European Commission

Geomatics in support of The Common Agricultural Policy

Proceedings of the 17th GeoCAP Annual Conference, Tallinn (Estonia) 2011

Edited by: D. Fasbender, K. Taşdemir, Ph. Loudjani, V. Angileri, C. Lucau, P. Milenov, W. Devos, R. De Kok, S. Lemajic, A. Tarko and P. Pizziol

2012

Report EUR 25533 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for Environment and Sustainability

Contact information
Neil Hubbard
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 266, 21027 Ispra (VA), Italy
E-mail: Neil.Hubbard @ec.europa.eu
Tel.: +39 0332 78 5725
Fax: +39 0332 78 5162

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

This publication is a Reference Report by the Joint Research Centre of the European Commission.

JRC73275

EUR 25533 EN

ISBN 978-92-79-26644-7 (pdf)
ISBN 978-92-79-26645-4 (print)

ISSN 1018-5593 (print)
ISSN 1831-9424 (online)

doi:10.2788/51820

Luxembourg: Publications Office of the European Union, 2012

Printed in Italy

Contents

CONFERENCE ABSTRACT

The 17th Annual Conference GEOCAP, took place from 23 to 25 November, in Tallinn, venue Meriton Hotel, and was organized by JRC MARS with the support of Estonian Ministry of Agriculture and of the Estonian Paying Agency (PRIA).

The Conference covered the 2011 Control with Remote Sensing (CwRS) campaign activities in the frame of CAP (common agricultural policy) controls for area-based subsidies. As usual, the Conference has offered an overview on the state of art technologies and methods applied to the above mentioned controls.

Registered participants were 301, but 270 turned up. The composition of the audience was Commission Services, industry (image providers and software providers), Member States administrations (Ministries of Agriculture, Paying Agencies and academia). Participants came from all MSs, plus Croatia, Turkey, FYROM, Iceland, Switzerland and Norway.

The opening speech was given by the Estonian Minister of Agriculture, Mr Seeder.

The Conference format had the following structure:

- Opening session dedicated to policy impact and policy developments.
- 4 Parallel sessions dedicated to technical discussions and developments about sensors, GAEC controls, LPIS and GNSS.
- Closing session dedicated (first part) to CwRS campaign statistics, GEOCAP WP, LPIS QA and (second part) to summarize sessions content then giving a forward look about policies, their implementation and technology.

We had a total of 36 presentations: 13 by industry, 12 by JRC, 9 by MSs administrations and 2 by DG AGRI. There were also 6 posters, 3 by JRC MARS and 3 by industry.

The presentations were made available on line. This publication includes the best of them according to the opinion of the Scientific Committee.

ACKNOWLEDGMENTS

We express our gratitude to Paolo Pizziol (JRC), Valentina Sagris (EE Ministry of Agriculture), Martin Tahvonen (Meriton Hotel) and Anu Aedmae (B&S Europe) for the sound organisation of the conference. We are grateful to presenters to agreeing to submit their work as papers, as well as to the scientific committee for contributing their valuable time at the meeting to select those presentations most suitable for publication.

PEER REVIEW PROCESS AND COMMITTEE

Up to the 11th Conference, GeoCAP had produced "proceedings" gathering the slides of all presentations made at the annual conference. In 2006 however, it was decided to go one step better and to produce a restricted set of papers in a special JRC publication, selected by a peer review committee during the conference.

Since the 12th GeoCAP annual conference held in Toulouse (France) in 2006, peer reviewed proceedings have been produced and published for each GeoCAP conference. To achieve credibility on these publications, a peer-review committee has been assembled, mostly external to the JRC. The committee members organize themselves to attend the technical sessions of the conference, and decide upon the short list of presentations for publication. The proceedings here are a result of that shortlist. In addition, as a result of the peer review process, an award is assigned for the best presentation and the best poster in the conference:

Best presentation: Markus Jahn et al. with the presentation "*Investigation of tolerances for on-the-spot checks: Results of the German workshop 2011*"

Best poster: Kadim Taşdemir and Csaba Wirnhardt with their poster "*Automatic assessment of land parcel identification systems for agricultural management*"

The conference organizers and the editors are grateful to the assistance provided in reviewing the presentations. The peer-review committee members were (in alphabetical order):

- **Mr. Carlo Del Lungo**, SIN-AGEA, Italy
- **Mr. Dominique Fasbender**, European Commission, Joint Research Centre, Italy
- **Mr. Juris Grinevics**, Rural Support Service, Latvia
- **Mr. Luc Hansen**, Unité de Contrôle, Luxembourg
- **Mr. Grega Milcinski**, Sinergise Ltd., Slovenia
- **Ms. Kadri Pärnpuu**, ARIB, Estonia
- **Ms. Brooke Tapsall**, RapidEye AG, Germany
- **Mr. Mike Wooding**, RSAC Ltd., United Kingdom

AGRO-ENVIRONMENTAL SURVEYS SUPPORTED BY SPATIAL INFORMATION FROM INTEGRATED ADMINISTRATION AND CONTROL SYSTEM (IACS)

Francesco Tropea[1], *Antonio de Meo*[2], *Lorenzo Fattorini*[3]

[1] Ministero Politiche Agricole Alimentari e Forestali, Via XX Settembre, 00187 Roma, Italy
[2] SIN, Via Salandra 13, 00187 Roma, Italy
[3] Department of Economics and Statistics, University of Siena, P.za S. Francesco 8, 53100 Siena, Italy

ABSTRACT

In addition to standard tools and information layers used for IACS by Member States, the Italian Ministry of Agriculture, Food and Forestry Policies and the AGEA-Coordination Body are developing methodologies for land cover data collection and land cover monitoring based on the information provided by the recent REFRESH project. While quantitative estimates of crops area and other agricultural trends are achieved by the AGRIT project (a sample survey similar to LUCAS survey), in 2011 the purposes of the project were enlarged to the assessment of environmental characteristics and to the estimation of agro-environmental indicators. An experimental sampling strategy was adopted in which an areal sampling frame was stratified using the large amount of IACS spatial information available for the whole country, while ground surveys were performed within the selected areas (quadrats). The newly-born AGRIT Agro-Environmental survey allows collecting quantitative and qualitative information concerning agro-environmental details that are non-detectable by the photo-interpretation performed during LPIS activity. The final aim of the project is the achievement of statistically sound estimates of selected agro-environmental indicators to be used for assessing and managing CAP policies, particularly for GAEC standards, and for monitoring the agro-environmental measures in Rural Development Programme.

1. INTRODUCTION

The increasing citizens concern about the environmental public goods, the attention to the issues of climate change and the environmental challenges imposed by the review of the Common Agricultural Policy (CAP) post 2013 require assessing and quantifying the interaction between Agriculture and Natural Resources. To this purpose, in 2011 the Italian Ministry of Agriculture, Food and Forestry Policies (MIPAAF) started an experimental project for the collection of data related to land cover and agro-environmental characteristics. By combining the existing large amount of spatial information from the Integrated Administration and Control System (IACS) with ground surveys, the project enabled the collection of information about the state of the environment and agro-environmental resources.

That made possible to acquire a first set of data for a reference base-line at the national-regional level aimed at monitoring the environment and estimating agro-environmental indicators. The gained information will be relevant for assessing and managing CAP, mainly for some aspects of Cross Compliance and Rural Development and for measuring the impact and the assessment of new greening measures of the CAP post 2013.

The experimental project is based on the integration of two instruments performed in Italy since many years: the LPIS as part of the Italian IACS and the AGRIT project.

The first component rests on the Italian Land Parcel Identification System (LPIS) as part of the Integrated Administration and Control System (IACS-LPIS[1]). The LPIS is the GIS that stores the parcel information to support the aid declaration and subsequent control. Since 2007, AGEA (Italian paying Agency) started a project for the LPIS upgrade (so named the REFRESH project) in order to achieve a complete photo-interpretation of the entire national territory (300.000 sq. km).

From 2009, the photo-interpretation is not limited to the area of the reference parcels declared for subsidy applications, but is extended including also the photo-interpretation of artificial, natural and forest lands. The photo-interpretation classifies the territory in different land cover classes (77) with a high geometrical precision of the polygons delineating the different land cover. REFRESH project updates land cover information, for 1/3 of the Italian territory every year enabling data collection and land cover monitoring through the years.

The second component is based on the AGRIT project, a sample survey performed by MIPAAF since

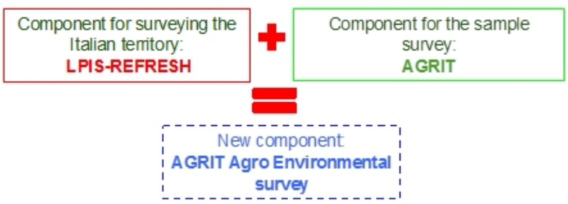
[1]European Community Council Reg. 3508/92, in particular the amendment 1593/00.
European Community Council Reg. 1782/03
European Community Commission Reg. 2419/01
European Community Commission Reg. 796/04

1988. From 2003, the survey is based on a two-phase sampling from a point frame (similar to the LUCAS survey), covering 56% of Italian territory, and 100% of UAA. Every year, 100.000 points sampled in the agricultural layers of the AGRIT sampling frame named POPOLUS (Permanent Observed POints for Land Use Statistics), are controlled in the field by 200 surveyors employed during the spring-summer period. On yearly basis, AGRIT provides estimation at regional level of extents and yields for the major crops of national importance.

In 2011, the flexibility and the robustness of the AGRIT survey enabled to combine the traditional sample survey with a new experimental survey. The new project used the REFRESH spatial information stored in the LPIS and by means of field surveys aimed to record categorical and quantitative variables of agro-environmental nature, otherwise undetectable by photointerpretation.

The integration of these two projects generated a novel survey named AGRIT Agro-Environmental survey (AEE) enabling the determination of unbiased agro-environmental indicators on a Regional scale. The 2011 AGRIT Agro-Environmental survey covered three Italian Regions: Marche, Toscana e Sicilia representing about 1/6 of the national territory.

Figure 1: LPIS-REFRESH update time schedule.



2. SAMPLING STRATEGY

The AAE sample survey is aimed at obtaining unbiased estimators for the totals of some interest variables and for some agro-environmental indicators at regional scale.

The sampling strategy was constructed and checked in a pilot survey performed during spring and summer 2010 in five Italian provinces (Alessandria, Ferrara, Siena, Taranto, Agrigento) which present different morphologies and a wide agronomic range and crops differentiation.

The choice of the interest variables to be recorded during the survey was previously performed by a working group including researchers of several Italian agencies and institutions. The 2010 pilot survey allowed to clearly define the quantities to be estimated, the sampling scheme to be adopted and the criteria to perform estimation together with the tools and the field procedures for the practical implementation of the recording activities. The sampling strategy makes use of the information available from IACS (LPIS-REFRESH), primarily adopted for CAP payments.

The 2011 AAE sample survey project phase are the following:

- Step 1 - Frame construction
- Step 2 - Stratification
- Step 3 - Sample selection
- Step 4 - Field Survey
- Step 5 - Estimation
- Step 6 - Final outputs

Step 1-Frame construction

From a methodological point of view, the AEE survey is an areal sampling in which a sample of spatial units is selected in accordance with a stratified scheme from the population of spatial units partitioning the study area, The study areas coincided with the Italian region selected for the survey while, for each region, the population was constituted by the quadrats of side 250 m in a grid superimposed to the study area in such a way that each quadrat contains at least a portion of the regional territory. The quadrat grid was constructed starting from POPOLUS network and dividing each quadrat into four (see Figure 2). As the nodes of POPOLUS network (1.206.536 points) constituted the target population of the above-mentioned AGRIT project, the information arising from this survey became available. Obviously, this choice of determinist nature precluded the use of other forms of tessellation based on random grids (e.g. Stevens, 1997). Accordingly, the population to sample turned out to be the set of size N, obtained from the grid by discarding the non agricultural quadrats, i.e those quadrats for which the cumulative extent of forest and woodland, artificial sealed surface, natural bare areas covered the whole quadrat.

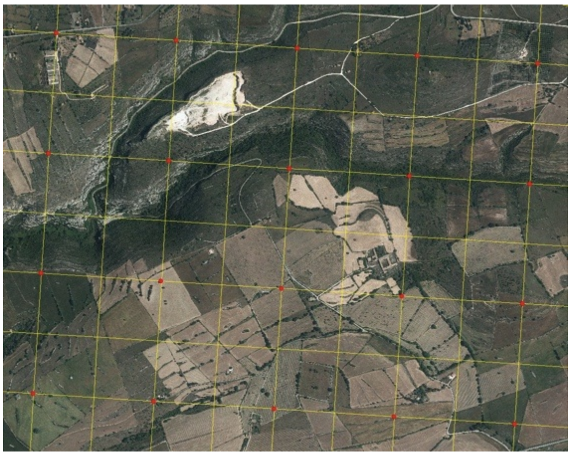


Figure 2: Frame construction from the POPOLUS network.

Step 2-Stratification
If some information is available for the whole population under study, the population can be partitioned into sub-populations (strata) which are homogeneous with respect to some characteristics. The partition is usually refereed to as stratification and is likely to provide noticeable benefits in the accuracy of the resulting estimates. Indeed, following stratification, the survey proceeds as a series of independent surveys performed within each stratum, in such a way that the overall estimate is obtained as the sum of the independent within-strata estimates and the overall variance of the survey is reduced in this way by eliminating the between-strata variability. In the framework the AGRIT agro-environmental survey, stratification was pursued by using LIPS-REFRESH information.

The LPIS-REFRESH information, i.e. the polygons delineating the land cover were superimposed to the regular grid of quadrats, obtaining the land cover extents for each quadrat in the population (see Figure 3). This procedure was performed through spatial processing in GIS environment with the purpose of constructing suitable indexes of quadrat use to be adopted in stratification together with the morphological and administrative information furnished by the National Agriculture Information System (SIAN), (see Annex Figure 24) i.e:

- REFRESH Shapefiles
- DEM (Digital Elevation Model)
- ADMINISTRATIVE BOUNDARIES
- PROTECTED AREAS (Natura 2000 areas)
- NVZs (Nitates Vulnerable Zones)
- AGRIT GRID

The REFRESH land cover data (polygons and codes) were subsequently re-classified on the basis of a set of new codes specifically defined for the AAE survey (so-called Environmental Code).

For each quadrat in the population the following stratification variables were considered: average altitude in the quadrat (X_1), percentage of cultivated land (on the basis of the REFRESH land cover codes) (X_2), Shannon index of use diversity (X_3). More precisely, the Shannon index was defined as

$$X_3 = -\sum_{k=1}^{K} f_k \ln f_k$$

where K is the number of land cover classes of REFRESH (which varied from region to region up to a maximum of 36 classes by the 77 classes envisaged in the REFRESH land cover legenda) and f_k is the number of polygons of the class k in the quadrat divided by the total number of polygons in the quadrat. For each stratification variable, four strata were determined on the basis of the values of the first, second and third quartiles in such a way that three different stratifications of the population were achieved (see Annex Figure 14, 15 and 16).

As to the relationships between the stratification variables, the scatterplots achieved by plotting each pair of variables showed in all the cases a very low level of correlation (see e.g. Figure 17, 18 and 19), proving how these variables accounted for different aspects of the quadrats. Accordingly, the three stratification criteria were combined for achieving a total of $4^3 = 64$ strata. Very small strata were pooled together in order to avoid strata with a small umber of quadrats. At the end of the stratification procedure, the population P was partitioned into L strata, $P_1, \ldots, P_L$ of size $N_1, \ldots, N_L$, respectively.

Figure 3: Example of REFRESH land cover information.

Step 3-Sample selection
Areal surveys frequently adopt network sampling. In this case the objects to be sampled, referred to as obser-

Table 1: Sampling effort adopted in 2011 Agrit Agro-Environmental regional surveys

Number of Sampled Units for each Region			
Region	N. of Sampled Units	Sampled Area observed in the field survey (ha)	Regional area (ha)
SICILIA	7.722	48.262,50	2.571.100
MARCHE	2.710	16.937,50	936.600
TOSCANA	5.539	34.618,75	2.299.351
TOTALE	15.971	99.818,75	5.807.051

vational units, are ecological structures such as streams, woodlots and tree rows, while the quadrats, referred to as sampling units, are just the artificial structures adopted to sample the observational units, i.e. an observational unit is sampled if it intersect at least one of the selected quadrats (see e.g. Thompson, 2002, Chapter 15). Hence, in order to record the interest variable associated with an observational units (e.g. length or size), all the quadrats intersected by the units should be surveyed. In this case, the sampling effort, i.e the number of quadrats to be visited, is a random variable and it may exceed the available resources.

To avoid the shortcoming, the use of network sampling in the AAE surveys was discarded and a fixed number of quadrats was simply selected in accordance with the stratified sampling scheme. In this case the interest variable was measured only for the portion of the objects lying within the quadrat. In other words, for any quadrat j in the population P the interest variable to be recorded was the total length or size of the portions of objects lying within the quadrat (e.g. the grey area represented in Figure 4), in such a way that the total length or size for the whole study area can be written as

$$T = \sum_{j=1}^{N} y_j$$

Accordingly, a sample S_l of size $n_l \geq 2$ was selected from each stratum P_l by means of simple random sampling without replacement. The sampling fractions adopted within each stratum were all about the 2%. Table 1 reports the total sample size adopted for the 2011 survey of Marche, Tuscany and Sicily. Figure 5 shows the spatial allocation of the sampled quadrats on the three Regions. On the whole, the quadrats surveyed in 2011 AAE surveys covered a surface of about 100,000 ha.

Step 4-Field Survey

As pointed out in Step 3, the observational and sampling units are quadrat portions of regional territory of size 250x250 m (6,25 ha). Each quadrat is partitioned into polygons defining the land use. The information gathered within each sample quadrats consists of:

- the current use and the extent of each polygon in the quadrat together with additional information regarding physical characteristics of the polygons which cannot be determined by the remote imagery and which are important for the analysis of the effects of Cross Compliance and for Rural Development;
- the detection of the ecological structures within the quadrat (hedgerows, tree rows, stone walls, streams and isolated trees) and the recording (using the Tablet embedded GIS tool) of quantitative and categorical variables associated with these structures.

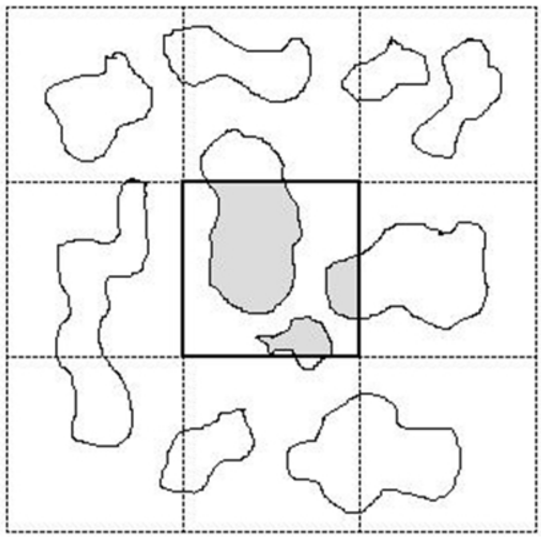


Figure 4: Graphical representation of the recording protocol within a selected quadrat: only the portion of unit within the quadrat is considered.

As already mentioned, the classification adopted for the survey was previously established and named Environmental Codes.

Field surveyors were equipped with a tablet PC running an embedded application for helping the navigation to the sampled quadrats, the data entry and some specific GIS function enabling to record during the survey any modification occurred in the shape of the different elements (see Annex figures 20, 21, 22, 23). The acquisition of data was performed by recording the GPS coordinates of the observation point and transmitting data gathered in the field in nearly real-time to the central database by means of a UMTS connection.

A control dashboard enabled to monitor the execution of the field survey and the presence of problems such as missed observations or excessive viewing distances. An accurate checking of the data quality and consistency were performed before acceptance.

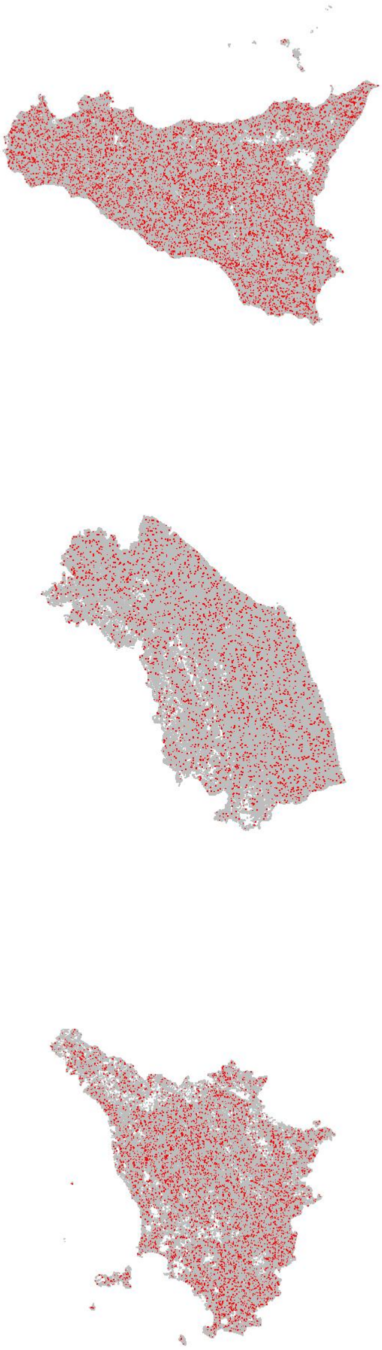


Figure 5: Spatial location for the sampled quadrats throughout Sicily, Marche and Tuscany.

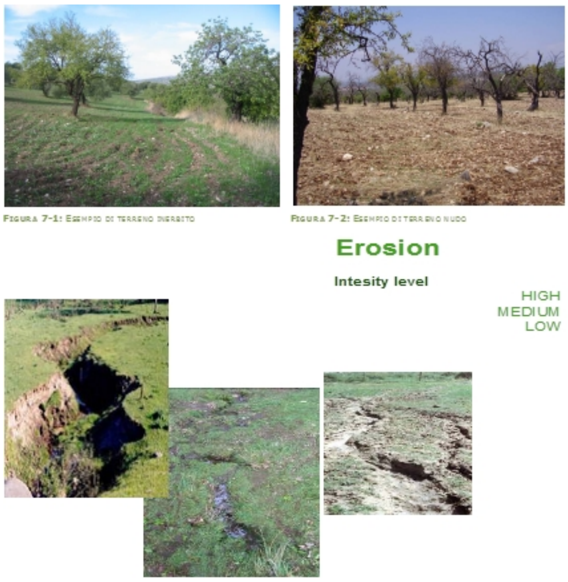
Features Type	Description	Parameters	Admitted Values
Line features	Small Water courses	Buffer area (>5M)	Yes/NO
		Water origin	Natural /artificial
		Water origin	Natural /artificial
		Water origin	Natural /artificial
	Hedgerows and tree lines	Age of plantation	<10 years / >10 years / NR
		Vegetation health	Good / poor / NR
		Vegetation type	Coniferous / Broad leaved / Mixed / NR
	Stone walls	Conservation	Good / poor / NR
Point features	Isolated trees	Foliage diam.	betw. 5 e 10 m / > 10 m / NR
		Age of plantation	<10 years / >10 years / NR
		Vegetation health	Good / poor / NR
		Vegetation type	Eucalipto, Ailanto, Robinia / Altro (Conif.) / Altro (Broad.leav.) / NR
	Secular trees	Species	Abies alba / Acer pseudoplatanus / Aesculus hippocastanum / Castanea sativa / Cedrus atlantica / Cedrus deodara / Cedrus libani / Bagolaro
		Vegetation health	Good / poor / NR
		Vegetation type	Coniferous / Broad leaved / Mixed / NR

Figure 6: Surveyor instruction: qualitative information to be collected for linear and point elements.

Figure 7: Surveyor instruction: buffer strips are polygonal elements, if larger than 5 m.

Tillage	Soil milling
	harrowing
	Else
	Zero tillage
Soil cover	Grassed
	Partially grassed
	Mulched
	Bare soil

Figure 9: Surveyor instruction some information to be collected in the field.



Step 5-Estimation

"The estimation of the totals of ecological and anthropogenic structures (e.g total lengths or total surfaces) was performed by using the well-known Horvitz-Thompson (HT) criterion which provides unbiased esti-

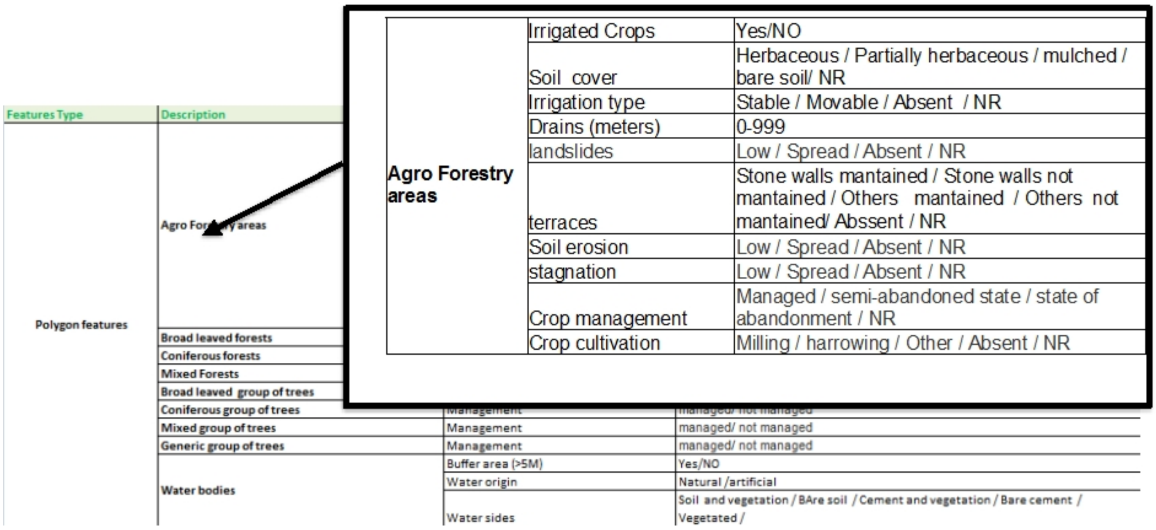


Figure 8: Surveyor instruction: some of the qualitative information to be collected for the polygonal elements.

mators of population totals irrespective of the sampling scheme adopted to select the sample (see e.g. Hedayat and Sinha, 1991, Chapter 9). In the case of stratified sampling the HT estimator of total turns out to be

$$\hat{T} = \sum_{l=1}^{L} \hat{T}_l$$

where $\hat{T}_l = N_l \bar{y}_l$ is the HT estimator of total within the stratum l, while

$$\bar{y}_l = \frac{1}{n_l} \sum_{j \in S_l} y_j$$

denotes the mean of the observations in the sample S_l ($l = 1, \ldots, L$). Since the estimators of totals within each stratum constitute independent random variables, the variance of $\hat{T}$ is given by

$$V(\hat{T}) = \sum_{l=1}^{L} V(\hat{T}_l) = \sum_{l=1}^{L} N_l (N_l - n_l) \frac{S_l^2}{nl}$$

where S_l^2 represents the variance within the stratum l.

Since some environmental indicators involve the estimates of the totals for some population subsets (e,g the plain, hilly and mountain quadrats), the estimators of total and the corresponding variances, for these subpopulations (usually referred to as domains) are obtained from the previous expression applied to the artificial variable $y_j u_j$ where u_j is a dummy variable equals to one if unit j belongs to the domain and 0 otherwise (e.g. Särndal et al, 1992, Section 10.1). As to the estimation of the ratio of a domain total to the total for the whole population (e.g the ratio of the total length of tree rows in the hilly region to the total length of tree rows in the whole study area), the interest parameter turns out to be

$$R_d = T_d / T$$

where T_d denotes the total for the domain d. Then, a very natural estimator for R_d is obviously given by

$$\hat{R}_d = \hat{T}_d / \hat{T}$$

where $\hat{T}_d$ is the HT estimator of T_d. Even if the exact properties of $\hat{R}_d$ are unknown, it can be proven that $\hat{R}_d$ is approximately unbiased with approximate variance

$$V(\hat{R}_d) = \frac{V(\hat{T}_d)}{T^2} - 2\frac{T_d COV(\hat{T}_d, \hat{T})}{T^3} + \frac{T_d^2 V(\hat{T}_d)}{T^4}$$

where $COV(\hat{T}_d, \hat{T})$ is the covariance between $\hat{T}_d$ and $\hat{T}$.

The estimation of the surfaces were calibrated in such a way that the sum of the extent estimates of land uses classes plus the non agricultural areas gave the true extent of the whole region. The estimation of variances of the calibrated estimates were performed by the jackknife procedure proposed by Berger and Skinner (2005). From the variance estimates, say $\hat{V}^2$, the estimates of the relative standard errors were achieved by the ratio $\hat{V}/\hat{T}$.

Step 6-Final outputs

The project provides the extent estimates for arable lands, permanent crops and permanent grassland and the extent estimates for EC and AGRIT codes at regional basis. Moreover the following information are provided:

- presence of irrigation - irrigated not irrigated (type of irrigation);
- presence of erosion and its intensity;
- presence of ditches and their length;
- presence of terraces;

- type of pasture;
- type of forest (broadleaved or coniferous) and management.

More in detail, the following estimates are make available:

I . For arable land, permanent crops and permanent grassland:

- irrigated extent;
- erosion extent;
- water stagnation extent;
- extent of areas with the presence of landslides;
- extent of areas with the presence of terraces;
- extent of areas with the presence of ditches

II . For permanent crops:

- extent by tillage method;
- extent by status of the crop (abandoned or not);
- extent by type of inter-row soil cover (bare soil, mulched or grassed)

III . For grasslands:

- natural pasture extent;

IV . For watercourses, ponds, reservoirs and small ponds:

- extent by type (natural or artificial);
- extent by type (permanent or temporary);
- extent by type of banks (e.g grassed or artificial)

V . For hedges and rows:

- the total length for the whole region and for plain, hill and mountain areas
- extent by Phylum (broadleaved or coniferous);
- extent by age;
- extent by vegetative condition (good-poor)

VI . For stone walls:

- the total length for the whole region and for plain, hill and mountain areas
- extent by condition (good-poor)

VII . For isolated tree in agricultural context:

- abundance by age;
- abundance by vegetative condition (good-poor)

VIII . For monumental trees:

- abundance by phylum;
- abundance by vegetative condition

In addition the following indicators are calculated:

- Ecological infrastructure indicators: the ratio of hedgerow and tree row extent to the UAA extent for the whole region and for plain, hill and mountain areas or the ratio of the total length of stone walls and ditches to the UAA extent for the whole region and for plain, hill and mountain areas.
- Erosion indicators: extent of the area affected by erosion (during the survey period) for the whole region and for plain, hill and mountain areas and in the presence of crops, trees and fodder.
- Stagnation indicators: extent of the area affected by water stagnation for the whole region and for plain, hill and mountain areas and in the presence of crops, trees or fodder.
- Landslide indicators: extent of the area affected by landslides for the whole region and for plain, hill and mountain areas and in the presence of crops, trees and fodder.
- Buffer strip indicators: water basin-rivers-channel extent with the presence of buffer strip
- Land cover indicators: extent of permanent crops with the inter-row soil grass covered, partially covered, mulched or with bare soil for the whole region and for plain, hill and mountain areas.
- Hedge and row indicators: extent of the areas occupied by hedges and rows for each of the four strata determined by the Shannon index of use diversity.

3. CONCLUSIONS

The AAE sample survey provides a feasible and statistically sound strategy based on remote sensing data and ground recording. The REFRESH-LPIS data are used for the definition and the stratification of the population frame (quadrats), while the ground surveys within selected quadrats enables the collection of quantitative and qualitative information concerning agro-environmental variables. The collection is performed in a fast and efficient manner by means of portable devices. Unbiased or approximately unbiased estimates of agro-environmental parameters. are provided in a faster and cost-effective manner. Interestingly, the survey allowed for the estimation of parameters regarding land cover, landscape elements, erosion phenomena and water stagnation that are not fully detectable by the photo-interpretation performed during LPIS activity as well as for the estimation of parameters needed in the environment evaluation or for CAP. Information about crop pattern, presence and length of hedgerows or buffer strips along the water elements such as ponds or stream is achieved and should play a basic role for the assessment of interaction between agriculture and the environment. Moreover, the estimates of agro-environmental indicators can be used for as baseline for :

- the monitoring and the assessment of AEM of rural development;
- the evaluation of cross compliance (mainly GAEC);
- measuring the impact and the assessment of new greening measures of the CAP post 2013.

The repetition of the survey at fixed time gaps (REFRESH update is planned every 3 years) will allow a diachronic observation of the study area enabling the monitoring of the environmental transformations. Some methodological refinements are under study in order to improve the estimation performance and to provide solution for some practical problem encountered during the survey. In particular, the following issues are under study:

- the increase of the sampling fraction due to the reduction of the number of quadrats in the population;
- the calibration of the estimates using the REFRESH-LPIS data as auxiliary information;
- the design-based treatment of missing data due to the impossibility of enter some selected quadrats.

Moreover, the construction of spatial maps of the presence for some risk variables (such as erosion extents) by means of novel design-based procedures which avoid stationarity assumptions and spatial correlation structures will be attempted.

ACKNOWLEDGEMENTS

This paper is the final output of a joint work performed by a large team of researchers from several disciplines. The authors wish to thanks Giuseppe Blasi Director general of the Directorate of competitiveness for rural development of the Ministry of Agriculture, Food and Forestry Policies and Paolo Ammassari manager of the Agriculture and Environment Unit of the same directorate, the AGEA Coordination body. Desideria Archinto, Paola Molinari and Sara Franceschi for their fundamental contribution to the AGRIT Agro-Environmental survey project and also Elisabetta Carfagna, Maria Rosaria Napolitano, Marco Ballin, Mario Perosino, Costanzo Massari Pasquale Falzarano, Domenico Zonetti, Alberto Masci as members of the Ministerial Commission for orientation, monitoring and tests of the AGRIT project; Antonio Frattarelli, Davide Liberati, Vincenzo Montalbano, Daniela Quarato, Stefano Soldano, Orazio Summo, Christian Vincentini as members of the working group of the Ministry for their contribution to the AGRIT Agro-Environmental survey project.

REFERENCES

Berger YG, Skinner CJ (2005). A jackknife variance estimator for unequal probability sampling, *Journal of the Royal Statistical Society (Series B)*, **67**, 79-89.

Hedayat AS, Sinha BK (1991). *Design and Inference in Finite Population Sampling*. New York, Wiley.

Särndal CE, Swensson B, Wretman J (1992). *Model Assisted Survey Sampling*. New York, Springer.

Stevens DL (1997). Variable density grid-based sampling designs for continuous spatial populations, *Environmetrics*, **8**, 167-195.

Thompson, SK (2002). *Sampling*. New York, Wiley.

ANNEX

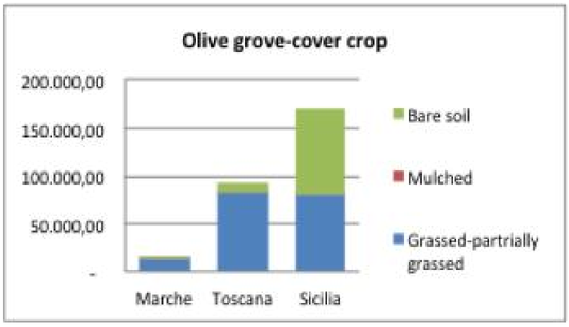


Figure 10: Soil inter-row cover crop in olive grove.

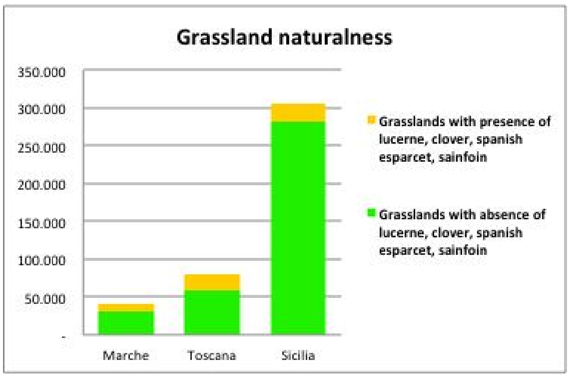


Figure 11: Grassland naturalness.

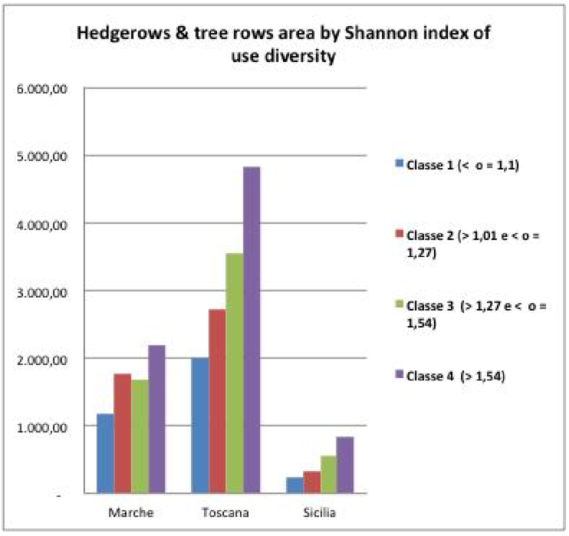


Figure 12: Presence of hedgerows and tree rows.

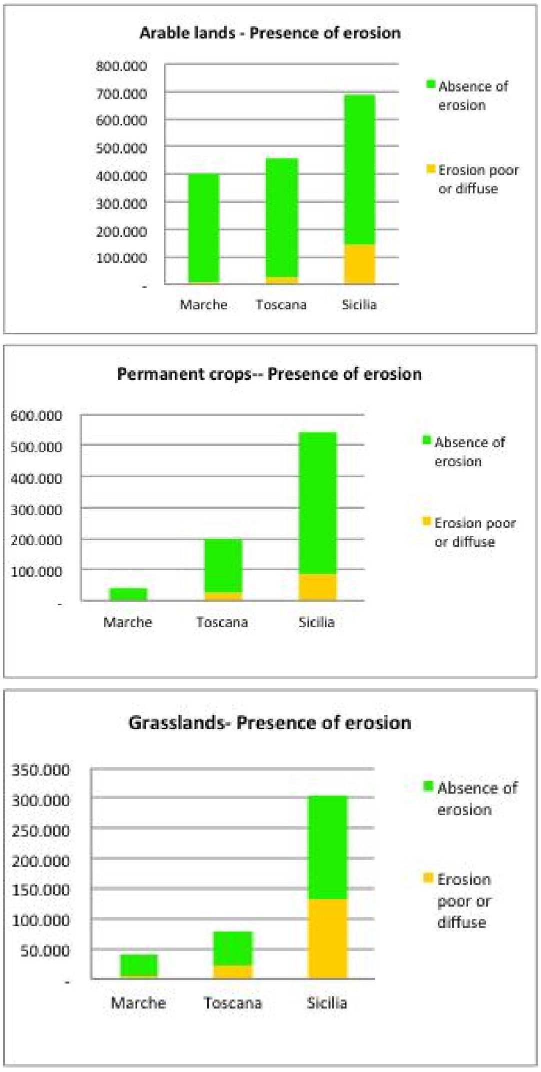


Figure 13: Presence of erosion phenomena for different land cover.

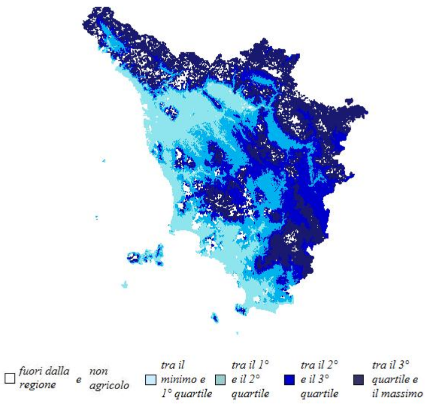


Figure 14: Stratification of quadrats in accordance with altitude (Region:Tuscany).

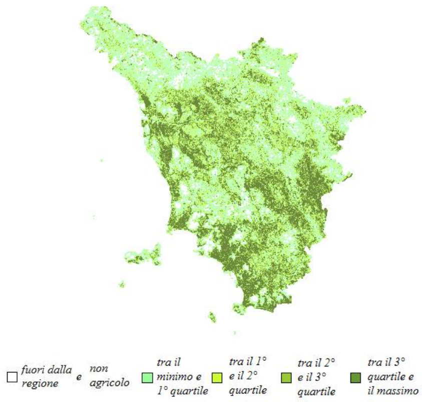


Figure 15: Stratification of quadrats in accordance with percentage of cultivated land (Region:Tuscany).

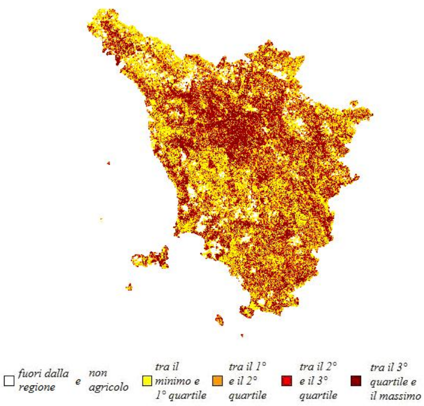


Figure 16: Stratification of quadrats in accordance with the Shannon index of use diversity (Region:Tuscany).

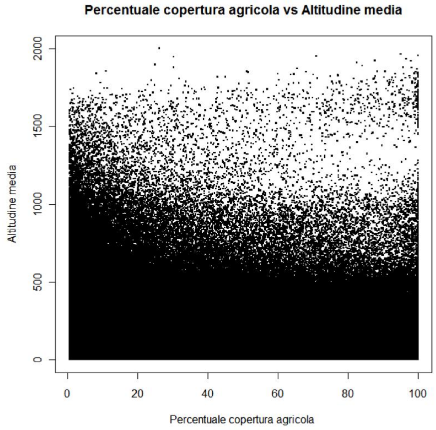


Figure 17: Altitude vs percentage of cultivated land (Region:Tuscany).

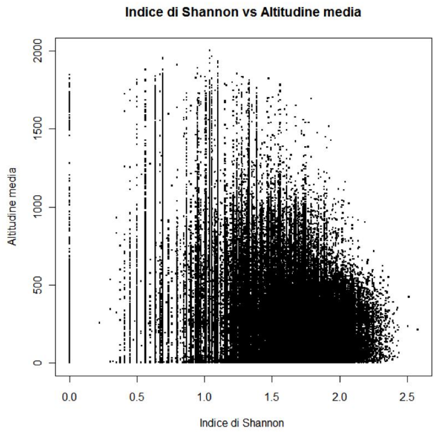


Figure 18: Altitude vs Shannon index of use diversity (Region:Tuscany).

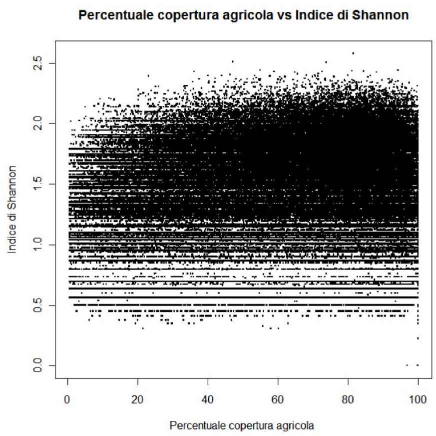


Figure 19: Percentage of cultivated land vs Shannon index of use diversity (Region:Tuscany).

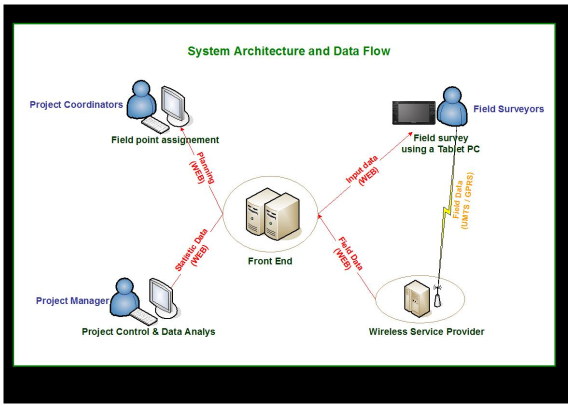


Figure 20: System Architecture and Data Flow.

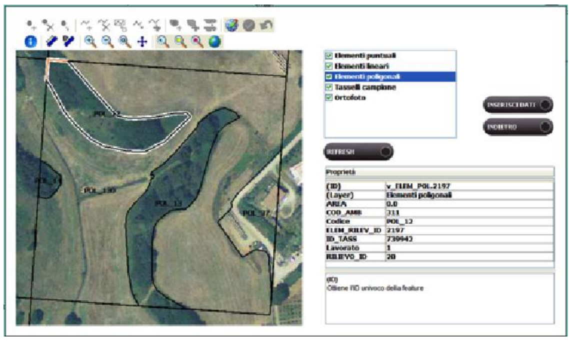


Figure 21: Mobile device SW editing tool.

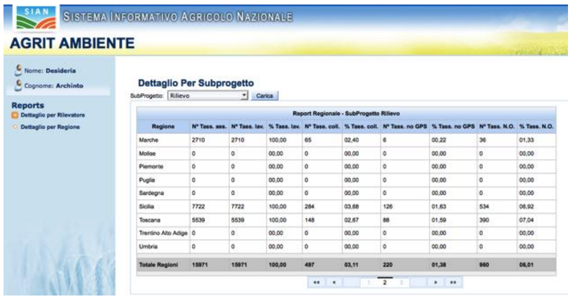


Figure 22: Supervisor control dashboard.

Figure 23: Embedded Navigator tool.

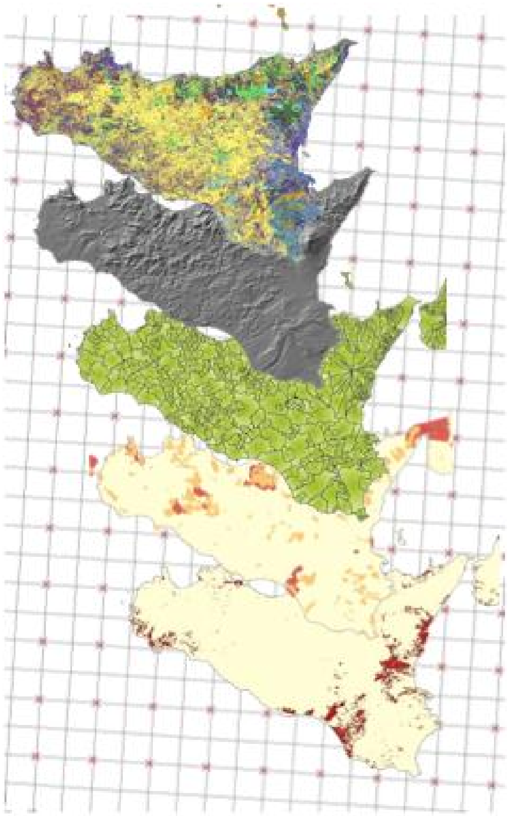


Figure 24: Graphical representation of the strata intersection in the GIS.

Table 2: Example of estimates (type of irrigation) Extension and Coefficients of variation

Region	Type of irrigation	Total		Arable lands		Permanent crops	
		Extention (ha)	CV	Extention (ha)	CV	Extention (ha)	CV
Marche	Fisso	6.674,51	14,88%	4.692,56	18,78%	1.923,83	22,51%
	Mobile	29.918,44	7,68%	28.602,91	7,90%	1.305,17	23,29%
	Assente	406.161,82	0,97%	356.659,84	1,08%	35.923,83	4,06%
	Presente non classificabile	11.611,18	10,86%	9.465,36	12,09%	2.145,81	18,34%
	NR	4.016,40	18,02%	3.376,09	20,72%	640,31	19,54%
	TOT	**458.382,34**	**0,64%**	**402.796,75**	**0,75%**	**41.938,96**	**3,86%**
Toscana	Fisso	43.985,21	5,96%	15.172,35	10,43%	28.203,08	7,11%
	Mobile	57.570,09	5,34%	50.205,77	5,80%	5.946,69	11,31%
	Assente	542.400,85	1,12%	372.420,01	1,53%	152.245,92	2,46%
	Presente non classificabile	32.465,63	7,03%	21.438,32	8,65%	8.847,47	11,76%
	NR	70.835,30	4,31%	52.080,88	5,05%	18.730,83	6,69%
	TOT	**747.257,07**	**0,60%**	**511.317,32**	**1,02%**	**213.973,99**	**1,96%**
Sicilia	Fisso	151.424,04	3,03%	16.639,99	8,44%	134.707,88	3,13%
	Mobile	116.396,40	3,82%	66.313,19	5,01%	50.083,22	5,54%
	Assente	877.178,30	1,07%	563.450,91	1,45%	311.823,09	1,90%
	Presente non classificabile	87.257,91	4,38%	44.184,92	6,21%	43.054,82	5,25%
	NR	116.521,43	4,12%	66.055,14	5,31%	50.466,29	5,62%
	TOT	**1.348.778,08**	**0,61%**	**756.644,15**	**1,10%**	**590.135,30**	**1,18%**

GLOBAL ORTHO: RAPID, HIGH EFFICIENCY ORTHO UPDATE TECHNOLOGIES

Michael Gruber[1], *Wolfgang Walcher*[2], *Robert Ledner*[3], *Josef Kauer*[4]

[1] Microsoft Bing Imagery Technologies, Graz, Austria, michgrub@microsoft.com
[2] Microsoft Bing Imagery Technologies, 1500 Pearl Street, Boulder, Colorado, wwalcher@microsoft.com
[3] Microsoft Bing Imagery Technologies, 1500 Pearl Street, Boulder, Colorado, robled@microsoft.com
[4] Microsoft Bing Maps for Enterprise, Munich, Germany, joekauer@microsoft.com

ABSTRACT

Microsoft Corporation is nearing completion of Phase I of its GlobalOrtho program. The GlobalOrtho program is the most ambitious, orthomosaic project undertaken in the history of modern aerial mapping. The 48 states of the continental United States, as well 14 countries of Western Europe, have been acquired and mapped using true color (30 cm) and NIR (60 cm) digital images, within a span of less than 2 years. The project is now over 90% acquired, with projections to achieve 100% completion by the end of September 2012. Unprecedented throughput and quality levels have been achieved via a marriage of advanced software, cloud computing, and next generation, wide area digital mapping cameras. These mapping technologies can be applied equally effectively virtually anywhere in the world, with extremely rapid throughput rates, high quality metrics, and economic advantages. The year 2010 saw the commencement of a new 3-year duration cycle to completely update the Land Parcel Identification System (LPIS), assisted by the use of ortho mosaics derived from newly acquired aerial imagery. These data sets will be used in support of the complete "refresh" of the LPIS, currently being undertaken by the Member States. Throughput, quality, and economic efficiencies are paramount to the success of these projects. This paper will provide an outline of Microsoft's current GlobalOrtho program in the United States and Europe, and will discuss how its advantages may potentially be applied to the benefit of the LPIS update program.

1. INTRODUCTION

Online mapping services, such as Microsoft's Bing Maps, offer end users historically unprecedented access to remote sensing data, encompassing a global, imagery rich experience. As a result, consumer and business users have come to expect immediate access to current imagery with high resolution and quality, everywhere in the world. Satellite imagery is no longer capable or adequate to completely meet these growing demands and expectations, and online mapping portals are therefore turning to newly collected aerial image acquisitions as one of their primary data sources. Traditional aerial mapping efforts have been local and project based, with differing requirements and resolutions. This approach lacks the broad area coverage, and the consistent resolution and quality levels required by modern, high performance, online mapping solutions.

This state of affairs triggered Microsoft's 2008 decision to create a suite of technologies capable of rapid production of uniform, affordable, high quality, and high resolution ortho mosaics on country wide and continent wide scales. The initial goal of the resulting GlobalOrtho program was simple, yet very ambitious: create 30 cm, color, coast-to-coast, seamless orthomosaics of the United States and Western Europe in 2 ½ years or less. Phase I of the program has been a great success, and is on track and on schedule to reach its initial goals by September 2012. The program is currently 98% acquired in the US and 60% acquired in Western Europe. Approximately 8,510,000 square kilometres (~76% of the total US and European project areas) are currently published to Microsoft's Bing Maps (http://www.bing.com/maps). With the completion of Phase I of the GlobalOrtho program clearly in sight, exciting opportunities are available to apply the program's advanced processing technologies, along with its advanced data acquisition and data processing infrastructure, to new markets, countries, and entire continents.

2. GLOBAL ORTHO PROGRAM SCOPE

Phase 1 of the GlobalOrtho Program covers the 48 states of the conterminous United States and 14 countries of Western Europe. Figure 1 show the respective maps, for the United States and Western Europe, overlaid with the 1-degree by 1-degree cell grid used to manage data acquisition and processing. The phase-1 coverage is comprised of approximately 1,567 complete and partial 1-degree cells totaling approximately 10.4 million square kilometers of land area.

It is worth noting that this program already significantly exceeds in scope most other aerial mapping programs. In 2011 the GlobalOrtho Program created 8,400,000 km2 of in-spec 30-cm orthomosaics along with a matching Color InfraRed (CIR) mosaic, and other by-products. Using the total number of pixels generated as a comparison measure, one finds that in 2011 the

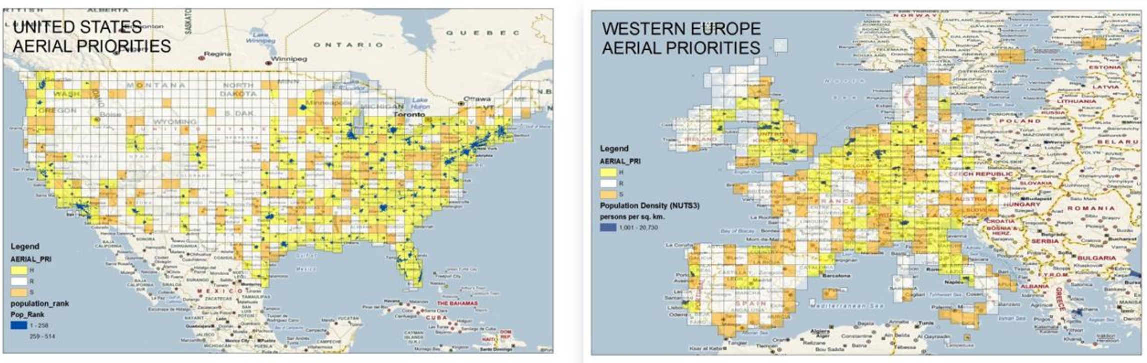


Figure 1: One degree grid layout for the United States and Western Europe. Colors show acquisition priorities based on population density.

GlobalOrtho Program, produced over 50 times as many pixels as the average annual output of the United States Government's National Agricultural Imagery Program (NAIP) [NAIP, 2009]. Even without accounting for the much higher quality of the GlobalOrtho products, this makes GlobalOrtho the largest commercial aerial mapping program to date.

3. ACQUISITION AND PROCESSING

The aggressive program timeline and cost considerations created the need for a highly productive camera system which includes not only a large number of pixels across track, but also full photogrammetric capabilities. The later was especially important to ensure that there would be no dependency on a pre-existing elevation model for the creation of high-quality ortho products.

In 2009 such a camera, the UltraCam-G, was invented and developed by the Microsoft Photogrammetry team doing business as Vexcel Imaging GmbH, Graz, a wholly owned subsidiary of Microsoft Corp. The optical system of this camera component has a focal length of 40 mm, and covers a field of view of +/- 40° across the flight line. All photogrammetric parameters of the camera are well tuned for aerial mapping. The UltraCam-G sensor consists of a number of individual camera heads. The camera itself is shown in Figure 2, and the configuration of the individual image frames is shown in Figure 3.

Figure 2: The UltraCam-G technology based on the design of the UltraCam family.

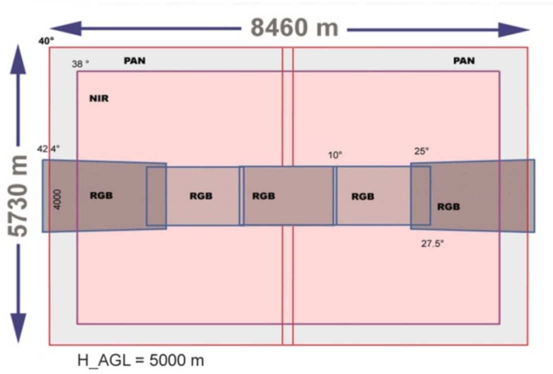


Figure 3: Frame format of the UltraCam-G. The swath width at a flying height above ground level of 5000 m is more than 8 kilometers. Pan and RGB cover the full size across track. The NIR has a slightly reduced format.

The UltraCam-G simultaneously captures 3 image frames with each exposure event: panchromatic (PAN), true-color (RGB), and near-InfraRed (NIR). The PAN channel serves as the geometric backbone of the camera. The RGB image frame is a slim rectangle with 28,200 pixel across track and about 3,900 pixel along track. The RGB frame is co-registered to the PAN channel and covers the entire width of the PAN image but not the entire height. The Ground Sampling Distance (GSD) of the final image at the standard GlobalOrtho, flying height of 5,000 meters, is 30 cm for the color channel, and 75 cm for the PAN channel. The NIR channel has a GSD of 125 cm.

The productivity of the UltraCam-G sensor significantly reduces the number of aircraft needed to acquire large project areas. Only 14 cameras have been required for the entire GlobalOrtho project. These have been operated by a number of experienced regional aerial photography firms. Once a 1-degree cell has been completely acquired the imagery and metadata are shipped to the Bing Imagery Technologies (BITs) production facility for further processing.

BITs uses a highly automated workflow to process the Imagery received from the UltraCam flying partners into the final mapping products. This workflow is built on top of Microsoft's proprietary Imagery Processing Framework (IPF). IPF is a massively parallel data processing architecture and is used by BITs for all Bing Maps processing and publishing.

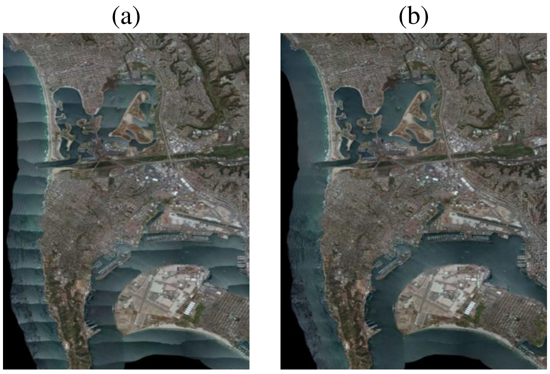


Figure 4: (a) Specular reflection on water near San Diego, CA and (b) Automated removal of specular reflections from water.

The shear horsepower of this photogrammetric cloud processing infrastructure is enormous. Throughput tests have demonstrated that the raw automated processing capacity exceeds 1 million km2 of GlobalOrtho data (RGB, CIR, and DSM) per 24 hours with over 1 Petabyte of data created in that timeframe. This raw power, in conjunction with highly efficient, operator assisted Quality Assurance and Quality Conrol (QA and QC) software, and advanced radiometric processing algorithms, allows Microsoft to output mapping image products at unprecedented rates, while maintaining high quality standards.

GlobalOrtho throughput and productivity are not gated by compute power or human labor, but by the rate at which aerial imagery can be acquired. The IPF processing environment is capable of completing the automated portion of the data processing for the entire imagery harvest of a whole year's worth of flying in about one week. Given the current levels of quality control and inspection the annual production rate per person is between 300,000 and 400,000 km2. With only minor changes to the product specifications this rate can be significantly increased.

Much of the success of the automated algorithms can be attributed to the high dynamic range of the UltraCam sensor: approximately 14 bit in each channel. The GlobalOrtho processing keeps all data in 16-bit representation until the very final step of product formatting to ensure no loss in dynamic range throughout the process.One example of the automated processing is shown in Figure 4. Figure 4.a illustrates typical specular reflection over water. In traditional mapping processes such artifacts are often edited and removed by hand using labor-intensive processes. In the GlobalOrtho program such reflections are removed entirely automatically with a suite of proprietary image processing algorithms. Figure 4.b shows the result of this automated processing applied to the image shown in Figure 4.a.

4. GLOBAL ORTHO MAPPING PRODUCTS

All components of the GlobalOrtho Program have been designed and optimized with the single purpose of creating a well-defined set of imagery products in the most efficient manner possible. The primary GlobalOrtho product is the 30 cm resolution True Color Orthophoto mosaic (Figure 5). This imagery is published to Bing Maps and also available offline from DigitalGlobe for professional use.

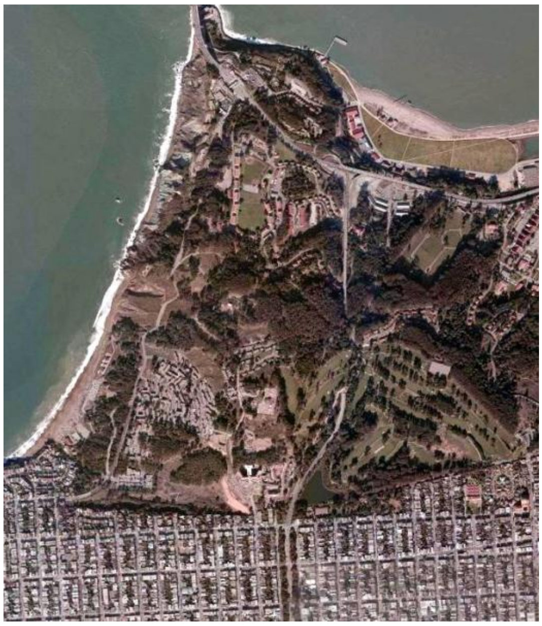


Figure 5: Color orthophoto mosaic of the Presidio in San Francisco, CA

Figure 6: Co-registered Color Infrared (CIR) ortho mosaic of the Presidio in San Francisco, CA

The second imagery product is a CIR (Color InfraRed) orthophoto mosaic at 60 cm resolution (Figure 6) that is co-registered to the color ortho. The CIR product is not published to Bing Maps and is exclusively available from DigitalGlobe.

The geometric quality and stability of the UltraCam-G combined with high overlap imagery acquisition also allows the creation of Digital Surface Models (DSMs) at 1 meter resolution (see Figure 7). These DSMs are used to create digital terrain models (DTMs). The DTMs are in turn used in the orthorectification of the GlobalOrtho imagery. The DSM product is available from Bing Maps. The DTM data has, at the time of this writing, not yet been released as a product. Since RGB, CIR and DSM data are all created from the same UltraCam images the products are perfectly aligned and consistent in time and space.

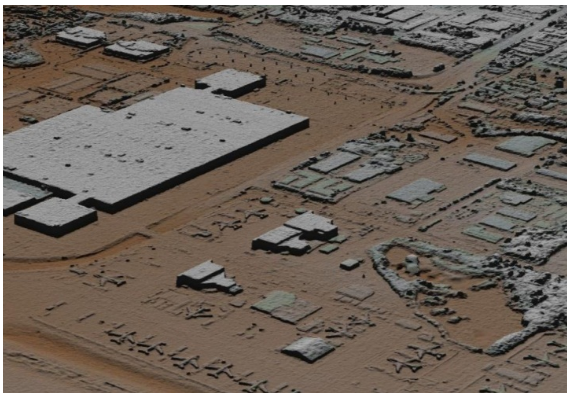


Figure 7: Digital Surface Model created from UltraCam G. Boeing facilities near Seattle, WA

A very significant achievement of the GlobalOrtho Program has been its ability to simultaneously maintain unprecedented acquisition and data processing throughput rates, while maintaining very high levels of relative and absolute spatial accuracies. The absolute horizontal accuracy of the RGB product was originally planned to be within 10 and 20 feet (3 and 6 meters) CE 95%, for urban and rural areas respectively. Independent measurements have shown that the actually achieved absolute accuracies are in the range of 5 to 10 feet (1.5 to 3 meters), far exceeding initial expectations. This level of horizontal accuracy is routinely achieved without the use of any survey ground control. However, for many 1 degree cells we continue to use up to 4 control points for reasons of quality assurance and to avoid vertical bias, which could affect the vertical accuracy of the DSM.

The relative spatial accuracy performance of the camera sensor and photogrammetric processing systems has been equally impressive. The GlobalOrtho image mosaics for an average 1 degree cell are typically constructed from approximately 2000 individual image frames, with a total cumulative linear seam line length of over 15,000 kilometers. The resulting orthomosaics, with fully automated seam line placement, have near perfect alignment of linear features across seam lines, and requires only minor manual local adjustments in isolated cases.

5. PROPOSED ACTIONS

The GlobalOrtho Program, because of its enormous scale and aggressive timeline, has triggered a large number of innovations in hardware, software, logistics, and data processing. This project has demonstrated what is possible with the most advanced computing architectures, algorithms, sensors and procedures. The expected completion of the initial Phase I coverage for the United States and Western Europe in early Fall of 2012 will free up significant acquisition and processing resources. These resources could become available in support of other national and trans-national mapping programs. The main focus of Bing Maps is to extend the coverage footprint of the GlobalOrtho Program. This will, at least in part, be done in close cooperation with external partners. At the time of this writing several national and international organizations have engaged in talks about expanding GlobalOrtho into their respective nations or areas of interest.

As the LPIS program seeks to update its various data layers on multi-year cycles, fresh ortho mosaics, including both color and infrared images, with associated digital surface models, collectively define a critical and foundational base layer for information extraction and updates. In any multi-national program, such as LPIS, rapid updates and economic efficiencies are crucial elements. The potential for using Microsoft's GlobalOrtho technology infrastructure in support of these needs and requirements is an exciting prospect.

The technical feasibility of using GlobalOrtho mapping products to support LPIS update activities has already been explored and demonstrated on an initial basis. Microsoft recently submitted a test area from its European Phase I GlobalOrtho image mosaic library to the European Commission's Joint Research Centre (JRC) for evaluation. The imagery submitted for testing was over the area of Maussane, France. JRC recently completed a first round of independent testing of this data vis-à-vis its suitability for the LPIS program. The imagery was found to meet LPIS requirements. These results provide a "green light" for further explorations regarding the use of GlobalOrtho imagery for LPIS update efforts, both in the 14 countries of Western Europe, which are mostly already collected, as well as in the countries of Eastern Europe as the planned expansion of the GlobalOrtho program commences.

AGRO-ICT + BUSINESS MODELS SUPPORTING LPIS/IACS, FMIS AND CAP AFTER 2013

DI Walter H. Mayer

PROGIS Software GmbH, Austria, mayer@progis.com

ABSTRACT

High Return On Invest for agriculture and forestry comes from integration of newest technologies and cooperation of public and private stakeholders. 30+/-cm ortho-images, GIS, Land Parcel Information System, farm- and/or forest-management systems supporting also advisory services, covering regions or countries for logistics-, precision-, or virtual- farming needs embed farmers support of GAP or more environmental-or risk-management tasks based on new models and precise information. Know-How transfer and setup in a country need 2-3 years, integrates local know-how and costs a neglecting amount on large scale for images, agro-sensor stations and ICT-solutions. Technology-integration and stakeholder-cooperation is a win-win-model for a bright agro-forest future supporting food/feed, biomass for energy and environmental caretaking and risk-management! The technology was developed in cooperation with a consulting office. Technologies, org-solutions and business-models support today thousands of customers worldwide.

1. INTRODUCTION

Based on the use of precise ortho-images such as those available from Microsoft Bing™ Maps, GIS based agro-ICT technology of PROGIS, agro-sensor technology and related data and rural area-management consulting services, the AGRO-ICT-Backbone® concept was developed. It provides not only the necessary IT-tools but is also a holistic model to establish an agro-infrastructure throughout a whole country and to foster better agricultural development. It contains of:

- The production of a high resolution 30cm ortho-image for the whole country as base for further planning and control with an update frequency of 3-4 years.
- Based on ortho-images and PROGIS' GIS software WinGIS® the setup or if available as in Europe the upgrade of existing LPIS systems (Land Parcel Information System) - or a cultivation register and/or a rural Open Street Map (OSM) is possible.
- The implementation of a sophisticated FMIS (Farm-Management Information System) which also supports farm advisory (extension-) services and serving the Ministry for regional or country-wide statistical needs
- The installation and integration of a logistic system incl. mobile solutions to support farmers and their chain partners as the industry, for any just in time delivery needs for seeds, fertilizer, harvest etc. or for traceability needs
- The installation of agro-sensor networks - consisting of agro-weather stations and soil sensors - for decision support and guidance
- Value added services for needs like precision-farming, virtual-farming, land consolidation, environmental management, carbon calculation, risk-management, after 2013 CAP needs etc. including consulting if needed. A special training concept enables users to develop own on-top applications solving local needs.
- Capacity building incl. education- and training-models enable local experts to be ready for a roll-out.
- The intelligent business-model enables the owner of the ICT infrastructure (public, private or pp) to generate Return On Investments (ROI) by supporting stakeholders such as banks, insurance companies, large farms, large forest enterprises, the chain partners like food-industry, suppliers of farm equipment, agro-chemistry and agro-resources as well as international investors

Beneficiaries are farmers and forest holders, also small-holder enterprises, groups of farmers, cooperation, advisory/extension services, other service providers, affiliated industries, Ministries, banks and insurance companies, researchers, rural population, the environment and the public as a whole.

2. SOLUTION FROM PROGIS

The implementation of this agro-ICT-backbone has to be realized within a large scale project together with a range of local partners and experts. It can be done in a public, public-private or private project and is partitioned into the following steps.

2.1 Ortho-image

Production of 30cm ortho-images with a vertical DSM of < 1,5 m resolution and a 60 cm infrared image. For examples of technical specifications of compliant ortho-images please look at the article of Microsoft (MS). “Global Ortho: Rapid, High Efficiency Ortho Update Technologies”

2.2 Preparation of LPIS

The first mission is the implementation of the GIS system WinGIS® and on base of MS images the setup of the LPIS- or cultivation register including the assignment of owners or leaseholders to the single plots and to build up a country-wide land parcel database. An Open Street Map technology can be integrated. As far as LPIS systems are implemented already (as in most of EC (27) countries) the update can be done directly by farmers or farm-advisors to increase precision and lower land administration costs by data transfer to the existing LPIS/IACS system (see details later).

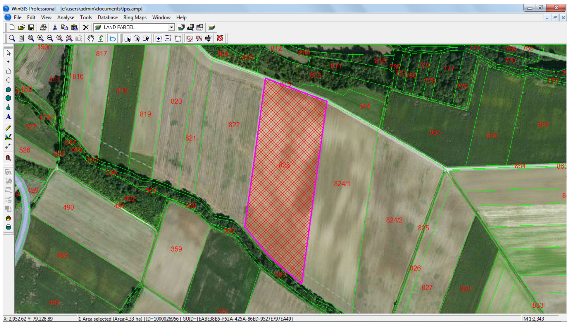


Figure 1: LPIS polygons on ortho-image.

2.3 GIS services

GIS-services for the generality and not only for experts was the name of the game of PROGIS when developing WinGIS® It is an easy to learn and use GIS software running on everyone’s PC , with extensive geographic application possibilities and facilities. Due to the ability to integrate online map data such as for example that of Microsoft Bing Maps as “embedded Module”, the access to worldwide available geographic data like satellite and aerial images, road maps and address databases is already part of the software package. Import and export interfaces support the most common GIS/CAD file formats like the ESRI™ shape files, the AutoCAD™ DXF, MapInfo™ MIF and also text based file formats like CSV or GPX for data import from e.g. GPS devices. In a few steps external spatial data can be loaded into the user’s project. By using the developer component, application developers have the possibility to link their application with WinGIS® in order to visualize, edit and administrate any data with a geographic relation. This is very relevant for realizing suggestions for local to be implemented IACS (Integrated Agricultural Control System) applications, to monitor GAP/CAP compliance or for on-top consultancy applications. With the help of such an SDK (Software Development Kit) local IT experts managing the local IACS system of an EC member country can easily implement an application to generate a subsidy form out of the FMIS and transfer it via Internet to the government homepage. The effect would be a “one stop shop software”, managed by a trained farmer or by an advisor that in parallel with the subsidy form also manages the business calculation, a nutrient balance, a carbon balance, integrates data for other future documentation needs like food traceability, business-plan, insurance data or after 2013 CAP´s ICT needs; not only governments would save enormous money, but farmers will save travel- and time-costs from driving to a subsidy centre. With the similar time effect, much more output can be realized on one side and if advisors are supporting farmers within a region - in all negotiations about a CAP reform new advisory concepts are asked for - much more can be reached in all sectors where single farmers alone cannot reach the targets but in groups they would be able. It are mainly environmental ones, landscape targets but also logistics, precision farming, land-consolidation missions etc.. This is also something the new GAP regulations will support - more see later.

2.4 Implementation of FMIS

When EU launched the CAP-reform (Common Agricultural Policy of the European Union) to increase food-quality and safety to the welfare of EU citizens, PROGIS developed on top of the described GIS-software tools for farmers and advisors to manage the many needs which this new legislation brought along. It was called DokuPlant™ and integrates expert database (all agricultural data and cultivation recommendations sustainably supported by local experts) and a perpetual calendar and documentation tool, facilitates planning, calculation, control and traceability. Extension officers/advisors are enabled to aggregate with it the data from fields, farms or a whole region and to prepare them for a Ministry or other public authority for statistical use or for projects. The following information will be generated from every field and can be accumulated country-wide:

- Activity management
- Crop rotation
- Cost calculation
- Nutrient balance and carbon balance
- All input/resource needs

- Harvest estimations

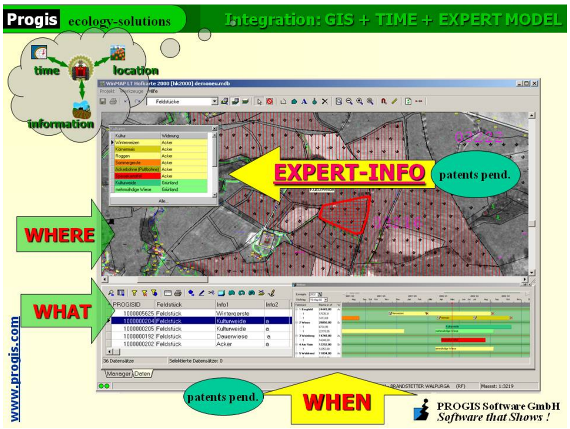


Figure 2: Farm-mgmt: where- what- when- expert-data.

PC-GIS, real-time management and the expert-data base are integrated. The mapping of plots/fields is supported and a perpetual calendar enables the display of any performed activity: what - when - where. The integrated database is filled with agro expert data, generated in close cooperation with local agro-forest-environmental scientists/experts and contains (sample: agro-Germany) 2.500 agro-machine data (KTBL, costs, time,...), data on thousands mineral-/organic-fertilizers, 850 herbicides with contents, crops incl. varieties and 400 plants with average yield and seed needs. The complete working process for a year with all activities and relevant data is predefined for all crops and enables planning with one click: Where (plot in the map) do I plan what (select crop from the expert data bank). This database is consequently also a knowledgebase and know-how transfer from scientists to the base, the farmers and foresters - daily and sustainably. After planning the data entry of the realization can be done manually or automatically.

2.5 Forest management

ForestOffice is FMIS for forest enterprises. It deals with sustainable forestry planning, forest facilities, forest management and forest logistics; the expert database contains local growth tables of different trees. Both agricultural and forest expert data have to be modified by local experts working within a “farmer/forester - advisor - expert” business model.

2.6 Logistic services

The protection of the environment and of natural resources is on everyone’s lips. Within the agricultural sector group management, activity based planning and sharing of production facilities contributes to reach these targets. PROGIS developed thereto a smart logistic solution. The base data are the accumulated ones from the a.m. FMIS and farmers, foresters and the industry deduce therefrom their planning. Process and time optimization, further “where to deliver what” or “where to pick up what and when” and how to come to a location (with the help of the rural Open Street Map (OSM)) supports all process related partners.

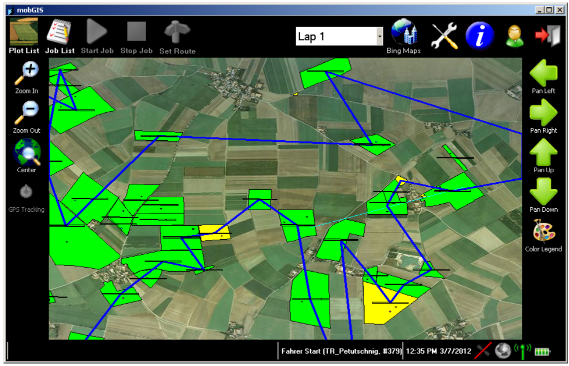


Figure 3: Logistics - where to do what.

The system leads to an optimization of daily and seasonal routing, accurate information of harvest status, GPS position data visualization, online two-way communication (GPRS/UMTS) between central and mobile terminals and order processing. The system consists of a central station and a number of mobile units (“mobGIS”). It handles crops for food/feed or biomass production, liquid manure deposits, forest harvesting or any other logistic task. Up to 30% cost reductions or even more can be achieved. The environmental pollution is far smaller than with conventional methods and due to the recordings ongoing improvements may happen.

2.7 Agro-sensor networks

A sustainable cultivation and protection of soils depends a lot on the application of fertilizers, pesticides and water. Agro-sensor-stations help to take decisions and to optimize rates: A network of agro-climate sensors - one station for every microclimate - and soil moisture sensors are needed. Based on the data and a tool-set, experts can provide farmers with tailor made recommendations (e.g. forecasts for weather situations) but also get protocols of the climate situation of the past and the related impact for the future - for example mass reproduction of a fungi or a beetle with an SMS induced decision “start spraying”.

The expert models - e.g. after which meteorological conditions collected during the last 4 weeks, which fungi or beetle will tend to outbreak - have, based on existing know how, training or know how transfer to be adjusted or developed and fine-tuned from local phytopathology experts. With the soil moisture sensors, also available in different depths, all necessary data for irrigation can be collected. It can be the fundament for an automatic controlled irrigation system.

Figure 4: Agro-sensor-network.

3. TECHNOLOGY AND CAP REFORM

The aforementioned developments in relation to the EC CAP Reform 2014-2020: Analyzing the new demands of CAP reforms, there is asked on one side more competitive capacity (some countries consider demanding a business-plan for every farm) and in parallel to strengthen local initiative innovation, sustainability of natural resource management and a balanced regional development. Without tools as described and regional support provided by advisors this will not be possible!

3.1 Europe 2020

The Europe 2020 strategy is asking for:

- intelligent growth (technological know-how and innovation, quality products with high added value, ecofriendly methods, information- and communication technologies, investment into vocational training, motivation for social innovation in rural areas, better integration of new R&D results),
- sustainable growth (preservation of all basics for a sustainable food- and feed production, for renewable energies, sustainable land-management, provision of public goods, more biodiversity, animal- and plant-health increase, higher efficiency of natural resource management due to innovation, reducing of emissions or increase of the carbon buffer capacity)
- integrative growth (use the potential in rural areas, growth of local markets including employments, support for restructuring of farms etc.).

These targets can never be reached without the use of new technologies. Neither the planning of these targets nor the management and control of them can be done, neither for a single farm nor for complete regions and no environmental friendly growth and management can be implemented without being supported by new technologies and educated, trained and certified advisory structures for small and large farms.

3.2 Eco-element

Today we know that many of the new CAP reform targets will have new eco-components to reach above cross compliance. To reach them new technologies like precision farming will be useful but due to the small structures they can be managed in many European countries only in a cooperative approach - managed by advisors or service providers equipped with latest ICT technology.

However, Precision Farming will be the future of agricultural management. To realize it, one needs a communication network between farmers, advisors and mobile units on agricultural machines and the integration of these machines via interfaces (ISOBUS, others). The implementation of precision farming is focused on using variable rate technology based on local measurements or created spatial recommendation maps. A decision support system (DSS) combines detailed data of the soil, plant and data from different sources like satellites, sensors, weather stations, FMISs. With the help of such DSS, experts are enabled to create spatial recommendation maps based on crop requirements, which will be transferred to mobile units to realize the optimized m^2 precise application of inputs and also protocol m^2 precise harvest results. This allows finally a m^2 precise cost benefit calculation.

4. ORGANIZATIONAL COMPONENTS

In the same manner as ICT has supported many other sectors throughout the last decades, ICT is able to support the agriculture but we need enabling structures and a new form of cooperation. The farmers will be able to support also the new requirements of the CAP reform, but they need better support, assisted by new advisory structures focusing on the farmers needs and NOT only on the stakeholder needs alone. The farmer is the integrative factor within the food/feed-, bioenergy- or even environmental- or natural-risk-chain-management and HE has to be supported. Then all other chain members will also benefit from the ICT structure.

4.1 New business models

New business-models are necessary - and available - that take care of the leverage effect due to integration of technologies and cooperation of structures! Less group egoism in agro-forest chain management is a must.

A prerequisite to start such an agro-solution is a local infrastructure comprising local hardware, communication technologies and the whole appropriate personnel organizational structures. It contains the hard- and software for aggregation of the data at Ministry level, the countrywide structure for LPIS and FAS (Farm Advisory System), the mobile solutions and the communication layout. Access to ortho-images and weather-data supporting all farmer´s needs is a must in the future. Making data available like Finland´s cadaster department did it recently is a must, private ortho-image suppliers like MS-BING an ideal option for future cooperation.

Benefits and beneficiaries who are the stakeholders in such a concept are described in Section 5 and 6 and to all groups mentioned there, the ICT-backbone can produce valuable services. For these services lots of ROI-money can be acquired due to the benefits delivered by the ICT, but it stays always a political decision to which extent the Ministry will support the achieved benefits or how much beneficiaries for the use of this ICT backbone will have to pay. (On request ROI calculations for single sectors can be done).

The business models may be different - public, private or public-private. A model is imaginable, where public (MOA) and private (banks, insurance, and investors) share the investment and setup a common structure to support the different beneficiaries with information against a fee.

4.2 New land management models

To reach 2020 targets, innovative concepts for a sustainable environment- and risk management have been developed in cooperation with the University of Natural Resources, Vienna and are a base for a new land management concept. They deal with biodiversity, sustainability, multipurpose land-use and economic advantages based on the carrying capacity and reliable criteria which must become part of a sustainable economy.

Another concept pursues the goal of land-consolidation. What is land consolidation? It means the re-parceling of the properties in a region by the exchange of plots according their values to optimize the situation for all farmers including the public (roads, landscape). Together with the Lower Austrian Government, a tool based on clear concepts and values to achieve reallocations and consolidations of agricultural land holdings was developed. PROGIS has the exclusive right to market them worldwide.

Another similar approach is virtual farming. To overcome the expensive cultivation of small and bad shaped fields, virtual land consolidation ("Gewannebewirtschaftung" in Germany) is also possible with technology. The farmer remains owner of his field but cooperates with neighbours for machine use on virtually new shaped fields. Costs (tillage, fertilizing, etc.) and/or returns (harvest results) are collected with m^2 precision (precision farming - technology) and the contribution margin is shared according to the original field layout.

4.3 Consulting

As emphasized above, for a sustainable development of agriculture and/or forestry there is essential a close cooperation with experts. Thereto we have integrated into our AGRO-ICT-Backbone concept also the ability of a growing network of consultants who there are best educated researchers, scientists and practitioners with long lasting experience and international reputation as well as trainers for a technology support for these experts how to use the WinGIS-SDK that allows to develop more local applications and link them to the existing ones. They can cover the following topics - as samples, further expert's enquiries for cooperation welcome - which in many fields are also part of the new CAP reform:

- Natural resource- and environment- management
- REDD+ projects and management
- Natural hazard and risk reduction management
- Wild-life management, natural parks, hunting, fishing,
- agro-forestry, nature conservation, eco-tourism, rural development etc.
- Infrastructures for rural areas.
- Carbon modeling and technology enabling carbon financing for complete countries
- Livestock and nutrients and the impact on fields
- Cooperative structures and their setup
- Machine- or other Cooperatives
- Inventory methods, forest management
- Precision farming
- Local land consolidation models
- Cloud based trust center
- Desertification (technology influencing drought, rainfall)

A "Train The Trainer - TTT" model gives within an education and training program relevant information for stakeholders, decision and policy makers, provides general information on agricultural, ecological situations and specific information on GIS and ICT technologies, as well as on responsibilities, expectations and chances for new farm / farm advisory systems is a very important pillar of the whole concept to assure its durability and sustainability. Local IT experts may develop their application based on local needs

5. BENEFICIARIES

A crucial effect of this agricultural ICT backbone concept is that data will be generated displaying the whole situation and the planning for the today and future situation of agriculture and forestry in a country. A certain time after implementation, the empirical knowledge derived from the storage of the history together with latest R&D leads to further actions. Many stakeholders are interested in these data and need them for their daily work. With an appropriate model data sharing can happen to bring benefits for several businesses. You can take it for granted that chain-partners will be ready to pay to get access to this information. The model in detail has to be worked out together with local structures and representatives from different stakeholders, based on a trust center concept that respects the ownership of information.

A public-private used ICT infrastructure, consisting of new ortho-images for the country covering GIS and IT solutions for rural area management in connection with land-management and extension-services, agriculture management and logistics can in that case be used by different governmental organizations, can also be used by private structures and can:

- Support the Minister of Agriculture for his needs to organize subsidies,
- Support the Minister responsible for landscape changes or for the cadaster and ground tax,
- Support consultants in their advisory work,
- Support food chain partners for traceability and for the documentation of the production,
- Support logistic service experts to do the right actions at the right field to find the right roads to the field and be there at the right time as well as deliver goods to the food industry "just in time"; it is a support to all suppliers and buyers of farm goods,
- Support the agro control organization for subsidies,
- Support the bankers to get a business-plan to be able to finance the farmers/forest holders and get output from the LPIS incl. a calculation of the growth period (costs and expected return),
- Support insurance companies to make right policies for the right crops on the right fields as they also can get output from an LPIS system that tells which farmers has which crops, how many hectares incl. a map and use this as a base for the insurance-policy,
- Support the ecology expert or also the natural-risk-manager for the appraisal of the risks related with field or ecological coherences,
- Support the human medicine expert to judge the influence of the activity of the farmers (food and environment) towards the people,
- And last but not least, support the farmer to give him tools for his economical calculations.

6. BENEFITS - COSTS

Whatever we do with ICT in agro-forest-environment-risk we have to verify costs and benefits. The latter has to show economic benefits but also benefits in ecology and valuate both of them. Different models are possible and also the change of the value of a piece of land, if it is managed well or bad has to be taken into consideration. The future integration model must verify that farmers are able to influence the quality and quantity of production of "water and bread" and not to optimize one element against the reduction of another one. We need both of them. In the following there are listed up the main advantages and beneficiaries of such an implemented integrated agro-ICT-concept.

6.1 On a macro-economic level

Imports will be substituted due to higher production based on better technology use within the country. Further, a higher productivity and clear ownership situation increases the value of farm land and in summary the value of the entire country. A farm-management system employed in a certain region provides the necessary data for local carbon financing projects (World-Bank recently requested for it).Well organized agro-management leads to an increased income of small holders, to better living standards, to more sustainability and a higher percentage of the agriculture to the GNP. Also investors will benefit from such an ICT backbone and the value of the land will also in parallel increase due to the better presentation with maps, calculations, available infrastructure, etc. ICT supporting extension-, advisory-services lead them to better performances and administration bodies will be able to optimize control. Also the cooperation between farmers and scientists will be increased and the implementation of cooperatives will change agricultural structures with positive effects. The shared use of an ICT backbone within the agro-chain reduces costs and has a positive impact on budgets. Further, banks and insurance companies can be integrated and will directly or indirectly benefit from such an ICT structure by getting tools to support financing (business plans for microfinance on click) and insurance of smallholders (insurance policy on click). Not to forget the education impact that farmers get through the system and the relatively easy way to guide them into the direction of an eco-social market economy. This again has effect on ecological- and natural-risk-factors. It is always cheaper to support farmers in preventing risk factors or environmental problems than to repair them at a later stage (CAP-reform!).

6.2 On a micro-economic level

GIS (Geographic Information System) gives detailed information on size and location of fields of single/group of farms. This information is the base for ALL further planning incl. logistics. Farm management tools allow cultivation planning, documentation (e.g. GLOBALGAP), traceability, nutrient- and CO2-balance, cost calculations and control and above all provide information for trust centers and support advisory services profiting also from the embedded scientific local know how.

Logistic solutions with central and mobile systems allow precise and accurate planning of logistic needs serve farmers, food-industries, contractors and the environment and will lead to enormous cost savings. Agrometeorology data and soil moisture data allow better decisions based on integrated local expertise. Risk management solutions are mainly for optimizing carrying capacities, plant protection, and food and feed safety etc.; and beyond that, such solutions can help to better define and measure farmer's integration into environmental caretaking. Business-plans assist the cooperation with banks and insurance companies.

Machine interfaces allow the set-up of precision or virtual farming solutions for group of users. Further, statistical analysis for regions or countries becomes possible and new NPK sensors measuring Nitrogen, Phosphorus and Potassium can also be integrated for optimized fertilizing. Forestry- and/or environmental-caretaking solutions are supported also by applications.

ICT supports the fast distribution of scientific know how; and an organized feedback will allow verifying and optimizing results over the time!

ICT enables farmers to become part of decisions and implementation of environmental caretaking measures which are based on defined targets of beneficiaries, defined work plans and returns for farmers.

As the farmer is in many cases not working alone but in cooperation with neighbors or cooperatives, an intelligent ICT solution has also to reflect the needs of that groups and the integration of parts of the farm management into these group needs. Large farms can be seen as "one owner of horizontal integrated fields". Small farms will be integrated and benefit from these new technologies together with service providers supporting farm-management and horizontal and vertical ICT needs. Land consolidation set up on LPIS datasets optimizes the farmer´s ownership structure and virtual land-consolidation optimizes the future of smallholder's cultivation management.

Trust centers will be a need and further possibility to work with the data for traceability solutions.

7. CASE STUDY

The largest project today is the cooperation with the German Machine Cooperatives with 250.000 members, more than 200 offices and 7.2 Mio ha throughout Germany. Beside DokuPlant that was evaluated within a customer satisfaction study based on at that time 574 answering PROGIS users in 2007 already (high satisfaction more training required 75% prized highly the integrated expert data); we enlarged the cooperation within a 2nd step with logistics integrating at first Südzucker - the largest food industry in Europe - and their 40.000 sugar beet supplying farmers. Key was beside technology integration also the cooperation of all chain partners: 40.000 farmers, 45 machine cooperatives running the central logistics servers and managing the contracts towards hundreds of mobile devices like sugar beet harvesters, pickups and trucks supporting 6 factories with just in time delivery of predefined amount of trucks per day. Every stakeholder is always online with central GIS stations and mobGIS™. The technology was fine-tuned during the last years integrating also the factories HQ-IT solution as well was successfully rolled out to other crops like biomass, potatoes etc.

8. DISCUSSION AND CONCLUSION

The technology is able to support all the needs of farmers today - technology integration is a must and available and possible. For the future the main challenges are: First the cooperation of stakeholders as today the main target of many large chain partners is to get access to the information of the farmer's field and the farmer refuses to give the data out of his hand. A "trust center" that defines in detail who is the owner of which information and when information must be transferred to the government (legal definition) or a chain partner (bilateral agreement) will solve this problem.

Second the business model behind, that allows many partners to cooperate around an integrated solution where every partner receives that information that he needs for his purpose and many partners share the costs and the benefits out of such an integrated system. Such systems will only be accepted if the costs are low. This is only possible if large projects integrating the Ministry of Agriculture and several other stakeholders set projects up together. The third challenge is the environment-risk-management integration but based on such a structure as mentioned above. The farmers will together with partners be heavily involved in environment- and risk-management as supplier of defined benefits to defined beneficiaries / groups of beneficiaries based on new eco-social policy models. The farmers create values for groups or for all of us and the whole society will benefit as farmers become social responsibility and get funded for clear defined benefits supported by the so called commons.

IMPROVING SEMI-NATURAL GRASSLAND ADMINISTRATION WITH TERRASAR-X

Kaupo Voormansik[1], *Thomas Jagdhuber*[2], *Prof Dr Irena Hajnsek*[2,3], *Dr Konstantinos P. Papathanassiou*[2]

[1] University of Tartu, Tähe 4-111, 51010 Tartu, Estonia
[2] German Aerospace Centre (DLR), Microwaves and Radar Institute, P.O. Box 1116, 82230 Wessling, Germany
[3] ETH Zürich, Institute of Environmental Engineering, Schafmattstr. 6, 8093 Zürich, Switzerland

ABSTRACT

In the current study parameters of dual polarization HH/VV TerraSAR-X data from Northern European grasslands are compared with in situ data in order to develop a methodology for monitoring the cutting practice of grassland farmers, where three stages are distinguished: high grass, low grass and grass cut. First results reveal that it is very difficult at X-band to distinguish high grass areas from the low grass ones, but it seems to be possible to detect the grass cut stage, where grass was left laying on the meadows. The dual-polarization mean scattering alpha angle indicated a value of 30° degrees or higher within these regions. Whereas for the other grassland stages (high grass, low grass), the mean alpha angle usually stayed below 25°. Additionally a medium (>0.4) polarimetric coherence between HH+VV and HH-VV channels was observed on the grassland areas where the grass was cut and left laying on ground, compared to the other grassland stages, where its value dropped to 0.2 or less.

1. INTRODUCTION

Semi-natural grasslands especially wooded meadows are one of the richest ecosystems in Northern Europe, if the number of species per hectare is considered. They have been developed along centuries under human influence. Annual mowing cycles have shaped the habitat into the present conditions. With the rise of intensive agriculture a mowing practice on these meadows is not feasible any more, as it was done in the 18th and 19th century. In order to preserve this unique habitat, governments have decided to pay subsidies to the farmers for maintaining the semi-natural grasslands and protecting them from complete re-forestation. The subsidies are paid on a yearly basis and exactly according to the area that was mown in a particular year, which demands a precise monitoring strategy.

Currently the grasslands are inspected in situ, which is personnel intensive and therefore expensive. A convenient alternative could be Synthetic Aperture Radar (SAR) remote sensing in order to avoid costly in situ inspections. In addition, large areas could be covered in very short time, independent of weather and daylight.

Hence, current study focuses on polarimetric SAR remote sensing in order to correlate the different growing stages of grassland with SAR parameters. Even though there are many studies about SAR for agricultural parameter retrieval, grassland SAR signatures are quite sparsely studied so far. In [1] it was shown that L-band HH and HV channel backscatter tend to increase with grass growth (variation up to 9 dB), whereas X- and C- band backscatter changed only 2-3 dB for the same grass observation area. Similar results have also been presented in [2], showing almost linear correlation between C- and L-band backscatter values and grass height, exhibiting the biggest dynamics for the L-band HV channel (sigma0 from -9 to -23 dB). In addition, it appears that using only shorter wavelength SAR (such as C- and X-band) backscatter information, it is very difficult to estimate the grass height and/or the mowing status. For example C-band HH backscatter was shown to have differed less than 2 dB, when comparing mowed and un-mowed grasslands [3]. Inundated conditions seem to be more favorable for above ground grass plant biomass estimation, as C-band VV backscatter was shown to vary more than 10 dB together with biomass density over Bolivian inundated grasslands [4]. In a recent study on rice fields with dual pol. HH/VV TerraSAR-X data the HH/VV backscatter ratio was shown to change in time according to the phenological cycle of the rice plants and dual polarization entropy increased as rice plants grew higher [5].

The current paper is organized as follows. In section 2 the Matsalu test site, SAR imagery and in situ field data are described. Sections 3 and 4 present the SAR data processing parameters and preliminary results, respectively. Finally section 5 draws the conclusions about the study results.

2. MATERIAL

The Matsalu test site used in the current study is located in Estonia, Northern Europe (scene centre coordinates N 58.76, E 23.91). The terrain near the Kasari river flood plain in Matsalu is very flat, elevation ranges 4-20 m asl. The test region (see Figure 1) is mainly covered by semi-natural grasslands and agricultural fields. The vegetative season in Estonia lasts usually from early May until late September. Yearly average air temperature in the area

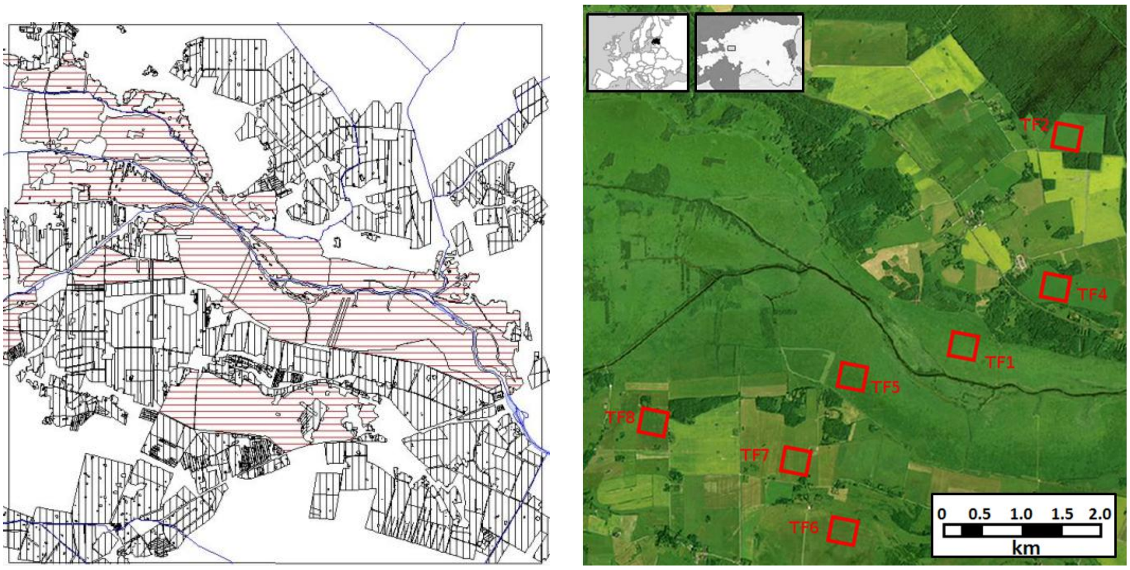


Figure 1: The Matsalu test site agricultural fields and semi-natural grassland borders (left) and the orthophoto from 2010 [7] (right). Red horizontally striped regions are the semi-natural grassland areas whereas black vertically striped regions are agricultural fields, rivers and streams are shown in blue color. Red boxes on the orthophoto indicate the test regions (described in the methodology section below) used for SAR data statistics calculation.

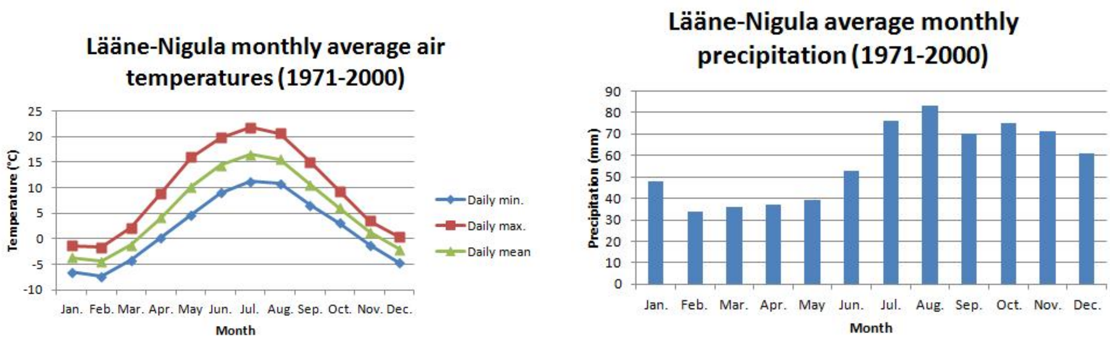


Figure 2: The climate norms at Lääne-Nigula meteorological station (20-30 km north from the Matsalu test fields) [6].

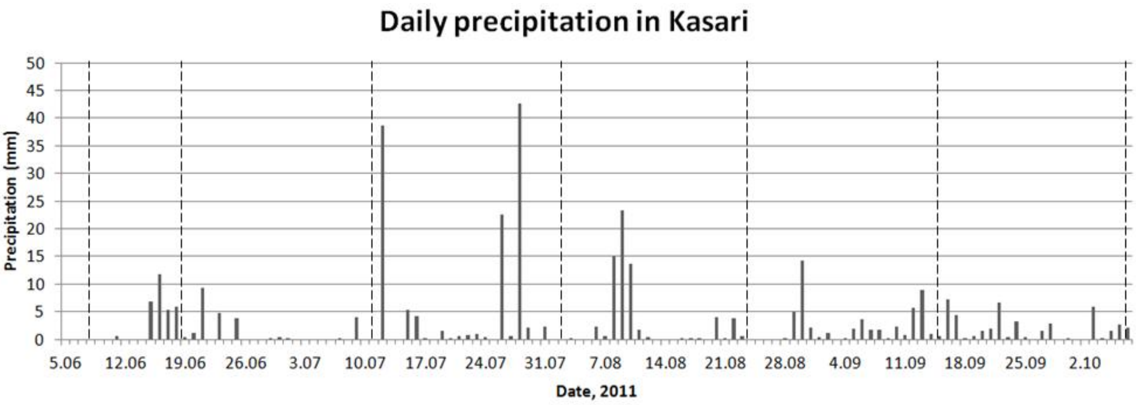


Figure 3: Daily precipitation at Kasari hydrological station (0-7 km away from the Matsalu test fields) [8]. Dashed lines indicate the TerraSAR-X data takes.

is 5.6° C and accumulated precipitation of 682 mm [6], please see Figure 2 for details.

A total of 7 TerraSAR-X spotlight HH/VV dual polarization images were used within the study. The data was acquired on 8th June, 19th June, 11th July, 2nd August, 24th August, 15th September and 7th October 2011. All the passes were descending orbit at 7:49 in the morning, local time with scene center incidence angle of 36.9°. The average ground range and azimuth resolution amounts to 1.96m and 3.20 m, respectively. The data was processed by DLR and delivered in the Single Look Slant Range Complex (SSC) format.

In parallel with the satellite passes field works were made. The data was collected within the same day as the satellite pass, except for 19th of June and 2nd of August, where the field works were made one day before. 7 different grasslands were covered by field works. On Figure 1 and Figure 5 one could see 7 red boxes noted as TF1, TF2, TF4, TF5, TF6, TF7 and TF8. Originally there was also test field 3 (TF3), but it was left out because during the growing season it turned out to be a rye field not a grassland. For each of the test fields the following data was collected:

- Grass height (5 point mean, measured in the middle of the meadow, center of the red boxes on Figure 1);
- Photographs to north, east, south and west (taken in the middle of the meadow);
- Grass cutting status (un-cut, cut, cattled);
- Qualitative grass moisture estimation (dry, wet, slightly humid etc);
- Qualitative grass density estimate (dense, sparse).

Two photographs, taken during field works, are presented on Figure 4, showing the high grass and cut conditions in a semi-natural grassland near the river Kasari in Matsalu.

Additionally, meteorological data was available from Estonian Meteorological and Hydrological Institute (EMHI). The Kasari hydrological station, located within the test site borders (not more than 7 km away from the studied meadows), precipitation recordings were useful for estimating the grass wetness conditions during the satellite passes. According to the precipitation data [9] relatively dry conditions can be assumed. For the first five passes (June to August 2011) there was no rain 24h prior to the TerraSAR-X overpass. On 15th of September and 7th of October there was respectively 0.2 mm and 4.6 mm of rain before the satellite data take. Daily precipitation sums of the Kasari hydrological station in 2011 is given on Figure 3. Even though it might seem that there was precipitation 24h prior the second TerraSAR-X acquisition on 19th June according to Figure 3, it is not true. The satellite passed 7:49 local time and the rain on 19th June occurred after it and the rain on 18th June was before 7:49 local time [9].

3. METHODOLOGY

Besides conventional backscatter analysis, polarimetric coherences were calculated and the newly suggested H2α dual pol. entropy/alpha decomposition [10] was applied. The H2α decomposition was used for the eigenvalue/eigenvector analyses with the Pauli basis 2x2 [T] matrix instead of the original implementation with [C] matrix. The following parameters were studied in terms of sensitivity to grassland changes:

1. HH, VV, HH+VV and HH-VV backscatter
2. HH/VV coherence magnitude and phase
3. T12 coherence magnitude and phase
4. Dual pol. entropy, alpha mean and alpha dominant
5. Ratio of HH/VV intensities.

Furthermore, interferometric coherences between the consecutive acquisitions were also investigated, but the results indicate almost complete de-correlation over grassland due to the 11/22 day interval between acquisitions. For the backscatter images, the polarimetric coherences and the H2α decomposition, a 9x9 pixel-average was applied to account for speckle effects. Within the backscatter sigma0 calculation [11][12] for TerraSAR-X SSC data, a simplified approach was used ignoring the noise equivalent beta naught (NEBN) term. This is considered appropriate, as for all test fields the average backscatter stayed over -15 dB, whereas the TerraSAR-X noise equivalent sigma0 (NESZ) locates at -19 dB.

In order to compare the SAR parameters with in-situ field data, test regions were established. 200x100 pixel rectangular areas within the TerraSAR-X image SSCs were used, corresponding to 300 m x 268 m areas (please see the red boxes on Figure 1 and Figure 5) in nature taking the pixel spacing of 1.50 m (ground range) and 2.68 m (azimuth) into account. Such test region size was chosen, because it was large enough (20 000 pixels) to get reliable statistics and yet small enough for extrapolating the field works collected data over homogeneous area. The test field grasslands homogeneity was validated using ground truth photographs and is well in line with the calculated SAR results (see Figure 5 for example).

4. PRELIMINARY RESULTS

As the most prominent changes within the grassland areas took place from late June until end of August, the discussion focuses on the results derived from the time series of TerraSAR-X imagery (19th June, 11th July, 2nd August and 24th August).

Figure 4: A Matsalu meadow in high grass (left, 11^{th} July) and cut grass conditions (right, 1st August).

Figure 5 presents the dual pol. mean scattering alpha angle of the Matsalu test site from the end of June until August 2011. Analyzing the images, one clearly recognizes the significant variations in time over the agricultural fields next to the grassland test fields (TF, red boxes). However, the mean scattering alpha angle changes also over the grasslands in time.

Comparing the observations with field works data, high grass (over 60 cm) was recorded on the semi-natural grasslands of TF1 and TF5 on 19^{th} June and 11^{th} July (Figure 5 a and b). On 2^{nd} and 24^{th} August (Figure 5 c and d) the grass was cut and grass height was reported less than 20 cm on TF1 and TF5. There are especially pronounced changes on TF1 comparing images b and c, the mean scattering alpha angle has increased from about 20° to over 30°, while it is important to remark that on 2^{nd} August (Figure 5c) the grass was laying on ground in TF1, whereas for 24^{th} August (Figure 5d) it was already collected.

Comparing the images c and d one could observe that the mean scattering alpha angle was higher on 2^{nd} August, when the cut grass was not collected yet. If the grassland areas within and around TF1 and TF5 are investigated for 2^{nd} August and 24^{th} August, one could clearly see the light blue (alpha over 30°) areas on both of the images, which are not observable on 19^{th} June and 11^{th} July images (except a small light blue region left from TF5 on the 11^{th} July image). The authors attribute these light blue regions (alpha > 30°) to the grassland areas, where the grass was freshly cut and not collected yet.

TF2, TF6 and TF7 on Figure 5 correspond to constantly low grass areas (height < 20 cm), also the mean scattering alpha angle appeared to remain steadily low (< 25°). On TF4 the grass remained uncut throughout the season (height over 60 cm), which results in low mean scattering alpha angles. On TF8 the grass was cut for 2^{nd} August (Figure 5c), but the cut was relatively high (grass height dropped from 60 to 30 cm), which led to no significant changes in the mean scattering alpha angle along the observation period. Figure 6 presents the grass height data and the investigated polarimetric SAR parameters as mean of field values for TF1. Most prominent changes in the polarimetric SAR parameters seem to appear from 11^{th} July to 2^{nd} August, when the grass was cut, but not collected yet. For instance, HH and HH VV backscatter increased about 3 dB, alpha mean and alpha dominant increased by about 10° and 15°, respectively. HH/VV polarimetric coherence phase dropped by 20° and T12 polarimetric coherence (between HH+VV and HH-VV channels) magnitude increased to more than 0.4. In order to show the T12 polarimetric coherence changes in detail, the histogram of the coherence magnitude for TF1 is presented on Figure 7. Generally, the coherence level between HH+VV and HH-VV channels is very low (average around 0.2) for high grass conditions on 11^{th} July and low grass on 24^{th} August. The coherence increases only (close to 0.5), when the cut grass is laying on the field on the 2^{nd} August image.

5. CONCLUSION

According to the experiment over the Matsalu test site in 2011, it reveals that it is very difficult to distinguish high grass (over 50 cm) from low grass (less than 30 cm) in relatively dry conditions using dual polarization HH/VV TerraSAR-X data, as no significant changes were observed with the investigated polarimetric SAR parameters. Backscatter values in HH, VV, HH+VV and HH-VV channels differed mainly less than 3 dB, when comparing high grass conditions with low grass conditions over of the same fields, which makes backscatter studies easily biased due to the small sensitivity range. HH/VV coherence, T12 coherence and dual pol. entropy changed less than 0.1 showing a quite stable trend over time. Alpha mean, alpha dominant and HH/VV coherence phase remained also almost stable (less than 10° variation) when the grass height dropped more than 30 cm. One reason, why there is very little difference between high grass and low grass SAR parameters might be due to the fact that the scattering is already complex even for low grass stages and growing to high grass conditions does not change the scattering much anymore.

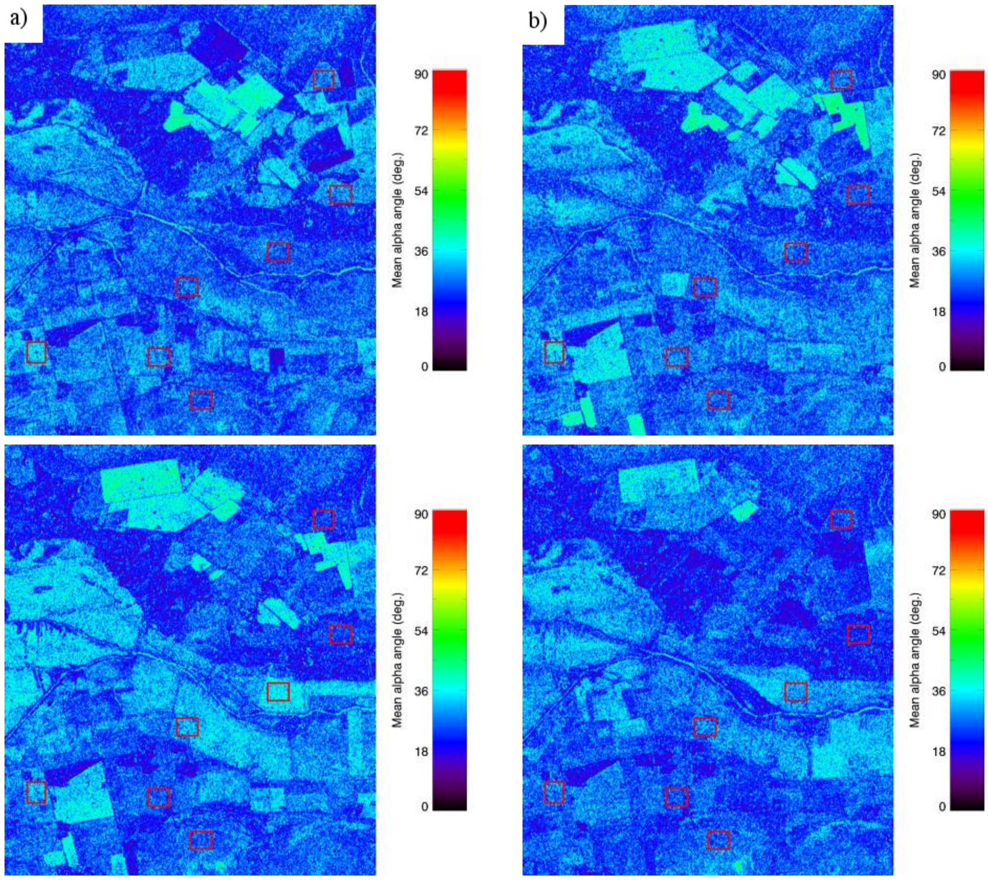


Figure 5: The dual pol. mean scattering alpha angle of 19th June (a), 11th July (b), 2nd August (c) and 24th August 2011 of the Matsalu test site. Red boxes indicate the grassland test field regions used for SAR parameters statistics calculus.

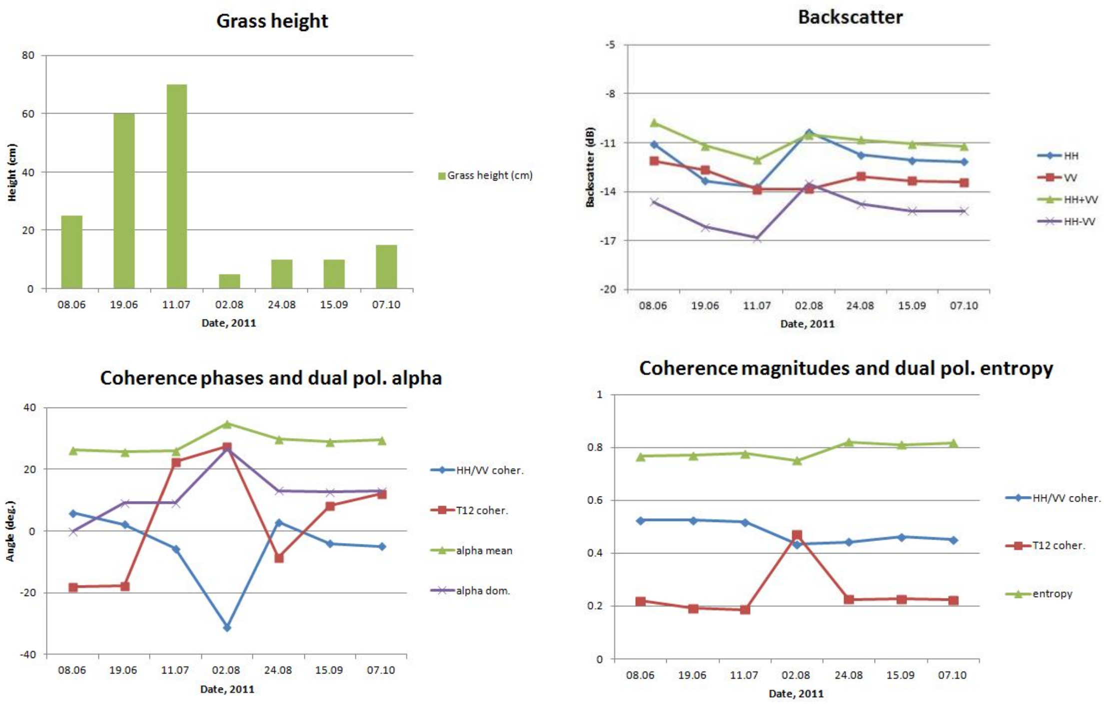


Figure 6: The grass height and the trend of the investigated SAR parameters of Matsalu test field 1.

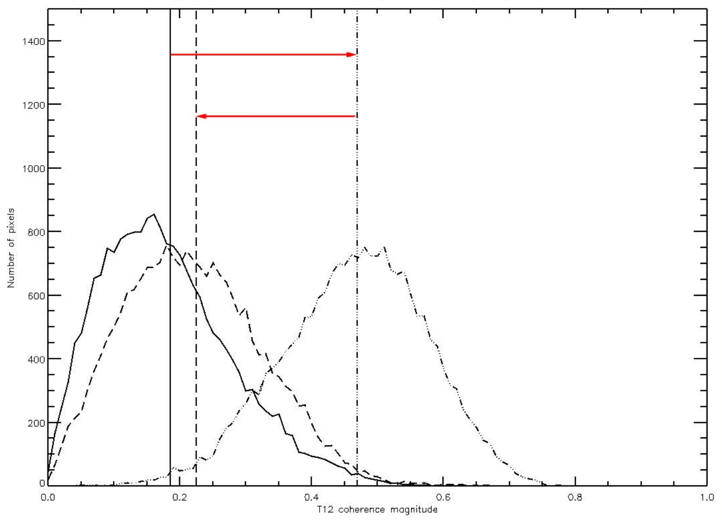


Figure 7: Histogram of T12 coherence magnitude for Matsalu test field 1 on 11th of July (solid line), 2nd of August (dash-dotted line) and 24th of August (dashed line). Vertical lines correspond to the mean values, arrows show the changes in time.

At the same time, it appears to be relatively easy to extract the areas, where grass was cut and left lying on ground using the dual polarimetric HH/VV data. Please see Table 1 for the list of parameters, which seem to be useful for distinguishing the areas, where grass was cut and laying on ground compared to the areas of high/low grass. Interpreting these results, given in Table 1, the higher alpha values for grass cut laying on ground, could be anticipated from a study with X-Bragg scattering model for a L-band wavelength [13]. According to that model, the mean scattering alpha angle increases together with surface wetness. It is assumed that the cut grass lying on ground accumulated the moisture and provided thus higher mean scattering alpha angles. This is a likely scenario, because there is dew over the grasslands in the morning hours and the satellite overpass was 7:49 am local time. Hence the grasslands could not completely dry up until the acquisition time when images were taken.

In order to further approach the question, how to distinguish high grass areas from low grass ones using polarimetric SAR data, additional experiments in lower frequency bands (C-,L-band) and with fully polarimetric data should be conducted in the next grassland studies.

ACKNOWLEDGMENTS

The work was carried out under the DoRa scholarship program of Foundation Archimedes during a research stay in German Aerospace Centre (DLR) Microwaves and Radar Institute. The authors would like to thank DLR for the TerraSAR-X imagery used in the study distributed under project LAN1123. We would also like to thank Estonian Agricultural Registers and Information Board for the geospatial data and information about the grasslands, used in the study.

REFERENCES

[1] M. Herold, C. C. Schmullius and I. Hajnsek, "Multifrequency and Polarimetric Radar Remote Sensing of Grassland - Geobiophysical and Landcover Parameter Retrieval with E-SAR Data," 2001.

[2] M. J. Hill, G. E. Donald and P. J. Vickery, "Relating Radar Backscatter to Biophysical Properties of Temperate Perennial Grassland," Remote Sensing of Environment, vol. 67, no. 1, pp. 15-31, 1999.

[3] N. Mino, G. Saito and S. Ogawa, "Detecting management practices of improved grasslands using ERS-1 SAR data," in ACRS, 1997.

[4] S. Moreau and T. L. Toan, "Biomass quantification of Andean wetland forages using ERS satellite SAR data for optimizing livestock management," Remote Sensing of Environment, vol. 84, no. 4, p. 477-492, 2003.

[5] J. M. Lopez-Sanchez, B.-B. J.D. and I. Hajnsek, "First Results of Rice Monitoring Practices in Spain by Means of Time Series of TerraSAR-X Dual-Pol Images," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 4, no. 2, pp. 412-422, 2011.

[6] Estonian Meteorological and Hydrological Institute, "Estonian Climate Norms 1971-2000," 19 03 2012. [Online]. Available: http://www.emhi.ee/index.php?ide=6,299,302. [Accessed 19 03 2012].

[7] Estonian Land Board, "X-GIS Public Webmap Service," [Online]. Available: http://xgis.maaamet.ee/xGIS/XGis. [Accessed 16 03 2012].

[8] Estonian Meteorological and Hydrological Insitute, "Last 24 hour precipitation sums of Estonian meteorological and hydrological stations.," 3 6 2012. [Online]. Available: http://www.emhi.ee/index.php?ide=

Table 1: Dual pol. HH/VV X-band SAR parameters showing sensitivity to cut grass laying on ground.

	High grass/low grass	Grass cut, laying on ground
Dual pol. alpha mean	< 30 °	> 30 °
Dual pol. alpha dominant	< 20 °	> 20 °
T12 coher. magnitude	< 0.4	> 0.4
HH/VV coher. phase	> 5 °	< 5 °
|HH|/|VV| ratio	< 4 dB	> 4 dB

21,328,469&liigu=2011-06-07&gtund=8. [Accessed 3 6 2012].

[9] Estonian Meteorological and Hydrological Institute , "Weather observations," 2011. [Online]. Available: http://www.emhi.ee/index.php?ide=21&v_kiht=2. [Accessed 15 03 2012].

[10] S. R. Cloude, "The dual polarization entropy/alpha decomposition: a PALSAR case study," in PolInSAR2007 Workshop, Frascati, 2007.

[11] T. Fritz, "TerraSAR-X Level 1b Product Format Specification," 10 12 2007. [Online]. Available: http://sss.terrasar-x.dlr.de/pdfs/TX-GS-DD-3307.pdf. [Accessed 2012 03 16].

[12] T. Fritz and M. Eineder, "TerraSAR-X Basic Product Specification Document," 15 10 2010. [Online]. Available: http://sss.terrasar-x.dlr.de/pdfs/TX-GS-DD-3302.pdf. [Accessed 16 03 2012].

[13] I. Hajnsek, E. Pottier and S. R. Cloude, "Inversion of Surface Parameters From Polarimetric SAR," IEEE Transactions on Geoscience and Remote Sensing, vol. 41, no. 4, pp. 727-744, 2003.

DETECTING ARTIFICIAL AREAS INSIDE REFERENCE PARCELS, AN INITIAL SETUP PREPARING A MULTI STAGE CLASSIFICATION ON NON-ELIGIBILITY IN AGRICULTURE

Roeland De Kok, Csaba Wirnhardt

MARS Unit, Institute for Environment and Sustainability, EC Joint Research Centre, Via E. Fermi 2749, Ispra (VA), Italy. roeland.de-kok@jrc.ec.europa.eu

ABSTRACT

A recent development in remote sensing is the increment of high quality imagery over very large areas. The sheer amount of such data at low cost and the repetitive acquisition at any global position might induce changes to existing practice of updating GIS databases. It also facilitates a full automatic scan of the LPIS database, which is now becoming possible for each growth-season. The aim of the complete scan is to "flag" parcels which are expected to require an update. Crucial in this procedure is not to miss parcels with such need. That condition aims at a classification procedure with a negligible amount of omission errors. On the opposite site, the "false alarms" or commission errors still will be subject to a visual inspection. Any additional reduction of the commission errors would limit the cost for visual inspection. To gather experience in such a procedure, a selection of mosaic tiles of nearly 21875 km^2 from the RapidEye coverage acquired in 2010 over Hungary have been classified. Due to the image resolution of 5 meter, a detailed assessment based on the same RapidEye imagery is insufficient. Alternatively, a visual interpretation was used on classified polygons using 50 cm orthophoto from the 2010 Hungarian coverage and applied on a subset of 1152 Km^2 using 2644 polygons. The aim was to detect artificial areas with characteristic high contrast in the imagery. The classification was designed in order to produce negligible errors of omission at the cost of tolerating a high level of commission errors. This biased approach only makes sense within a multi-stage procedure. The study delivers some practical considerations for a possible first stage of a multi-stage procedure. Estimated processing time can be given for the classification of the total LPIS database. The assessment of a multi-stage process however might require a large scale construction of a visual reference. The reference set, based on visual evaluation with data at aerial photo quality, might be costly. Although the assessment on representative subsets could be expensive, the repeatable classification result itself will aim at a cost effective procedure for the analysis of wall-to-wall satellite coverage.

1. INTRODUCTION

Since 2010, a wall-to-wall coverage per season at the national level is feasible using satellite data with 5 meter resolution. The concept became established due to the deployment of RapidEye's constellation of five satellites. This cluster approach will be followed by other satellite providers such as DMC and SPOT successors. Wall-to-wall availability of high resolution satellite data is now expected to become a frequent product. This data might also assist the evaluation on eligibility in the LPIS by screening all polygons.

This study delivers a statement on practicability of a complete mosaic classification. It also gives an estimated calculation time, develops requirements on additional data and delivers an impression about the bottlenecks likely to be encountered in the design of a follow up pilot study.

The first setup focuses on the possibility for a full automatic screening of the national set of agricultural parcels for a small selection of anomalistic subcategories. A critical issue inside eligible agricultural parcels is the presence of areas with "permanent physical change" [1]. Among these, the "artificial areas" can be regarded as a sub-category. A second sub-category can be "voluminous textural vegetation" such as tree-plantations and forest which has a minor role in this study. The first stage of the study is to demonstrate that a sub-category can effectively be detected automatically on the total population of eligible parcels.

The design of this assessment is biased on purpose. A sharp reduction of omission errors is possible if, for dubious cases, a lower threshold is accepted. In a situation of doubt about contrasting areas being present or not, the dubious case will be classified into the potential problematic parcels. This tips the balance towards an increment on the commission errors (more false alarms). This is not uncommon in screening procedures and can be applied in a "multi-stage" classification [2]. The multi-stage design requires a continuation of the initial classification to remove these commission errors. For this study, only the first stage is evaluated and the conditions for multi-stage assessment are described.

The image feature "contrast" as detector for artificial areas is well known and elaborated in the Pantex method by Pesaresi et.al.[3]. Contrast can be related to cast-shadow and this links to objects containing a certain height. The factor height and automatic detection on non-eligibility in agricultural parcels is solved in a preceding study by Zieliński's [4]. The full height information of the complete national coverage (normalized digital surface model, nDSM) needed for this approach, is at present an expensive dataset. Especially, compared to the wall-to-wall seasonal coverage at 5 meter resolution with an estimated 1 euro/km^2. The height related factor of contrast due to shadow casting is an important factor besides other physical reasons for high contrast such as variety of building materials. The enhancement of this contrast is therefore the main factor linked to artificial areas in this classification.

The study follows the intentions of the Zieliński's approach [4]. Although technological solutions for anomaly detection already can be demonstrated, this study aims to stay at a parallel course using less superior datasets. This comes at the cost of a loss in accuracy. The presented results should be evaluated mainly on their budget advantages.

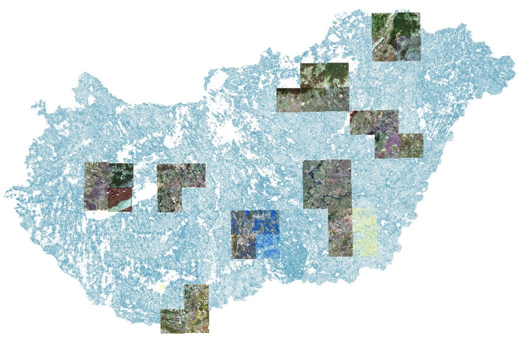


Figure 1: Selected tiles of a total of 209 tiles from the national mosaic (20000Km^2), ±20% of Hungary, agricultural areas of HU in blue.

2. UNIFORM CHARACTERISTICS ON ENHANCED IMAGE DATA

A satellite mosaic with tiles compiled throughout the season (Figure 1) is sensitive to spectral differences among these tiles. A reduction of image complexity and a concentration on specific information content can be created in a derived image with limited but essential information. A very basic approach is the edge enhanced image. From a natural color detail of the RapidEye image (figure 2) only the transition zones of strong spectral difference among neighbouring pixels is preserved (Figure 3). Figure 3 is created using the red band input on a "Laplace" kernel, a standard edge detection algorithm in image processing [5]. The only role of Figure 3 is to illustrate the principle effect of essential information extraction using a well-known technique in remote sensing. In this study, an alternative to the "Laplace" edge extraction is based on a single contrast calculation expressed in equation 1 (see Section 3 and Figures 4 and 5). The more uniform as well as enhanced contrast image replaces the original spectral information in the classification process. The enhanced imagery basically has a binary quality; pixels with high response and those with low response which includes homogeneous areas. This makes it easier for a single master classification protocol that responds to those pixels which have a high value in the contrast map over all the mosaic tiles. Artificial areas are expected to respond both to edge detection and contrast analysis and deviate from their homogeneous agricultural surrounding.

Figure 4 visualizes the contrast to neighbours using equation 1 (Section 3). It is expected that agricultural parcels remain smooth and contain much less contrast than settlement areas. This would mean they appear black (in Figure 3) or gray (in Figure 4). Although Figure 4 is created using equation 1, the result highlights similar pixels as those normally highlighted in traditional edge detection algorithms. The advantage of equation 1 over traditional edge detection is the possibility to choose a flexible neighbourhood distance. This permits incrementing on an enlarged spatial context using thousands of neighbouring pixels (Figure 5).

Because of the sensitivity to contrast, the master protocol can handle the classification of artificial areas but encounters difficulties with textural vegetation such as hedges, forested rows and forest plots, in case only mono-temporal image is applied. For multi-temporal imagery the difference of the red bands helps to solve this issue as well as limited NDVI changes.

For this first stage, the category "artificial areas" is selected and classification takes place on 35 Tiles. Each tile (24x24 km) of the 209 Tiles of the complete coverage for Hungary in 2010 (see Figure 1). These 35 Tiles are covering the 9 LPIS control zones for 2010 and about 20% of the total area of Hungary.

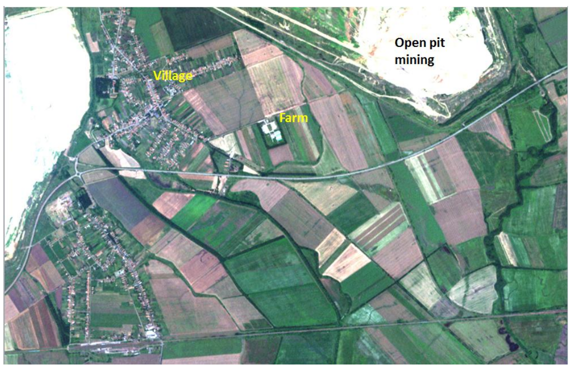


Figure 2: Detail from a RapidEye tile (RGB, "natural colors").

Figure 3: A standard edge extraction using the "Laplace" 3x3 kernel on the red band of Figure 2.

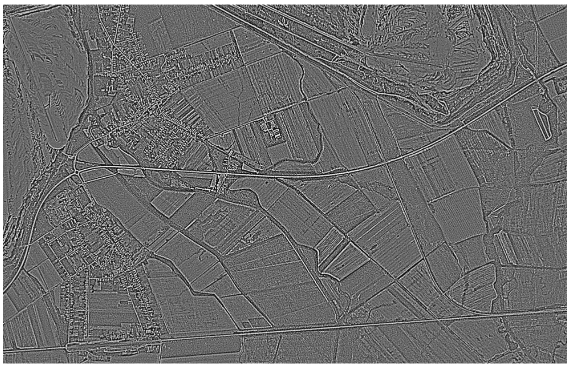


Figure 4: The contrast to direct neighbours using equation 1 on the same detailed image with distance "d=1".

Figure 5: Contrast on larger neighbourhood using distance d=25 on the red band (25 pixel radius, ±5 Ha, in equation 1.

The example of the edge enhancement image in Figure 3 and contrast in Figure 4 visualizes the reduction of complexity from the original tile in Figure 2. Smooth homogeneous areas become dark/black surfaces in edge detection imagery. Negative values with darkest graytones appear in Figure 4 for hedges, forest plots and maize.

Contrasting artificial structures are expected to return a sharp edge and a high value in the contrast maps (Figure 4). Especially settlements are in the maximum range in these contrast derivatives. The classification of settlement structures is a simple task, missing a few buildings does not affect the overall return of settlements layout, which can be confirmed in visualizing the result as KMZ over a GoogleEarth™background. The aim here, however, is to go to individual artificial structures. This requires more efforts. It is the combination of close and far neighbourhood contrast (combined Figures 4 and 5) that gives the advantage over classical edge detection (Figure 3 only). If a pixel is highlighted in Figure 4 and maintains its high value in Figure 5 it is registered as a contrasting object.

3. A SINGLE CONTRAST FOR CLOSE AND ENLARGED NEIGHBOURHOODS

Figure 4 can be produced with a 3x3 close neighbourhood (8 neighbouring pixels). This responds to contrasting objects in general, including open soil spots inside the parcels. Also contrasting elements in forested and mountainous areas are showing a positive response. The advantage of contrast on larger neighbourhoods [6] is the differentiation among the contrasting objects, aiming at separation of specific artificial structures from other contrasting objects. For the creation of Figure 5, the central contrast calculation from an object based approach was used with a large neighbourhood at distance; d = 25, using equation 1. The distance d is defined as object distance but is used in this study for single pixels [6]. In this case, d = 25 means a radius of 25 pixels around the central pixel, thus a neighbourhood of ±5 Ha for 5 meter resolution. The contrast calculation used in this study is derived from the eCognition ReferenceBook [7] that accompanies the software version 8.64:

$$\overline{\Delta_k}(v) = \frac{1}{w} \sum_{u \in N_v(d)} w_u(\bar{c}_k(v) - \bar{c}_k(u)) \qquad (1)$$

where u, v are object mean values, $\bar{c}_k$ is the mean intensity of the image layer k, and w is the image layer weight, defined as the sum of the weights of image object

$$w = \sum_{u \in N_v(d)} w_u \qquad (2)$$

with

$$w_u = \begin{cases} b(v,u), & d = 0 \\ \#P_u, & d > 0 \end{cases}$$

where $b(v,u)$ is the length of the common border between u and v and $\#P_u$ is the total number of pixels/voxels contained in P_v. N_v is the direct neighbour to image object v with

$$N_v = \{u \in V_i : \exists(x,y) \in P_v : (x',y') \in N_4(x,y)\} \qquad (3)$$

while $N_v(d)$ is the set of neighbours to v at a distance d

$$N_v(d) = \{u \in V_i : d(v,u) \leq d\} \qquad (4)$$

A single (red) spectral band for a contrast analysis on a 3x3 kernel (distance $d = 1$) is not sufficient to deliver enough image information for a separation of normal agricultural area, anomalies and artificial areas. Visual inspection reveals open soil, often induced by machine opening or compaction of the soil and in addition temporary waterlogging is responsible for many cases of contrasting locations inside agricultural fields. However, the contrast inside agriculture parcels, related to the field management with machines, does not create cast-shadows. Cast shadow and related contrast are expected to be part of artificial areas or trees.

By using contrast for local (8 pixels) and larger (1964 pixels) neighbourhoods in the red as well as the infrared spectral band, it can be expected that the artificial structures are to respond stronger to a combination of contrast features than the bright spots of open soil inside the parcels due to a larger variety of pixel values in artificial areas of which bright roofs and cast-shadows play an important role. Bright spots of open soil are expected to be the main contributor to the errors of commission. It is also assumed that open spots of soil are affected by vegetation change during the season. This gives an extra reason in favor of a multi-stage approach. Because contrasting spots of open soil might lose their contrast in at least one of the multi-temporal and multi-spectral images. This is due to vegetation cover (change) in an alternative part of the season. For artificial areas there is no reason to expect differences in spectral response during the season and maintain their low NDVI values. The NDVI as well as red band differences become important in the second stage as a follow up on this study.

4. SETUP FOR DETAILED TILE ANALYSIS

After processing of 35 tiles, the amount of correct hits is difficult to assess based on a visual interpretation of the satellite mosaic alone. Additional high resolution data is required. The only confirmation that visual inspection on 5 meter data delivers, is the high concentration of contrasting elements in known urban areas and much less over agricultural areas. A Shapefile to KMZ transformation allows a drape of the results on GoogleEarth™to see the context on the settlement structure. The aim is to detect higher details than urban footprints and reach the level of single large building detection, larger than 100 square meters [8]. The overall visual inspection of the 5 meter resolution satellite imagery does not allow detailed assessment. To solve this problem, more detailed background imagery becomes necessary which is more updated than GoogleEarth™. Only the northern part of Hungary, about 30% of the country is covered with an up to date 2010 orthophoto with 50 cm resolution. A part of the 2010 orthophoto is covering mountainous terrain in which the chosen automatic detection encounters problems due to contrast of rock outcrop. The problem is not dominant in large agricultural zones in the alluvial part of Hungary among the main rivers of Donau and Tisza.

The bottleneck for completing the study is the reference dataset. Each classified tile produces several thousand polygons and each polygon needs to be visually checked against a detailed orthophoto image and the LPIS parcel overlay. A visual check over ten thousands of polygons was not considered an option within the frame of this study. It might be recommended to apply this extensive assessment however in a full scale multi-stage approach that could follow up on this case study. To allow a feasible amount of polygons to be checked it was decided to make a detailed assessment on 2 tiles out of 35. This detailed analysis for 50x25 km already contains 2644 agricultural parcels as reference area. As these 2 tiles are a preferential selection, the conclusions from this analysis are limited in representation of the results for the whole 209 tiles. From the processing of the remaining 33 tiles without using the details from the orthophoto reference, still a limited conclusion can be reached for wall-to-wall classification concerning feasibility and processing time.

5. VISUAL ASSESSMENT ON ORTHOPHOTO

For the detailed test site, the standard master protocol for object based analysis is used, identical to the one applied in all 35 tiles. The design of a master protocol is a time consuming part, based on previous experiences and trial and error findings. The contrast for close and far neighbourhoods (Figures 4 and 5) plays a central role in this master protocol. Once it has been developed, the existing projects can be executed in batch mode. The master process now contains also information useful for any follow up classification due to the availability of crucial feature descriptions. This will also reduce trial and error experiments in the follow up stage. A single tile classification requires 3 hours of processing on an i7 processor (64 bit environment).

After classification of contrasting objects in infrared and red on local and larger neighbourhood, the resulting image objects equal or larger than 0.01 ha [8] are analyzed in a GIS environment using a spatial join operation with 2644 agricultural parcels. All 2644 parcels are than checked visually on the orthophoto 2010, if an evaluation can be made over agricultural use or not. The aim of the matrix (Figure 6) is to display two correct and two incorrect categories. One of problem-free parcels containing only agricultural use and another correctly detected permanent physical change related to non-agricultural use. The off-diagonal displaying the category of artificial areas inside agricultural parcels which were not detected (omission) and the “false alarms” on parcels with only agricultural use but recorded as containing anormalistic contrast (commission). Due to this design, the parcels with non-permanent contrasting objects inside agricultural parcels have no place in the matrix. In a mono-temporal image however, no valid attribution can be given on how permanent these contrasting areas might be. An existing tractor path for example, which is a meaningful contrasting object, might be ploughed under in the next season. For 183 parcels in the complete set of 2644, the procedure detects a contrasting area that does not belong to a permanent physical changed area. There are arguments to add this population to correct hits, which flatter the outcome. Assigning these 183 parcels to commission errors would also not be correct as the contrasting area can be correctly assigned to a non-permanent physical area, deviating from normal agricultural production area. It has been decided in this case that this set of 183 parcels are inconclusive and are excluded in the further evaluation process (Figure 6). Depending upon the chosen strategy, visual inspection might be required for 183+247 parcels (16%) but ineligibility is only likely in evidently permanent physical change on 247 parcels (10% correct hits). Non-permanent contrast remains difficult to evaluate without multitemporal imagery. This is another argument in favor of a multi stage approach.

The first and most important result is the selection of polygons without any contrasting element. These are the parcels without any trouble and should have only agricultural use. For the test site this delivers a score of 1453 "no-problem parcels" (59%, Figure 6). It is crucial that the amount of parcels scanned without trouble contains only minimal errors of omission. Although it cannot be completely avoided, only 15 parcels are registered as non-problem parcels but in the visual inspection afterward, still show some overseen artificial areas with evidently physical change. This is 0,6% of the total population.

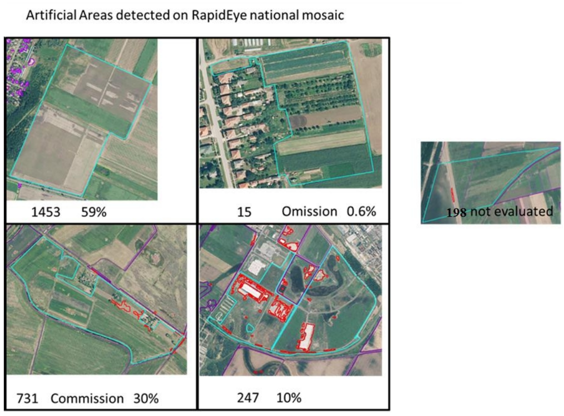


Figure 6: Illustrated confusion matrix for evaluated polygons. 1453; "no-problem" parcels + 247; confirmed "problem parcels" on the diagonal, contrast areas in red. Additional; 15 + 731 errors at the off-diagonal.

For 247 parcels (10%) the visual inspection confirms the parcel contains artificial areas related to permanent change and contrasting objects that cannot be considered part of a normal agricultural use. This population would be candidate for an LPIS up-date process to reduce the maximum eligible area inside the LPIS. A visual interpretation of these flagged areas will result in a satisfying delineation in the update process. The delineation derived from the automatic detection is insufficient.

There is also a certain amount of parcels (198=183+15) which are removed from the evaluation. For 183 parcels the relationship with non-permanent contrasting areas is explained previously. In the strict sense, these 183 parcels cannot be assigned to a detection error. The same is the case with 15 non-problem parcels where a visual inspection reveals a garden construction or greenhouse which is not an ineligible feature but contains an obvious contrasting object. Although not a permanent physical changed area in the sense of the other 15 omission errors with evidently permanent artificial areas like large sheds and buildings. These 198 non-evaluated polygons correctly contain meaningful contrasting features, they cannot be used to support a claim these 198 parcel cover non-agricultural use and permanent change. Therefore they are left out of the matrix. In a multi stage approach they will respond similar as parcels containing commission failures and moved to "no-problem parcels" if they contain vegetation cover during the growth season. For "non-problem parcels", in the visual evaluation of the satellite analysis, it must be evidently, that in the orthophoto no contrasting area can be found and the area is under normal agricultural use. Due to a lower threshold, the amount of omission errors is purposely reduced. In case of doubt, the detected parcel is moved into the population of "problem areas". By moving it mainly into the commission errors, it is expected that it will result in a minimal population of omission errors. With less than 1% omission errors in the total population, the strategy can be considered functional. The critical part of this evaluation is the set of 731 errors of commission. This is 30% of the evaluated population (731/(2644 -183)).

A too large amount of commission errors could be too costly to make the proposed procedure practical. The choice to opt for a lower threshold and a large population of commission errors makes sense only in the preparation of a multi-stage classification procedure (Figure 7).

The amount of automatic classified contrasting objects inside a single parcel is less important but emphasis lies on the "per parcel occurrence". It is sufficient if a single contrasting object inside a parcel is highlighting non-agricultural use inside this parcel. Additional contrasting areas do not make the parcel more a candidate for further review. The parcel with expected non-agricultural areas can be subject of an LPIS update process, which will be a visual interpretation. A correct detection of an anomaly occurrence does not result in a perfect delineation of this anomaly.

The second stage of this foreseen approach (Figure 7, blue background) is not part of this case study. A potential second stage of the evaluation would start with the information that a negligible part of the artificial areas will be missed and that only the problem areas enter this second stage evaluation, That would be 40% ((731+247)/2461) of this population. The classification of the second stage can be made with an additional cheaper dataset which does not require the image quality of the first stage. The strategy to make a reduction of the errors of commission can be achieved with a simplified classification procedure. Rejecting the population of "problem areas" based upon a positive detection of vegetation development during the season while using only 10 or 15 meter pixel resolution from other cheaper sensors would already reduce the commission errors. This approach would accept the existing developed stage of the classification protocols or simplify them but would improve its overall results by investing in additional dataset to solve the problem.

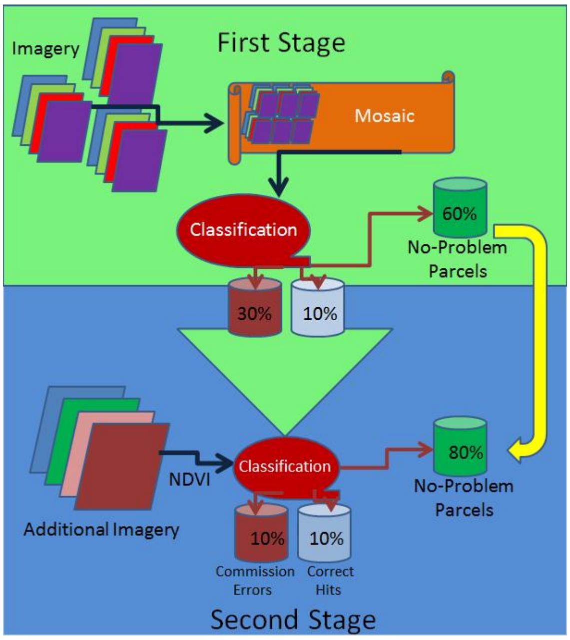


Figure 7: Illustrated workflow for a multistage approach. In this paper only the results for the first stage (green background) are elaborated.

6. DISCUSSION

The restriction of a detailed analysis of only 2 tiles (1152 km^2) makes the creation of the reference set less problematic. Evidently, the visual check with over 2500 polygons can be done in a reasonable time. To extend this procedure over 35 or even 209 tiles of the satellite mosaic requires a visual inspection of tens of thousands of polygons. The scale of such an approach might be useful in a follow up pilot study which incorporates more stages in the multi-stage approach and equally designs a feasible budget limitation for a full scan of the total LPIS parcel population.

The reduction of complexity and focus on contrast for near and far neighbourhoods are favorable for high contrasting objects with little variety in spectral response during the season. For other textured objects like trees and forest plots, the change of absorption in the red band during the growing season is a crucial feature. As it is expected that these changes remain below the very large red absorption changes in agricultural fields, a follow up study using the multi-stage strategy might assist in detecting non-eligibility of agricultural land due to wood production, encroachment and land abandonment. Single mosaic RapidEye imagery encounters difficulties in correct extraction of vegetated landscape features such as small forest plots and hedges. It is not impossible to extract a forest mask from RapidEye single mosaic but overlap with textured agricultural crops such as maize complicates this task. A two stage approach adding one additional multispectral imagery to the RapidEye mosaic tile while using the red band difference in a season might already improve the situation considerably. First test adding a single SPOT 5 image to the mosaic already indicates potential for this approach. This topic is in preparation as a foreseen follow up of this study.

The availability and cheap access to remote sensing data satisfies a long and constant request for more and better imagery. In addition, the present state of excellent and abundant imagery now makes a full scan of the LPIS possible at a seasonal base. To remain within budget, it is crucial to have a very large majority of "no-problem" parcels in a full automatic scan. A first stage with nearly 60% "no-problem" and an additional second or third stage bringing "no-problem" parcels up to 80%-85% becomes realistic in an environment where less than 5% of agricultural land is yearly lost due to urban sprawl, infrastructural projects and building construction. The less than 5% yearly loss of agricultural area is a reasonable assumption which requires a crosscheck with CORINE landcover update from the EEA [9]. Using the presented biased strategy and finishing the first stage with a negligible amount of omission errors, the additional reduction of commission errors is influenced by the amount and quality of the additional data. From a budget point of view it becomes important to set a limit to the percentage of commission errors that are acceptable in a full seasonal scan. The first stage with 30% commission errors is not ready for a seasonal visual check. In a full functional LPIS with less than 2% non-agricultural area, it needs to be discussed if a 10% commission error is acceptable. This would make it necessary to visually evaluate ±15% of the total LPIS population every season. For a MS like Hungary it means ±30.000 polygons at 300 polygons per man-day. That is a project of approximately 5 man-month per year for a full visual check of the national LPIS using "potential problematic parcels" after the second stage. This estimation is applicable to a MS with a size comparable to Hungary, adaptations are proportional to the MS size.

Due to the role of RapidEye mosaic in the GMES project, budget cost for data might be impacted by ESA policy. A realistic cost/km^2 should then be achieved below the general costs for a comparable project at similar scales of resolution like UrbanAtlas with a classification at 2,45 euro/km^2.

7. CONCLUSIONS

The national mosaic of RapidEye allows an assessment on the detection of artificial areas of all parcels in the LPIS. The choice for a strategy with a biased approach would in the first place result in a majority of parcels for which the classification reports "no-problem". This population of "no-problem" can be considered to require no urgent LPIS update.

This complete processing for a first stage would require 3 hours per tile (625 km^2) on a single processor. The whole of Hungary requires an estimated 5 man-months. A 120 hour computer-week in batch processing would reduce the task to 1,5 months on a single processor. The batching of the process is likely feasible as the unchanged classification process for 35 tiles delivers no problems.

A minority of the total parcels or the so called "problem-parcels" are responsible for it is the largest part commission errors. Additional cheap image data should be used to reduce the commission errors in a multi-stage approach by just recording the NDVI value in a different stage of the growing season. This would not exceed calculation times considerably. Based upon the visual inspection of the 2644 parcels, a fair amount of the commission errors seems to be due to open soil and stagnant water areas within the parcels. Reducing the commission errors with a multistage approach in the order of 15 to 20% does not seem to be an unrealistic goal. As it can be expected that these commission errors are part of the normal agricultural areas and vegetation development during the season are therefore a likely occurring event. A reduction of an estimated 20% commission error thus becomes the target of the follow up of this study.

The overall LPIS polygons in general are not expected to contain artificial areas. The update for the total population at national level will be restricted mainly to the extension of new building constructions and infrastructure development. If the flagged candidates for LPIS updating are also subject to further spatial analysis (density of update candidates per km^2), a priority on an update per region might come into focus.

The experience gathered with a master rule set for classifying a RapidEye national mosaic is uniformly applicable over very large RapidEye coverage. The essential feature attributes on contrast for direct and larger neighbourhoods will not be only a contribution to agricultural analysis but can be applied to a much larger amount of land cover classes. In this case the "lessons learned" will offer a solid base for constructing a master classification protocol in a follow-up study. The search for increasingly sophisticated classifiers is useful. The true dynamics of up to date remote sensing however is the sheer amount of quality data at affordable budgets. Adding additional data to an already existing GIS database makes effective use of all available knowledge. The development of RapidEye, DMC and SPOT (Pleiades) indicate that wall-to-wall seasonal coverage will be a continuous standard remote sensing product. This data availability is the basis for any strategy involving a multi-stage approach.

REFERENCES

[1] Devos W., 2011, LPIS quality inspection: EU requirements and methodology. ftp://mars.jrc.ec.europa.eu/LPIS/Documents/13422_October2011.pdf (assessed Jan 2012)

[2] Senator T.E. Multi-Stage Classification. '05 Proceedings of the Fifth IEEE International Conference on Data Mining, IEEE Computer Society Washington, DOI 10.1109/ICDM.2005.102.

[3] Pesaresi, M., Gerhardinger,A. Improved textural build-up presence index for automatic recognition of human settlements in arid regions with scattered vegetation. IEEE Journal of selected topics in applied earth observation and remote sensing vol. 4, no. 1, march (2011) DOI 10.1109/JSTARS.2010.2049478

[4] Zieliński, R., 2010; An automated method for detection of selected non-conformities within LPIS database based on image object extraction approach, Ph.D. dissertation, Warsaw University of Technology (WUT) Faculty of Geodesy and Cartography. Warsaw.

[5] Marr, D., Vision, Freeman Publishers , NewYork, 1982.

[6] de Kok, R., Taşdemir, K., 2011. Analysis of high-resolution remote sensing imagery with textures derived from single pixel objects. SPIE Remote Sensing Conference 8181, Earth Resources and Environmental Remote Sensing/GIS Applications, 19-22 September, Prague

[7] Trimble/Definiens, eCognition Developer 8.1, Reference Book, Accompany version 8.1.0; build 1653 x64, Sep 17, 2010 (Part of the installation package), (2010).

[8] WikiCap 2011; http://marswiki.jrc.ec.europa.eu/wikicap/index.php/LPISQA2011_3.d#We_need_more_instruction_on_how_to_count__and_report_the_occurrence_of_the_non-agriculture_land_cover_features

[9] http://www.eea.europa.eu/themes/landuse/interactive/clc-viewer

MAUSSANE STUDY ON GNSS MEASUREMENTS: PRELIMINARY RESULTS

Beata Hejmanowska[1], Philippe Loudjani[2], Cozmin Lucau[2], Krasimira Ganisheva[2], Dominique Fasbender[2]

[1] AGH Univeristy of Science and Technology, al. Mickiewicza 30, 30-059 Kraków, Poland, galia@agh.edu.pl
[2] MARS Unit IES, JRC, Via Fermi 1, 210 20 Ispra, Italy,
philippe.loudjani/cozmin.lucau/dominique.fasbender@jrc.ec.europa.eu; krasimira.ganisheva@ec.europa.eu

ABSTRACT

Preliminary results of so called "Maussane study" are presented in the paper. Proficiency test (PT) was performed for the parcel area validation method elaborated in the MARS Unit in 2008. Obligatory validation procedure consists of the sequential area measurements of the parcel set. Before measurements parcels borders are marked by pegs, contrarily to the conditions during the real controls. In parcel area validation procedure statistical analysis is also performed according the workflow prepared by the JRC. Finally from validation we obtain the value of the buffer tolerance reflecting the area measurement accuracy. The tolerances are grouped in classes (0.5 - 1.5 m). The main objective of the study was to verify if the tolerance can be successfully applied in the real agriculture conditions. Besides GNSS measurements also digitization of orthoimageries were tested. In conclusion can be state that PT was failed for the buffer 0.5 m what means that the experimentally determined parcel area difference between reference value (the highest accurate area measurements - RTK) and the area measured by controllers exceeds the allowed value in average 30% instead of expected maximum 5%.

1. INTRODUCTION

The Monitoring Agricultural ResourceS (MARS) Unit, Institute for Environment and Sustainability (IES) DG Joint Research Centre (JRC) of the European Commission is made up of four Actions: GeoCAP, AGRI4CAST, FOODSEC and CID (see http://mars.jrc.ec.europa.eu/mars for detailed information on the different actions). Our Mission is to provide scientific and technical support on EU Agriculture and Food Security policies. The GeoCAP Action addresses new information needs for European Policies related to Agriculture and Regional Development, such as Cross Compliance, Farm Advisory System, food quality and product origin traceability. Furthermore, the Action supports future reforms by the definition, development and testing of standardized and sustainable control methods in a variety of agriculture-related areas. The Action also follows future development in Geomatics techniques, and support land administration (cadastre) and multipurpose large scale mapping approaches; common specifications, standard measurement and data management tools, and validated methods will be studied to reinforce the consistency of land parcel identification and measurement across the Union and in Candidate Countries.

In the frame of the control of farmers' declarations, Members States have to perform, among other controls, a control of the declared parcel areas. Art.34(2) and 34(3) of E.C. Regulation 1122/2009 provide the legal basis on how area measurements have to be performed. Indeed, Member States shall use measurement tools that are "proven to assure measurement of quality at least equivalent to that required by applicable technical standard, as drawn up at Community level". As from 1 January 2008, it has been decided that only the perimeter "buffer" tolerance shall be applied to agricultural parcels to express the measurement accuracy of a given tool. Only tools (e.g. GNSS equipment, remote sensing orthoimages - cf. Art.20 of R.73/2009) with a buffer width not exceeding 1.5m should be used (Art.34(1) of R.1122/2009).The buffer tolerance of each specific tool has to be determined through an area measurement validation test or through certification. In the late 90's, the GeoCAP Action has started some research studies over an area located close to Maussane in the south-east of France. Since then, different images from different sensors have been acquires over that area together with other ancillary data (e.g. GCP, digital elevation model). This location has become the GeoCAP so-called "Maussane test site" area applied also in this study.

2. BACKGROUNDS

Review of the recommended by JRC workflow: from validation of the parcel area measurements method to the real agriculture area control in IACS was the inspiration for Maussane campaign in 2011. Control measurements in direct subsidies for agriculture cover area measurement of the parcel declared by farmer and also crops recognition. For the control area measurements GPS technology is applied and orthophotomap digitalization as well. Area measured during control is compared with area declared by farmer and the difference (v) is computed:

$$v = \text{area measured during control} - \text{declared area} \quad (5)$$

The difference (v) is compared with the buffer area (B):

$$B = T * \text{parcel perimeter} \quad (6)$$

where T is an area measurements tolerance, reflecting area measurements accuracy.

The declaration is considered as correct declaration if the difference (v) is smaller than or equal to the buffer B. Buffer (B) is calculated for all controlled parcels. In the formula (2) parcel perimeter varies with the parcel, whereas tolerance (T) is constant for applied measurements methodology. According Commission Regulation (EC) No 1122/2009 of 30 November 2009 Article 34 boundaries of tolerance (T) are defined:
"*A measurement tolerance shall be defined by a buffer of maximum 1,5 m applied to the perimeter of the agricultural parcel. The maximum tolerance with regard to each agricultural parcel shall not, in absolute terms, exceed 1,0 ha.*"

Tolerance (T) is determined for each applied for the control area measurement methodology according validation procedure developed by MARS Unit JRC Ispra, Italy (Kay and Sima 2008).Validation procedure were initiated by JRC in 2002 (Kay and Spruyt 2002, Kay 2003, Spruyt 2004), researched in some scientific projects (Hejmanowska et al. 2005, Oszczak 2004) and finally worked out as validation schema (Kay and Sima 2008). GPS validations were applied by many bodies for many equipments and methods since 2007 (GNSS receivers validated).

In GPS validation procedure parcels set is composed of few artificial parcels marked by pegs on the border each 25 m. Generally two measurements methods in parcel area assessment using GNSS are used: continuous and vertex method. During the validation procedure parcel set is sequentially measured by few observers. Statistical analysis is performed according ISO 5725. In the first step outliers are recognized and removed. Then tolerance (T) is calculated as follows:

$$T = 1,96 * \sqrt{2} * \text{reprod SD} \simeq 2,8 * \text{reprod SD} \quad (7)$$

where reprod SD is the reproducibility standard deviation (i.e. the standard deviation of test results obtained under reproducibility conditions).

In ISO 5725 3.18 reproducibility conditions are defined as: "*Conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment.*"

Consequently the tolerance (T) obtained in validation procedure allows actually for the comparison of two different operators making the measurements using the same equipment and the same method (formula 3). This comparison is thus slightly different from the comparison of the parcel area measured during the control with the area declared by farmer. In our approach (making the validation and control like is recommended by JRC) we assume that the controller and farmer use the same equipment and method, which is in reality not totally true. If we however leave the validation procedure like it is we can look at the other aspects.

The main objection to validation process is that it is made on artificial parcels. The equipment is validated in artificial condition than it is applied in real agriculture situation. Therefore we posed the following question, never posed before: "how does the validated GPS work in reality?".

3. METODOLOGY AND TEST SITE

Answering the question posed above we decided to perform proficiency testing (PT). According ISO/IEC Guide 43-1:1997 (Proficiency testing by interlaboratory comparisons – Part 1: Development and operation of proficiency testing schemes):
"*Proficiency testing (comparative testing) is an important way of meeting the requirements of ISO/IEC 17025 in the area of quality assurance of laboratory results. It is also mandated by accreditation bodies that laboratories participate in proficiency testing programs for all types of analyses undertaken in that laboratory, when suitable programs exist.*"
"*Proficiency testing involves a group of laboratories or analysts performing the same analyses on the same samples and comparing results. The key requirements of such comparisons are that the samples are homogenous and stable, and also that the set of samples analysed are appropriate to test and display similarities and differences in results.*"

In Mars Unit we planned and successfully performed an in situ measurements campaign. The measurement experiment consisted in the simulation of real controls of agriculture parcels' areas. We decided to perform the GPS measurements of the same parcel set and analyze area differences in the context of validation tolerance (T). Additionally, we also measured the parcel area on orthoimageries. Since the main objection for validation is that we use artificial, marked by pegs parcels, we decided to perform the measurements firstly on the real agriculture parcels. Secondly the borders were marked by pegs and the parcels' areas were measured again. Few operators have measured the same parcels using the same methods.

The test areas were selected near Maussane in France, where the JRC has already conducted other field campaigns and has thus archive datasets (Figure 1). 30 parcels were selected over two test sites. In the first set (parcels 1 to 20),, the parcels were covered by the different crops (cereals, crops, pasture, cabbage etc.). In the second set (parcels 101 to 110), the parcels were covered by olive trees (Figure 2). After field visit 2 parcels were excluded, because of their difficult accesses. Finally 28 parcels were measured in the field and analyzed. There were 9 operators in the study; 8 external experts and one expert from the JRC.

The main issue of the project was to simulate real control performed on the same parcel set by different operators. At the beginning parcels were measured like they are in nature (border between the parcels were natural). The parcel area were measured by GPS using continuous method (operators were walking along the parcel border having GPS equipment switched on) and so called vertex method (making the GPS measurements only on point along the parcel border each 25m). Operators in this case have interpreted the parcel border. Then the borders were marked by pegs in the field, and the area measurements were made again (both methods: continuous and vertex). In this case operators were following the path determined by the pegs. Examples of measurements with and without pegs are presented in Figure 3 and 4. Parcels of different border recognition possibilities were selected; some parcels were easy to interpreted, ex. covered by cabbage, Figure 2.b and Figure 4.c while the borders of some parcels were fuzzy and very difficult for interpretation (see Figure 3). To sum up, the experiment was as follows:

- 28 parcels were measured;
- Continuous and vertex methods were applied;
- Parcels' borders were natural - without pegs, and next marked by pegs;
- Each parcel was measured 4 times by each operator: without pegs C (continuous), without pegs V (vertex), with pegs C (continuous), with pegs V (vertex);
- Each set was composed of 240 area measurements (28parcels x 8experts);
- Totally 896 results of the area measurements were collected (28parcels x 8experts x 4repeatitions).

As a reference RTK area measurements were performed. Tolerance (T) of applied GPS have been taken form JRC table or from validation certificate if applicable (see GNSS receivers validated in the reference section).

Collected data were analysed to verify if the area control measurements fulfil requirements concerning the tolerance obtained from validation. The differences of the parcel area measured by two controllers were analyzed if the area difference does not exceed the buffer area (B, formula 2). Tolerance (T) used in formula (2) is calculated on the 95% confidence level (formula (3)) what was the base of PT creation. Two PT decision rules were defined.

Observed area difference (OAD) was compared with the allowed area discrepancy (AAD) and the first decision rule was defined as follows:

if OAD ≤ AAD in 95 cases on 100, PT passed , else PT failed.

Observed tolerance (OT) instead of the observed area can be compared with the tolerance from validation tolerance (VT). In this case OT is calculated from the following formula:

$$OT = \frac{OAD}{\text{perimeter}} \quad (8)$$

The second decisions rule in is now defined as follows:

if $abs(OT) \leq VT$ in 95 cases on 100, PT passed, else PT failed.

4. RESULTS AND DISCUSSION

Results of proficiency test performed using GNSS measurements are presented in chapter 4.1 and using ortophotomap digitization in chapter 4.2.

4.1 ANALYSIS WITH GNSS

The Maussane campaign took place in September 2011. Nine experts (called also operators) were chosen for Maussane experiments. Names, organization and country of the experts are presented in Table 1. Details of GPS equipments can be found in Table 2.

Table 1: Sampling effort adopted in 2011 Agrit Agro-Environmental regional surveys

	Name of expert	Organization (*)	Country
0	Maciej MURAWA	ARMA	PL
1	Alan TRAILL	RPID	UK-Scotland
2	Maria NISKANEN	Swedish Board of Agriculture	SE
3	Edgars BORDANS	LPA	LV
4	Krasimira GANISHEVA	JRC Ispra IT	EC
5	Luc HANSEN	Unit of control	LU
6	Antoine DUBOIS	ASP	FR
7	Patrick FLORY	ASP	FR
8	Stanislav ROSNEV	SFA	BG

(*)

- ARMA - Agency for Restructuring and Modernisation of Agriculture

- RPID - Scottish Government - Rural Payments & Inspectorate Directorate Land Service Branch
- LPA - Latvian Paying Agency, Rural Support Service, Area Control Methodology Division of Control Department
- ASP - Agence de Service et de Paiement
- SFA - State Fund Agriculture - Paying Agency, Sofia

Table 2: Sampling effort adopted in 2011 Agrit Agro-Environmental regional surveys

	GNSS equipment
0	RTK
1	GPS Type - Trimble SPS361 Version of firmware - 4.15 Measurement mode - DGPS OmniSTAR or Beacon Setting of device - Max. HDop = 3.0, Max. VDop = 4.0, Max. correction age = 60 seconds, No validation certification delivered, GPS is not on JRC web site Assumed T: 0.5 m (C, V)
2	GPS Type - Trimble SPS361 Nomad TDS, Use GLONASS, Auto Integrated SBAS , (Tracking mode auto) No validation certification delivered, GPS is not on JRC web site Assumed T: 0.5 m (C, V)
3	Trimble GeoXT 2005, post-processing with Trimble GPS Pathfinder Office 4.20 T: 0.5 m (C, V) No validation certification delivered, GPS is not on JRC web site Assumed T: 0.5 m (C, V)
4	GARMIN GPSmap60Cx, software Map Source Trip and Waypoint Manager, standalone No validation certification delivered, GPS is not on JRC web site
5	GeoXT Trimble differential correction, Any validation certification delivered Assumed T: 0.5 m (C, V)
6	Trimbe GeoXT 2008, D3E - ArpentGIS, mobile 4.8, Post-processing Certification of GPS validation delivered T: 0.5 m (C, V)
7	GeoXT Trimble Standalone Certification of GPS validation delivered T: 0.5 m (C, V)
8	Magellan - No additional information was delivered

Two first equipments (Table 2, op0 and op1) are placed on the top in view of the accuracy with tolerance of 0.5 m. The accuracy of equipments used by next operators: 2, 3, 4, 6 and 7 are also very high so the tolerance is also assumed as 0,5 m. Some comments should be here given. Only the French operators (op6 and op7) have delivered certification from GPS validation. Any other GPS' were validated before measurements in Maussane. However all equipment were generally of the highest accuracy, and measurements in Maussane were performed with differential correction, therefore the lowest value of tolerance (0,5m) can be assumed for them. GPS' used by operator: 5th (Garmin) and 8th (Magellan) are less precisely. Unfortunately Garmin used for the tests was not validated even though it was used by JRC operator. Four Garmin equipments can be found on JRC web site (GNSS receivers validated): Garmin 60 continuous, internal antenna T = 0.75 m; Garmin GPS Map60 with EGNOS correction, continuous, internal antenna, T=1.00 m; Garmin GPS Map60, standalone, internal antenna, continuous, T= 1.25m, Garmin GPS Map60CX - standalone external antenna Garmin, T=0.75m. Hence tolerance for Garmin varies: 0.75m, 1.0m, 1.25m. It is difficult to state how the external antenna or differential corrections influence the Garmin measurements. Therefore no assumption of the tolerance was assumed for Garmin. Similar situation we have for Magellan. No specific information was delivered about the equipment. Magellan tested in Poland have tolerance from 0.5 m to 1.5m, tested in Bulgaria: 0.75m and 1m. Similar results were obtained in Hungary. Therefore any tolerance was assumed a priori for Magellan.

PT was performed on the basis on reference area from RTK measurements. Six measurements of parcel area made by operator: 1, 2, 3, 5, 6 and 7 were compared with the RTK parcel area. Areas' differences for all operators and all parcels were analysed for all methods (no pegs C, no pegs V, pegs C and pegs V). Number of differences exceeding the allowed area differences was divided but the number of all measurements. The percentage of the cases that PT was failed in particular method is shown in Figure 5. For the case "no pegs" the amount of measurements exceeding allowed area difference was averagely 30% instead of expected 5%. Measurements performed on pegs gave better results but still the number of differences exceeding the allowed area difference was 2 times more then 5%. We analysed the area measurements for each observer separately to see the influence of the operator. Generally operator1 delivered the best results almost in all cases: no pegs C: 23%, no pegs V: 15% and pegs V: 4% (please see bottom line on the chart with range of the exceeding percentage for operators). For the method “pegs C” ex aequo operator 6 and 7 gave the best results 4% (by the way below 5% limit).

Therefore the next comparison was made more specifically on the French experts (op 6 and op 7, Table 3) as they know the agriculture conditions in France better than other operators. The difference between the parcel areas, measured by the two operators allowed for OT calculation. For natural borders we observed in Table 3 the exceeding the allowed area differences in 31% and 46% (PT failed). For French operators continues method on pegs fulfills the requirements and PT passed (4%), however for vertex method PT did not pass (12%). The results of the comparison between two controllers (op6 and op7) are generally similar to the results of the comparison between RTK and other equipments (Figure 5). Generally the same trend is observed for natural border using both methods: C and V, which gave significant number of the exceeding the allowed area differences. For marked borders roughly 3 times less exceeding are observed.

Table 3: Comparison between French operators, OT (m) calculated from OAD between op6 and op7; in yellow: OT exceeding VT=0.5 m

			OT (m)			
	Av. Area op6, op7	**Av. Perim op6, op7**	**no pegs C**	**no pegs V**	**no pegs C**	**no pegs V**
1	11405	455	0.30	0.23	0.09	-0.15
2	14960	545	-0.10	-0.14	0.07	0.04
3	18505	600	-0.12	0.28	0.01	0.06
4	21560	663	-0.45	-0.21	-0.18	-0.01
5	5255	349	-0.22	-0.02	-0.07	-0.06
6	6165	407	0.34	0.61	0.00	-0.21
7	18370	616	4.22	4.24	0.10	0.04
8	6370	529	0.49	0.66	-0.11	-0.04
9	12395	573	-2.71	-1.06	-0.22	-0.54
10	6585	475	-0.33	-0.09	-0.26	0.02
15	6275	546	-0.33	-1.23	0.88	0.72
16	12600	564	0.28	0.05	-0.09	0.09
17	1800	244	-0.06	-0.61	0.18	-0.20
18	15870	497	0.19	-0.97	-0.04	-0.66
19	21140	627	0.27	1.15	-0.24	-0.04
20	6265	310	-0.65	-0.80	-0.22	0.01
101	12995	455	0.17	0.28	0.02	-0.04
102	6015	303	0.40	0.36	0.15	0.08
103	8705	373	-1.61	0.16	-0.14	0.23
104	2275	191	0.18	0.05	0.31	0.31
105	3860	256	-0.15	0.13	-0.29	-0.03
106	5520	363	0.52	0.46	-0.09	-0.08
107	3070	252	0.27	0.34	-0.03	0.08
108	7000	330	0.30	0.49	-0.18	0.04
109	2995	234	0.97	0.09	-0.07	-0.01
110	13800	549	-0.04	0.07	-0.02	0.02
111	1650	163	0.26	-0.70	0.12	-0.25
112	4615	302	-0.15	0.21	-0.03	0.14
Percentage of OT exceeding VT=0.5 m			**31%**	**46%**	**4%**	**12%**

Hence, for measurements without pegs PT does not confirm the possibility of the applying buffer limit of 0.5m in any cases. The exceeding of the allowed area difference was observed from 15% to 50%, averagely in 30%.

For measurements with pegs PT:

- In continuous method in 2 cases (4% for op5 and op7) confirmed the possibility of the applying buffer of 0.5 m while in 3 other cases it was not confirmed;

- In vertex method, the confirmation that the buffer of 0.5 m can be applied was obtained only in one case - 4% for op1.

The same analysis, like presented for Trimble GNSS, was applied for 2 less accurate equipments: the Garmin and the Magellan devices. Any detailed results for the equipment are presented in the paper. But generally OT of Garmin in vertex method on pegs comes to 1.25 m, in other cases to 1.5 m. OT of tested Magellan exceeded the limits of 1.5 m in all measurements.

Table 4: OT for orthophotomap of 0,3m and 0,2 pixel size, in yellow: OT outliers

Parcel number	**OT(0.3)**	**OT(0.2)**	**Remarks**
1	0.71	-0.45	
2	0.8	0.33	
3	0.62	0.81	
4	-0.31	-0.08	
5	-0.63	0.42	
7	-0.4	-0.28	
8	1.1	0.13	
9	1.86	-0.5	Mistake with order recognition on orthoimagery (OT. 0.3)
10	0.04	1.17	
no RTK			
no RTK			
12	-0.23	0.44	
17	1.31	1.43	very bad border
18	-0.82	-0.2	
19	0.22	-0.83	
20	0.32	-0.39	
101	0.19	0.1	
102	0.74	0.24	
103	-0.81	0.01	
104	-0.01	-0.57	
105	-0.2	-0.37	
106	-0.34	-0.18	
107	-1.71	-0.79	very bad border
108	-0.47	-0.52	
109	-0.38	out UAV	
110	-0.02	0.25	
111	0.15	0.02	
112	-0.3	-0.76	very bad border
Mean	**0**	**-0.05**	
Median	**-0.02**	**-0.08**	
1.94 standard deviation	**1.04**	**0.97**	
Percentile (absolute value (OT))	**0.82**	**0.83**	

4.2 ANALYSIS ON ORTHOIMAGES

Complementary to the in situ GNSS parcel area measurements digitization of orthophotomaps were performed. Two new orthoimagery acquired in 2011 for test site Maussane were tested (see an example on Figure 6):

- Airborne Bing utlracamm RGB (pixel size =0.3 m),
- Unmanned Airborne Vehicle (UAV) RGB, acquired by SKYMAGING in August 2011, (pixel size =0.2 m).

Results of the comparison between RTK, in situ, area measurements with the area from two mentioned above orthoimageries area presented in Table 4. After visual interpretation and outliers removing values of the OT were statistical analyzed: mean, median, standard deviation and percentile of absolute value of OT were calculated. Observed tolerance for Bing ultracam calculated on the 95% coefficient level basing on SD comes to 1,04 m and on the percentile to 0.82 m. Similar values we obtained for UAV: 0,97 m and 0,83 m respectively. It seems that increasing of spatial resolution of orthoimageries does not cause decreasing of the buffer tolerance (T) in all pixel size range. We observed this relationship also in previous study (Figure 7, right side of the curves), (Hejmanowska et. all 2005). Now we obtained the confirmation for the smallest pixel size that we have ever tested (Figure 6, left side of the curves).

5. CONCLUSIONS

As the conclusion of proficiency test performed in 2011in Maussane can be stated as following:

1. A proficiency test (PT) for the validation method of the buffer tolerance limit was performed by the JRC for the first time.
2. The GNSS equipments were analyzed in 2 groups:
   - Group 1: six of the most accurate equipments that are currently available;
   - Group 2: two commonly used and less precise equipments.
3. Results of PT for group 1:
   - PT failed for the buffer limit (0.50m) calculated during validation procedure;
   - PT could pass for the areas marked by pegs for buffer 0.75 m, and for natural borders for buffer 1.0 m.
4. Results of PT for group 2:
   - Garmin passed PT generally for 1.5 m;
   - Magellan did not pass PT at all.
5. PT using airborne orthoimages could pass for pixel size of 0.20 and 0.30 m for a buffer tolerance approximately equal to 0.9 m

One can notice the buffer tolerance for the parcels with natural borders was estimated to 1 m, independently on the applied method (GNSS, orthoimagery). It is worth to notice that the presented results concern the most accurate equipments applied in IACS.

REFERENCES

Hejmanowska B., Palm R., Oszczak S., Ciecko A., 2005 -Validation of methods for measurement of land parcels areas, http://mars.jrc.ec.europa.eu/mars/content/download/800/5268/file/ValidationMethodFinalVer2_2.pdf

Hejmanowska B., Palm R., 2005 - Validation of methods for measurement of parcel areas - near-VHR imagery, http://home.agh.edu.pl/~zfiit/raporty_pliki/ue_raport_konc_22581200412F1SCISPPL_cz2.pdf

Hejmanowska B., Loudjani P., Lucau C, Ganisheva K. 2011, Maussanne study on GNSS measurements: preliminary results - 17th Conference GEOCAP - Tallinn 23-24-25 November 2011 “Geomatics in support of the CAP”

Hejmanowska B., Loudjani P., Lucau C, Ganisheva K Proficiency test for parcel area validation method the first results of Maussane campaign September 2011 - GNSS - MARS Unit of the Joint Research Centre, Workshop GNSS 24th-26th October, 2011, Gavirate

Hejmanowska B., 2011, Proficiency test for parcel area validation method the first results of Maussane campaign September 2011 - orthoimagery- MARS Unit of the Joint Research Centre, Workshop GNSS 24th-26th October, 2011, Gavirate

Kay S., Spruyt P. 2002 - JRC GPS validation scheme (ref. JRC IPSC/G03/P/SKA/ska D(2002)(1092))

Kay S., 2003 - JRC Technical Information Document: Technical tolerances for On the Spot checks (ref. JRC IPSC/G03/P/SKA/ska D(2003)(1576))

Kay S., Sima A. 2008 - Area measurement validation scheme, http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Area_measurements_validation_scheme

Oszczak. S., 2004 - “Assessment and development of selection criteria for GPS measurement methods and equipment to ensure required accuracy and reliability of area-bases subsidies control in IACS system” - a collective study, developed under direction of Prof Dr Eng Stanislaw Oszczak, February 2004

Oszczak. S., 2004 - “Examination of accuracy and usefulness of Thales Mobile Mapper GPS receiver for area-bases subsidies control in IACS system” - a collective study, developed under direction of Prof Dr Eng Stanislaw Oszczak, April 2004

Spruyt P., 2004 - JRC Protocol for reference field-measurement (ref. JRC IPSC/G03/P/PSP/psp D(2002)(1108))

Buffer tolerance validation method: http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Buffer_tolerance_validation_method, MARS wikicap, JRC, Ispra, Italy.

GNSS receivers validated http://marswiki.jrc.ec.europa.eu/wikicap/index.php/GPS_receivers_validated#The_GNSS_devices_validated_by_Reference_Laboratories

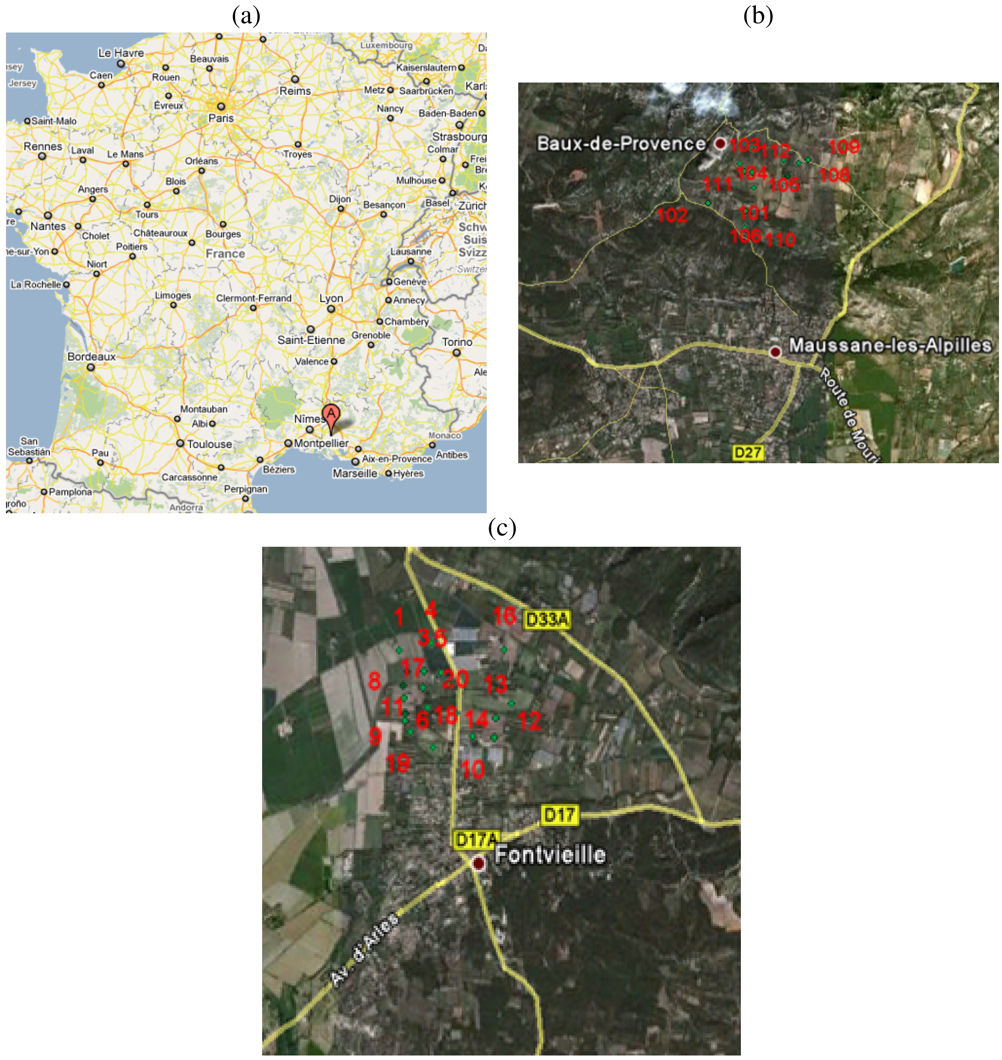


Figure 1: Location of the Maussane test sites. (a) in the south of France near Marseille, (b) test site 1 (parcels: 101-110, (c) test site 2 (parcels:1-20).

Figure 2: Illustrations of the different measured parcels. (a) olive trees (test site1) and (b) parcel number 4 covered by cabbage (test site 2).

Figure 3: An example of parcel covered by olive trees, with difficult borders, number 107 (test site1), measurements without pegs (a), measurements with pegs (b). Border misunderstanding was treated as a gross error and was removed from the statistical analysis.

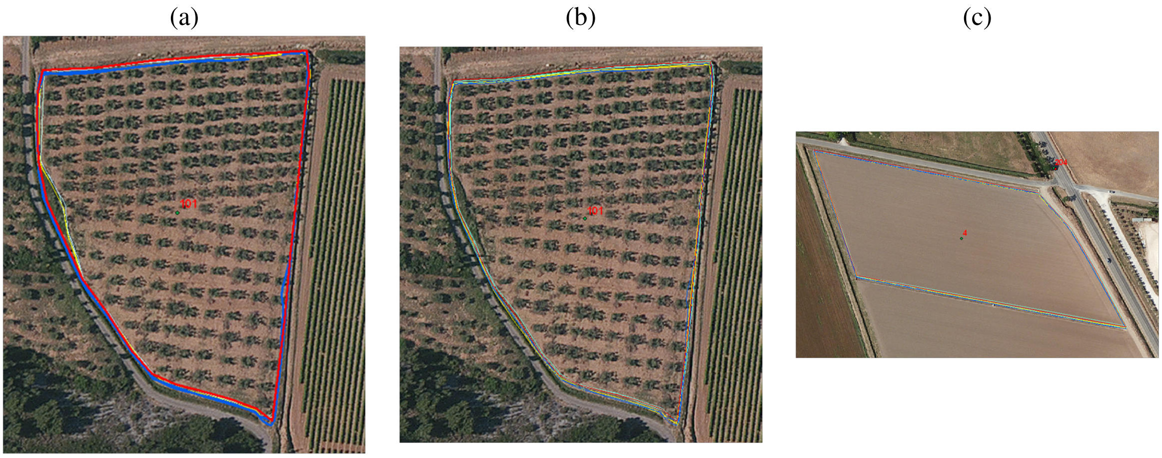


Figure 4: Parcel 101 (a) measurements without pegs, (b) with pegs (see misinterpretation of the border - bushes on left side), parcel 4 with clear border, there is not any border misunderstanding.

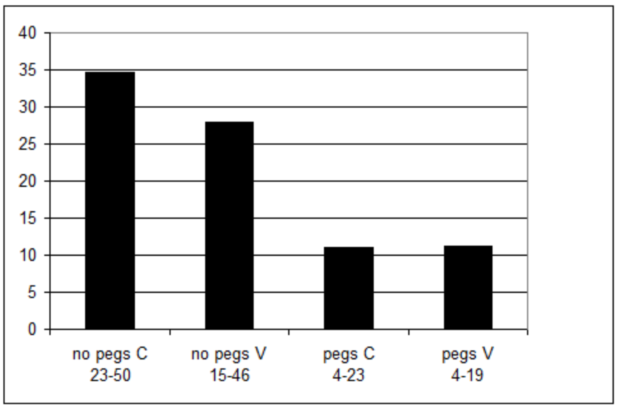


Figure 5: Percentage of exceeding of allowed parcel area difference.

Figure 6: An example of orthoimagery: (a) Airborne Bing utlracamm, RGB (pixel size of 0.3m), (b) Unmanned Airborne Vehicle (UAV), RGB (pixel size of 0.2m).

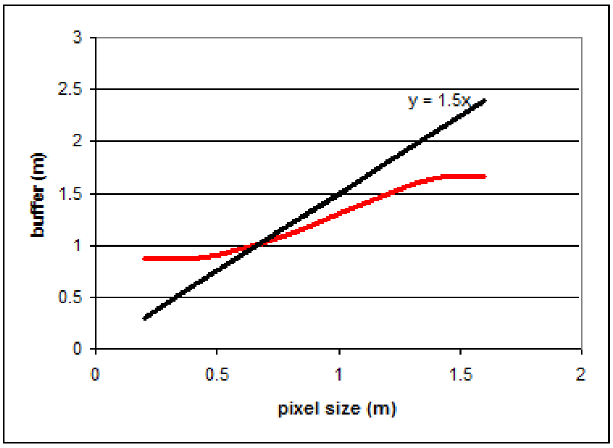


Figure 7: Relationship of buffer tolerance and pixel size, in black estimation basing on the assumption: T=1.5 pixel size; in red experimental curve.

INVESTIGATION OF TOLERANCES FOR ON-THE-SPOT-CHECKS RESULTS OF THE GERMAN STUDY 2011

Markus Jahn[1], Sylvia Grabarse[2], Marina Ewen[2], Stephanie Linden[2], Hans-Peter Dammann[3], Prof.Dr.Ing. Manfred Ehlers[4], Dr. Kai Behncke[4], Sascha Klonus[4]

[1] Economic and Infrastructure Bank Hesse, Strahlenbergerstr. 11, 63067 Offenbach , Germany; http://www.wibank.de/hlb/generator/Sites/LTHneu/SpecialContent/WiBank/hsWiBank.de.html
[2] Federal Office for Agriculture and Food, Deichmanns Aue 29, 53179 Bonn, Germany; http://www.ble.de
[3] Ministry for Agriculture, Environment and Rural Areas Schleswig-Holstein, Mercatorstr. 3, 24106 Kiel, Germany; http://www.schleswig-holstein.de/MLUR/DE/MLUR_node.html
[4] Steinbeis Transfer - Center for Applied Geoinformatics and Environmental Studies (STAGU), Tannenweg 17, 49377 Vechta, Germany; http://www.stagu.de

ABSTRACT

Area measurements within on-the-spot-checks are used for the verification of the applications for aid of farmers within the EU, and are thus required to deliver precise and reproducible results. The determination of the parcel sizes during the on-the-spot-checks is carried out by GNSS-measurements, on-screen measurements on a digital orthoimage or a combination of both. Therefore, different technical tolerances have to be applied. These are stipulated by the Joint Research Centre (JRC) based on the results of the certification or validation. For on-screen measurements in the absence of validation, a calculation formula is used. Validation of GNSS-devices takes into account the technical accuracies of the device. The technical accuracy of the GNSS-devices and the quality of the imageries is constantly increasing. This leads to ever smaller tolerances for the area measurements according to the JRC guidelines. The constant decrease of tolerances causes the following concerns: Firstly, the area measurement may lead to different results for one and the same parcel depending on the system of measurement or equipment which is used. Secondly, the results of the measurement could be less reproducible the smaller the tolerance to be applied of the measurement system is. Thirdly, a tolerance based only on the technical uncertainty of the device does not take into account other sources of measurement inaccuracy, e.g. unclear parcel limits. However, due to the increase of GNSS devices performances, the influence of other sources of area measurement errors which are not included in the validation of GNSS devices process (e.g. border recognition) can become higher. To explore the possible consequences of the guidelines, an extensive research project was performed in Germany in 2011. The results indicate that the measurements marked with pegs, as used for validation, do not reflect the measurement uncertainty for measurements for on-the-spot measurements without pegs. The tolerances based on the R-values obtained for on-screen measurements were higher than those calculated according to the formula in the JRC guidelines. Consequently, an increase of tolerances is suggested. These tolerances should be unique and independent of the type of measurement.

KEYWORDS: On-the-spot checks, area measurements, tolerances, GNSS, remote sensing, combined measurements

1. INTRODUCTION

1.1 Motivation

National authorities have to carry out on-the-spot checks to verify the applications for aid of farmers receiving direct payments or payments for area related rural development measures. Area measurements should deliver precise and reproducible results. According to Article 34 of Commission Regulation (EC) No. 1122/2009 the agricultural parcel area shall be determined by means proven to assure measurement of quality which is at least equivalent to that required by applicable technical standard, as drawn at Community level. The applicable technical standard at Community level is stipulated by JRC in the document titled "Article 34" of WikiCAP. As described in the document, GNSS-devices have to be validated or certified in order to prove their accuracy. The validation scheme for area measurement was described in detail in the JRC guideline "Area measurement validation scheme" by Simon Kay and Aleksandra Sima. The tolerances for area measurements are based on the results of the certification or validation and calculated on the basis of the obtained buffer reproducibility limit value (R-value). In the absence of validation for on-screen measurements, a calculation formula (1.5 times the pixel size multiplied by the perimeter length) is to be used. According to the aforementioned Regulation 1122/2009, Article 34, the tolerance to be determined shall not exceed a buffer of maximum 1.5 meters applied to the parcel perimeter and in absolute terms, 1.0 hectare.

The technical accuracy of the GNSS-devices and the quality of the imageries is constantly increasing. This leads to ever smaller tolerances for the area measurement according to the JRC guidelines. The constant decrease of tolerances causes the following concerns: Firstly, the area measurement may lead to different results for one and the same parcel depending on the measurement system or equipment used. Secondly, the results of the measurement could be less reproducible the smaller the to be applied tolerance of the measurement system is. Thirdly, a tolerance based only on the technical uncertainty of the devices does not take into account other sources of measurement inaccuracy e.g. unclear parcel limits. However, due to the increase of GNSS devices performances, the influence of other sources of area measurement errors which are not included in the validation of GNSS devices process (e.g. border recognition) can become higher.

1.2 Objectives

The aim of the project was to explore whether the tolerances to be applied according to the guidelines are sufficiently high for on-the-spot-checks and whether a unique tolerance should be used which is independent of the selected measurement method and device.

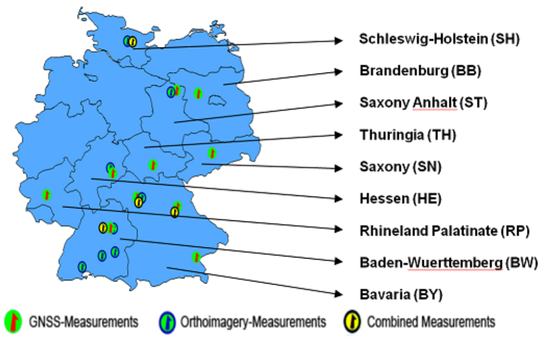


Figure 1: Locations of measurements by type and federal state.

2. DESCRIPTION OF THE PROJECT

2.1 Extent

Altogether, thirteen German federal states were involved in the implementation of the project. Nine federal states carried out measurements and field studies. The extent of the research project was as follows:

- 4.512 GNSS measurements, 141 data sets with regard to 53 different agricultural parcels,
- 15.120 on-screen measurements, 630 data sets with regard to 180 different agricultural parcels,
- 800 combined measurements, 25 data sets with regard to 16 different agricultural parcels.

This article takes into account not only the preliminary results on the project which were presented during the last year's 17th GeoCAP conference of the JRC, but also further statistical analyses.

2.2 Setup

In choosing the measurement parcels, care was taken to select parcels representative of those parcels which are usually measured with GNSS during on-the-spot-checks. Therefore the examination was performed in different regions with a wide range of landscape characteristics which can be distinguished by type and density of vegetation, parcel structure, slope inclination etc. Furthermore, the investigated parcels were selected according to different sizes spread along the typical size range of the relevant federal state, shape factors, visibility of border limits and horizon obstruction. The exact number of measured parcels categorized according to size and shape is shown in Tables 1 and 2 below. Figure 2 contains examples of measured parcels with different visibilities of parcel limits.

Figure 2: Examples for different visibilities of the measured parcel limits (clockwise from the upper picture on the left: clear limit pasture - street; unclear parcel border due to different cultivations; forest borders, tree crowns: where does the parcel end and where does the forest begin?

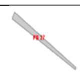
All GNSS measurements, on screen measurements and combined measurements were carried out according to the validation scheme of the JRC, taking particular account of the required number of operators, repetitions and measurement sets.

The measuring devices, correction signals and imagery were those used locally for on-the-spot checks in the German federal states. The operators carrying out the measurements originated from the respective federal states and were well experienced with on-the-spot checks. The operators did not have prior knowledge of geometries of the parcels or of earlier measurement re-

Table 1: Numbers of measured parcels by parcel size and measurement type.

parcel size	total no. of parcels measured with **GNSS**	no. of parcels GNSS measured **with as well as without pegs**	total no. of parcels measured **on-screen**	no. of parcels measured **on-screen** at **map scale 1:1000**	total no. of parcels with **combined measurements**
0,1 to 0,5 ha	18	6	67	63	4
0,51 to 2,0 ha	27	10	57	56	8
> 2 ha	8	5	53	53	4
parcels excluded	0	0	3	8	0
∑	53	21	180	180	16

Table 2: Number of measured parcels by parcel shape factor (SF=(perimeter/4^2/area) and measurement type.

Shape factor	Total no. of parcels measured with **GNSS**	No. of parcels GNSS measured **with as well as without pegs**	Total no. of parcels measured **on-screen**	No. of parcels measured **on-screen** at **map scale 1:1000**	Total no. of parcels with **combined measurements**	Examples for shape factors
SF1	21	8	58	56	5	
SF2	16	6	74	72	7	
SF3	16	7	45	44	4	
parcels excluded	0	0	3	8	0	
∑	53	21	180	180	16	

sults.

GNSS-measurements

The devices used for measurements during the project are shown in Table 3. Correction signals Beacon Egnos or Sapos were used according to practice in the German federal states and availability of the signals. In addition to the vertex measurements in all federal states, TH, SN und BB collected data also in continuous mode. All operators were requested to rank the visibility of the parcel limits.

Of the 53 parcels investigated, 35 were marked with pegs and 43 were measured without pegs. Furthermore, of the 53 parcels, 21 were measured with as well as without pegs.

On-screen measurements

On-screen measurement orthoimages had 20, 30 or 50 cm pixel resolution as shown in Table 4.

The satellite or airborne Very High Resolution imagery (VHR) was that which was available in the German federal states (see Table 4). It is worth noticing that in BW, the same 30 parcels were measured with 20 and 50 cm pixel resolution, respectively. In BY, 30 distinct parcels were measured with WorldView 2 images and 30 other parcels were measured with airborne digital orthophotos (DOPs) of 20 cm resolution.

To prevent the operators from memorizing the parcel limits, the sequence of the orthoimages was changed for measurement repeats. Different map scales were used for digitalization: 1:500; 1:750; 1:1000; 1:1500; 1:2000 (see Table 4).

Additionally, the operators ranked the suitability of map scale for interpreting parcel limits. The most favoured map scales were 1:750 and 1:1000. In SH, parcel limits were not only derived from orthoimagery, but also compared to their own reference system and adjusted accordingly. Therefore, analysis of these data was performed separately.

Furthermore, a sample of parcels was measured with GNSS as well as with on-screen measurements.

Combined measurements

Combined measurements comprising on-screen and GNSS measurements were performed with two different procedures. In procedure 1, applied by SH, the obtained measurement results taken in the field were reported on the archive orthoimagery and adjusted to the reference. In procedure 2, applied by all other German federal states, measurement results taken in the field were reported to a current orthoimagery. However, adjustments to the reference system were omitted.

For combined measurements, a unique map scale of

Table 3: Overview of all GNSS-devices used by federal states during the project.

GNSS device	Correction signal	Federal state	Method	Validated/certified?	Tolerance
Altus APS 3	EGNOS	BW		no	
Altus APS3	SAPOS	BW	vertex	certified	< 1.25 m
Leica GS 20	BEACON	BW	vertex	under validation	0.5 m
Topcon GMS-2	BEACON	BY		no	
Topcon GMS-2	without	RP	vertex	certified	0.8 m
Topcon GMS-2	EGNOS	BY		no	
Topcon GMS-2	ASCOS	BB	vertex	under validation	0.75 m
Topcon GMS-2	without	BB	vertex, contin.	certified	<1.25m
Topcon GMS-2	without	BY	vertex	certified	1.0 m
Topcon GRS-1	without	RP		no	
Trimble GeoXT	BEACON	ST	vertex	certified	1.25 m x perimeter
Trimble ProXT	BEACON	SH		validated	0.5 m
Trimble ProXT	SAPOS	HE		no	
Trimble SPS351	BEACON	SN	contin.	no	
Trimble SPS351	SAPOS	TH	vertex	validated	0.75 m
Trimble SPS351	SAPOS	TH	contin.	validated	1.0 m

Table 4: Type of imagery used for on-screen measurements by federal states, map scale and number of measured parcels.

<table>
<tr><th>No.</th><th>Imagery</th><th>Federal state</th><th>No. of parcels</th><th>Map scale 1</th><th>Map scale 2</th><th>Map scale 3</th></tr>
<tr><td>1</td><td>orthoimagery 20 cm</td><td rowspan="2">BW</td><td rowspan="2">30</td><td rowspan="2">1:500</td><td rowspan="2">1:2000</td><td rowspan="2">1:1000</td></tr>
<tr><td>2</td><td>orthoimagery 50 cm</td></tr>
<tr><td>3</td><td>VHR imagery Worldview2 50 cm</td><td rowspan="2">BY</td><td rowspan="2">30</td><td>1:750</td><td>1:2000</td><td>1:1000</td></tr>
<tr><td>4</td><td>orthoimagery 20 cm</td><td>1:750</td><td>1:1500</td><td>1:1000</td></tr>
<tr><td>5</td><td>VHR imagery Geoeye 50 cm</td><td>HE</td><td>30</td><td>1:750</td><td>1:1500</td><td>1:1000</td></tr>
<tr><td>6</td><td>orthoimagery 50 cm</td><td>SH</td><td>30</td><td>1:500</td><td>1:2000</td><td>1:1000</td></tr>
<tr><td>7</td><td>orthoimagery 40 cm</td><td>ST</td><td>30</td><td>1:750</td><td>1:1500</td><td>1:1000</td></tr>
</table>

1:1000 was used.

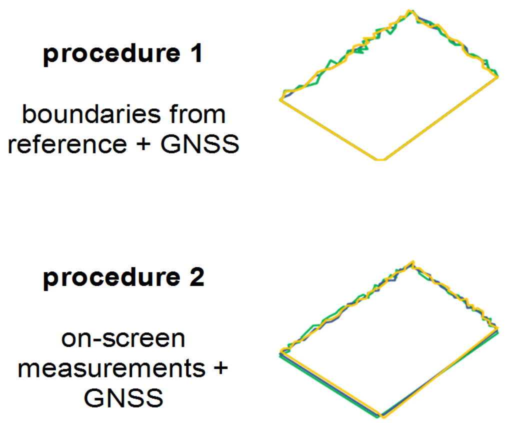


Figure 3: Comparison of procedures for combined measurements based on measured borders (example).

2.3 Statistical analysis

All measurement results were analysed by the Steinbeis Transfer-Center for Applied Geoinformatics and Environmental Studies (STAGU) according to ISO-5725 and JRC measurement validation scheme. Different factors possibly influencing the measurement accuracy such as characteristics of the device, the time of day, measurement direction (clockwise or counter clockwise), shape and size of the parcel and visibility of parcel limits were examined and mean R-values were determined.

3. ASSESSMENT ON RESULTS

3.1 Results of the GNSS measurements

For the 21 parcels measured with as well without pegs, the mean R-value for measurements with pegs was 0.85 meters and thus within the class 0.75m < R < 1.0 m. This is equivalent to a tolerance of 1.0 m according to the document titled "Article 34" in WikiCAP.

For the measurements without pegs, the mean R-value was 1.09 m, and thus even higher than the measurements with pegs on the same parcels. Therefore the class to be applied was 1.00 m < R < 1.25 m which would lead to a tolerance of 1.25 m, according to WikiCAP.

The partition of the measurement results on different devices and correction signals is shown in Tables 5 and 6. The 21 parcels were measured in vertex mode. Additionally, 5 parcels were measured in continuous mode by TH with a Trimble SPS 351 device.

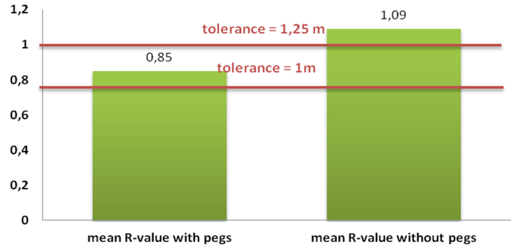


Figure 4: Comparison between mean R-values of all GNSS measurements on 21 parcels measured with and without pegs. Red lines depict the relevant thresholds of JRC-classification of buffer limit = 1.0m for mean R-value inside (0.75m, 1.0m] and 1.25m for mean R-value inside (1.0, 1.25m].

Table 5: Comparison between statistical characteristics of GNSS measurements on 21 parcels measured with as well as without pegs.

Device		No. of parcels		Mean R-value
Topcon GMS-2 (BY, BB)		11	with pegs	1.0311
			without pegs	1.1639
Trimble GeoXT (ST)		5	with pegs	0.5020
			without pegs	0.8760
Trimble SPS 351 cont. (TH)	Trimble SPS 351 vertex (TH)	5	with pegs	0.7130
			without pegs	1.0620

Table 6: Comparison between statistical characteristics of GNSS-measurements with Topcon GMS-2-device on the 11 parcels (Table 5) but different correction signals.

Topcon GMS-2 with	No. of parcels		Mean R-value
ASCOS/SAPOS (BB)	5	with pegs	0.5220
		without pegs	0.7360
BEACON (BY, 5 parcels)	6	with pegs	1.3640
		without pegs	1.3280
EGNOS (BY, 3 parcels)		with pegs	1.5600
		without pegs	1.7833
no correction signal (BY, 5 parcels)		with pegs	0.8900
		without pegs	1.0560

BY measured six parcels altogether using the Topcon GMS-2 device without correction signals and with the Beacon and Egnos correction signals. Due to the lack of correction signals received, valid data were obtained only for 5 of these 6 parcels measured with the Beacon correction signal, for 5 of these 6 parcels measured without correction signal and for 3 of the 6 parcels with the Egnos correction signals.

With the exception of measurements performed with Topcon GMS-2 device and Beacon correction signal, all results confirmed the assumption that the mean R-values for measurements with pegs are smaller than the mean R-values for measurements without pegs. The deviating results regarding the Topcon GMS-2 device with the Beacon correction signal were mainly caused by a single parcel which is completely surrounded by forest having a very high R-value of 3.38 m but could not be removed as outlier. Besides this parcel, two other parcels also had considerable high R-values above 1.0 m. Presumably, the mask effects of the trees in combination with unfavourable satellite constellations may have led to this result.

Moreover, comparable differences between measurements with and without pegs were also found among the continuous mode which is shown in Table 7.

Table 7: Comparison of results for continuous and vertex measurements on 21 parcels measured with as well as without pegs.

Method of measurement	No. of parcels		Mean R-value
Continuous (TH)	5	with pegs	0.8400
		without pegs	1.1180
Vertex (TH)		with pegs	0.4969
		without pegs	1.0060
Vertex (total)	21	with pegs	0.8571
		without pegs	1.0843

The measurements on the 53 parcels resulted in a mean R-value of 0.77 m for measurements with pegs and a mean R-value of 0.97 m for measurements without pegs. Thus, the results of all the 53 parcels appear to confirm the results found for the 21 parcels described above.

As shown in Figure5, the mean R-value for all measurements with pegs is just above the limit of the class 0.75m < R <1.00m, while the mean R-value for all measurements without pegs almost reaches the class 1.00 m < R < 1.25 m.

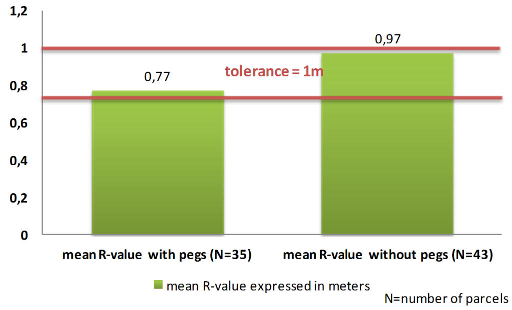


Figure 5: Comparison between mean R-values of all GNSS measurements.

The statistical analyses on the measurement results showed that neither parcel size nor parcel shape influenced the level of the R-value. For the measurements without pegs, factors influencing the R-values were particularly those describing difficulties with defining border limits, e.g. caused by fuzzy, badly visible parcel borders, troubles with interpretation of parcel limits between one and the same crop-culture, or the influence on the R-value was caused by disturbances of satellite reception because of mask effects from trees. Besides these factors, the respective characteristics of the measurement device, time of day, direction of measurement (clockwise, counter clockwise) also influenced the R-values.

Regarding the measurements with pegs, the influence of the aforementioned factors was much lower except for the influence of measurement direction, which was slightly higher.

3.2 Results of the on-screen measurements

Since the on-screen measurements of SH included the adjustment on their reference system, the results were considered separately, see Table 9 below.

As shown in Figure 6, at a map scale of 1:1000 a mean R-value of 0.92 m was obtained for on-screen measurements using parcels with an image resolution of 20 cm. For parcels with 40 cm and 50 cm image resolution, the R-values determined were 1.46 m and 1.10 m respectively.

Independent of the resolution used, the tolerances resulting from the mean R-values of this study for map scale 1:1000 were considerably higher than those obtained from the calculation formula “pixel size × 1.5 × perimeter length” (see Figure 6).

The valid data determined from 28 out of 30 examined parcels in BW, measured on-screen with 20 as well as with 50 cm resolution, resulted in quite similar mean R-values around 1.1 m (see Table 8). These would lead to a unique tolerance of 1.25 m. Thus, the data indicate that the image resolution does not influence the R-value to a large extent. Therefore, the use of pixel size in the calculation of tolerances appears to be questionable.

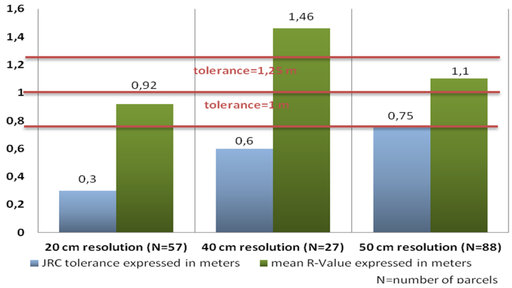


Figure 6: Comparison between mean R-values of the on-screen measurements on non-identical parcels by resolution (map scale 1:1000) (green bars). Red lines depict the relevant thresholds of JRC-classification of buffer limit. Blue bars depict tolerances to be used in absence of on-screen validation (1.5 times the pixel size multiplied by perimeter).

Table 8: Comparison of statistical characteristics of the on-screen measurements by BW on identical parcels by 20cm and 50 cm resolution (map scale 1:1000); mean R-value expressed in meters.

Resolution	No. of parcels	Mean R-value
20 cm	28	1.16071
50 cm		1.11179

A mean R-value of 1.10 m was determined for all 172 valid measurements on-screen with a map scale of 1:1000. This would result in a tolerance of 1.25 m using the classes defined for GNSS-measurements (cf. Figure 6).

Regarding the measurements of SH using a map scale of 1:1000, Table 9 shows that the mean R-value of all valid 28 out of 30 parcels were lower than those for the other German federal states. This can be explained by inclusion of data from the more precise reference system of SH.

This procedure is, however, only applicable if the parcel limit to be measured is situated on the limit of the reference parcel and with reference systems that do not change frequently.

Table 9: Statistical characteristics of the Schleswig-Holstein measurements (map scale 1:1000); mean R-value expressed in meters.

Imagery	No. of parcels	Mean R-value
50 cm aerial image	27	0.53444

Independent of the resolution used, the tolerances resulting from the mean R-values of this study for map scale 1:1000 were considerably higher than those obtained from the calculation formula "pixel size × 1.5 × perimeter length" (see Figure 6).

As shown in Figure 7, the mean R-values of all on-screen measurements with exception of the SH measurements were also higher than those obtained from the calculation formula "pixel size × 1.5 × perimeter length".

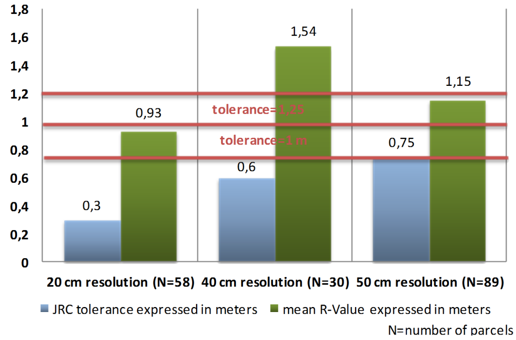


Figure 7: Comparison between mean R-values of all on-screen measurements by resolution (all map scales) (green bars).

In contrast to the results depicted in Figure 7, all on-screen measurements of SH resulted in a mean R-value lower than those for the other German federal states because of the aforementioned inclusion of data from the more precise reference system (see Table 10).

Table 10: Statistical characteristics of all Schleswig-Holstein measurements (map scales 1:500, 1:1000, 1:2000); mean R-value expressed in meters.

Imagery	No. of parcels	Mean R-value
50 cm aerial image	29	0.52

Similar to the results of all GNSS-measurements, the statistical analyses of all on-screen measurement results showed that neither parcel size nor parcel shape had influence on the level of the R-value.

Factors of high influence on the R-value were also those concerning difficulties with defining border limits, e.g. caused by fuzzy, badly visible parcel borders because of mask effects from trees or troubles with interpretation of parcel limits between one and the same crop-culture.

3.3 Comparison of the results of GNSS and on-screen measurements

Table 11 shows the results of the examined sample of parcels of HE which were measured with GNSS device as well as on-screen on a map scale of 1: 1000 and with 50 cm image resolution. The measurement results indicate that, for one and the same parcel, different mean R-values were determined, dependent on the applied measurement procedure. In the sample, the mean R-values obtained for the on-screen measurements were higher than those of the GNSS measurements, which could be explained through the mask effects within the orthoimages (see Figure 8).

Figure 8: Images of the 5 parcels measured with GNSS and on-screen (white numbers correspond to parcel numbers in Table 11).

Table 11: Comparison between mean R-values of 5 different parcels each measured via GNSS (without pegs, device Trimble Pro XT, SAPOS) and on-screen (50 cm orthophoto, 1:1000).

Parcel no.	On-screen measurement	GNNS measurement	Shape factor	Size
1	2.16	0.53	1	1
2	0.42	0.2	1	2
3	1.05	0.62	2	1
4	0.27	0.19	1	2
5	0.45	0.35	3	2

3.4 Results of the combined measurements

In the combined measurements, procedure 1, using 40cm image resolution, 7 parcels measured by SH were analysed. The analysis showed a relatively small mean R-value of 0.51 m. This can be explained by inclusion of data from the more precise reference system of SH.

In the procedure 2 of the combined measurements applied by BW and BY, 9 measured parcels were analysed altogether. Therefore orthoimages with 20 and 50 cm resolution were used. In Figure 9, it is depicted that the parcels measured with Topcon GMS-2 device and orthoimages resulted in much higher mean R-values than parcels measured with Altus APS-3 device and orthoimages. However, the mean R-value of all parcels measured within procedure 2 was 1.16 m.

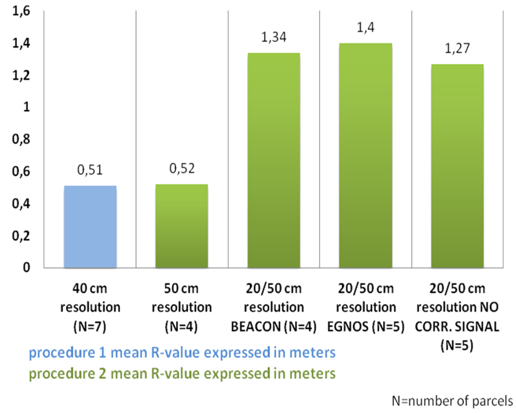


Figure 9: Mean R-values of procedures 1 and 2 (map scale 1:1000) for the following device/imagery type: 40 cm orthophoto: Trimble ProXT, Beacon; 50 cm orthophoto: Altus APS-3, SAPOS; 20/50 cm orthophoto: Topcon GMS-2 and above mentioned correction signals.

Table 12 shows a partition of all results obtained for the Topcon GMS-2 device with different correction signals and different orthoimages.

Table 12: Mean R-values of the Bavarian combined measurements on a total of 5 parcels.

Topcon GMS-2 with	Beacon	Egnos	No correction signal
mean R-value for 20 cm resolution (N=2)	0.49	0.39	0.68
mean R-value for 50 cm resolution (N=3)	2.21*	2.07	1.67

*: N=2 due to the lack of Beacon-reception on one of the three parcels

4. CONCLUSION

The results of the study for the GNSS measurements and for the on-screen measurements indicate that the tolerances to be applied according to the document titled “Article 34” of WikiCAP are not in line with the actual requirements for the on-the spot checks.

The GNSS measurements with pegs used for validation do not reflect the GNSS-measurements on-the-spot without pegs. The mean R-values obtained for measurements without pegs were higher than those obtained for measurements with pegs.

Besides the measurement inaccuracy caused by technical imprecision of the GNSS-devices, there are other factors influencing the measurement quality. The most important factors could be summarized as difficulties in defining border limits, as an effect of landscape diversity and quality differences in satellite reception. Despite the use of skilled and experienced surveyors for the on-the-spot-checks, these measurement inaccuracies typically occur.

Consequently, it is recommended that one consider including these factors in the calculation of tolerances.

Therefore it seems worth considering not only calculating the tolerances on the basis of device validations with pegs.

Moreover, calculation formula "1.5 × pixel size × perimeter length", to be applied in the absence of a validation for on-screen measurements, does not meet the tolerances needed for on-screen measurements in practice. This is also caused by existing uncertainty factors as difficulties in defining border limits, e.g. through the impact of mask effects on the orthoimage. Furthermore, the data analysed for 28 parcels, which were measured on-screen with 20 cm as well as with 50 cm resolution, indicate that the image resolution does not influence the R-value to a large extent. Therefore, the use of pixel size in the calculation of tolerances, given the current image quality, appears to be questionable.

Both the results of the study on the GNSS measurements and the results on the on-screen measurements show that higher tolerances are required to receive reproducible measurement results. The obtained tolerances for on-the spot-checks without pegs and for on-screen measurements were be-tween 1.00 m and 1.25m. The obtained tolerances for all measurements in procedure 2 of the combined measurement were likewise 1.25 m. However, the number of parcels examined was very small.

Increasing and bringing in line the tolerances for GNSS measurement and on-screen measurement would help to avoid one and the same parcel being measured with different results on the correct area size dependent on the applied measurement method. It is important to exclude such events since both measurement methods are considered equivalent according to the Commission Regulation (EC) No. 1122/2009. National authorities which are obliged to verify applications for aid of the farmers and therefore have to determine precise area sizes are confronted with those results since the measurement method used on the same parcel could change over the years, and remote sensing controls are often accompanied by rapid field visits with GNSS.

ACKNOWLEDGEMENTS

The authors want to thank the German federal states for initiating the project, performing the field studies and providing the data. The Steinbeis Transfer Center for Applied Geoinformatics and Environmental Studies (STAGU) is acknowledged for analysing the data. Furthermore, the authors want to thank Beata Hejmanowska for her support as well as Philippe Loudjani, Simon Kay and other members of the JRC team for the inspiring discussions.

REFERENCES

Kay, S. and Sima, A. (2009). *Area measurement validation scheme*, JRC Technical Notes.

Article 34-document WikiCAP http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Category:Art34

IDENTIFYING AND MODELING SOURCES OF UNCERTAINTY IN GNSS AREA MEASUREMENTS

Dominique Fasbender[1] *and Cozmin Lucau*[1]

[1] European Commission, Joint Research Center, Via E. Fermi, 2749, 21027 Ispra, Italy
Dominique.Fasbender@jrc.ec.europa.eu, Cozmin.Lucau@jrc.ec.eupopa.eu

ABSTRACT

In the last decade, Global Navigation Satellite Systems (GNSS) proved to be useful for on-the-spot checks of parcel area within the Common Agricultural Policy (CAP). During such controls, the operator is sent on the field and measures the area by delimiting the parcel contour. As it is the case with every type of measurements, this measured area is affected by a certain number of sources of uncertainty and is therefore not exact.

In this presentation, we propose to focus on three different sources of uncertainty, namely: (i) the identification of the parcel corners (INT), (ii) the wrong use of the GNSS receiver by the operator (OP) and (iii) the inerrant GNSS position error (POS). A methodology is proposed in order to quantify these three sources of uncertainty separately. We propose then to compare the effect of both size and shape on these three components. The preliminary results show that, for the factors INT and OP, the components of uncertainty can fairly be modeled as proportional to the square of the perimeter. Although, the proportion corresponding to the OP factor term is only linked to the skill of the operator, the proportion for the INT factor is also influenced by the shape of the parcel. Regarding the GNSS error term, no specific relation to the perimeter could be found, even though the cube of the perimeter seems to be a fairly good approximation.

1. INTRODUCTION

The CAP, since the 2003 reform, aims to provide for a stable farmer's income, decoupled from production, within a framework of sustainable development of the rural areas while respecting environmental and other societal needs. The EU Institutions, and in particular the European Commission, identify general policy principles which are laid down in legislative acts specifying common rules and requirements needed to carry out the policy and the verify that systems are implemented to comply with requirements laid down by the common rules.

To distribute Community aid, the member states have to establish a Paying Agency to collect, control and reimburse all farmers' applications. For control, the purpose of on-the-spot checks (OTSC) in general is to check the conditions under which aid is granted on a sample of applications. The control methods used for the OTSC may use a variety of approaches and tools but main methods are Remote Sensing (aerial and satellite imagery) and GNSS receivers. The measurement of parcels area, either by orthophotos, either by GNSS, is always affected by errors (systematic and random).

The evaluation of the uncertainty of the area delimited by a polygon is a classic example of an error propagation problem and is thus not restricted to the context of the GNSS area measurements. The propagation of errors in a system depends both on the system itself and the properties of the errors. In our context, the system is mainly the formula of the area described by a polygon (see Hejmanowska 2003 for the formula). Among the different types of error structures, several have already been considered for the evaluation of the propagated uncertainty. These previous studies all aimed at finding the expression of the variance of the area; Hejmanowska (2003) assumed uncorrelated errors both in x and y coordinates; Milčinski *et al*. (2011) used a corrected version of Hejmanowska's formula in which an additional term proportional to the number of corners and the square of the point variance has been added; Chrisman and Yandell (1988) assumed that (i) the x errors were uncorrelated, (ii) the y errors were uncorrelated but (iii) for a given point, the x error and the y error were correlated. While Hejmanowska (2003) and Chrisman and Yandell (1988) provided exact expressions but for specific correlation structures, Bogaert *et al*. (2005) proposed an expression based on a linear approximation of the area but does not assume a particular correlation structure. Recently, Fasbender et al (2012) proposed a new formula that does not rely on any approximation and that can be applied regardless of the correlation structure, providing thus the more general formula.

Up to now, as mentioned above, the research has been mainly focused on the propagation of the GNSS position error and on its correlation structure. Recently, Milčinski *et al*. (2011) proposed to both identify and quantify the main sources of uncertainty in the Land Parcel Identification Systems (LPIS). They identified three main sources, namely: the orthorectification of the image, the interpretation of the parcel limit and the digitalization itself. They showed that the relative uncertainty is a function of both the size and the shape of the parcel.

In this paper, we propose to do the same kind of exercises in the case of GNSS area measurements. First, we will try to identify the main sources of uncertainty that are due to the manipulations during the measurements (thus excluding the outer sources such as, e.g., the stability of the signal or the perturbation of the signal by natural obstacles). We will then propose to quantify each of these sources and compare their contributions to the total uncertainty. Four different shapes at different scales ranging from 1 m^2 to 10 ha were compared. The results showed that both the size and the shape of the parcel have indeed a non-negligible effect on the uncertainty of the area measurement.

2. IDENTIFICATION OF THE SOURCES OF UNCERTAINTY

In order to have a relevant model for the evaluation of the error sources in GNSS area measurements (e.g. OTSC), it is crucial to describe adequately how the operators perform their area measurements. This process is described hereafter.

1. The operator must interpret the border of the parcel. To do so, he determines the corners of the parcel and walks between two consecutive corners. Being subject to the judgement of the operator, each identified corner is uncertain. We will additionally assume that the interpretations are rather similar in order to avoid the comparison of markedly different polygons. Let us denote it as the INT factor.

2. The operator does not measure the position per se. The measurements are done by the GNSS receiver. It is thus important to distinguish the path of the operator from the one of the receiver. Indeed, should the operator hold the receiver on his left, the polygon described by the receiver will be consistently smaller (resp. larger) for counter-clockwise (resp. clockwise) measurements. Let us denote it as the OP factor.

3. The receiver measures the positions according to both the interpretation of the operator and the way the operator holds it. As for every kind of measurements, there is a measurement error that is mainly due to the quality of the GNSS signal. We will assume here that the signal is stable along the period of measurement. This excludes thus the case of signals that are (partially) obstructed by obstacles (e.g. trees, buildings…). Let us denote it as the POS factor.

Consequently, assuming that there is an unknown reference for the measured parcel, then the total variability of the measurement is the variance between this unknown reference and the area of the polygon as measured by the GNSS receiver.

3. QUANTIFICATION FOR EACH SOURCE

First, let us note that the factors INT and POS share some similarities. Indeed, they both are the result of successive measured points. However, they differ in that the point errors can be considered as independent in the case of INT factor while technical features of the receivers lead to correlated errors in the case of POS factor. This correlation structure has also been confirmed by the experience consisting of measuring continuously the position of a receiver lying on the ground. Recently, Fasbender *et al.* (2012) proposed a new formula for the variance of the polynomial area under the hypothesis of correlated GNSS errors and interpretation errors. The formula depends on both the covariance matrix of the point errors and the reference polygon. As the reference polygon is not known during OTSC, the authors also proposed an estimator for the variance based on the observed polygon. The properties (i.e. bias and variance) of this estimator are also computed. Finally, as there is no restriction on the correlation structure, the independent case can be seen a particular case. For more details, the interested reader is invited to consult Fasbender *et al.* (2012). Let us note σ^2_{INT} and σ^2_{POS} as the variances respectively due to the interpretation and the GNSS measurement.

Regarding the OP factor, experimental results show that the difference D between the area measured by an operator and the area measured using the same path but with the receiver d meters outside of the polygon is

$$D = d * P$$

where P is the perimeter of the polygon. Considering that (i) each operator has a (constant) way to hold his receiver, (ii) the maximum distance between the operator and the receiver is equal to d_{max} and (iii) the distribution of this distance is approximately normal, then one can use the following empirical formula for the part of the variance σ^2_{OP} due to the OP factor

$$\sigma^2_{OP} = (d_{max} * P/q)^2$$

where q is a quantile of the normal distribution corresponding to a high probability (i.e. in order to ensure that the distance d_{max} is indeed the maximum distance). Finally, the total variance σ^2_T is computed as the sum of the three separate variances σ^2_{INT}, σ^2_{OP} and σ^2_{POS}.

4. ILLUSTRATIONS

In this section, we assess the effects of both the shape and the size of the parcel on the three variance components. To that regard, we selected four synthetic parcels with different shapes: a square, two rectangles with different elongations and an irregular polygon. These synthetic parcels were first rescaled so that they all measure 1 m^2 (see Figure 1). Then we gradually increased their areas up to 10 ha and the three variance components were computed at each step. For each parcel, we can thus draw the evolution of the three variance components with respect to the size of the parcel (e.g. its perimeter). We can also compare these curves according to the four different shapes.

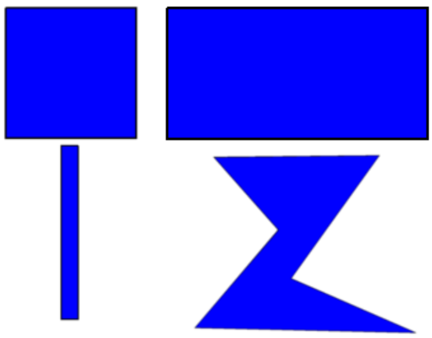


Figure 1: Selected synthetic parcels (not at the same scale).

Regarding the choice of parameters in the three different models, we used the following conventions:

- dmax was set to 0.5 m;
- q was set to 4.265 (i.e. the quantile of probability 0.99999 of the standardized Gaussian distribution);
- the point standard deviation for the interpretation effect was set to 0.5 m;
- the correlation structure for the GNSS measurements was set to a Gaussian covariance function with a variance equal to 0.5 m^2 and a range equal to 2000 s. These values were found from previous tests conducted on static GeoXT devices.

Figure 2 shows the evolution for the three variance components with respect to the perimeter for the four selected shapes. One can notice that although these evolutions are rather similar for each shape, the amplitudes are different. Indeed, comparing Figure 2a to Figure 2b, one can see that the greater are the ratios lengths on widths of the rectangles, the greater are the variance components for the factors INT and POS. The variance component of the factor OP is the same for each shape as it is by construction completely determined by the perimeter. The main components seem to be the factors INT and GNSS for the regular shapes while complicated shapes (Figure 2d) are more affected by the factor OP. This effect is probably due to the very large perimeter compared to its area.

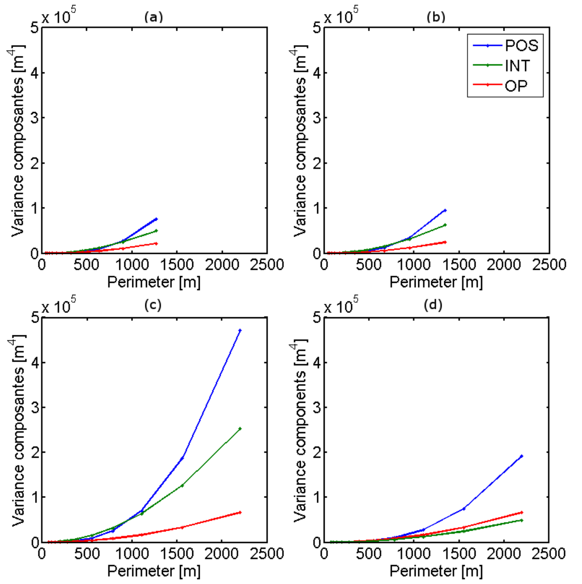


Figure 2: Evolution of the three components of the variance model for (a) the square, (b) the first rectangle, (c) the very elongated rectangle and (d) the irregular shape.

The three components of the variance are increasing with respect to the scale. However, the pace of increase is not the same for the three components. Figure 3 shows how the relative contribution of each of the components on the total variance. The INT factor seems to be dominant except for the irregular shape (Figure 3d). In that case, the main effect is due to the OP factor. For larger parcels (i.e. characterized by a perimeter larger than 1000 m), the POS factor is the dominant component.

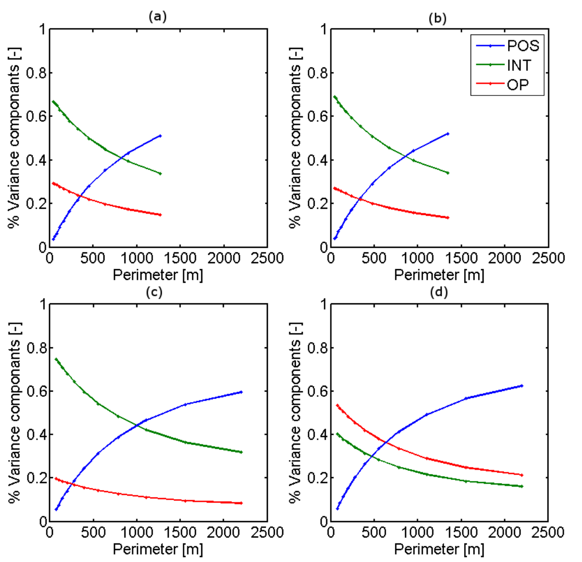


Figure 3: Evolution of the relative contribution of the three components of the variance (same conventions as in Figure 2).

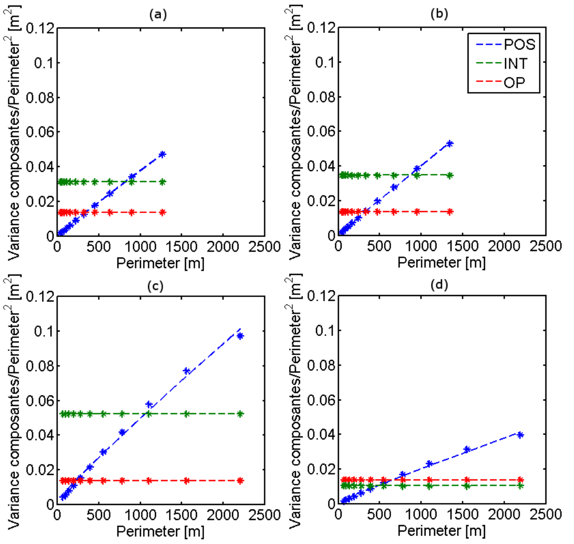


Figure 4: Evolution of the three components of the variance divided by the square of the perimeter. The stars represent the values computed from the proposed models and the lines represent the regression on the square of the perimeter (same conventions as in Figure 2).

As we see in the previous figures, the scale has an effect on each of the three components. It is thus worth trying to give a more pragmatic model that will describe this effect. Figure 4 shows the comparison between the square root of the total variance (e.g. the standard deviation) from the model and the square root of a polynomial expression of the perimeter. For the factors INT and OP, we used the square of the perimeter as dependent variable while the cube of the perimeter was used for the POS component. This was motivated by the observation that the evolution of the INT and OP components on the scare of the perimeter is constant while the evolution is linear for the POS component (see Figure 4). As already mentioned, the influence of the scale is function of the shape of the parcel. Consequently, the coefficients of the quadratic form vary along with the shape of the parcel. One can also notice that this quadratic approximation is fairly accurate. The advantage of this approximation relies in the fact that, once this approximation is fitted, it is significantly simpler and faster to compute. Indeed, for very large parcels, the computational cost is prohibitive because it implies the manipulation of very large matrices; a quadratic expression of the perimeter may thus be a pragmatic alternative to the exact evaluation of the total variance.

5. CONCLUSION

In this paper, we proposed to assess what are the different sources of uncertainty in the context of OTSC. This discussion was launched in order to better understand what could influence the result of an OTSC and is similar to what Milčinski *et al.* (2011) proposed in the context of LPIS data. In the case of GNSS area measurements, we identified three sources of uncertainty: (i) the identification of the parcel limits, (ii) the proper use of the GNSS receiver during the measurement and (iii) the position error of the receiver and its temporal correlation structure. Each of these three components was then modelled in order to assess quantitatively their influence on the total uncertainty.

The results based on a synthetic case study showed that both the shape and the size of the parcel are influent. Each of the three components increases with the size. However, there is an effect of the shape on both the identification and the GNSS precision components so that the size does not have the same effect on these components. It was also demonstrated that the relative contributions of the three components are dependent on both the size and the shape. For small parcels with regular shapes, the dominant component is the interpretation factor, while, for the irregular parcel, the proper use of the receiver was also quite influent. For larger parcels (i.e. with a perimeter larger than 1000 m), the position error was seen to be the biggest component.

This work must be seen as an on-going discussion. Indeed, there are other factors that also influence the uncertainty of the area measurements: stability of signal, physical obstacles on the surroundings that may affect the quality of signal…Moreover, although it has been motivated and parameterized by some preliminary experiences, this model needs to be validated and confronted with more studies using real data. We are currently working on an experimental design that should be able to infer more precisely the parameters involved in this model.

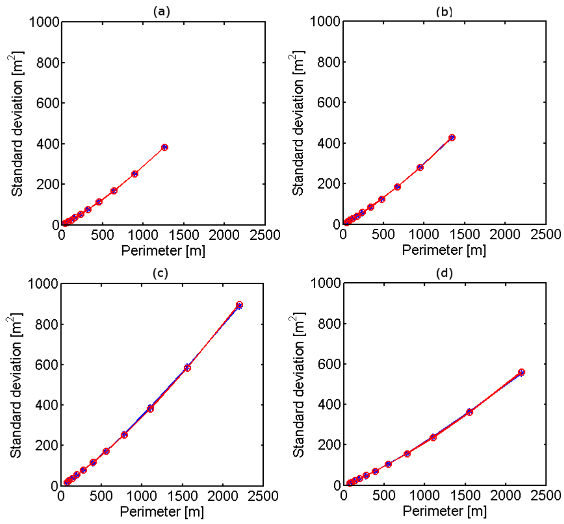


Figure 5: Comparison of the evolution of the total standard deviation evaluated from (i) the model (in red) and (ii) from the square root of a quadratic expression of the perimeter (same conventions as in Figure 2).

REFERENCES

Bogaert, P., Delincé, J. and Kay, S. (2005). Assessing the error of polygonal area measurements: A general formulation with applications to agriculture, *Measurement Science and Technology*, 16(5), pp1170-1178.

Chrisman, N.R. and Yandell, B.S. (1988). Effects of point error on area calculations: A statistical model, *Surveying and Mapping*, 48(4), pp 241-246.

Fasbender, D., Lucau, C. and Bogaert, P. (2012). A new theoretical framework for the assessment of error propagation on polygonal area measurements, *In preparation*.

Hejmanowska, B. (2003). Data inaccuracy in geographic system - propagation of DTM and orthophotomaps in the spatial analysis, Geodesy 40, Publishing of Geodesy and Environmental Engineering, Polish Academy of Science, Kraków.

Milčinski, G. *et al*. (2011). Uncertainty of LPIS data or how to interpret ETS results, *Proceedings of the 16th GeoCAP Annual Conference*, Bergamo, Italy.

BEST PRACTICES FOR ASSURING THE QUALITY OF LPIS DATA

G. Milčinski[1], *A. Rotter*[2], *Z. Tušek*[3]

[1] Sinergise, Slovenia, http://www.sinergise.com
[2] Ministry for Agriculture, Forestry and Food, Slovenia, http://rkg.gov.si/GERK
[3] Paying Agency for Agriculture, Fisheries and Rural Development, Croatia, http://www.apprrr.hr

ABSTRACT

Under the increasingly strict control requirements of the EU, the quality of LPIS data is becoming more and more important. We addressed this topic at GeoCap 2010 conference, focusing on the technical aspects of quality. However, most errors occur due to human factors. This is easy to understand as there are millions of land parcels in the system with a significant amount of them being changed every year under the direction of a large group of farmers, affected by a group of authorized editors. Therefore, in order to assure a proper level of quality, member states have to introduce different methodologies, business processes and technologies - internal quality controls, field control, better assurance of proper quality of input data, etc.

We have been supporting establishments of three LPIS systems - in Slovenia, Croatia and Macedonia. Different countries at different stages, with different environments and different national specific conditions exposed different kind of errors. Our experience shows that whenever a new problem is found, it is important to try to improve the whole business process, not just correct a specific mistake.

In this paper, we review best practices related to assuring quality while setting up and updating the LPIS, many of which do not require a considerable investment.

1. INTRODUCTION

In the last few years all member states are spending a significant amount of time in order to assess the quality of LPIS data. These actions were mostly triggered by the justifiable requirement of EC to perform extensive testing to assure quality - ETS. However, EU legislation should not be the only reason to assure quality of LPIS. Because of its national coverage and level of detail, it is more and more often being used for purposes out of the original scope, e.g. for setting national agriculture strategy, statistics or even for real-estate value assessment. Therefore, lack of quality affects other processes in the country. Another important reason for clear, auditable quality is to prevent farmers suing the Paying agency for improper reductions.

2. OCCURENCE OF ERRORS

Identifying the most common sources of error is a first step:

1. Initial input data is not of sufficient quality - outdated aerial imagery, not updated cadastral parcels data, topologically incorrect initial LPIS data, etc. This is especially true in the countries establishing LPIS - it may take several years to correct errors, which do come in the system in the first few months.
2. Technical obstacles - limitations of the digitization process, GPS technology and even computer mouse precision are all technical sources of error that make it very challenging, if not impossible, to achieve the required level of accuracy ([1], [2]).
3. Editors' imprecision - there are a large number of people being involved in editing and managing LPIS data and there are always a few who do not perform their work up to the required quality.
4. Random errors - due to large number of LPIS parcels in each country some random problems are inevitable - either produced by a glitch in the software, database or other reason.
5. Deliberate errors can also occur, entered by ill-intended people who seek to profit from the system.

All of these should be taken into account during a robust and complete QA procedure. Some can be trapped during the Regular LPIS update, which is prescribed by the legislation, but we can also identify some additional processes, which are useful to identify and update problems.

3. AUTOMATIC CROSS-CHEKS

Automatic computer-based cross-checks are probably the easiest and least expensive to include. Usually they require only an initial investment into designing a test. Afterward it can be run and re-run cheaply and effectively forever.

3.1. Topology errors

These usually originate either from cloning of the original input data or in the digitization process - the software not being optimized for full topology checking and editing. They may not indicate problems related to distribution of funds but they can cause significant problems in any kind of spatial processing of these data (e.g. double counting or overlaps, intersections etc.). Additionally, they might indicate some digitization related problems, e.g. lack of accuracy. There is often strong correlation between careless editing and technical (e.g. topology) errors. That is why it is essential to identify and correct them. There are several off-the-shelf available tools focused to analysing large amounts of data for slivers, loop-backs, gaps, overlaps, duplicated features, etc. (FME [3], Topocheck [4] and even a new on-line tool called Socium [5]).

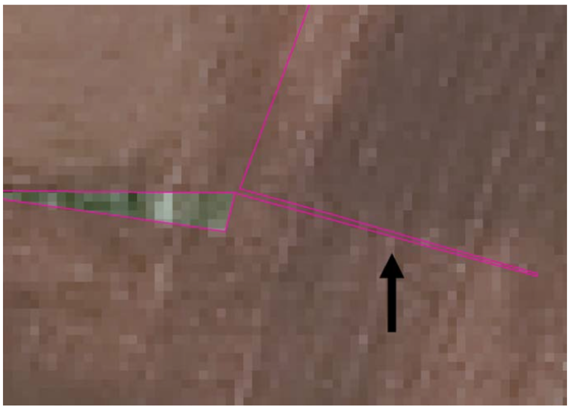


Figure 1: An example of a spike, lying in a neighborhood LPIS.

Once the data are clean of topological anomalies, it is important to maintain that integrity:

- Before inserting any kind of external spatial data, which is directly or indirectly related to the business processes, we have to perform topology validation and reject/fix the dataset if problems are found.

- LPIS digitization tools should perform on-the-fly validation before committing the entry in the database. If problems are found, the user should be warned to update it. This is an additional alert/prompt to the user, that his editing must pass a minimum acceptable standard, and that careless editing will not be permitted.

There are two types of topological errors, which are critical in terms of downstream quality and processing - duplicated features and overlaps - which can directly influence on the wrongly-calculated subsidies. Therefore we have to be especially careful about those.

Additional to topology, the validation should also focus on the consistency of the alpha-numerical attribute data associated to LPIS parcels (e.g. land-use, area, etc.).

Ideally topology errors will be stopped at source, but it is still advisable that the Agency performs topology validation of the full LPIS dataset every year before the annual campaign starts.

3.2. Cross-checking with land cover

Independently acquired and updated land cover layer is being used in several countries to perform regular updates. Being based on recent aerial imagery, it helps to perform a "content-related" analysis of the LPIS data. Instead of cross-checking with ortho-photo (normally restricted to manual visual process), we use vector-based representation of interpreted land cover. There are then two common problems, which can be easily identified by intersection of LPIS and land-cover layers:

- Illegible areas within the parcels - e.g. built-up areas, roads, and ungrazeable/uncroppable vegetation such as patches of forest and gorse/bracken.

- Change of borders due to reforestation or similar processes.

In Slovenia for example, the land cover is digitized shortly after aerial imagery is produced. Then, overlay with LPIS is carried out and any inconsistencies marked (Figure 2). Afterward, for larger areas, the farmer is notified that problems were found on his/her holding and he is invited to clear these. In case of minor problems, warnings are left in the system until the farmer comes to submit the claim. In either way, the claim cannot be submitted before the problems are solved either by updating the LPIS to fit the identified deductible features or by farmer's declaration that land cover data are wrong (in which case he can expect a prioritisation for in-field inspection).

Figure 2: Process for resolving LPIS/land cover inconsistencies. The user can decide whether to update the LPIS or declare wrong land cover for reconciliation with farmer.

After identifying these kinds of problems we again have to act to prevent them in the future. That is why we implemented cross-checking before any insertion or update of LPIS data. The user cannot, by any means, change the LPIS to contradict the newly-updated land cover layer.

This cross-check is a truly efficient way to improve the quality. However, land cover digitization is an additional cost to be justified. This is perhaps mitigated by using the national updated land cover for additional multiple purposes, for example, flood/run-off modelling, and landscape analysis including promotion and monitoring of agri-environment measures.

3.3. Cross-checking with other layers

In case the land cover data are not available, one could still use several other sources to validate declarations - e.g. forest cover, roads and highway paths, building registry, environmental habitats, even football stadiums and airplane fields coming from national mapping or other sources.

Such datasets are usually available in abundance. However, when using them we have to be aware about their quality (temporal, spatial and data-wise). To perform any kinds of automatic updates, the quality and currency should be at least as good as LPIS or better. In other cases we can still use them to perform cross-check and identify potential candidates of inconsistencies. We then have to manually check these using the aerial imagery. Effort used is still negligible compared with 100% manual/visual check.

4. VISUAL CONTROLS

EC legislation requires 100% administrative controls to be carried out. So after options for automatic checking are completed, we have to continue manually. Since aerial imagery is used as one of the basic controls of IACS it should be regularly updated (minimum every 5 years, recommended every 3 years). And after every update we have to check if reference parcels still fit aerial imagery. One option to do this is using land cover as an intermediate layer (as described in previous section). The other is to check every parcel visually. This is not as easy as it sounds due to vast number of parcels - in Croatia for example they update one third of aerial imagery annually which means that about 500,000 parcels should be checked every year before the payments are made.

4.1. Visual control on aerial imagery update

Because of the large number of parcels to be observed, the process must be highly optimized, and it is important to note that:

- Most of the parcels are OK and no change is required.
- Wherever a change is noticed, it is best to update it straight away otherwise it will necessitate another interpretation and edit at a later date.

Hence the system was designed in a way to present the editor (support centre staff) with a number of tasks, each task being one parcel, all residing on a nearby area (so that the imagery features are common). The editor is presented with a parcel and has to decide whether any change is needed and whether the change is minor or major (Figure 3). If minor, the editor can open the LPIS application and update it. In case of major problems the parcel is marked and the farm is scheduled for a meeting with the farmer to resolve the overall anomaly.

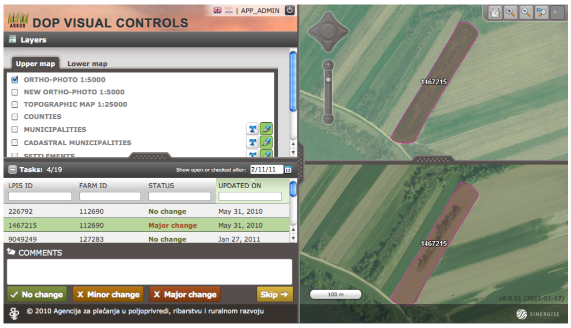


Figure 3: Visual control application shows the parcel in two synchronized windows. By being able to see both old aerial imagery (above) and the new one (below) the editor can easily identify changed features from acquisition changes effects.

4.2. 4-eyes check on editors

A large number of editors demand some level of control over them. Even though they go through the same trainings and they have the same work assignments, some simply work better than others. Since it is Agency's responsibility to ensure the proper quality of work, they have to double-check some part of the work. Most common problems noticed are:

- Inaccurate digitization of the borders (Figure 4, for this we recommend to mark border points every few meters, not only on the corners of the parcel [1]).
- Improper use of supportive layers - e.g. as the farmers are more used to cadastral parcels than LPIS polygons they insist on using that layer for digitization even though it is not in line with aerial imagery (shift problems or similar). In Slovenia this problem was solved through time by modifying software to turn-off cadastre layer while editing. It was only visible as reference before the editing starts.
- Improper interpretation of land cover.

The system designed to perform 4-eyes control requires very similar functionality to that described above. We decided to perform the following number of checks:

- For new editors (after successful training) we check 100% of his/her edits for the first 20 farms. This period is extremely important as people start getting used to their work. Errors are identified and the editors are made to correct their own mistakes, thereby learning and taking responsibility of their work.

- Afterward 5% of the parcels are randomly chosen and checked, but the amount can be increased or decreased depending on the editor's experience, quality and previous scores. Whenever a problem is noticed, the support center staff calls up the person and they jointly go through the problem using Conference editing mode (kind of "share screen"). As the editors know that they are being watched, they perform their work better. If we tell them what they are doing wrong, they will improve.

Figure 4: Inaccurate digitization, probably due being done at to too small scale. After noticing these problems the software was modified to not allow editing under specific scale levels.

5. ON-THE-SPOT (OTS) CONTROLS AND CONTROLS WITH REMOTE SENSING (CWRS)

The basics of OTS and CwRS control mechanisms are well known and documented across member states. However, it is useful to describe the additional processes for updating LPIS based on the results of the controls, and implemented as a result of EU audits.

5.1. Slovenia - rigorous about position

In Slovenia, the position of the reference parcel is observed very strictly. If the field inspector identifies that the parcel is positioned differently (GPS or aerial imagery shifting are excluded), only the area within the declared polygon will be taken into account as determined area. Even though this rule might sound too uncompromising, it was identified that it is the only way to prevent double declaration of specific area.

The update of the LPIS will therefore happen only within the parcel - excluding illegible areas, splitting the parcel in two parts due to different land use etc. This makes it easier to perform the update - there are automatic mechanisms, which do this without the human interaction in about 95% of the cases. Only the remaining few have to be dealt manually.

5.2. Croatia - standard, area based controls

In this case, the control is focused on comparing the eligible area with the declared area in an alphanumerical way. This makes it easier to do the terrain part. The update of the LPIS, however, is much more complex as it affects not only the one specific parcel but also neighbouring ones.

The process (Figure 5) was designed to be semi-automatic:

- Spatial intersection between the declared parcel and the inspector's findings is carried out. The resulting polygons represent areas, which are in line with declaration (both declared and determined), illegible areas and newly found areas.

- Small and elongated polygons are processed automatically. These are usually the result of GPS error and are neither removed nor added.

- The user then goes through all areas and decides whether to update it or not. This is done by simply ticking a box.

- If needed, the user does some manual spatial editing.

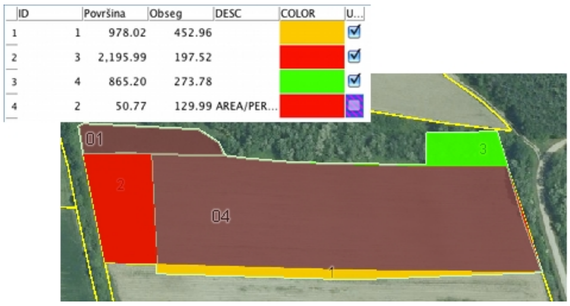


Figure 5: The brown area represents the area, which is in line with declaration. Green - newly found area and will be added. Red - illegible area will be excluded. The orange one is newly found area, which overlaps with the neighboring parcel.

5.3. Integration of control's process flow

Design of the controls process is usually focused only to determine what is an eligible area and what is not - simply due to the focus on preventing improper payments. However, when one is trying to use the findings to update the LPIS, it becomes clear that some processes do need major refinement. Either to support automatic procedures or simply to provide the person updating the LPIS enough information so that he/she can make a right decision. The improvements over the last couple of years include:

- The result of the control is topologically correct set of polygons (parcel parts), which do represent whole reference parcel area and newly found neighbouring areas.
- Post-processing of the results is necessary in order to eliminate GPS measurement errors.
- Each finding should contain documented proofs - digital photos with exact location and bearing (Figure 7). This is very important to be able to interpret the results in the office and protects us from any challenges at the court of law.
- GPS tracks should be stored both in original form and post-processing form. We went one step further (having implemented also the GPS part of the workflow) - we are storing metadata about each point being recorded by the GPS (time, HDOP, EGNOS availability etc. - Figure 6).

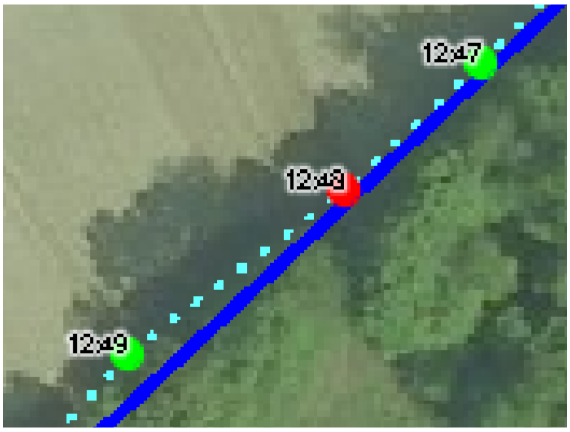


Figure 6: Green GPS points were taken using EGNOS correction, red one without it, probably due to a shadow of the trees.

Figure 7: Orange arrows represent locations of photos, pointing to the object being photographed. Each photo contains also notes and meta-data.

All of these data give us great insight into the quality of the control and accuracy of specific findings. Additionally, they do provide some form of control over the work of inspectors, as well as rich training material for others.

6. SHARING AND RE-USING THE DATA

A nice alternative for performing quality assurance checks without spending too much effort is simply to share the data with other users and organizations. There are several ways to do this:

- Put the export from LPIS database (without personal information) for free-of-charge download.
- Establish publicly-available GIS viewer with all relevant information inside (Figure 8).
- Integrate LPIS data in as many other systems as possible (e.g. Veterinary and Phytosanitary systems, real-estate valuation, etc. - see [6] for further examples).

Sharing the data improves transparency and engages public and other professional users to provide feedback. By integration we go one step further as we do systematic cross-checks with other related content. Of course, the acceptance of changes is still normally processed.

Figure 8: Public LPIS viewer displaying LPIS and cadastre data, visibly shifted.

7. CONCLUSIONS

We have described several ways, which help us to identify the problematic cases. However, what it is crucial is that whenever problems are found, the process should be adapted in a way to prevent or limit further similar cases in the future. It is not sufficient to just correct errors each time, without adapting the processes to prevent them in the future.

Hence, we recommend including the following checks in the processes of digitization:

- Minimum scale at which the digitization is allowed.
- Checks for minimum distances between the points.
- Before each update in the database, topology should be thoroughly checked in order to ensure the overall quality of the data and to prevent potential double declarations.

- Perform cross-check with other data layers (land cover, forest lines, etc.) before the entry. Prevent inconsistencies before they occur.
- Fully respect the positional accuracy of the data - LPIS should not be just about areas, it should also be about location.

At the same time one should also be aware that going into such details with quality assurance could have some negative aspects - when looking for errors, one will find them. The better the tools to look for errors, the more will be found and as the current EU legislation focuses only on total absolute numbers, without a consideration on the relative ranking of the problems, these findings might cause inconvenience to member states. In Slovenia, for example, we do spend a disproportionate amount of time dealing with illegible areas in the range of 10 sq. meters, which are in some cases a result of one point being shifted by one pixel. The effect on distribution of funds of these areas is negligent and it is not rational to increase costs of controls because of them.

We are therefore hoping for some changes in the DG Agri practices. It should be clearer to the member states, which problems are important and they have to focus on them and which problems are OK and should be treated as negligent. And it is important to align audit processes accordingly. Only then will the member states be motivated to use available data and tools to maximum possible detail.

REFERENCES

[1] Milčinski et al, Uncertainty of LPIS data or how to interpret ETS results, 2010, GeoCAP

[2] M. Jahn, Investigation of tolerances for on-the-spot checks, 2011, GeoCAP

[3] FME http://www.safe.com/fme

[4] TopoCheck, spatial data validation tool, http://topocheck.com

[5] Socium, on-line spatial validation tool, http://www.socium.co.uk/

[6] Milčinski et al, Extending the use of LPIS Infrastructure, 2007, GeoCAP

CHALLENGES IN USING GNSS TRACKS FOR UPDATING LPIS AND PARCEL BOUNDARIES

Tamme van der Wal[1], *Henk Janssen*[2], *Marcel Meijer*[2]

[1] AeroVision BV, Bussummerstraat 3, 1411 PK Naarden, The Netherlands, Tamme.vanderWal@AeroVision.nl
[2] Alterra - Wageningen UR, PO Box 47, 6700 AB Wageningen, The Netherlands, Henk.Janssen@wur.nl

ABSTRACT

Farmers are the first to know when and how their land is changing in size and shape. Farmers therefore seem to be a good source for updating the LPIS. This can be ranked as a Voluntary Geographic Information system. Challenges in using farmer-originated GNSS tracks for updating the LPIS and parcel boundaries are many. The aspects involved range from technical to social: Adequate training and equipment, digital exchange procedures, data quality governance protocols, trust etc. In the Netherlands, increasing numbers of farms already measure field boundaries for their own information management. Re-using these measurements for LPIS and subsidy application purposes will reduce administrative burdens at the farm level and improve the efficiency of the authority involved.

1. INTRODUCTION

Farmers increasingly use high-tech Global Navigation Satellite System (GNSS) equipment for machine guidance, site-specific crop management and other precision agriculture practices. The benefits of these precision agriculture technologies are numerous. Farmers primarily use it for improving the efficiency of their field operations and thus reduce the cost of labour, fuel and inputs. These are relevant business goals especially as energy, water supply, fertilizer and agro-chemicals become more expensive. The side effect of these reductions results in greener agriculture with fewer emissions and less pressure on the environment. Also, thanks to GNSS farmers can operate a so-called large scale agricultural management practice in a small scale landscape, aimed at preserving valuable landscape elements such as trees, hedges and local depressions that are important for landscape and biodiversity preservation. In the Netherlands, farmers increasingly use surveyors to measure their fields with GNSS tools. Parcel boundaries, shapes and areas are used to optimize the farm operations. The main uses of parcel boundaries are:

- To apply for income support;
- To prove compliance to regulations;
- To plan the work;
- To instruct contractors;
- To calculate amounts of inputs needed;
- To guide machines;
- To order Remote Sensing image products.

The CAP reform of 2013+ will have an effect on the boundaries stored in the Land Parcel Identification System (LPIS). Small differences in definitions of what is agricultural land, what is eligible area and how to claim income support will have an effect on the shape, size and boundary-location of parcels. This may also affect the LPIS.

2. BENEFITS FROM FARMERS' MEASURED BOUNDARIES

The main benefit from involving farmers in updating the LPIS is the fact that farmers are the first stakeholder involved to know what changes took place on his boundaries, even in cases where community expansion, infrastructure construction or other planned developments take place, the farmer knows its impact on his fields. He is also responsible for the crop plan and structural changes to his fields - like drainage installation, removal of ditches and hedges etc.

As the LPIS is based (at best) on last years' inputs (ortho-photos, control results etc.) it is inevitable that it is outdated in several places at the time of the application period. For instance, temporary ineligible areas in an LPIS parcel will adjust its boundaries, but also changes in land use might cause an update. For farmers to indicate changes in LPIS - in particular when in their benefit - is not an easy task. Making farmers in charge of their own field boundaries will also reduce the administrative burden when completing the annual income support application or claim.

Changing to an LPIS update process with larger responsibilities for farmers has also a positive psychological effect. Farmers become responsible for the correct measurements of their boundaries and have nobody else to blame if the boundaries appear incorrect. It will have a positive effect on the number of appeals (in the Netherlands last year over 1000 farmers).

Figure 1: Surveyor measuring the agricultural parcel. Photo: courtesy of Facto Geo Meetdienst.

3. DRAWBACKS of FARMERS' MEASURED BOUNDARIES

Farmers' measured boundaries basically mean that the farmer or more likely a contracted surveyor, with surveying equipment establishes the field boundaries (see figure 1). Nowadays, most surveying equipment will be based on GNSS. Professional surveyors invest in high-precision equipment such as RTK. Farmers are familiar with these instruments as similar systems are used in precision agriculture. Measuring boundaries with RTK provides accurate results within 2 cm. The disadvantage is that a surveyor is on the ground and is lacking the better "idealization" that digitalization on orthophotos provide. Where exactly is the field boundary? In particular discussions can arise concerning the eligibility of land, for instance with vegetation at open water borders and land under trees.

Another drawback is of course that administrations need to deal with the technical issue of mixing the photogrammetric reality with terrestrial reality. When is a terrestrial deviation a correct indication of the course of a boundary? How are slivers (due to the inevitable differences in accuracy between pixels and terrestrial measurement) dealt with? But more importantly: how will object identification be dealt with?

The most encountered reservation from administrations to refrain from farmers measured boundaries is trust. Can the farmer be trusted? Will the farmer make calculations for his benefit and measure accordingly?

4. REASONS IN FAVOR

Despite the drawbacks we believe that the balance will be in favour of farmers measured boundaries. Firstly, an increased tendency can be observed that farmers have a vested interest in accurate boundaries for their operation. At least in the Netherlands farmers want accuracies in the same range of their RTK guided machinery, a trend that can also be observed in other countries. When these boundaries are used for LPIS update and income support claims, farmers will use their own boundaries. Farmers are put into the lead of the acquisition process.

For administrations it is an opportunity to get boundary data with a very high accuracy, more than can be achieved with orthophotos alone. These boundaries are of use in many other governmental processes and are therefore worth having. Also farmers can become in a position to re-use or even sell their boundaries to other interested administrations. One of the main concepts of administrative burden reduction - measure once, use often - can be implemented in this way.

Finally, when farmers become and feel responsible for accurate boundary measurements this can change the way farmers and administrations collaborate in this information management process. It is a variant of Voluntary Geographic Information acquisition. Although, you may question the voluntary part in this respect, farmers do take a voluntary responsibility for accurate boundaries.

5. WHAT IS NEEDED

To use farmers' measured parcel boundaries for the LPIS update, definitions of what is agricultural land, what is eligible and what is the fields' boundary must be coherent. These definitions must correspond to the farmers' reality and daily practical use. The CAP2013+ reform may offer a useful momentum to create standardization.

These definitions must also lead to adequate measurement / surveying instructions. To any surveyor it must be clear how a parcel boundary must be measured. Even though two independent measurements of two surveyors will always show differences, the risks of occurrence of these differences can be minimized with adequate instructions. Administrations or payment agencies need adequate tools and systems to handle the delivery of parcel boundaries as digital files. In the Netherlands the payment agency can handle digital shapefiles and nowadays track files from GPS systems as input, but it is not accepted as parcel boundaries: these data are used as a "drawing aid". To improve this situation, adequate tools, protocols, controls etc must be implemented. Much can be learned from for example Open Street Map with the notion of course that here the community is not always capable of correcting unintended mistakes, so other control procedures must also be in place.

An often-indicated issue is the so-called "Human Factor". When measuring in the field, the surveyor must interpret and respect the instructions and this is often a matter of training and of course of trust. It is sensible to develop formal training and even certification for surveyors. This has already been put forward by different stakeholders. Dealing with the human factor is possibly the most challenging issue to work towards farmers' measured boundaries.

6. RECOMMENDATIONS FOR ACTION

It can be observed that the uptake of GNSS tools at farms is rapidly growing. This calls for a need for accurate and up-to-date boundaries for farm operations. These boundaries can be used by administrations for managing the reference system as well as for applications for subsidies etc. In order to do so, administrations must have the ability to trust and accept these boundaries. This implies that the farming community (as well as the surveying community) must work on procedures and standards that prove their compliance to what is expected from a regulation standpoint. If administrations are open to accept farmers measured boundaries as adequate indications of the geography of agricultural land, the sector gets an incentive to move forward in this direction.

Inversing the information flow where the administration is tapping into farmer measured boundaries creates a new responsibility of the farmer.

ACKNOWLEDGEMENT

This paper has been prepared in the context of UNIFARM, an FP7 project to set up a forum for agricultural users of GNSS tools. UNIFARM develops scientific and policy roadmaps to improve the use of GNSS at farms and its application in regulated processes. UNIFARM is carried out in the context of the Galileo FP7 R&D programme supervised by the GSA. (nr. 277679-2). For more information please check http://http://www.project-unifarm.eu

REFRESH 2.0: A NEW APPROACH TO LPIS UPDATE

F. Slaviero[1], *A. Iori*[2]

[1] VP of Business Development, Abaco Srl Corso Umberto I 43, 46100 Mantova, Italy; http://www.abacogroup.eu
[2] President and CEO, Abaco Srl Corso Umberto I 43, 46100 Mantova, Italy; http://www.abacogroup.eu

ABSTRACT

Since 2006 Abaco has invested in the field of IACS-related technologies, working together with real users in order to apply several techniques available in the IT industry, with a focus on the spatial data included in the IACS (Integrated Administration and Control System). The Land Parcel Identification System (LPIS) is the IACS' container of the spatial information which holds the reference parcels and the land cover; often the LPIS limits the potential to payment schemes support. Currently many LPISs contain relevant information that, together with historical information recorded during the years in the IACS, can be used as a facilitator to streamline and reduce work for mass or systematic updates. The annual update of the land cover information of the LPIS using photo-interpretation techniques is a well-known process applied by the Member States according to the EU and national regulations and methodologies. The rules require a periodical refresh of LPIS datasets (in Italy every 3 years), among which the Reference Parcels. When dealing with the second round on area digitized in the past, this process can be handled in two different ways: either completely re-digitizing the zone under inspection, or just re-digitizing the assessed changes between the past land cover, the RPs, and the new imagery. The second approach (innovative), which is about selectively operating on real changes, should be shorter, but it requires new types of software solutions. Those techniques imply a proper calibration of old polygons and new imagery, image analysis rules and the definition of what a "potential change" is, e.g. reference parcels that might be changed due to changes of the land cover; then these "potential changes" have to be processed to find the "real changes" finally applying them. The analysis and the implementation of this new methodology, together with software tools, and called "Refresh 2.0" brought interesting results in terms of costs and impacts on the overall Integrated Administration and Control System. The study considered applying the same thresholds specified by the European Commission for the Quality Assurance test suites (ETS), to maintain the results within the required quality parameters.

KEY WORDS: LPIS, IACS, Refresh, LPIS Update.

1. INTRODUCTION

The LPIS (Land Parcel Identification System) is one of the main systems required by the CAP Regulations to identify land and to control the claimed parcels. The LPIS requires systematic updates and shall contain data with high quality standards; achieving such level of quality requires a considerable effort. Quality levels are not an option for Member States, they are required by the current EU Regulations.

Since the LPIS relies on GI (Geographic Information) technologies, it is possible to take advantage of the so-called "spatial" functionalities to streamline the process of updates.

This paper proposes a new methodology and algorithms to update the LPIS datasets while reaching the required level of quality; the approach is taking advantage of existing information present in the LPIS, especially when the Member State has already done at least a complete cycle of "Refresh".

We refer to "Refresh" as the activity for periodic updating of the land cover layer, which should be a separate layer from the Reference Parcels' one. Refreshing the land cover has side effects on the boundaries of Reference Parcels (RP), which therefore may require corrections themselves, and on the eligibility profile of each RP. The analysis and the implementation of this methodology, together with software tools, called "Refresh 2.0" brought interesting results in terms of costs and effectiveness, including benefits for the overall Integrated Administration and Control System. The study considered applying the same quality thresholds specified by the European Commission for the Quality Assurance test suites (ETS), to maintain the results within the required parameters.

2. IACS CONTEXT

The data collected during the different processes required to deal with CAP subsidies are entered into the IACS by several actors. Such recorded information, together with advanced spatial data analysis techniques, enable people to cross-check relevant land information. Getting to a streamlined process requires a real integrated approach, e.g. we must consider that the other IACS modules provide relevant information to update the LPIS itself.

For the purpose of this study we are focusing mainly on the information stored in the LPIS.

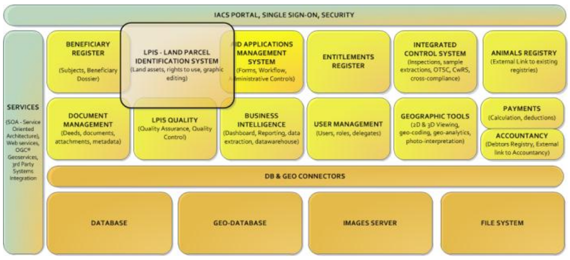


Figure 1: LPIS within the IACS.

3. EXTENDED LPIS

With "extended LPIS" we refer to an LPIS that contains (or access externally to) additional information apart that required by the LPIS Core data model. As much as the information stored in the LPIS is already broadly used by other external users, the LPIS shall use the information that can be accessed within external systems to enrich the attributes of the Land Cover and the Reference Parcels.

Additional information includes features beyond the reference parcels, or the land cover, which might affect eligibility in the context of specific payment schemes.

Among these feature layers, which can "collaborate" with the LPIS, there are:

- Buildings;
- Water features;
- Roads;
- Non-agricultural land (forests, etc.);
- Permanent features.

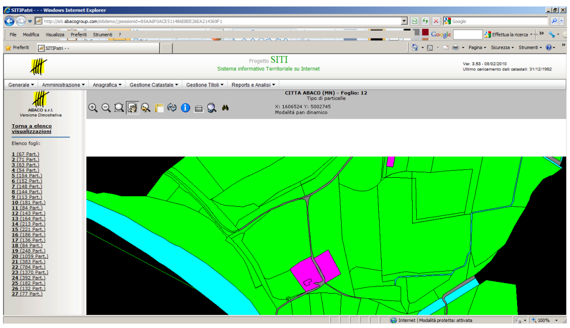


Figure 2: Full mapping of features.

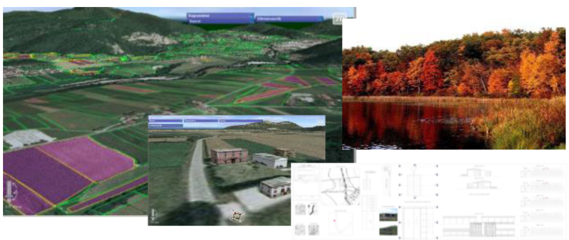


Figure 3: Examples of Spatial Units.

4. THE NEW REFRESH APPROACH

As mentioned, Refresh is the systematic update of the land cover information of the LPIS using photo-interpretation techniques. Updating the land cover has side effects on Reference Parcels boundaries, which are also subject of this study.

In 2011, Italy has done the second refresh cycle on a zone that was already interpreted in the past. This new digitization cycle could be handled in two different ways: either (a) completely re-digitizing the zone as done in the first cycle, or (b) re-digitizing only the changes between the existing land cover and the new imagery (and therefore updating the affected RPs).

The first approach (traditional) does not require to change the existing procedures for photo-interpretation, but the estimated cost and the side-effects on land cover and RP's boundaries, mostly caused by technical shifting, bias, or new quality of images, advice against it.

The second innovative approach, which is about selectively operating on changes, should be shorter, but it requires re-thinking the whole process and new types of software solutions.

While the traditional approach is completely manual and results in a final "intersection" between the layer of reference parcels and the land cover layer, the innovative approach requires the ability to compare objects on a timeline and to apply proper thresholds, to guarantee the fairness of the update, reducing excessive side-effects on the LPIS and limiting the changes to clear and evident changes.

These new techniques imply a proper calibration of old polygons and new imagery, image analysis rules and the definition of what a "potential change" is, e.g. reference parcels that might be changed due to changes of the land cover; then these "potential changes" have to be processed to find the "real changes", finally applying them.

5. A BIT OF BACKGROUND

Our study considered the following topics:

- The two rounds of refresh have collected a valuable datasets that might be re-used;
- Land cover update has side-effects on the Reference Parcels which implies expensive manual work for corrections;
- Changes to Reference Parcels, even if they are just technical, have consequences on the perception that farmers have of consolidated data;
- There are plenty of studies on technical tolerances and quality thresholds that we can use as a reference. There are of course certain activities that

require manual work and, to the current state-of-the-art of IT tools and automated image processing, we cannot avoid but executing them manually. Among those there are:

- Image shifting and calibration;
- Photo-interpretation; although the methodology described wants to focus only on a fewer number of elements;
- Corrections of RPs which are previously known as changed; these issues can be solved as a continuous update during the year.

The objectives of the study were therefore defined as to:

- Reduce the effort for updating of the land cover layer;
- Reduce the effort to apply changes caused on the Reference Parcel boundaries;
- Focus photointerpreters' effort only on relevant changes, through a guided mechanism, and limit manual changes to unclear situations;
- Insure compliance with the expectations on the update process and on the QA requirements, among which insuring a 100% coverage of the area under refresh and a 100% detection of changes on agricultural land;
- Reach the highest level of computerization to execute the changes on RPs (changes to boundaries or changes to the "usable agricultural land");
- Diminish the administrative burden to communicate the changes to affected farm holdings;
- Diminish the administrative burden for farm holdings, avoiding communications on insignificant changes, causing the need of re-submitting data required for annual applications.

6. ANALYSIS OF THE PROCESS

The analysis of a new process started effectively as a "thought experiment" (in German: Gedankenexperiment) with the goal to explore the potential consequences of the principle in question.

As thought experiment it was an "a priori" experiment conducted with imagination to go beyond the boundaries of already established methodologies and to examine the extent to which past activities might have been done differently. Therefore we avoided using technology during the analysis, although keeping in mind the achievements of the past.

The process started by imagining the representation of the land cover as a result of the previous years' refresh.

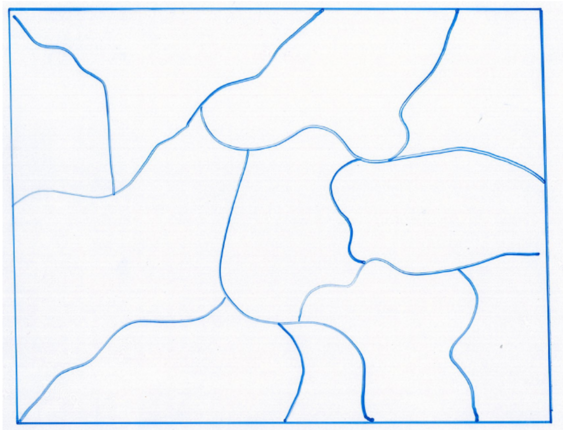


Figure 4: Land cover polygons on a plastic sheet.

Then, we know that there is information collected every year, which indicates potential changes to the land cover, which is provided by the several IACS processes affecting the LPIS dataflow, among which farmer's notifications, OTSC/CwRS inspections, routine LPIS verifications, etc.

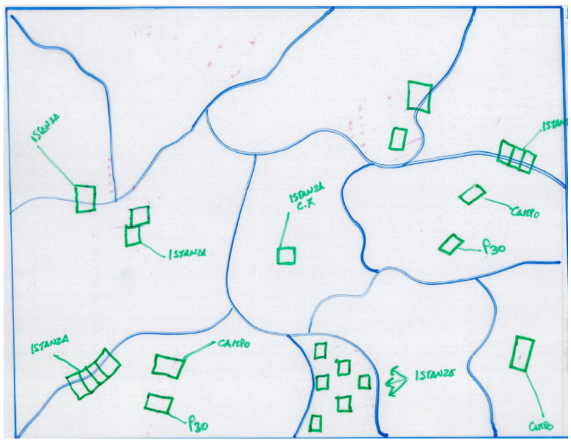


Figure 5: Adding known LPIS changes.

By looking at other GI layers, it should be immediately visible that the use of land has changed (on the raster imagery), or that new ineligible features are present (for example overlapping permanent datasets, like the water network). These evident areas can be immediately marked. We should consider, at this stage, to limit the size of the area under inspection (that we called "quadrant"), to be sure that a photo-interpreter inspects the whole area.

Figure 6: Adding evident land cover changes.

Once the areas on the land cover are marked for possible changes, we can superimpose the layer of Reference Parcels to find the affected RPs.

It's important to notice that not all the possible changes cause actual changes to polygons, since some elements might be either too small, e.g. under a certain threshold possibly caused by image bias, or they might be still eligible for certain payment schemes (Note: we avoid to deal now with the concept of "eligibility" since it is linked to policies and it is not strictly related to pure land changes).

Figure 7: Marking areas with actual changes.

We end up with a quite clear idea of the areas that require some work. We then introduced a final phase of "cleaning", since we know that certain changes on boundaries are either too small (side effects caused by image acquisition techniques), or we know that they might have been introduced by automated processing (for example some slivers).

Figure 8: Identifying technical side-effects.

7. SAMPLE AREA

We built a set of tools and did a proof of concept on a sample of the Italian territory in parallel with the traditional refresh process.

The total area covered by the refresh process in Italy in 2011 was roughly 100000 km2, covering 29 provinces and about 16 million polygons. The chosen sample was a 3% of the interested area, covering 1 province and 195813 polygons, with a mixed landscape containing flat and mountainous areas.

8. IMPLEMENTING THE PROCESS

The process has been divided in steps, following the ideas of the "thought experiment" and getting inside photo interpreters' tasks.

Step A - Shifting
One of the known problems with raster images is to fit them with the vectorized layers to homogenize images and to limit the technical differences before photointerpretation is done. For this purpose the same Digital Terrain Model used for the LPIS was chosen.

Since we needed to document the process, in order to make it replicable and verifiable, we calculated Δx-Δy shifts to be applied to the new orthophotos. Δx-Δy shifts are based on "permanent areas" represented as polygons. These polygons are drawn on the basis of permanent ground features (roads, water basins, or water courses). For the same purpose, we also calculated the average shift Øx-Øy, and the RMSE using homologous points on quadrants; we used them to verify any points out of range (according to a threshold).

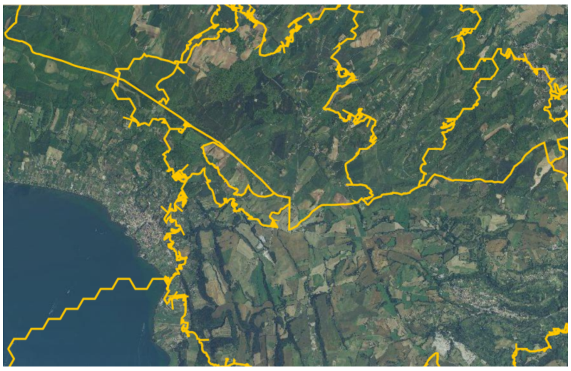


Figure 9: Permanent ground features.

We found a maximum shift of ±2 m (on flat areas) and ±4 m (on hilly areas).

PRE_SHIFT	X_MIN	Y_MAX	POST_SHIFT	X_MIN	Y_MAX	Δ_X	Δ_Y			RMSE
REFRESH_AREA_1	1657840.435	4823545.414	REFRESH_AREA_1	1657841.815	4823547.714	-1.380	-2.300	1.905	5.291	2.682385803
REFRESH_AREA_2	1668612.507	4820924.548	REFRESH_AREA_2	1668614.163	4820926.745	-1.656	-2.197	2.741	4.825	2.75054738
REFRESH_AREA_3	1681317.303	4824521.186	REFRESH_AREA_3	1681319.458	4824524.086	-2.155	-2.900	4.642	8.413	3.613144375
REFRESH_AREA_4	1685123.238	4821629.052	REFRESH_AREA_4	1685124.133	4821630.128	-0.895	-1.076	0.802	1.157	1.399470305
REFRESH_AREA_5	1657755.095	4814119.62	REFRESH_AREA_5	1657755.957	4814121.346	-0.863	-1.725	0.744	2.977	1.92910239
REFRESH_AREA_6	1680631.752	4812419.872	REFRESH_AREA_6	1680632.708	4812420.828	-0.956	-0.956	0.915	0.915	1.352523233
REFRESH_AREA_7	1694209.621	4811213.464	REFRESH_AREA_7	1694209.263	4811214.18	0.358	-0.716	0.128	0.512	0.800137884
REFRESH_AREA_8	1658161.19	4806117.792	REFRESH_AREA_8	1658162.276	4806117.249	-1.086	0.543	1.180	0.295	1.214402593
REFRESH_AREA_9	1669085.13	4803093.954	REFRESH_AREA_9	1669085.13	4803093.954	0.000	0.000	0.000	0.000	0
REFRESH_AREA_10	1679235.268	4798950.836	REFRESH_AREA_10	1679236.207	4798951.587	-0.939	-0.751	0.882	0.564	1.20236728
REFRESH_AREA_11	1693071.196	4805754.822	REFRESH_AREA_11	1693070.303	4805756.013	0.893	-1.191	0.797	1.418	1.488284228
REFRESH_AREA_12	1705142.849	4802922.29	REFRESH_AREA_12	1705142.589	4802925.184	0.260	-2.894	0.068	8.378	2.906136461
REFRESH_AREA_13	1654982.804	4794822.031	REFRESH_AREA_13	1654983.338	4794822.453	-0.534	-0.421	0.285	0.178	0.680234296
REFRESH_AREA_14	1690875.354	4796877.931	REFRESH_AREA_14	1690874.918	4796877.64	0.435	0.291	0.190	0.085	0.523710942
REFRESH_AREA_15	1697540.66	4789781.556	REFRESH_AREA_15	1697541.139	4789783.954	-0.480	-2.398	0.230	5.748	2.444988617
REFRESH_AREA_16	1714186.805	4792904.236	REFRESH_AREA_16	1714186.376	4792902.697	0.429	1.539	0.184	2.369	1.597860132
REFRESH_AREA_17	1666534.649	4785839.498	REFRESH_AREA_17	1666536.059	4785841.143	-1.410	-1.645	1.988	2.705	2.166273057
REFRESH_AREA_18	1685542.141	4780038.287	REFRESH_AREA_18	1685544.908	4780037.868	-2.768	0.418	7.660	0.175	2.799074773
REFRESH_AREA_19	1706048.695	4774641.673	REFRESH_AREA_19	1706051.197	4774642.388	-2.502	-0.715	6.261	0.511	2.602397709
REFRESH_AREA_20	1725886.082	4777095.545	REFRESH_AREA_20	1725889.111	4777094.409	-3.029	1.136	9.172	1.290	3.234520478
REFRESH_AREA_21	1713350.16	4759642.022	REFRESH_AREA_21	1713352.143	4759641.378	-1.983	0.644	3.934	0.414	2.085230158

Figure 10: Values (Δx-Δy, RMSE, etc.) stored to replicate the process (illustration).

Figure 11: Previous and this year's images.

Figure 12: Previous and this year's images overlapped.

Figure 13: Difference with ground control features.

Figure 14: Shifting raster image according to control features.

Step B - Photointerpretation
Once images are at the right place, the photointerpretation work begins. Photo-interpreters are required to inspect the quadrants totally, according to the specifications and methodology on CAPI, which includes a detailed and guided manual.

The aim is to:

- Re-use data collected in previous rounds of the refresh;

  Find the side-effects that the land cover update has on the Reference Parcels, which implies expensive manual work for corrections;

- Focus the attention of interpreters on "change recognition", or on visible errors, of the land cover by using guided masks;

- Confirm and commit un-varied land cover polygons (no new digitization needed).

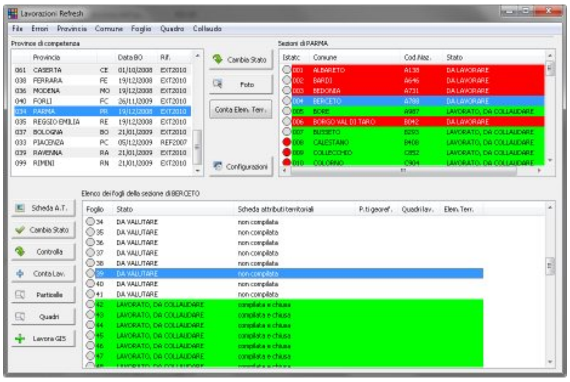


Figure 15: Software tool focusing on specific elements to be checked.

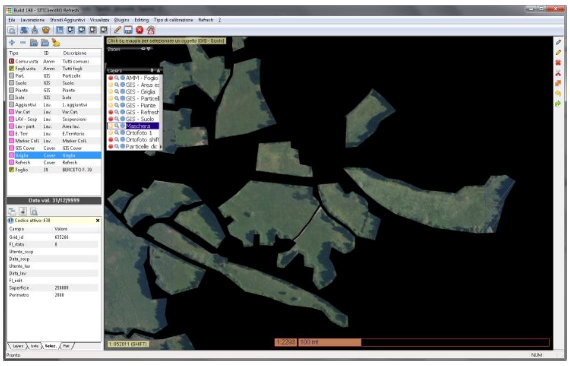


Figure 16: Masking land on potential changes.

At this point of the process, we found that the Usable Agricultural Area under potential change is just the 0,43Basically the photo interpreters needed to verify some specific, and most of the time "visible", elements, like in the examples shown below.

Figure 17: Need change on land cover due to presence of a lake.

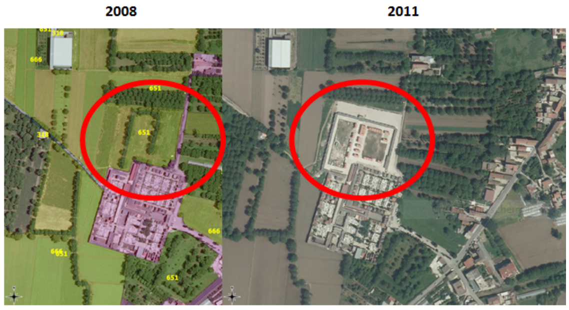


Figure 18: Land cover changed from agricultural to non-agricultural.

Figure 19: No changes needed, just a shading effect.

At the end of the process, the photo interpreters have covered the 100% of the territory, having either changed or confirmed the situation of the land cover polygons.

Step C - Intersect reference parcels

A fairly simple operation that can be done on spatial-enabled databases is to "intersect" vectorized layers. Now that the land cover has been processed, we can focus on the effects on Reference Parcels, by intersecting the land cover layer with the RPs layer.

The purpose is to select the RPs with potential changes and/or confirm unchanged RP polygons. This preliminary filter will limit the number of RP objects requiring digitization.

At this point of the process, we found that the number of polygons (RPs) touched by at least 1 change of the land cover is representing the 16,4% of the total sample, but just the 1,6% is "Usable Agricultural Area". The list of polygons with potential changes is saved for further processing.

Step D - Digging up

We are now entering the core of the process that can be automated thanks to the information that we collected in the extended LPIS.

First of all, we have to classify the changes on Reference Parcels. We have:

- RPs with previously known request for changes (those notified by farmers and inspectors during the years)
- RPs intersecting with the changes to the land cover, further categorized in:

1. Below a threshold
2. Above a threshold

The parcels with known problems are known before the refresh process is done, so they are not counted in the statistics. The thresholds used on the other RPs are those described in the guidelines for QA-LPIS, or they can be technical thresholds. RPs below a given threshold are automatically confirmed (committed).

IMPORTANT: we considered the new concepts of ETS v5.1, so we repeated the exercise with thresholds differentiated by payment scheme.

At this point of the process, the number of polygons (RPs) with changes above the threshold for SPS is 0,6% of the Usable Agricultural Area.

Here follows some definitions required to introduce the algorithms used:

$\mathbf{RP_{Anomaly}}$: Reference Parcel with a known anomaly

- Notified by farmer, or inspector
- Topology error
- Land cover not available
- Land cover only partial
- RP under minimum size (0,1 ha)
- At least 1 "agricultural" land cover intersection under threshold (0,1 ha)
- At least 1 "non-agricultural" land cover intersection, or linear landscape feature, under threshold (2 m)
- Those described in the "Ecological Model": Trees-, Man-made-, Water-, Boundaries-related anomalies

Each $\mathbf{RP_{Anomaly}}$ can be identified by specialized analysis algorithms within the LPIS (or it has been already notified by farmers, or it has been found during field surveys).

LC: Land Cover polygon

- $\mathbf{LC_{Changed}}$: Land Cover changed polygon
- $\mathbf{LC_{Agricultural}}$: Land Cover representing agricultural classes

RP: Reference Parcel

- $\mathbf{RP_{Before}}$: RP polygon at n cycle of land cover update
- $\mathbf{RP_{After}}$: RP polygon at n+1 cycle of land cover update
- $\mathbf{RP_{Filed}}$: RP filed/kept/maintained also in other registries (vineyards, olives, generic permanent crops, pastures, etc.)

- **UAA**(**RP**): Usable Agricultural Area inside a RP =

$$\sum \mathbf{Area}\left(\mathbf{RP} \cap \mathbf{LC_{Agricultural}}\right)$$

- **UAA** $_{\mathbf{Var}}$(**RP**): percentage variation of UAA inside a RP =

$$\frac{\left|UAA(RP_{Before}) - UAA(RP_{After})\right|}{\mathbf{UAA(RP_{Before})}}$$

Note: $\mathbf{UAA_{Var}}$(**RP**) should be below a 2% threshold.

Now let's introduce the concept of Set To Be Processed ($\mathbf{RP_{STBP}}$), which is the "set of Reference Parcels that have not any known anomaly and that intersect with a change in the land cover"

$$\mathbf{RP_{STBP}} = \left\{\mathbf{RP} \in \mathbf{LPIS}, \mathbf{RP} \neq \mathbf{RP_{Anomaly}} | \mathbf{RP} \in \mathbf{LC_{Changed}}\right\}$$

We are now ready to introduce the main algorithm (presented as pseudo-language) to work the Reference Parcels. The process covers automatically all the Parcels.

Here is the algorithm for flagging the RPs:

```
for each RP in RP_STBP
 for each LCType
  if |Area(RP_Before) - Area(RP_After)| <
            Threshold_LC-type
   then
    flag RP as "unchanged"
    else flag RP as "changed"
 end LC loop
 if UUA_Var(RP) < Threshold_UAA
  then
   flag RP as "unchanged"
   else flag RP as "changed"
end RP loop
```

The RPs flagged as "changed" are those with changes above a defined set of thresholds, either on the boundaries, or the Usable Agricultural Area. The process is done for each Land Cover type. Now we can re-process the RPs either manually, in case of RPs that need a manual process, or just to automatically confirm (commit) the changes, notifying it to the farmer. In this second case we are sure that there was a change and it can be simply done by clipping the RP using the land cover boundaries). The algorithm to be applied for the final "commit" is then the following:

```
for each RP in RP_STBP
  if RP is "changed" then
    if RP is RP_Filed then
move RP to "manual to-do list";
    else
```

Table 1: Parameters/thresholds by land cover class and payment scheme (extended eligibility profile).

LAND COVER	Range 1 (mq)	Range 2 (mq)	Tolerance +/- (V1)	Max (V2 mq)
Arable	0	2000	7.00%	
	2000	5000	5.00%	
	5000		3.00%	10000
Permanent crop	0		5.00%	100
Landscape feature	0		5.00%	100
Forest	0	2000	7.00%	
	2000	5000	5.00%	
	5000		3.00%	10000
Ecc.				

```
      update RP based on LC_Changed;
      set RP as updated;
      set update and validity date;
      execute SliverScrubbing();
      notifyFarmer();
  else  // RP "unchanged"
    set RP as updated;
    set update and validity date;
end RP loop
```

Note:

`SliverScrubbing()`

clears errors caused by automated clipping. The function is parametric and takes care of filling gaps/slivers between polygons (by using a “max neighborhood perimeter” concept) and spikes (by using angle, sides length and vertexes distance).

At this point of the process, the number of polygons (RPs) that require “real” manual work is 3.483 parcels, representing the 1,8% of the total sample. We found that these are polygons maintained in other registries (for example permanent crops), therefore a cross-check becomes straightforward.

9. CONCLUSIONS

Re-thinking the refresh process to manage also the changes caused on Reference Parcels of an LPIS in light of a new methodology, recent results of research, and new software tools streamlines the work of a Managing Authority while maintaining the requirement to re-digitize the 100% of the Usable Agricultural Area and maintaining the desired Quality thresholds.

The approach reduces significantly the manual work, thus reducing costs and human errors, while remaining replicable and documented. It also applicable to different payment schemes by using different eligibility profiles.

The tools to manage the whole process have been built and, we think, they should be considered as a clear and valid approach for the procedure to be used for updating the LPIS, as required by the Regulations.

The new methodology goes in the direction of having the reference parcel to be reliably validated against external information (topographic mapping, photo interpretation on orthophotos, information exchange and field check with farmer, on the spot visits), adding validated methods available through automated spatial processing, further reducing dependency on technical tolerances due to image processing.

It also helps the annual assessment of the currency of the reference parcels to reflect the farming system in terms of the accuracy of the parcel boundaries stored in the spatial database.

All the new tools and effective techniques can be applied and provide tangible results. The new functionalities, together with additional datasets, therefore can now be used to lower the manual effort required by annual updates.

ACKNOWLEDGMENTS

We would like to thank the people at SIN, the public company responsible for the National Management Information System for Agriculture, and the R&D department of Abaco, which gave the possibility to make it real. A special thank is also due to the team members: L. Brillo, C. Del Lungo, V. Fortuna, A. Bignotti and M. Gilberti; they were able to transform ideas into real and usable methodology and tools.

REFERENCES

COUNCIL REGULATION (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:030:0016:0016:EN:PDF

WikiCAP - LPIS - http://marswiki.jrc.ec.europa.eu/wikicap/index.php/LPIS http://marswiki.jrc.ec.europa.eu/wikicap/index.php/LPIS_dataflow

Abaco SITI Agri http://www.abacogroup.eu/pdfview/SITI_Agri_EN.html

WikiCAP, Digital Elevation Model (http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Digital_Elevation_Model)

Valentina Sagris, Wim Devos, LPIS Core Conceptual Model (2008)

Grandgirard, D. and R., Zieliński, (2008), Land Parcel Identification System (LPIS) Anomalies Sampling and Spatial Pattern: Towards convergence of ecological methodologies and GIS technologies

Zieliński, R. (2008) Automatic detection of potential non-conformities in the LPIS

AUTOMATIC ASSESSMENT OF LAND PARCEL IDENTIFICATION SYSTEMS BASED ON UNSUPERVISED CLUSTERING USING SELF-ORGANIZING MAPS

Kadim Taşdemir and Csaba Wirnhardt

MARS Unit, Institute for Environment and Sustainability, EC Joint Research Centre, Via E. Fermi 2749, Ispra (VA), Italy, kadim.tasdemir@jrc.ec.europa.eu

ABSTRACT

Land Parcel Identification System (LPIS) has to be as up to date as possible, to correctly quantify the eligible/ineligible area in each LPIS parcel. The LPIS quality assessment is often done by interactive computer-aided photo-interpretations by domain experts as well as by field visits. To address the need for an automated LPIS quality check, we propose an automated anomaly detection method based on land cover identification, using self-organizing maps (SOM) based spectral clustering (Taşdemir, 2011). We apply our method for LPIS anomaly detection in Hungary which is covered by 209 Rapideye image tiles (each image has 4800x4800 pixels, covering an area of 576 km2). By using three test zones (one with an imagery acquired in the early vegetation season), we show that the proposed method helps detection of ineligible lands that were assigned as eligible, as well as eligible lands that were assigned as ineligible. Hence, it can be useful for LPIS quality check to significantly reduce the huge processing time required for interactive control by domain experts.

1. INTRODUCTION

The land parcel identification system (LPIS) is the reference system for locating and identifying each agricultural parcel declared in the farmers' annual applications. For correct quantification of the eligible/ineligible area in each LPIS parcel, the LPIS should be updated regularly. This in turn requires annual assessment of the LPIS quality, using current year very high resolution remote sensing imagery. The quality assessment is often done by experts (using interactive computer-aided photo-interpretations, hence requiring a significant expert time) and by limited field visits. Automated methods, which can precisely detect anomalies in the LPIS to aid for yearly updates, are necessary for fast and accurate LPIS quality control. To address this need, we propose an unsupervised two-step anomaly detection method based on i) clustering with self-organizing maps (Taşdemir, 2011), and ii) a textural measure (Pantex), proposed by Pesaresi *et al*. (2008), for detection of artificial surfaces. Our two-step method is unsupervised, to omit high cost of field inspection and significant processing time required for supervised approaches to collect the necessary training samples throughout the whole country.

The first step in the proposed method is self-organizing maps (SOM) based clustering to determine different land cover types (clusters). The SOM is an unsupervised neural network which produces a faithful vector quantization in a topology preserving manner and therefore it is commonly used for cluster extraction from remote sensing images (Ji, 2000, Villmann *et al*., 2003, Merényi *et al*., 2009). Then SOM quantization prototypes are clustered by a recent method (Taşdemir, 2012), utilizing the advantages of the SOM and spectral clustering, using a local density-based similarity measure. The preliminary SOM quantization makes the spectral clustering feasible for remote sensing imagery which cannot be clustered by spectral methods directly, due to their computational complexity and memory requirement. Taşdemir and Wirnhardt (2012) show that an automated LPIS quality assessment solely based on the SOM based spectral clustering can provide fast and accurate detection of anomalies in the LPIS, except for discrimination among artificial and bare surfaces. This is because spatial/contextual information is often necessary to discriminate these surfaces. A novel method for accurate detection of artificial surfaces in high-resolution imagery is the Pantex (Pesaresi *et al*., 2008), which is an anisotropic rotation-invariant textural measure. Thus, the second step of the proposed method extracts artificial surfaces automatically detected by Pantex. Detailed description of the method is given in Section 2.

The proposed method was tested for LPIS anomaly detection in Hungary which is covered by 209 Rapideye image tiles (each image has 4800x4800 pixels, covering an area of 576 km2). The high resolution imagery provided by the recent Rapideye constellation was preferred, since its spatial resolution and its daily overpass capability enable acquiring annual imagery encompassing a whole country (Tapsall *et al*., 2010). Out of the 209 image tiles, three test zones with different land cover characteristics and with images acquired at different dates were selected for analysis. Section 3 shows the experimental results and indicates how the proposed method can help for automated LPIS control. Section 4 concludes the paper.

2. AUTOMATIC LPIS ASSESSMENT

The two-step automatic LPIS assessment is summarized in Figure 1. First, data representatives are obtained by an SOM and those representatives are clustered using spectral clustering with CONN similarity (described in Section 2.1). The number of clusters (k=30) is set according to the number of different land cover types declared in the zones (Taşdemir and Wirnhardt, 2012). Then resulting clusters are labelled as eligible/ineligible using the current LPIS. A cluster is assigned eligible if at least 50% of its pixels are eligible with respect to the current LPIS.

Second, spatial characteristics of the pixels are examined by a rotation invariant textural measure, to extract artificial surfaces which could not be distinguished from permanent bare areas. The two steps are explained in detail below.

2.1 SOM based spectral clustering with CONN similarity

First, an SOM is used for quantizing the data samples so that spectral clustering is feasible for the reduced number of data representatives. An SOM has neural units ordered on a (usually) 2-D rigid grid (as shown in Figure 1), and each unit has an associated n-D weight vector where n is the data dimensionality (in case of pixel-based clustering of remote sensing imagery, D is the number of image bands.) These weight vectors become data representatives after an iterative learning process that can be summarized as follows: A data sample v is randomly selected and its best matching unit i, whose weight vector w_i is the closest weight vector to v, is found by

$$i = \arg\min_j \|v - w_j\|, \; j = 1, 2, \ldots, N. \tag{9}$$

Then w_i and its grid neighbors (determined by a neighborhood function $h_{i,j}(t)$ based on grid distances between i and j) are adapted using

$$w_j(t+1) = w_j(t) + \alpha(t) h_{i,j}(t) \left(v - w_j(t) \right) \tag{10}$$

where $\alpha(t)$ is a learning parameter decreasing with time. These random selection and adaptation steps are repeated until either a predefined error criterion or a maximum number of iterations is reached. For the SOM based spectral clustering in this study, 2500 data representatives are obtained (for our datasets which have 4800x4800 samples) by an SOM with a 50x50 rectangular grid using sequential learning and Gaussian neighbourhood (with Matlab SOMtoolbox developed by Helsinki University of Technology, http://www.cis.hut.fi/somtoolbox/).

Second, the data representatives are partitioned into K clusters by spectral clustering since it achieves higher accuracies than traditional methods (Kannan *et al.*, 2004). Spectral clustering algorithms are associated with relaxed optimization of graph-cut problems by a graph Laplacian matrix L built on a similarity matrix S (Shi and Malik, 2000, Ng *et al.*, 2002, Meila and Shi, 2001. We use the spectral clustering algorithm in (Ng *et al*. 2002), modified with a local density-based similarity matrix CONN developed by Ta?demir and Merényi (2009). Leaving the details to Ta?demir (2012), we briefly explain the clustering method. Let $G = (V, S)$ be a weighted, undirected graph, its nodes (V) represent N data representatives $W = \{w_1, w2, \ldots, w_N\}$ to be clustered, and $S = CONN$ be a NxN similarity matrix defining its edges. Each pairwise similarity, $s(i, j) = CONN(i, j)$, for units w_i and w_j, is defined as the number of data samples for which w_i and w_j are the pair of the closest and second closest representatives. Formally,

$$CONN(i, j) = |RF_{ij}| + |RF_{ji}| \tag{11}$$

where RF_{ij} is the set of data samples for which w_i is the closest representative (Equation 1) and w_j is the second closest representative; and |.| is the cardinality of the set. Contrary to the distance-based similarity requiring user-set parameters, $CONN$ similarity is advantageous for spectral clustering, since it is constructed using intrinsic data details without any user-set parameters, it is sparse by definition, and it is supported by empirical studies (Ta?demir, 2012). Let D be the diagonal matrix denoting the degree of N nodes where $d_i = \sum_j s(i, j)$. The normalized Laplacian matrix is defined

$$L_{norm} = D^{-1/2} S D^{-1/2} \tag{12}$$

Then, the K eigenvectors $\{e_1, e_2, \ldots, e_K\}$ of L_{norm}, associated with the K highest eigenvalues $\{\lambda_1, \lambda_2, \ldots, \lambda_K\}$, are used to construct the NxK matrix $E = [e_1, e_2, \ldots, e_K]$. The matrix E is normalized to have unit norm, and its N rows are clustered with the k-means algorithm. Finally, data samples obtain the cluster label of their corresponding representatives.

The SOM based spectral clustering finds a land cover mapping with a predetermined number of clusters (K) in an unsupervised manner. Thanks to current LPIS (eligible-ineligible fields), an eligibility mask is constructed by checking whether each of K clusters are eligible or ineligible, i.e, if the majority of the data samples in a cluster is eligible according to the LPIS, then that cluster is eligible, and vice versa. This construction is based on the assumption that LPIS has to be (mostly) correct even though it may contain anomalies due to changes in land cover/use (in other words, the assumption that potential errors/anomalies have a minor influence on the overall validity of the eligibility mask). The areas, where the resulting eligibility mask and the LPIS have different labels, indicate possible anomalies in the system.

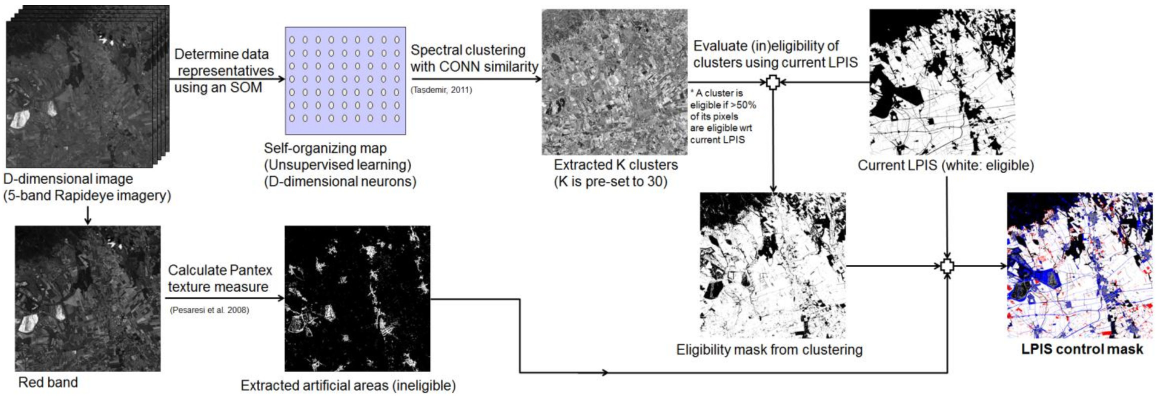


Figure 1: Automatic LPIS assessment based on two-steps: 1) SOM based spectral clustering, 2) Pantex from red band.

2.2 Pantex: a measure for detecting artificial surfaces

A drawback of the unsupervised clustering method, described in Section 2.1, is the possible confusion between urban and agricultural patterns due to the spatial resolution of the imagery. This can be explained by the fact that for images with the necessary spatial resolution approaching the size of built-up structures, spectral (radiometric) information becomes less relevant, and even may add more noise than discriminatory information (Pesaresi, 2000). We refine our method by adding a textural measure, Pantex, shown successful in discrimination of urban settlements (Pesaresi *et al*., 2008). Pantex is a built-up presence index exploiting stable structural characteristics of the artificial surfaces (high contrasting edges) for high resolution (5 m) imagery. It is constructed by rotation-invariant anisotropic textural analysis based on grey level cooccurrence matrix (GLCM) contrast. GLCM parameters (window size, vector displacement, number of gray levels) should be set carefully for desired textural delineation of different patterns. For discrimination of standard built-up structures (with side dimensions ranging from 10 to 20 m, using 5 m resolution imagery), Pantex is derived using a window size of 5x5 (empirically set), 10 different displacement vectors specifically determined to cover all possible different directions and 256 gray levels (Pesaresi *et al*. 2008). Based on the assumption that "*In an image having spatial resolution approaching the size of buildings, built-up areas are regions of the image where the textural contrast is high in all the directions.*", Pantex is then constructed by merging the GLCM contrasts calculated at 10 possible directions, using a fuzzy operator min (setting the minimum contrast value). We refer to (Pesaresi *et al*., 2008) for detailed description and discussions on its success to capture built-up areas. Thanks to the 5m resolution of Rapideye imagery, Pantex can be directly applied to find artificial surfaces in this study.

3. EXPERIMENTAL RESULTS

Three test zones-either with different land cover characteristics or with images acquired at different dates-were used for analysis. Zone1 is mostly covered with arable lands (65% eligible), together with forests at the north-west corner, and outcrop lignite mines at the mid-west, as well as urban settlements. Zone2 is dominantly non-agriculture (35% eligible), mostly covered with forests and urban settlements, and limited agricultural land (mainly pastures and fodder crops). Zone3 has a balanced coverage (45% eligible), mainly covered by forests together with some urban settlements, pastures and winter crops. We refer to Taşdemir and Wirnhardt (2012) for detailed descriptions of these zones. We note that the imagery for Zone1 and Zone2 was acquired on 10 July 2010 (vegetation season), whereas the imagery for Zone3 was acquired on 3 April 2010 (very early in the vegetation season).

Figure 2 shows the false colour composites of the zones and resulting LPIS control masks. These automatically produced masks significantly diminish the necessary interactive process to find required updates in the LPIS only to those blue and red areas. Red indicates possible ineligible fields that are eligible in the LPIS, whereas blue shows possible eligible areas that are ineligible in the LPIS. Gray areas in the masks indicate artificial surfaces (which are ineligible) extracted by Pantex based on their discriminative texture, i.e. sharp contrast change at the edges. It was not possible to accurately extract these artificial surfaces (gray) without using spatial information (Taşdemir and Wirnhardt, 2012).

The accuracies (percentage of pixels correctly identified as eligible or ineligible over all pixels with respect to the current LPIS) and corresponding confusion matrices for the two-step (SOM-based clustering and Pantex) method and its predecessor (only SOM-based clustering as introduced by Taşdemir and Wirnhardt, 2012) are given in Tables 1, 2, and 3. Thanks to effective discrimination of artificial surfaces with Pantex, the proposed combined method achieves better overall accuracies for all three zones (86.2% for Zone1; 86.0% for Zone2; and 82.2% for Zone3). Due to the same reason, producer accuracies for ineligible areas significantly increase with the Pantex: from 62.6% to 73.4% for Zone1, from 81.8% to 88.6% for Zone2, and from 81.4% to 83.6% for Zone3. Similarly, user accuracies for eligible areas are improved: from 81.8% to 86.2% for Zone1, from 71.8% to 81.8% for Zone2, and from 78.4% to 80.4% for Zone3. For Zone3, eligible/ineligible areas are detected with an acceptable accuracy, despite an image acquired in the very early vegetation development.

Table 1: Confusion matrices for Zone1.

SOM clustering	Ineligible	Eligible	Producer Accuracy
Ineligible	5,168,734	3,091,497	62.57%
Eligible	845,342	13,934,427	94.28%
User Accuracy	85.94%	81.84%	82.91%
SOM clustering + Pantex	Ineligible	Eligible	Producer Accuracy
Ineligible	6,059,033	2,201,198	73.35%
Eligible	984,501	13,795,268	93.34%
User Accuracy	86.02%	86.24%	86.17%

Table 2: Confusion matrices for Zone2.

SOM clustering	Ineligible	Eligible	Producer Accuracy
Ineligible	12,427,072	2,775,112	81,75%
Eligible	960,639	7,069,17	88.04%
User Accuracy	92.82%	71.81%	83.92%
SOM clustering + Pantex	Ineligible	Eligible	Producer Accuracy
Ineligible	13,469,868	1,732,316	88.60%
Eligible	1,510,628	6,519,188	81.19%
User Accuracy	85.94%	81.84%	86.04%

Table 3: Confusion matrices for Zone3.

SOM clustering	Ineligible	Eligible	Producer Accuracy
Ineligible	10,228,528	2,334,575	81,42%
Eligible	1,994,077	8,482,820	80.97%
User Accuracy	83.60%	78.42%	81.21%
SOM clustering + Pantex	Ineligible	Eligible	Producer Accuracy
Ineligible	10,505,323	2,057,780	83.62%
Eligible	2,033,626	8,443,271	80.59%
User Accuracy	83.78%	80.40%	82.24%

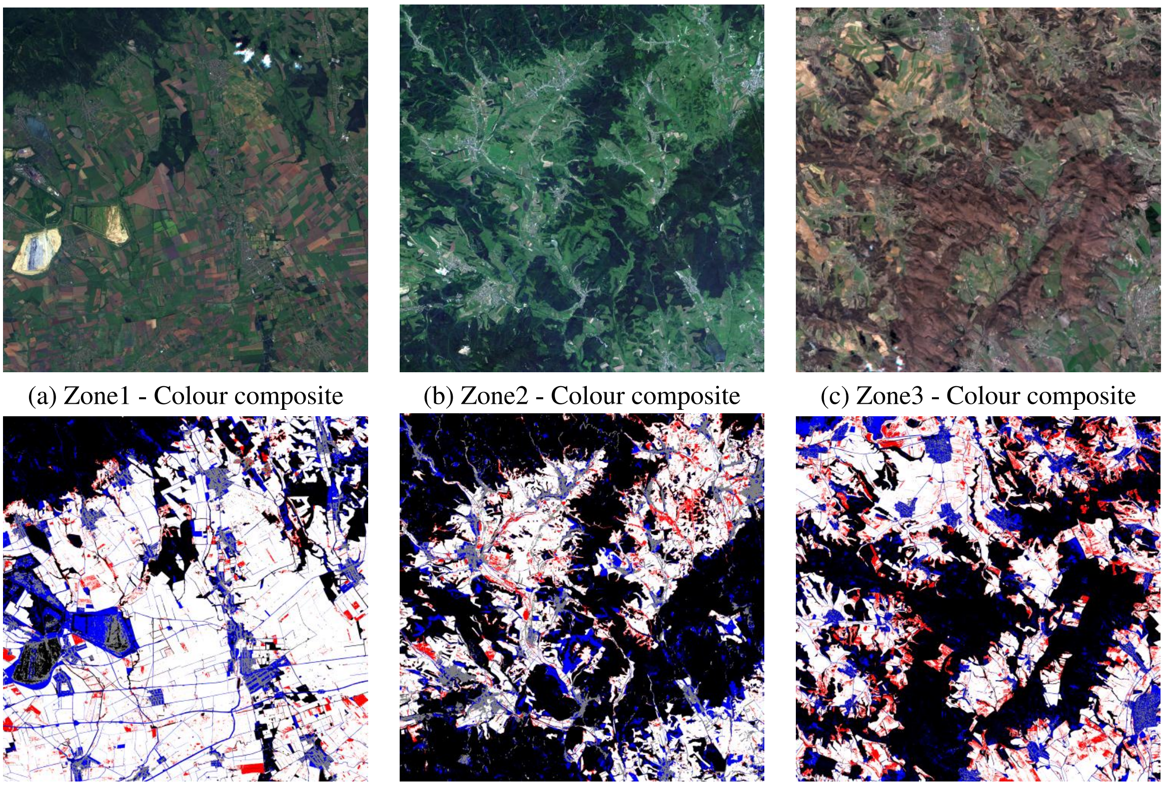
An example anomaly detection is in Figure 3 to show how automatically produced mask can help for the LPIS assessment. Figure 3.a shows false colour composite of the 5-band Rapideye imagery (used for clustering) with the current LPIS. Figure 3.b shows the mask obtained by the proposed two-step method: white/black stand for eligible/ineligible regions which require no adjustments whereas red/blue regions indicate possible anomalies in the LPIS. For example, the red area labeled with "A" is eligible in the LPIS, however it should be ineligible according to the mask.

In this case the detected anomaly corresponds to a forest parcel (as can be visually identified from the Rapideye false colour composite in Figure 3.a and from the VHR image in Figure 3.c), which is not eligible under the Single Area Payment Scheme applied in Hungary and therefore should be part of the LPIS ineligible mask. Similarly, the areas marked with "B" also show real anomalies detected: forest patches along a watercourse (visually identifiable both from Rapideye and VHR imagery) that should have been marked as ineligible in the LPIS mask. The parcel "C" is indeed a false alarm since that parcel is a maize area and due to acquisition time, maize may be confused with woodlands or forests due to the spectral similarity. Another type of anomaly is in the parcel "D" which is ineligible in the LPIS but the mask recommends it to be eligible. Visual interpretation of both Rapideye and VHR images suggests that this parcel may indeed be agricultural according to its land cover. For evaluation of mask-based anomalies, Figure 3.d shows a newer LPIS updated using interactive interpretation of VHR imagery and ancillary data. (We note that this newer LPIS is partly available only for some regions). Both A and B are in line with the manual update, however D and its surrounding are excluded (made ineligible) because no subsidy application has been submitted for those parcels within the previous 4 years, despite their eligible land cover. We refer to Taşdemir and Wirnhardt (2012) for other detection examples.

4. CONCLUSION

For automated assessment of land parcel identification systems, we proposed a two-step unsupervised method to find necessary updates. The predecessor of this method (Taşdemir and Wirnhardt, 2012) used solely SOM-based spectral clustering, while additional spatial information-with a contrast based texture measure Pantex (Pesaresi *et al.*, 2008)- is considered in this study to extract artificial surfaces. The results indicated that the proposed method produces control masks with high accuracies and can guide for LPIS update (even with an imagery acquired in the very early vegetation season). We used Rapideye imagery as the data source, since this imagery is suitable to capture remote-sensing imagery encompassing the country and to accurately determine the eligibility mask.

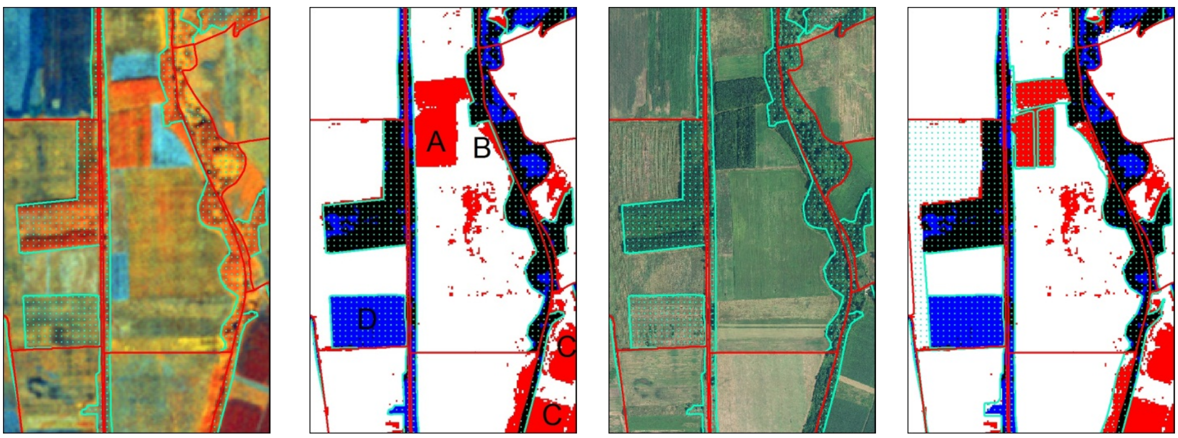
Our method is pixel-based and hence determines eligibility of each pixel. In order to capture the anomalies in the LPIS (with respect to the automated method), a cumulative eligibility index on the parcel level (based on the number of pixels in parcel, with contrasting values in the produced mask and in the LPIS) can determine the importance of necessary updates for each parcel and rank the parcels in terms of required changes in the LPIS.



(a) Zone1 - Colour composite (b) Zone2 - Colour composite (c) Zone3 - Colour composite

(d) Zone1 - LPIS mask (e) Zone2 - LPIS mask (f) Zone3 - LPIS mask

Figure 2: Natural colour composites of the zones and corresponding LPIS masks produced by the proposed two-step method.



(a) False colour composite (b) LPIS control mask (c) VHR imagery with current LPIS (d) Mask with updated LPIS

Figure 3: An example anomaly detection (from Zone1) using LPIS control mask in (b). The (current or updated) LPIS is overlaid on the figures. Red lines show the boundaries of the LPIS physical blocks, cyan lines are the boundaries of eligible/ineligible areas with cyan-dotted regions are ineligible.

ACKNOWLEDGMENTS

The Authors thank the Hungarian Administration: the Agricultural and Rural Development Agency (ARDA) and the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) for providing us LPIS vector data and orthophotos.

REFERENCES

Ji, C. Y. (2000). Land-use classification of remotely sensed data using Kohonen self-organizing feature map neural networks. *Photogrammetric Engineering and Remote Sensing*, **66**(12), pp. 1451 -1460.

Kannan, R., Vempala, S. and Vetta, A. (2004). On clusterings: Good, bad and spectral. *Journal of the ACM*, **51**(3), pp. 497-515.

Meila, M. and Shi, J. (2001). A random walks view of spectral segmentation. *In: 8th International Workshop on Artificial Intelligence and Statistics (AISTATS).*

Merényi, E., Taşdemir, K. and Zhang, L. (2009). Learning highly structured manifolds: harnessing the power of SOMs. *In: M. Biehl, B. Hammer, M. Verleysen and T. Villmann (eds), Similarity based clustering, Lecture Notes in Artificial Intelligence*, Vol. 5400, Springer-Verlag, pp. 138-168.

Ng, A., Jordan, M. and Weiss, Y. (2002). On spectral clustering: analysis and an algorithm. *In: T. Dietterich, S. Becker, and Z. Ghahramani (Eds.), Advances in Neural Information Processing Systems 14*. MIT Press.

Pesaresi, M. (2000). Texture analysis for urban pattern recognition using fine-resolution panchromatic satellite imagery. *Geographical and Environmental Modelling*, **4**(1), pp. 43-63.

Pesaresi, M., Gerhardinger, A. and Kayitakire, F. (2008). A robust builtup area presence index by anisotropic rotation-invariant textural measure. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, **1**(3), pp. 180-192.

Shi, J. and Malik, J. (2000). Normalized cuts and image segmentation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **22**(8), pp. 888-905.

Taşdemir, K. (2012). Vector quantization based approximate spectral clustering. *Pattern Recognition*, DOI: 10.1016/j.patcog.2012.02.012.

Taşdemir, K. and Merényi, E. (2009). Exploiting data topology in visualization and clustering of Self-Organizing Maps. *IEEE Transactions on Neural Networks*, **20**(4), pp. 549-562.

Taşdemir, K. and Wirnhardt, C. (2012). Neural network based clustering for agriculture management. *To Appear in EURASIP Journal on Advances in Signal Processing, Special issue on Neural Networks for Interpretation of Remotely Sensed Data*.

Tapsall, B., Milenov, P. and Taşdemir, K. (2010). Analysis of Rapideye imagery for annual landcover mapping as an aid to European Union (EU) Common Agricultural Policy. *In: Wagner W., Szekely, B. (eds.): ISPRS TC VII Symposium 100 Years ISPRS, Vienna, Austria, July 5-7, Vienna, Austria, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVIII, Part 7B, pp. 568-573.

Villmann, T., Merényi, E. and Hammer, B. (2003). Neural maps in remote sensing image analysis. *Neural Networks, Special Issue on Self-Organizing Maps for Analysis of Complex Scientific Data*, **3-4**(16), pp. 389-403.

CONFERENCE AGENDA

17th GeoCAP Annual Conference: Geomatics in support of the CAP
Meriton Grand Conference & Spa Hotel, Tallinn, Estonia, 23-25 November 2011

Day 1 (November 23, 2011)

11.00-12.30	Registration
12.30-14.00	Lunch Break
Opening Plenary Session ROOM PETERSON Policy: CAP 2014-2020 Chair: Andres Oopkaup (Deputy Secretary General for Agriculture and Trade Policies EE) Co-chair: Olivier Leo (JRC)	
14.00-14.15	Opening (Minister Mr Seeder, Estonian Ministry of Agriculture)
14.15-14.20	Welcome (Olivier Leo, JRC)
14.20-15.00	Estonia: 7 years of CAP (Mr Andres Oopkaup, Deputy Secretary General for Agricultural and Trade Policies)
15.00-15.30	Future CAP: proposal to reform direct payments (Charlotte Sode, DG AGRI D.1)
15.30-16.00	Coffee Break
16.00-16.30	New GAEC scope based on proposals for 2014 CAP (Emmanuel Petel, DG AGRI D.3)
16.30-17.00	Agro-environmental statistics supported by IACS LPIS data: the Italian experience (F. Tropea, A. De Meo, SIN spa)
17.00-17.10	Conference Organisation (P. Pizziol, JRC)
17.10-17.30	Posters' flash introduction (R. De Kok, JRC)
19:00-20.00	Icebreaker

Day 2 (November 24, 2011)

	Parallel Session 1 ROOM JACOBSON Satellite and aerial imagery: new sensors, satellite tasking, image processing Chair: Frithjof. Barner (Euromap) Co-chair: Par Astrand (JRC)	**Parallel Session 2 ROOM PETERSON GAEC and rural areas management Chair: Emmanuel Petel (DG AGRI) Co-chair: Vincenzo Angileri (JRC)**
9.00-10.30	Pléiades: on track for launch! (Charlotte Gabriel-Robez, Astrium) Constellation tasking during CwRS 2011: a backstage look at how to best combine WV2, QB2, and WV1 (George Ellis, EUSI) How to reach an high precision orthorectified image in all Europe for CAP requirements? (Alain Killmayer, Geosys) Microsoft Bing Maps Aerial Imagery Program for West/Central Europe and embedment into PROGIS technologies (J Kauer, MS Bing; W Maier, Progis)	GAEC workshop 2011 (Vincenzo Angileri, JRC) New GAEC standards 2010-2012: a new comparison between RS and ground survey control's capability (U.Minelli, S.Paolini, L.Rossi, P.Tosi, SIN spa) Using radar images for identifying mowing on semi-natural grasslands (Kaupo Voormantsik, University of Tartu)
10.30-11.00	Coffee Break	
11.00-12.40	Rapid access to satellite imagery for data evaluation & delivery (Lars-Åke Edgardh, Spacemetric AB) DMC - the 2nd Generation DMC Sensors and New Satellites launched in 2011(Gary Holmes, DMCii) RapidEye - Our Future Focus (Brooke Tapsall, RapidEye) Time and Resolution: CosmoSkyMed VHR data in support to precision farming applications (L. Pietranera1, L.Cesarano1, V.Gentile1, F.Britti 3, F.Strehl 2,A.. Relin 2,R. Siegmund 2 1) e-GEOS; 2) GAF AG; 3) e-GEOS /SIN) LIODOTNET introduction to training and new issues (Simone Gentilini, JRC)	Implementation of GAEC in Croatia (Pavel Trojáček, Ekotoxa; Zdravko Tušek Tomislav Jurina, PAAFRD, HR) Potential of LPIS data for monitoring of environment policy integration: focus on NHV farming in Estonia (Valentina Sagris, Min of Agric.EE; Tambet Kikas, Tartu University; Vincenzo Anglieri, JRC) Detecting artificial areas inside reference parcels. A technique to assist the evaluation of non-eligibility in agriculture (R.De Kok, C.Wirnhardt, JRC) Time and Resolution: CosmoSkyMed VHR data in support to precision farming applications (L. Pietranera[1], L. Cesarano[1], V. Gentile[1], F. Britti[3], F.Strehl[2], A. Relin[2], R. Siegmund[2], [1] e-GEOS; [2] GAF AG; [3] e-GEOS /SIN) New GAEC controls through high revisit SAR (Filippo Britti, e-Geos)

12.30-14.00	Coffee Break	
	Parallel Session 3 ROOM PETERSON Area measurement by GNSS Chair: Co-chair: P.Loudjani (JRC)	**Parallel Session 4 ROOM JACOBSON LPIS Chair: Marcel Meijer (Univ. Wageningen) Co-chair: Wim Devos (JRC)**
14.00-15.40	Maussanne study on GNSS measurements: preliminary results (B. Hejmanoska, Uni. Krakow; P. Loudjani, C. Lucau, K. Ganisheva, D. Fasbender, JRC)	An assessment of the Bing imagery for LPIS purpose (Slavko Lemajic, JRC)
	Investigation of tolerances for on-the-spot checks (Markus Jahn, WIBank Essen)	Best practice for assuring the quality of LPIS data (Grega Milcinski, Sinergise)
	Identifying and modeling sources of uncertainty in GNSS area measurements (D. Fasbender, C. Lucau JRC)	Challenges in using GNSS tracks for updating LPIS and parcel boundaries (Tamme Van der Wal, AeroVision)
	GNSS workshop 2011 (C. Lucau, JRC)	Refresh 2.0: a new approach to LPIS update (Fabio Slaviero, ABACO)
15.40-16.10	Coffee Break	
	Training and Bilateral meetings ROOM GRAND PANORAMA	**Second part of Parallel Session 4 in ROOM PETERSON**
16.10-17.50	New LIODOTNET training (Simone Gentilini, JRC)	Key Findings of the Amsterdam LPIS WS (Martijn Kromjongh, EL&I)
	Bilateral meeting with Image Providers (CID-IA Team JRC)	Lesson learnt from the 2010 LPIS QA implementation (Pavel Milenov, Piotr Wojda, JRC)
		GIS in Estonian ARIB - latest developments (Romal Belov, ARIB)
		Pro-rata management in pasture land eligibility evaluation (M. Piomponi, P. Guerra, AGEA)
20.00-	**Gala Dinner Meriton Grand Conference & Spa Hotel offered by EE Ministry of Agriculture with participation of Minister Mr Seeder**	

Day 3 (November 25, 2011)

Closing Plenary Session ROOM PETERSON Chair: Olivier Leo (JRC)	
9.00-9.30	CwRS Campaign: image acquisitions (Eugenio Gervasini, JRC)
9.30-9.50	CwRS Campaign: MS statistics (Paolo Pizziol, JRC)
9.50-10.10	LPIS QA 2012 (Wim Devos, JRC)
10.10-10.30	GEOCAP Activity 2011 + Workprogramme 2012 (Philippe Loudjani, JRC)
10.30-11.00	Coffee Break
11.00-11.40	Summary of parallel sessions (10’ x 4) (Session’s Rapporteurs, JRC)
11.40-12.00	Conference Awards (Dominique Fasbender, JRC)
12.00-12.30	Highlights, forward look & closing (Olivier Leo, JRC; C.Sode, DG AGRI D1; Philippe Loudjani, JRC)
12.30-14.00	Lunch Break

End of the conference

Gold Sponsors

e-geos
AN ASI / TELESPAZIO COMPANY

EUROPEAN SPACE IMAGING
MEMBER OF WORLDVIEW GLOBAL ALLIANCE™

ASTRIUM
AN EADS COMPANY

Silver Sponsors

RapidEye
Delivering the World

SINERGISE

dmc
International Imaging

20 years
ABACO

European Commission
EUR 25533 – Joint Research Centre – Institute for Environment and Sustainability

Title: **Geomatics in support of the Common Agricultural Policy – Proceedings of the 17th GeoCAP Annual Conference, 2011**

Editors: D. Fasbender, K. Taşdemir, Ph. Loudjani, V. Angileri, C. Lucau, P. Milenov, W. Devos, R. De Kok, S. Lemajic, A. Tarko and P. Pizziol

Luxembourg: Publications Office of the European Union

2012 – 91 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1018-5593 (print), ISSN 1831-9424 (online)

ISBN 978-92-79-26644-7 (pdf)
ISBN 978-92-79-26645-4 (print)

doi:10.2788/51820

Abstract

The 17th Annual Conference GEOCAP, took place from 23 to 25 November, in Tallinn, venue Meriton Hotel, and was organized by JRC MARS with the support of Estonian Ministry of Agriculture and of the Estonian Paying Agency (PRIA).
The Conference covered the 2011 Control with Remote Sensing (CwRS) campaign activities in the frame of CAP (common agricultural policy) controls for area-based subsidies. As usual, the Conference has offered an overview on the state of art technologies and methods applied to the above mentioned controls.
Registered participants were 301, but 270 turned up. The composition of the audience was Commission Services, industry (image providers and software providers), Member States administrations (Ministries of Agriculture, Paying Agencies and academia). Participants came from all MSs, plus Croatia, Turkey, FYROM, Iceland, Switzerland and Norway.

LB-NA-25533-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Publications Office

ISBN 978-92-79-26644-7