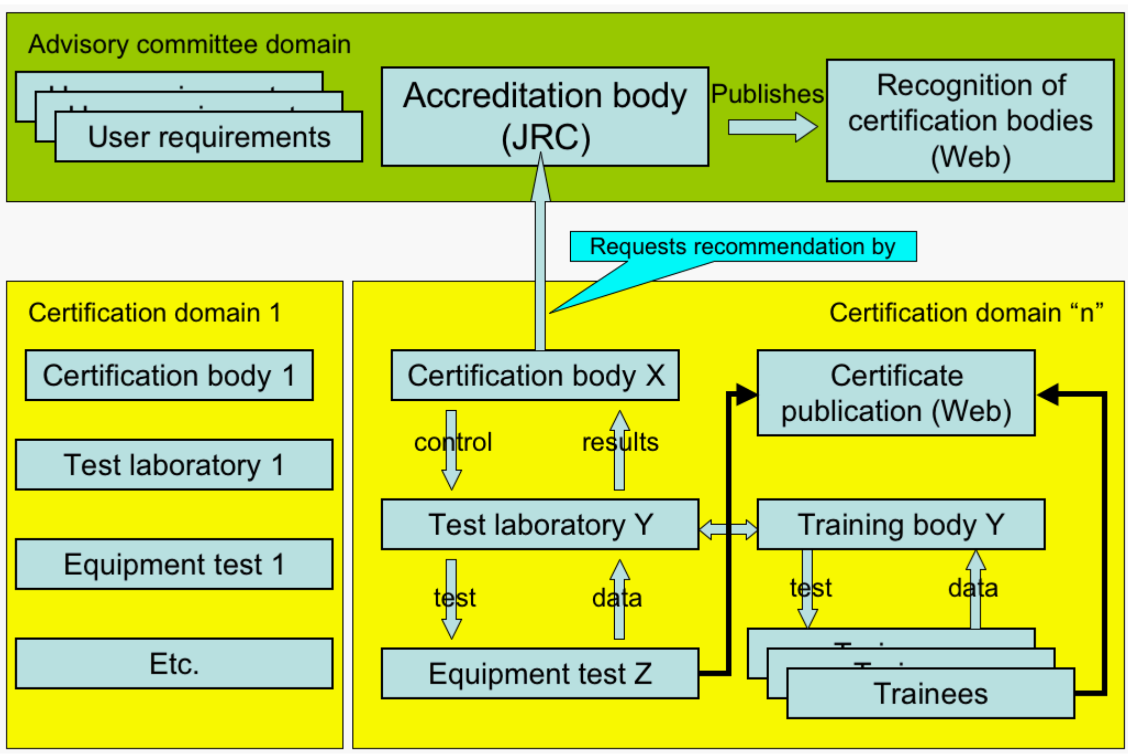


Figure 1: Outline of the certification process

2.1.3. In this process, an **advisory body** – currently the JRC, but to incorporate stakeholders from the wider community – provides user requirements and guidelines for testing (i.e., this document). A **certification body** will propose a test plan, in accordance with these guidelines; the body will petition the advisory body for recognition of its plan, which, if successful, will be made public via the advisory body's web site. The certification body will in turn contract with a **test laboratory,** which will operate under their control and supervision, to undertake tests and produce data through **equipment testing**. These data will in turn be analysed to produce results, which will, following the review and evaluation by the certification body, lead to **Certificate Publication**, again on the web.

2.1.4. An analogous process may be envisaged whereby the test laboratory may possibly also be accredited to undertake operator training, whereby again results from this training are used to demonstrate the competence of an operator, leading again to public certification by the certification body.

2.2. Method validation

2.2.1. Method validation is a well-established procedure in analytical science, albeit more frequently in chemical analysis or branches of reference material production. The **objective of the procedure** is to design and implement a series of tests that ensure that an analytical methodology is accurate, specific, reproducible and rugged for the proposed application. The result of the test determines to what extent a measurement method is suitable for the intended application, or that it is so-called “fit for purpose”.

2.2.2. The statistical framework for the validation of measurement methods is laid out in ISO-5725, “Accuracy (trueness and precision) of measurement methods and results”. The approach aims in determining estimates for a series of parameters[1], which enable a user to determine if a certain system is suitable or not for the application.

- Precision: relates to the spread of experimentally determined data. The smaller the data variation, the greater the precision of the analytical method. In parcel area measurement, precision relates to the width of the confidence interval;
- Bias: Error systematically occurring during the measurement. Bias can result from a lack of calibration, is constant within a method and thus should be predictable. For a method to be useful, the avoidance of bias through the use correct measurement protocols needs to be ensured.
- Accuracy: defined as a measure of the difference between the "true value" and a set of experimentally determined data, and is affected by both systematic error (bias) and random error (precision).
- Repeatability: the standard deviation of a series of quantitative measurements performed with the same method and sample under similar conditions (e.g. instrument, analyst, etc) over a short period of time.
- Reproducibility: the standard deviation of a series of quantitative measurements performed with the same method and sample under different conditions (e.g. different instrument, analyst, laboratory etc) over a long period of time.
- Range: the useful range for which measurements can be made.
- Robustness: sometimes called ruggedness, is the measure of a method’s capacity to remain unaffected by small variations in the conditions of use.

2.2.3. Examples of these definitions of performance parameters, as applied to parcel measurement techniques, are given in Table 1.

---

[1] Definitions taken from http://www.vam.org.uk/biomeasurement/biomeasurement_quality.asp

Table 1: Performance parameter examples

Term	Example
Precision	Can be described as the range of values that might occur with a certain level of probability, for example a buffer calculated from the Standard Deviation or RMSE of differences between a reference area and measured areas.
Bias	The instrument should, when following the standardised measurement protocol, produce a result that is on average very close to the expected result, and not consistently larger or smaller.
Repeatability	The variability of a parcel area estimate if it was measured by the same operator in quick succession.
Reproducibility	The variability of a parcel area estimate if it was measured by the different operators, on different occasions.
Range	In terms of parcel size, the minimum and maximum sizes that can be measured and achieve a certain level of accuracy
Robustness	The sensitivity of an instrument to various extraneous effects, such as battery low power conditions, rain, tree cover, electric power cables, satellite constellation changes etc.

3. Background to agricultural parcel area measurement testing

3.1. Early studies (development of buffer approach)

3.1.1. Initial studies in the 1990's within the Commission focussed on the suitability of two main tools for agricultural parcel area measurement: high resolution (10-20m ground sampling distance, or GSD) satellite imagery, and code-differential GPS using pairs of low cost receivers.

3.1.2. Most testing at this early stage did not conform to structured, designed experiments and produced useful, informative but not statistically dependable results. The data collected were used more as guidance and orientation, and were not intended – for example – to provide a legally sustainable context for area measurement.

3.1.3. The conclusions from this period pushed technology adoption mainly in two directions: standalone GPS receivers (following the removal of Selective Availability encryption on GPS) and Very High Resolution (GSD <1m) satellite imagery.

3.2. Trial validation scheme (*football pitch*)

3.2.1. In response to various efforts by member states and manufacturers to collect data to assess area measurement tools (most frequently GPS), the JRC proposed in 2002 a trial scheme based upon the collection of a repeated measurements of a well defined object, namely a football pitch. The results of this simple, designed experiment were then analysed used ANOVA statistical tools, to produce an estimate of area variance along the lines of ISO-5725, specifically the parameters of most interest – Reproducibility (expressed as uncertainty on the parcel perimeter), and bias. Despite the apparent ability of this testing scheme to produce consistent, comparable results, the main limitation of these tests was that the simplistic testing scheme only imperfectly reproduced the more normal field conditions. The results were however, useful for benchmarking and direct comparison of equipment in ideal conditions.

3.3. Theoretical results on Variance (Bogaert et al., De Bruijn et al., Hejmanowska)

3.3.1. In parallel to the trial scheme and in response to the trial validation results, several authors conducted research into the statistical structure of variance and uncertainty of area measurements (mostly with GNSS receivers). The publications generally agreed upon the structure of the variance model required to describe and explain the uncertainty in these measurements, permitting the development of various simulation tools.

3.4. Designed experiments and validation testing (AGH University of Science and Technology)

3.4.1. In 2005, in response to the need for more basic data, the JRC ran a large trial (over 7,000 measurements) to assess the adequacy of the ISO-5725 approach to determine the performance of area measurement tools. The conclusion of this trial – undertaken on both GPS and remote sensing measurements – confirmed the suitability of general ISO approach, helped determine the most likely factors needing to be tested in a validation scheme, and provided data upon which conclusions could be drawn concerning the size and structure of the designed experiment at the heart of any validation scheme.

3.5. Independent trial validation (University of Warmia and Mazury/Satcon)

3.5.1. In 2007, the UWM (Poland) and a private company (Satconsystems) trialled a validation scheme based upon the collective experience above, implementing ISO-5725 statistical computation. The results were reported at a workshop hosted in 2007 by the JRC.

3.6. Implementation of certification by NavCert GmbH

3.6.1. In late 2007, NavCert GmbH, a specialised company regarding the development and the marketing of products and services of positioning and navigation systems, began certification of area-measurement GNSS devices in accordance with a draft of this scheme. To date (March 2009), eight systems have been certified. Implementation of certification by NavCert GmbH

3.7. In-house validation by JRC, MARS Unit

3.7.1. In 2008, the MARS Unit applied the scheme to the validation of TerraSAR-X and CosmoSkyMed radar imagery, to assess the use of these remote sensing data for area measurement.

3.8. Conclusions

3.8.1. The experience collected permits the identification of the following important statements:

- Area measurement tools may be assessed statistically using the mainstream approaches for validation, namely ISO-5725;
- Practicable, cost effective schemes may be devised for the collection of the necessary data.

4. Validation procedure

4.1. Aim

4.1.1. The aim of the test is to provide an objective estimate of the performance parameters listed in Table 1 above.

4.2. Theoretical design

4.2.1. A number of approaches are presented in ISO-5725, the simplest of which is a **balanced design** involving usually 8 to 12 independent sets of measurements of reference object(s). Each set of measurements must include a number (at least two, preferably four) of repeated measurements of the objects.

4.2.2. The factors to be incorporated into the experimental design, in accordance with the conclusion of the trials noted in Chapter 3, are:

- A range of parcel sizes should be included in the design.
- Border quality: a range of quality factors should be incorporated into the design. For example, with GNSS measurements systems, factors that potentially could disturb the signal (e.g. tree cover) should be incorporated into the experiment.

4.2.3. Furthermore, a number of other assumptions are usually required by ISO-5725:

- The precise value (reference area) of the objects should be (according to ISO 5725) unknown to the operator undertaking the measurement, a condition that is difficult to maintain when tests sites are permanent.
- Usually the same object (or replicates of the object) is used in the measurement sets; in the case of parcel area measurement, however, this is not possible since the parcels to be measured would be in different places geographically. In this case it is therefore proposed that the independent measurements at specific different temporal times,are performed on the same objects.
- In case of a validation test of a GNSS device, not less than five parcels of different sizes (i.e. sample levels in ISO-5725) across the intended range should be defined.
- In case of a validation test of orthoimagery, preferably not less than 25 parcels of different sizes, shapes, land cover and border visibility should be defined.
- The operator(s) undertaking the measurement must have received a level of training compatible with the reliable operation of the system being tested and clear instructions on the objects to be measured during the test.

4.3. Approach proposal

4.3.1. The basic design of the test (outlined in Figure 2 below) will consist of:

- Collection of preliminary, pre-validation data.
- Analysis of these data and possible simulations, design of the main validation trial.
- Use of reference parcels with well defined limits for which the area has been measured with a precise system (surveying tools, geodetic quality GNSS receiver, etc.).
- Finalisation of the operating protocol.

- Use of one or more operators, who has initially become familiar with the equipment operation and the test site before commencing the trial.
- Collection of 8 to 12 independent (with respect to date) sets of measurements, for example at different times of the day over several days.
- In each set of measurements, between 2 and 6 repetitions will be made; the number of repetitions should be determined at the beginning of the trial and be fixed.
- All results, including those which are determined by the operator to contain gross (blunder) errors will be recorded.
- Statistical processing of the data collected will be performed in order to assess the quality of performance of the receiver.

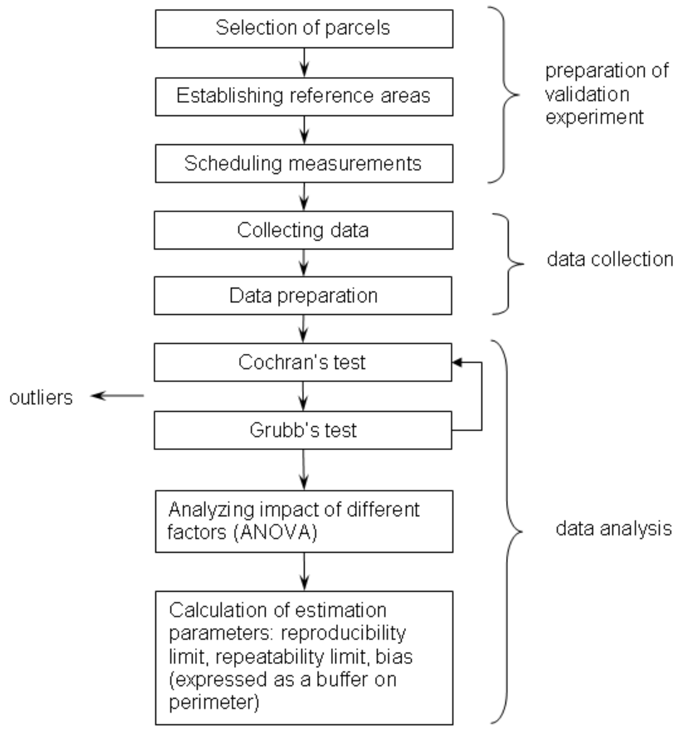


Figure 2: Outline of validation test steps

5. Validation execution: preparation

5.1. Pre-validation

5.1.1. In order to design the actual validation experiment, it is necessary to undertake preliminary testing of the area measurement system, thereby gathering data that can be used to assess the experimental design required: number of repetitions, objects to be measured, initial estimate for the performance of the equipment. A specific need at this stage is to provide input to simulation tools, permitting the design of the number of parcel sizes (levels) to be incorporated into the experiment, as well as the number of repetitions to be collected to provide reliable statistical estimates of performance.

5.1.2. Furthermore, this "pre-validation" trial will ensure that difficulties of use of the measurement system – particularly inadequate operating protocols, equipment robustness, and so forth – are usually identified at this stage and permit refinement of procedures, before the start of the definitive validation test (after which point modifications to protocols and test design will invalidate the results).

5.1.3. Based upon the experience noted above, it is concluded that the simple “football pitch” validation scheme is well suited for this task. To summarise the experiment to be run in this pre-validation phase:

- Observations may be made using a single operator, target object (well defined) and measurement system;[2]
- Data should be collected with a maximum of two repetitions;
- A minimum of 5 sets of measurements should be made, until observations are considered stable (that is, variance within repeated measurements approaches that of between measurements)

5.1.4. In the pre-validation phase measurement system performance may be assessed on the basis of the Root Mean Square Error (RMSE) of the perimeter uncertainty (buffer). Outlier determination may be performed iteratively on the basis of elimination of observations that exceed 3 times the RMSE. Similarly, bias may be assessed by comparing the mean area of observations with the true area of the reference object.

5.1.5. The results of this pre-validation should then be applied to determine, through simulation, the probable performance of the measurement system in the planned validation scheme. For example, multiple of parcels (with variations of size, or shape) may be used in a simulation. Positional accuracy as observed with the measurement system in the pre-validation trial may be used in the simulation, together with assumptions of rates of data collection. The resulting dataset maybe large (thousands of simulated observations) and once again many (sub)samples may be made of this dataset, with the intention of simulating the confidence interval of the buffer estimate, and analysed in function of the type, shape, size of parcels to be measured, or of the number of repeat observations to be made.

5.1.6. For example, in Figure 3 below, four parcels have been used in a simulation to determine the effect of number of repeat observations upon the buffer estimate confidence interval, and the probable effect of parcel shape upon the same parameter. The analysis of this result confirmed that the proposed design – 24 measurements per parcel, divided up in 12 measurement events, each with two repetitions – would be satisfactory and provide an expected 0.06m Standard Deviation of the buffer estimate confidence interval. This result, placed in the context of the actual design incorporating 6 parcels, with an expected perimeter uncertainty at one-sigma of 0.5m, was judged an acceptable design.

[2] for remote sensing systems, multiple operators may well be substituted for repeat measurements.

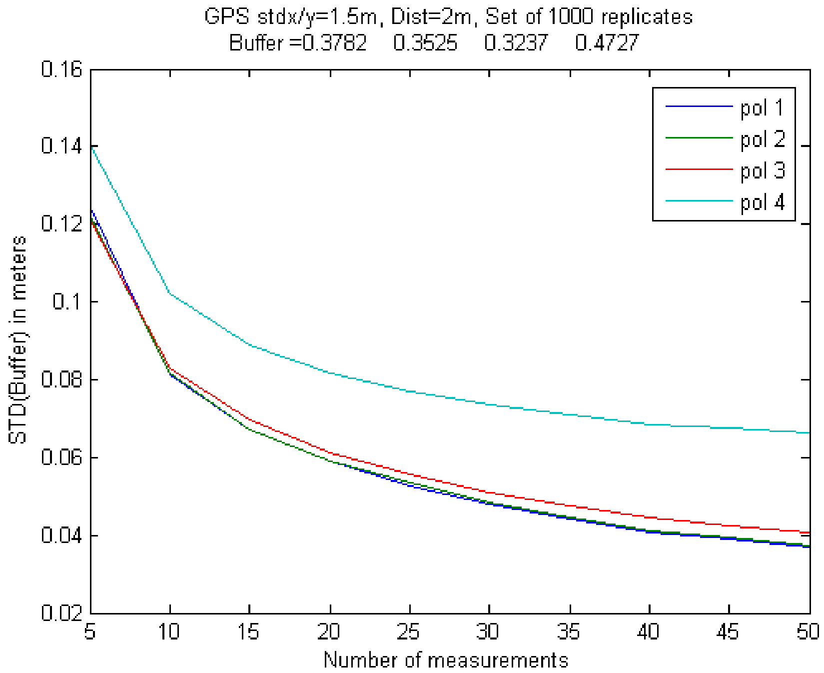


Figure 3: Example simulation of expected buffer estimate confidence interval

5.2. Validation test parcel areas, preparation

5.2.1. Reference parcels (not less than five) should be designed to have:

- Various sizes: ideally, the size range of the parcels should cover the full range expected feasible with the measuring system. The upper and lower limits of this range – the so-called limits of quantisation – represent the range within which the system produces reliable measurement results. These limits should be determined via some kind of sensitivity analysis and/or simulation; however, the range may be constrained to conform with the intended application.
- Various shapes: it is recommended that at least one parcel should represent an elongated shape, and that at least one parcel should represent an irregular object (e.g. Parcel f on Figure 4.).
- Various visibility of the horizon from the border: clear or partially obstructed border (for example row of trees very close to the border).

5.2.2. An example parcel configuration scheme is given in Figure 4, below.

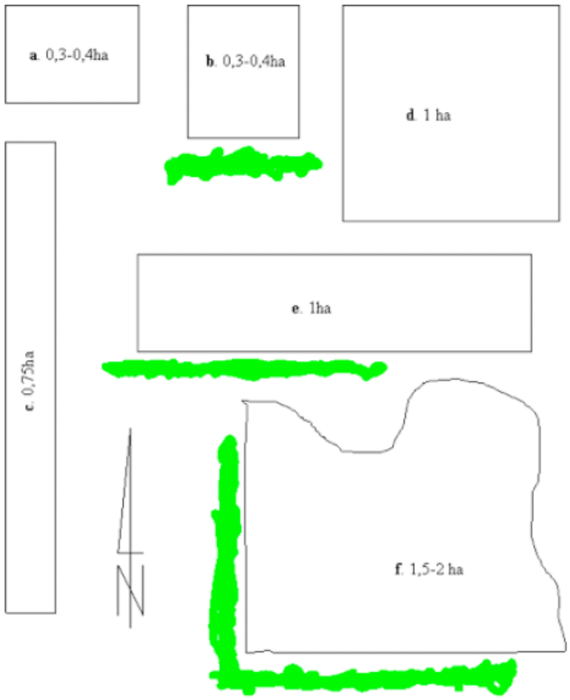


Figure 4: Example parcel configuration scheme for GPS measurement system validation. Obstructions of the horizon marked in green. (Oszczak and Ciecko, 2007)

5.2.3. In the field, parcels should be clearly marked, for example with pegs every 15m-20m, so as to define the area without ambiguity. The test site in general and the marks should assure comfort of walking so that the operators could focus on the measurements, e.g. rough ground or walking obstacles should be avoided. A straightforward distinction of the borders of neighbouring or overlapping parcels should be assured, for example by using coloured pegs.

5.2.4. For screen-based measurements (usually with remote sensing systems) clear and detailed digitization guidance should be devised. An example of the graphical illustration of the digitization key is shown on Figure 5.

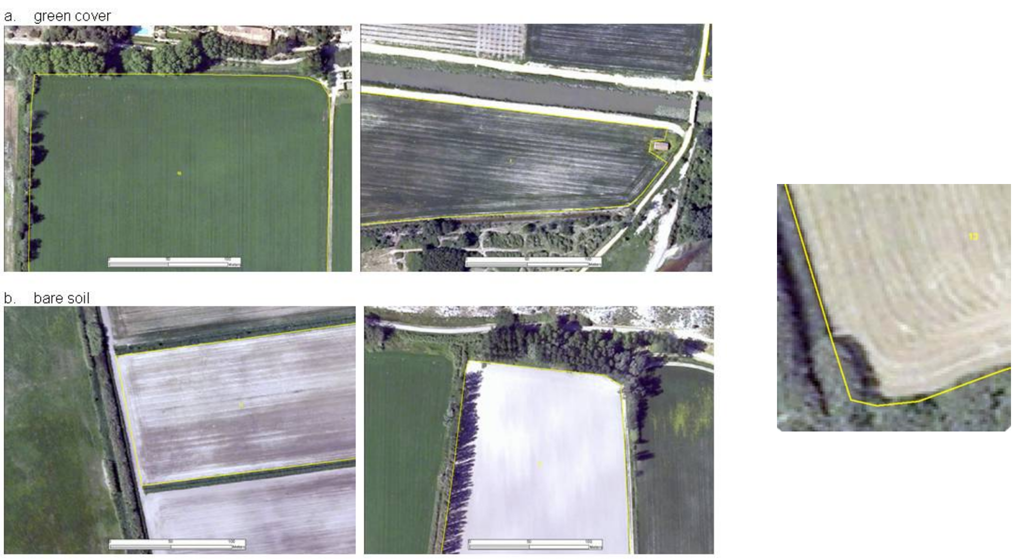


Figure 5: Example of the graphical illustration of the digitization key defined for different land covers (Pluto-Kossakowska, 2008)

5.2.5. The preferred survey approach for the reference measurement is centimetre-level survey (differential phase GNSS receiver, or total station measurement) of the coordinates of the parcel vertices, and area calculation using a standard GIS tool of the derived polygon.

5.2.6. In any case, the area measurement of the reference objects should be determined with a method shown to produce an uncertainty on the parcel perimeter of at least three times better than the target validation result. The area should be known to the nearest square meter (0.0001ha) (precision).

5.2.7. The area should be calculated using a standard, native geodetic system (such as WGS84 or ETRS89) ellipsoid and datum, and a standard projection system, such as the UTM zone applicable for the locality of the parcel, in order to avoid errors due to geodetic transformations.

5.3. Operator training,

5.3.1. The operators taking part in the test should be at least familiar with the practical difficulties encountered in typical field inspections. Furthermore, the operators involved should have undergone training or familiarisation of the system to be tested, to ensure that gross (blunder) errors are minimised. As mentioned above, such operator training should be in accordance with ISO 17025 or equivalent.

5.3.2. The operators should also be briefed precisely on the test area definition, to ensure that the area measured corresponds to the reference area. In case of the GNSS measurements, a walk around the borders of all the parcels is advised before kicking-off the data collection. Care should be taken in the protocol to avoid typical blunder errors due to the incorrect understanding of the equipment functioning, for example the radiometric characteristics of the remote sensing image used, or the basic knowledge of ensure good GNSS satellite signal reception. In case of validation of the remote sensing materials, an exercise dedicated to digitization of fields with different land cover types should be performed and followed by discussion of results between all the operators.

6. Measurements protocol

6.1. Configuration of the measurement system

6.1.1. For digitization of parcels on ortho-imagery, a proper scale of display should be identified and used during the test. Furthermore, the maximum distance between two successive vertices should be defined in order to avoid generalization of the parcel borders by operators.

6.1.2. In case of GNSS measurements, instrument settings such as code/phase measurements, value of the horizon mask, maximum PDOP allowed, maximum allowed Signal to Noise ratio, logging interval, velocity filters enabled, accuracy based data filtering, coordinate system used, will influence the quality of the measurements. Values of these parameters should be selected in accordance with the protocol used during the operational use of the receivers (e.g. manual for the operators). In case several examples of one measurement system are used in the test, all should have an identical configuration.

6.1.3. In the case that supporting accessories are used - such as a backpack for the receiver and external antenna, or a cap holding the external antenna - attention needs to be paid to position and stability of the antenna over the reference border.

6.2. GNSS measurements - Continuous measurement approach

6.2.1. When data are collected in a continuous mode (e.g. with time interval of 1s, 5s or a distance interval of 1m, 3m, 5m, etc) special attention should be paid to the position of the antenna over the reference border at all times.

6.2.2. The operators should assure collection of the data on corner points by following the procedures indicated in the protocol (i.e. by stopping for at least one epoch (depending on the logging interval selected for the measurements: for at least 1s, 5s, etc),

6.2.3. In order to eliminate (or identify) a potential source of the systematic error, operators should collect the data in both: clockwise and anti-clockwise directions, e.g. first repetition of the measurement of Field A – clockwise, second repetition of the measurement of Field A – anti-clockwise, third repetition of the measurement of Field A - clockwise, fourth repetition of the measurement of Field A – anti-clockwise.

6.2.4. The operators should constantly observe the parameters of the measurements system like number of satellites in view, PDOP, etc in order to identify possible interruptions of the signal. Signal outages, that might often occur in the neighbourhood of the border obstructions, should be identified by the operators and the measurement should be paused or the appropriate action – in accordance with the protocol - taken.

6.3. GNSS measurements - Vertex measurement approach

6.3.1. In case of area measurement done by logging of the vertices of the reference fields, the distance between two successive vertices should not be greater than 30m (and preferably fall into a range of 15m -20m). This is to “simulate” the natural landscape measurement conditions, where the borders are rarely straight and data are logged more frequently than when measuring rectangles.

6.3.2. A proper number of data should be collected on each of the vertices, depending on the protocol of the operational use of the receivers (cf. manual for the operators).

7. Data collection

7.1. Quality Management

7.1.1. The processes of collection and documentation of these data (i.e., test results) should be in accordance with the ISO/IEC 17025 Quality Management System Model, or equivalent.

7.2. Data collection plan

7.2.1. The data should be collected in accordance with the experimental design (statistical plan), based upon ISO 5725 or equivalent.

7.2.2. In case of validation of an ortho-image, the sequence (display order) of the parcels to be digitized should change from one repetition to another in order to reduce as much as possible the memorisation of parcel boundaries by operators. This is because with remote sensing data, the variability in the measurements is mainly related to the ability of interpreters to identify parcel boundaries. In contrast, with GNSS devices, the parcel boundaries are known without ambiguity and the variability results from the different satellites configurations and factors related to the signal reception (e.g. obstacles, atmosphere).

7.2.3. In case of GNSS measurements, different measurement sets should be collected with different satellite constellations (e.g. at different times of the day).

7.2.4. Data within one measurement set (e.g. 4 repetitions of measurements of field A) should be collected in the shortest time possible. This way the stability of the GNSS satellite constellation can be assumed within a set of measurements.

7.2.5. If feasible, several examples of the device should be used (e.g. 3 devices, each operated by another operator).

7.2.6. When several operators take part in the data collection, the measurement schedule should be designed so that they do not interfere with each other (for example because of different walking speeds).

7.3. Recording of results

7.3.1. Results should be recorded electronically (PDA, laptop, GIS module, etc) and include a full set of data normally available at the end of the measurement. These data should be downloaded onto a computer for further analysis.

7.3.2. In addition, it is recommended that results (area, perimeter) may be recorded manually to ensure a secure trace of the measurements concerned.

7.3.3. Typically, the following parameters should be noted:

- ID of the parcel measured
- ID of the measurement (from experimental design protocol)
- Date, time of measurement
- Operator identification
- Result: perimeter and the area together with units of measurement
- Result: GIS trace of parcel measurement (XML file, for example)
- Other observations, anomalies

8. Data analysis

8.1.1. After elimination of the outliers the results should be evaluated using the analysis of variance (ANOVA) procedures defined in ISO 5725 in order to identify the significant factors influencing the results (e.g. operator, direction of the measurement, field, etc). Outlier measurements will be determined using the defined procedures, namely Grubbs and Cochran outlier tests. The number of excluded measurements sets will be limited to a maximum of 2/9.

8.1.2. The repeatability limit and **reproducibility limit** will be derived **per parcel** from the repeatability and reproducibility standard deviations using all valid data and expressed as a buffer width:

- The repeatability limit represents the maximum expected difference at a 95% confidence level between two measurements made under repeatability conditions (usually same operator, same occasion);
- The reproducibility limit represents the maximum expected difference at a 95% confidence level between two measurements made under reproducibility conditions (usually different operators, different occasions)

8.1.3. The **bias** of the system will be determined by calculating the mean measured area, after removal of outliers and through the analysis of variance procedures. Bias will be expressed as a percentage of the total parcel reference area.

8.1.4. In absence of significant difference between the values of reproducibility limits calculated per parcel, an arithmetic mean of all the parcel reproducibility limits will be calculated.

8.1.5. The range of use of the equipment will focus on the minimum size of parcel for which – using the buffer reproducibility limit value – the appropriate area tolerance defined in accordance with Commission regulations can be met.

9. Reporting

9.1.1. A detailed report from validation should be prepared, including:

- detailed description of the measurements system tested: model version of the hardware, including external antennas if used, software version used for the area measurements, correction signals if used,
- detailed description of the setting of the receiver: code/phase measurements, horizon mask, max. PDOP allowed, Signal to Noise ratio, logging interval, velocity filters enabled, accuracy based data filtering, coordinate system used, etc,
- method of measurements used: continuous logging of the data; if logging vertices of the field, the mean distance between the successive points collected should be noted together with the number of logs per a vertex; use of supporting materials like a pole or a backpack for the external antenna should be reported,
- description of the test site: sizes, perimeters, shapes and description of the borders of the fields preferably accompanied by an ortophotography,
- results of statistical analysis of the data per parcel: number of outliers detected and rejected, problems identified by use of ANOVA, bias and repeatability and reproducibility limits,
- overall value of the reproducibility limit: in case of a balanced experiment an arithmetic mean of the reproducibility limits on all the fields,
- all the additional observations crucial for evaluation of the measurements system.

10. Certification of products

10.1. Accreditation

10.1.1. The advisory body, currently the JRC, provides user requirements and guidelines for testing (i.e., this document). In order to obtain an accreditation of the JRC, a certification body will propose a test plan, in accordance with these guidelines. The advisory body after recognition of the plan, if successful, will make the certification body public via the advisory body's web site. The certification body will in turn contract with a test laboratory, which will operate under their control and supervision, to undertake tests and produce data through equipment testing. These data will in turn be analysed to produce results, which will, following the review and evaluation by the certification body, lead to Certificate Publication, again on the web.

10.1.2. Proposals from any organisations interested to act as certification bodies on the behalf of manufacturers should be communicated in a form of a letter of application to simon.kay@jrc.it, outlining:

- the target instrument scope (GNSS, imagery, other),
- the draft test plan, to be submitted for review and completeness,
- details of the organisation, demonstrating competence and experience in the certification domain.

10.2. Review

10.2.1. An independent person who was not involved with the data collection and analysis described above has to review the work performed in the collecting and analysis phases together with the work done by the reviewer. This person has to have at least the same or higher technical qualification as the reviewer of the previous phase.

10.2.2. Based on their technical knowledge, the reviewer will perform an in-depth analysis of the documents generated in the data collection / validation phase and during the review. This review should ascertain that the collected / validated data and the documents produced during the review are reliable. If there should arise any doubt, the technical certifier must check with the reviewer or the person collecting and validating the data, and if necessary ask to redo all or parts of the previous phases.

10.3. Certification

10.3.1. If the technical certifier is convinced of the authenticity of these results, and that the equipment under test fulfils all requirements based on the available documentation of the previous phases, then the formal certification process may start. In this phase, formal certification takes place by checking that all relevant documents have been generated according to the specific requirements. Here also all references to specific requirements / standards are checked beginning with the sequence of the work performed, e.g. that the data collection and data analysis has been performed according to EN ISO/IEC 17025.

10.3.2. If no inconsistency is identified then the certificate will be formally issued, printed and forwarded to the requesting party. The certificate number and the company will be published in the internet providing information to any interested party.

11. Training Certification

11.1. Motivation

11.1.1. As the efficiency of the measurements in the field is highly dependent on the fact that the operator is using the measurement device properly in accordance with the protocol, e.g. manufacturer's specific requirements, it is highly recommended that each operator has to pass a training how to use a specific area measurement tool.

11.1.2. In order to achieve a similar high quality in the training as with the certification of the equipment itself, the training should be certified as well. As currently no standard or requirements describe the content of such training, such as specific content concerning the equipment to be used, a process needs to be established for this formalisation.

11.1.3. The company issuing such certification should be accredited according to ISO IEC 17024:2003. It should follow the following five principles:

- Objective catalogue of criteria
- Well defined certification standard
- Transparent requirements
- Independent examination board
- Ongoing improvement process

11.2. Framework

11.2.1. The first step is the foundation of a multidisciplinary *advisory committee* consisting of representatives of the Commission, representatives of manufacturers and of the various user groups like farmer, member state or auditor.

11.2.2. As the next step the advisory committee would propose criteria for the concept, content structure of the training and the type and content of the examination.

11.2.3. At present the proposed forum for such a committee is the annual workshop managed by the JRC concerning use of GNSS for area measurement.

11.3. Implementation

11.3.1. Based upon the recommendations of the committee, a certification company may then define the formal criteria for certification. As a guide, training certification can be done assessing the content, the concept, aim, accompanying material, based on the well-defined criteria by the certification organization. The results have to be documented within a detailed assessment report.

11.3.2. To ensure a high quality of the training in the next phase, an audit by the certification body of the training institute and the trainer is required. An on-site assessment of system, training institutes, trainers and their qualifications has to be performed. The results have to be documented within a detailed assessment report.

11.3.3. An ongoing feedback of participants has to be established. This requires the evaluations of participant feedback and complaints, if any, and the establishment of a system for responding immediately to such feedback and initiating effective corrective and preventive action

11.3.4. If the results of concept, contents, examination system, hardware, training institutes and trainers' assessments are positive, the certification of the training course can be issued. The certification mark will be published together with the training institute and the trainer in the internet for further reference.

11.4. Certification of users

11.4.1. To ensure that the trainees have fully absorbed the training material, an examination is required at the end of the training. This examination could, for example, be done via a multiple choice test taking into account the available certified equipment as well as the one used within the training course. The test should consist of a variety of different forms each with a different set of questions.

11.4.2. The examination has to be carried out under the supervision of an accredited person, who cannot be the trainer. The examiner will collect all tests papers, and forward these to the certification company for evaluation. The certification company will calculate the result of the examination, and those persons having successfully passed the examination will be issued with a certificate. At the same time, it is considered appropriate that the name of the person will be published together with the certificate number in the internet by the certification company, thus providing independent and transparent demonstration of the operator's proficiency.

12. References

12.1. Legislation:

- Commission Regulation (EC) No 796/2004 of 21 April 2004 with amendments, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004R0796:EN:NOT
- EU Directive 2004/22/EC on Measurement Instruments, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:135:0001:0080:EN:PDF

12.2. References :

- ISO 5725: Accuracy (trueness and precision) of measurement methods and results.
- ISO 17025: General requirements for the competence of testing and calibration laboratories
- Validation of methods for measurement of land parcels areas, Beata Hajmanowska, Rodolphe Palm, Stanislaw Oszczak, Adam Ciecko, 2005 http://mars.jrc.ec.europa.eu/mars/content/download/800/5268/file/ValidationMethodFinalVer2_2.pdf
- Validation of methods for measurement of parcel areas – near-VHR imagery, Beata Hajmanowska, Rodolphe Palm (2005), http://home.agh.edu.pl/~zfiit/raporty_pliki/ue_raport_konc_22581200412F1SCISPPL_cz2.pdf
- Assessing the error of polygonal area measurements: a general formulation with applications to agriculture Patrick Bogaert, Jacques Delincé, Simon Kay, 2005, http://iopscience.iop.org/0957-0233/16/5/017/pdf?ejredirect=.iopscience

12.3. Other related work:

- Assessment Of The Area Measurement On Cartosat-1 Image, Joanna Pluto-Kossakowska, David Grandgirard, Rafał Zieliński, Simon Kay, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B1. Beijing 2008, http://www.isprs.org/congresses/beijing2008/proceedings/1_pdf/223.pdf
- Propagation of positional measurement errors to field operations, Bruin, S. de; Heuvelink, G.B.M.; Brown, J.D., 2008, http://www.itc.nl/ISSDQ2007/proceedings/Session%202%20Spatial%20Statistics/Paper%20Sytze%20de%20Bruin.pdf
- Proposed procedure fo validation and certification of GNSS instruments and observers, Stanislaw Oszczak, Adam Ciecko, Geographical Information in support of the Common Agricultural Policy. Proceeding of the 12th MARS PAC Annual Conference 2006. EUR 22160EN-2007
- Agricultural parcels measurement on VHR SAR images, Joanna Pluto-Kossakowska, presentation on 2008 MARS Annual conference "Geomatics in support of the CAP", http://mars.jrc.it/mars/content/download/1183/6964/file/T3_Kossakowska_Assessment%20of%20SAR_JPK.pdf
- Agricultural parcels measurement on vhr sar images, Joanna Pluto-Kossakowska, poster presentation on 2008 MARS Annual conference "Geomatics in support of the CAP", http://mars.jrc.it/mars/content/download/1208/7043/file/Poster_Parcel%20measurement%20on%20SAR_Kossakowska_JRC.pdf
- Validation of GNSS receivers: step by step, Aleksandra Sima, poster presentation on 2008 MARS Annual conference "Geomatics in support of the CAP", http://mars.jrc.it/mars/content/download/1255/7259/file/Poster_Sima_Validation_JRC_updated.pdf

European Commission

Joint Research Centre – Institute for the Protection and Security of the Citizen
Title: Area measurement validation scheme
Author(s): Simon Kay, Aleksandra Sima
Luxembourg: Office for Official Publications of the European Communities
2009 – 19 pp. – 21 x 27.9 cm
ISBN 978-92-79-08714-1
DOI: 10.2788/77728

Abstract
The purpose of this document is to define an approach for the validation of area measurement methods for agricultural parcels, using mainstream forms of equipment (GNSS, remote sensing, or in general geomatics based survey tools).

How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

LB-80-08-274-EN-C

EUROPEAN COMMISSION

ISBN 978-92-79-08714-1

9 789279 087141

Publications Office
Publications.eu.int