POSSIBLE INFLUENCE FACTORS OF TECHNICAL TOLERANCE

[1]D. Molnár, [2]A. Surányi, [3]V. Grónás, [4]J. Skutai

[1] Szent István University, Páter Károly utca 1, 2100, Gödöllő, Hungary,
e-mail: molnar.daniel@kti.szie.hu
[2]GeoAdat Kft., Szentkirályi utca 8, 1088, Budapest, Hungary,
e-mail: andrassuranyi@t-online.hu
[3]Szent István University, Páter Károly utca 1, 2100, Gödölllő, Hungary,
e-mail: viktor.gronas@kti.szie.hu
[4]Szent István University, Páter Károly utca 1, 2100, Gödölllő, Hungary,
e-mail: julianna.skutai@kti.szie.hu

ABSTRACT

Legitimate users of agricultural areas can receive land-based payments based on the area of either the cultivated plants or the uncultivated land kept, in line with the provisions of community and national legislation, in condition eligible for support. Furthermore, land-based support can be received via other rural development measures as well.According to European Commission regulation the appropriate and eligible claim of the land-based supports shall be controlled by the member states. The most robust technique of this process is the remote sensing control. The observed discrepancies shall be sanctioned based on their extent and intentional nature. A measurement tolerance interval shall be set in case of remote sensing operations so that the extent of discrepancy is to be determined in the most objective way possible. As far as the measurement tolerance interval is concerned the goal is to minimise the cumulative faults appearing during the measurements (such as the scale of agricultural activities, the inaccuracy of farmers' drawings necessary for the claiming of support and the inaccuracy of control materials and methods).The establishment of the measurement tolerance interval is based on the fact that the reference parcels selected by the validation protocol are made by several operators in iterations. As a result of this process the following conclusions can be drawn:The validation method of multi-level tests required by the Joint Research Centre (JRC) properly detects the measurement results strongly affected by faults. Although this method is to be used exclusively to determine the technical tolerance in the Control with Remote Sensing (CwRS) process of the Integrated Administration and Control System (IACS), as independent validation process it does not take the further imagery and other vector references into account. In our examination we assessed the possible inclusion of the smallest identification unit of the Land Parcel Identification System (LPIS) – i.e. the physical block – as well as its impact on the value of technical tolerance.

Keywords: technical tolerance, orthoimagery, validation, LPIS, CwRS

1. INTRODUCTION

The Integrated Administration and Control System (IACS) is a tool used by the European Commission and EU member states to carry out checks on payments granted to farmers for particular crops and livestock based on the Land Parcel Identification System (LPIS) [1], [2], [3], [4].
The aim of the IACS is to establish, coordinate and control the payment processes. By the form of the so-called e-application LPIS provides opportunity for farmers to delineate by drawing their cultivated areas. It is also possible to enter the relevant attributes of the polygons created in such way. Among others these attributes are the code of use (the plant species grown in the given year), parcel size, other support applied for the same area (e.g. agri-environment schemes, Natura 2000 compensatory payments etc.).
The base unit of the LPIS is the physical block. It has permanent and on-site easily identifiable borders (e.g. roads, railroads, drains, embankments, forest margins etc.) and is usually under one type of cultivation (e.g. arable land, grassland, plantation, forest etc.). Generally there are more agricultural fields (parcels) within a physical block and its area can be utilised by more than one farmers. Each physical block is divided into eligible and non-eligible areas. Eligible areas are those that are justified for receiving support. The size of this area can be calculated by subtracting the non-eligible areas from the total size of the block. The non-eligible areas are clearly indicated in the maps. Most common examples for non-eligible areas are residential or farm buildings, small groups of trees, drains and wetlands. Farmers can claim support for only those lands that lie on eligible areas (with the exception of the reed management sub-measure of the agri-environment measure).
In case of supports connected to the land size the identified base unit is the agricultural parcel. It means that each farmer has to indicate the agricultural parcels in the rows of the support claim. The agricultural parcel is a contiguous agricultural land on which one producer cultivates one plant species (or variety).
The adequate utilisation of the European Union Funds is thoroughly controlled by the accredited organisation. As for the land-based supports the control is consisted of cross-checks and physical control; the latter can implemented by on-the-spot checks or remote sensing. During the cross-check the data of the

claims are compared to that of relevant databases. In this way parts of the unjustified claims as well as the double/multiple claimed areas and the overclaiming can be filtered out. (Overclaiming occurs when the farmers involved in a certain physical block altogether claim support for larger area than the eligible size of the given physical block.) During remote sensing the actual size of the parcels and their cultivation types are determined. Within the framework of the on-the-spot checks the inspectors complete a report on the results of the check: in case of area-based supports the actual size of the area measured by using GNSS equipment, the cultivated plant species and the level of complying with the rules of the Good Agricultural and Environmental Conditions (GAEC). According to the provisions the cross-checks shall be implemented for 100% of the claims; in case of direct payments at least 5% and at least 1% of the total supported area shall be covered by remote sensing and on-the-spot checks, respectively.

The European Union sets the extent of the sanctions in legislation depending on the degree of discrepancy between the size of the area claimed by the farmer and the actual size of the area cultivated by him/her.

Since the process of the remote sensing control can be affected by multiple faults, a tolerance interval shall be determined. This interval shall be incorporated into the compensation mechanisms as regards of area discrepancies when applying remote sensing control.

2. MATERIALS AND METHODS

During the remote sensing control both the so-called farmer drawings (the outlines of cultivated parcels drawn on the web surface by farmers) and the parcel maps vectorised by using the remote sensing images.

Primarily the following sources of errors called for the establishment of the measurement tolerance interval: 1: the size of the scale of agricultural activities; 2: the inaccuracy during the claiming process (farmer drawings); 3: the inaccuracy of the control data sources and 4: the inaccuracy of the control methods.

The essence of validation of orthoimagery is to calculate more exact tolerance value in an environment similar to that of the parcel assessment. This tolerance value is adequate for both the local circumstances (e.g. terrain and parcel structure) and the sensory (e.g. radiometric or spectral) attributes of the reference images.

The goal of validation of orthoimagery is only to determine the tolerance value (in metres) used in CwRS (Control with Remote Sensing) processes.

Although the parcels selected for the validation provide a representative sample of the given parcel structure, besides VHR (very high resolution imagery) as the primary reference the validation does not take other references, such as a physical block, other claims, other vector layers or local interpretation rules into account.

According to the European Commission Regulation a Member State are required to use "means proven to assure measurement of quality at least equivalent to that required by applicable technical standard, as drawn up at Community level" [5].

The quality of a measurement tool can be characterized by a number of parameters such as its bias, precision and accuracy. Assuming there is no bias, it can also be characterized by its reproducibility limit, which is the parameter used to determine the technical tolerance [6].

The method of calculating tolerance interval for a given parcel (1):

$$[\text{shape.Area (m}^2) - (\mathbf{X}\text{ (m)} * \text{shape.Perimeter (m)}), \text{shape.Area (m}^2) + (\mathbf{X}\text{ (m)} * \text{shape.Perimeter (m)})] \qquad (1)$$

where,   shape.Area   the area of the parcel,
         shape.Perimeter the perimeter of the parcel and
         X   the value of the tolerance and $(0{,}5 <= X <= 1{,}5)$
Calculating the tolerance value (2) based on the general rule of thumb:

$$X = \text{pixelsize (m)} * 1{,}5 \qquad (2)$$

According to the validation protocol 30 parcels (class) are digitalised using 4 repetitions (set) due to the repeatability and reproducibility examinations by 6 operators. Therefore the tolerance value can be determined based on 720 measurement results.

2.1. Set of Parcels

Validation tests can reliably run on a sample consisting of at least 30 parcels.
Each of the images to be validated covers one CwRS control zone, i.e. the selection population is equal to all claimed parcels of a zone. Therefore the 30 parcels are generally selected from among 1,500 to 5,000 parcels. Based on the recommendation of the Joint Reseach Center (JRC) the parcel size [small (0,05 - 1ha), medium (1 - 5ha), large (5 - 10ha)], shape (compact, elongated, very elongated) and the clarity and recognisability of the parcel borders (easy, fuzzy) shall also be taken into account.
The 6 operators interpret the selected parcels using four repetitions, in four separate days and in various order.
Sketches created by a 15 m negative buffer help the orientation regarding the images and the identification of the selected parcels. In this way these sketches do not influence the operator but provide general orientation in case of poorly visible borders.

2.2. Metadata about Orthoimageries

The VHRs selected for the examination are those image references that are characteristic to the two platforms and, considering their parameters, are used the most widespread.

As training fields we have an aerial and a satellite imagery:

	Airborne imagery	*Satellite imagery*
Acquisition date	17th April 2014	25th April 2014
Number of Bands	RGB and CIR	RGB and CIR
Cell size (X; Y) (m)	0,2; 0,2	0,5; 0,5
Pixel Depth (bit)	8	16

2.3. Statistically analysis and tolerance estimation

This measurement accuracy is determined through an area measurement validation test, whose main output is a reproducibility limit at 95% confidence level, expressed as buffer width [7].

The tolerance value estimation was performed according to the JRC guidelines on validation. All measurements were prepared and analysed statistically according to the ISO 5725-2 based method [8].

The foremost applied Cochran's test checks variation of standard deviation between classes. The outlying observations are classified in outliers and stragglers.
Here given a set of p standard deviations S_i, all computed from the same number (n) of replicate results, Cochran's test statistic (3), C, is

$$C = \frac{S_{max}^2}{\sum_{i=1}^{p} S_i^2} \qquad (3)$$

where S_{max} is the highest standard deviation in the set.

Grubbs' test (Nr.1) (4) for single observation checks the variation of observed value in class, where the standard deviation is calculated within a Cochran's test resulted straggler class:

$$G_1 = \frac{\overline{X} - X_1}{S} \qquad (4)$$

Grubbs' test (Nr.2) (5) for two outlying observations checks the variation of means between classes, where standard deviation is calculated between classes:

$$G = \frac{\sum_{i=1}^{p-2}(X_i - \overline{X}_{p-1,p})^2}{\sum_{i=1}^{p}(X_i - \overline{X})^2} \tag{5}$$

Following the exclusion of outlier measurement results, sets or classes the determination of tolerance value derived from the average of the tolerance values of the given classes can be commenced by also taking the area and perimeter of the reference parcels into consideration.

2.4. Use of physical block

The goal of the examination is, besides the comparison of the two acquisition platforms and resolutions, to run the validation process based on the new data series created by taking into account the borders of the physical blocks representing a strict limitation in CwRS and a border for the claimed and control parcels as well as to compare the results.

The borders of the physical blocks that have great significance in CwRS are taken also into account here similarly, by cutting the polygons of the parcels, see Fig. 1.
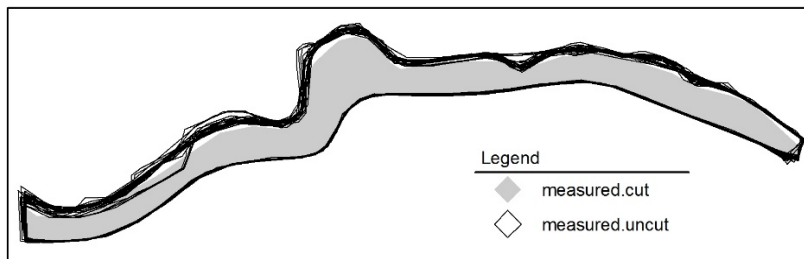

Figure 1. A sample parcel with fuzzy boarder

Fig. 1 illustrates, that the area and the perimeter of the parcel variations shows notable differences and the border of the parcel is not regularly easy or fuzzy on every border unit.

3. RESULTS

Results of the validation process run in both the original (.uncut) and cut (.cut) versions of the measured and reference parcels are summarised in Tab. 1. The X values in the cells represent the calculated tolerance value according to the given combination of the input data types. Data series *measured* includes the 720 validation measurements while *reference* covers the 30 reference parcels.

Table 1. Estimated tolerance values by platform and method

Airborne imagery	reference.uncut	reference.cut
measured.uncut	$X_{V1} = 0{,}9672$ m	$X_{V3} = 0{,}9346$ m
measured.cut	$X_{V2} = 0{,}4991$ m	$X_{V4} = 0{,}4767$ m
Satellite imagery	reference.uncut	reference.cut
measured.uncut	$X_{V1} = 1{,}4419$ m	$X_{V3} = 1{,}4573$ m
measured.cut	$X_{V2} = 1{,}0924$ m	$X_{V4} = 1{,}1004$ m

The results of the validation process, thus the tolerance values are in line with the previous expectations. By including the borders of the physical blocks, i.e. by cutting the overstretching parcel borders and hence

having homogenising effect within the class the standard deviation decreased and so did the determined tolerance value.

The relatively subjective selection method of the parcels has rather significant influence on the results. Having examined the class results it can be observed that the most remarkable impacts are clearly made by the parcel border types (easy or fuzzy). Therefore the selection of the parcels influences the results in at least as great extent as the applied measurement methods do [9] (Fig. 2).
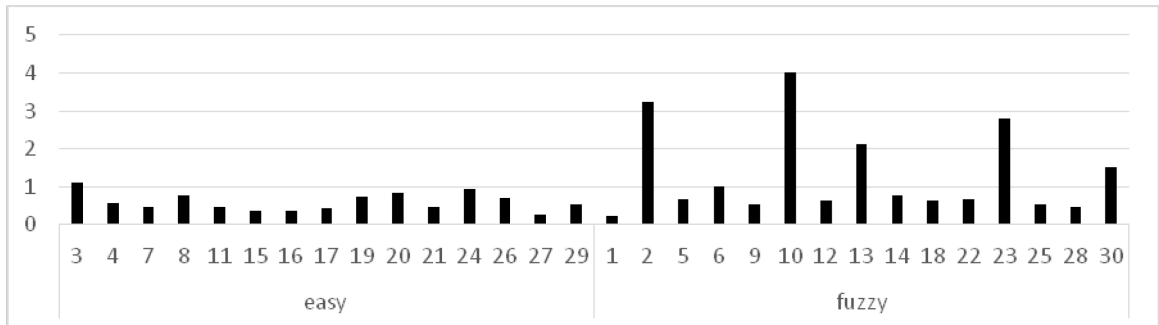

Figure 2. Buffer limit (m) for each parcel of airborne imagery version V1 (reference/measure.uncut), sorted by border type (easy/fuzzy)

4. DISCUSSION

The method ignores the faults originated from the inner distortions of the image that can lead to considerable anomalies during CwRS interpretation. This method could take into account this impact indirectly, by considering the reference parcels. However, it can be seen by the results indicated in the table that combining the same measurement results with different versions of the reference parcels (.uncut/.cut) brings no significant result. Furthermore, the direction of this effect cannot be pre-defined, since it decreased the tolerance value in case of airborne imagery while in case of satellite imagery the tolerance value has been increased [10].

Including the physical blocks in the determination of tolerance value is not recommended due to – among others – its unknown accuracy. As a conclusion of the examination it can be stated that the tolerance value determined by this method and used in countries applying the physical block system can be appropriate for the CwRS interpretation and in some cases can be favourable for those under control.

During measuring the method adequately detects those measurements that considerably deviate from the average within the set and/or class, thus are strongly affected by measurement faults.

5. CONCLUSIONS

There are no direct results on the geometric accuracy of the validated image since the validation process is based on the multiple validation of the same image. This deficiency is intended to avoid by a step in the validation process that takes also the values of the reference parcels into account. Nevertheless, it can be seen by the results interpreted in the scale between 0.5 m and 1.5 m that while cutting the parcels (measured.uncut/.cut) the difference can be as large as 0.4681 m, in case of cutting the references (reference.uncut/.cut) the biggest difference is only 0.0326 m.

The validation process takes account of neither the geometric, nor the orthorectification inner faults and distortions of the image. These faults can emerge during the CwRS process when joint utilisation together with the other raster reference material is implemented.

It can be concluded that this validation method emphasize rather the given parcel structure and interpretation rules than the given image. Therefore this method is rather an estimation of a value as technical tolerance for CwRS and not a validation of a sensor or imagery.

The validation method in its recent form is rather conform to on-the-spot GNSS measurements than to image tolerance calculations.

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