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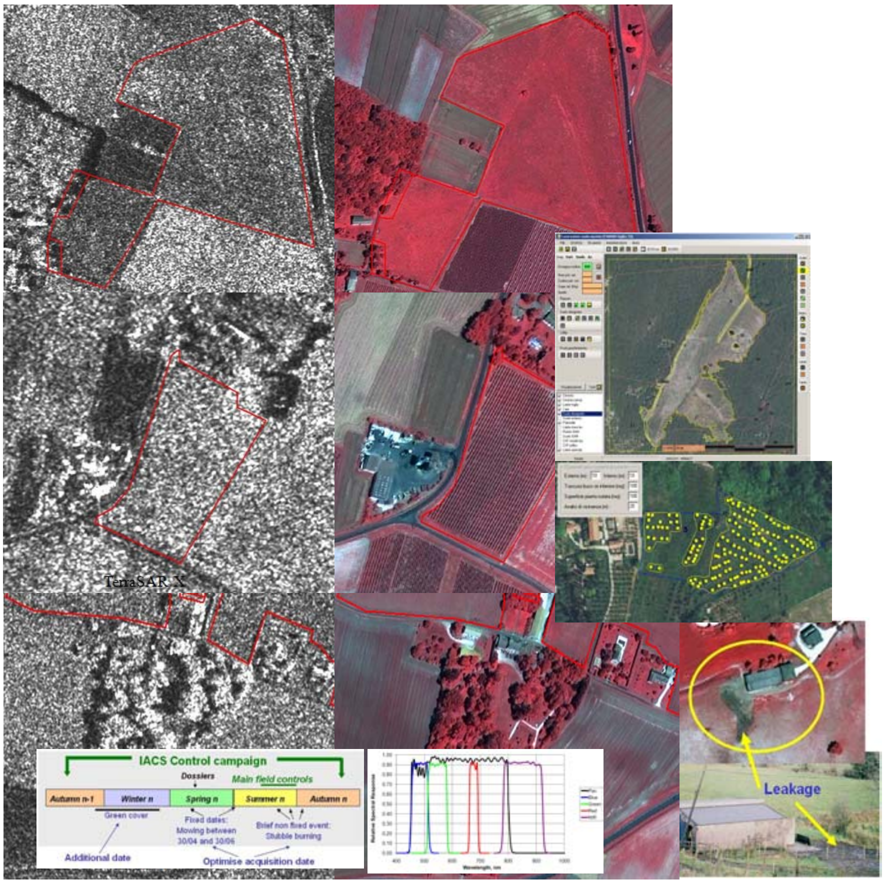
Geomatics in support of the Common Agricultural Policy

Proceedings of the 14th GeoCAP Annual Conference, 2008
Cankarjev dom Cultural and Congress Centre, Ljubljana 3rd-5th December 2008

Edited by: Vincenzo Angileri, Simon Kay, Hervé Kerdiles and Philippe Loudjani



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Contents:

Conference Abstract

The 2008 Annual Conference, jointly organised by the GeoCAP (former MARS PAC) action of the Joint Research Centre (Ispra, Italy) and the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia, covered the Control with Remote Sensing activities as well as technical aspects of Land Parcel Identification Systems (LPIS) and ortho-imagery use in Common Agricultural Policy (CAP) management and control procedures. The conference was the 14th organised by GeoCAP to review this important and still growing area of technical activity, in support of the CAP implementation.

The program was structured into two days of plenary sessions (Wednesday 3rd and Friday 5th December) and one day (Thursday 4th December) with parallel sessions, including a restricted session for national and regional administrations. More than 350 participants from 36 countries attended.

The presentations delivered during the conference were made available on line within some days of the event, and this publication represents the best presentations judged worthy of inclusion in a conference proceedings aimed at recording the state of the art of technology and practice of that time.

Acknowledgements

The editors of this publication, as well as all team members of the GeoCAP action, would like to express sincere thanks to the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia, for both material and logistical support in the organisation and hosting of this successful and popular meeting. They would like to thank all persons from the Slovenian administration that were involved and without whom the conference could not even have taken place. A special thank to Alenka Rotter and Branko Ravnik of the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia for their important contribution.

We would also like to thank the presenters for agreeing to submit their work as papers, as well as the peer review committee for devoting their valuable time at the meeting to identify the most suitable presentations to be published.

Peer review process and committee

Up to the 11th Conference, MARS PAC 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, selected by a peer review committee during the conference. Moreover, it seemed worthwhile to start making a more ambitious historical record of the information presented, with real proceedings that collects the more interesting scientific and technical work undertaken by the stakeholder community represented at the conference. It was decided, therefore, to encourage better quality presentations by selecting the best ones with the possibility of including a conference-style paper in a special JRC publication.

Since the 12th MARS PAC annual Conference held in Toulouse (France) in 2006, peer reviewed proceedings have been produced and published for each MARS conference.

To achieve credibility on this publication, a peer-review committee was assembled, mostly external to the JRC. This committee members organised themselves to attend the technical sessions of the conference, and decided upon the short list of presentations and one poster for publication.

The proceedings here are a result of that shortlist, and the conference organisers and the editors are grateful to the assistance provided in reviewing the presentations in the short time frame available.

The Peer Review committee members were:

- Mr. Krištof OŠTIR, Chairman of the Committee, Scientific Research Centre of the Slovenian Academy, Slovenia;
- Mr. Birger PEDERSEN, Aarhus University, Denmark;
- Mr. Borut PEGAN ŽVOKELJ, Geodetic Institute, Slovenia;
- Mr. Axel RELIN, GAF AG, Germany – sponsor;
- Mr. Rupert WAITE, Rural Payments Agency, United Kingdom;
- Mrs. Michaela WEBER, European Space Imaging, Germany;
- Mr. Csaba WIRNHARDT, Institute of Geodesy, Cartography and RS, Hungary;
- And Mrs. Joanna PLUTO-KOSSAKOWSKA, Joint Research Centre, European Commission.

As a result of the proceedings selection and thanks to GAF AG that kindly sponsored it, awards for the best presentation, poster and software demonstration were assigned to:

Best presentation: Aleksandra Sima, Results of GNSS test;

Best poster: Rafal Zielinski, An automatic detection of potential non-conformities in the LPIS;

Best software demonstration: Lars-Åke Edgardh, The Saccess national Swedish satellite database as a platform for access to large volumes of imagery.

Plenary session 3: Land Parcel Identification System

QC LPIS: AN AUTOMATED SYSTEM FOR LPIS DATA QUALITY CONTROL, USING KNOWLEDGE MANAGEMENT AND INFERENCE TECHNIQUES

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KEY WORDS: Land Parcel Identification System (LPIS), Integrated Administration and Control System (IACS), Quality Control, validation

ABSTRACT
Since 2006, Abaco invested in the field of LPIS quality control, working together with real users in order to apply several techniques available in the IT industry, with a special focus on the quality assessment of spatial data included in IACS systems. Paperwork has been published on the subject, including the recent "Scientific and technical Report" of the JRC named "Land Parcel Identification System – Anomalies' Sampling and Spatial Pattern", and the more general "LPIS Core Conceptual Model: methodology for feature catalogue and application schema". Furthermore, it's some years that automated recognition of patterns has been applied through the well known Olicount and Oliarea components procedures. Today the image processing and pattern recognition techniques, combined with knowledge management and inference techniques, and finally with Spatial Analysis, can be used to perform automated quality assessment of the data stored within an LPIS. In addition, knowledge management can play an important role, allowing the system to take advantage of historical analysis accomplished on the geographical data, to find out recurring patterns and storing effective knowledge. The objective has been that of building a formalized and repeatable process, continuously checking for geographical data quality, and advising on possible inconsistencies or needs, in order to take immediate actions to correct anomalies over and over.

1. INTRODUCTION

The LPIS is the main instrument called upon by the Common Agricultural Policy (CAP) Regulations to identify land and quantify area eligible for payment. From these common requirements, more than 30 different implementations have been developed in Member States. The importance of the quality of these LPIS systems, i.e. the degree to which they perform as a tool for controlling the direct aid to farmers, is driven by the extremely high value of the aid concerned (some € 38 billion annually).

To date, quality assessment is mostly performed on an ad-hoc basis, during audit missions that cover the full IACS aid system of which LIPS is one component. The Geo-information management team of the JRC (GeoCAP- MARS Unit) is currently designing a Quality framework that is more inclined on a Quality Assurance (QA) approach rather than on quality audits. The QA approach requires Member States and the Commission to agree on requirements, translated into specifications with acceptance levels, and testing procedures. This would enable the Member States to perform the controls and the test results should demonstrate a satisfactory performance.

This quality framework implies:

- Identifying, specifying and quantifying the critical quality elements,
- Developing and testing test procedures, including sampling and inspection procedures,
- Designing the reporting system,
- Offering tools that support its implementation.

International Standards (ISO) offer a conceptual basis for this quality framework and our design is strongly relying on these. Following this approach, Abaco and Agea started working on an automated tool (code name QC_LPIS) which allows to:

- perform a **formalized** and **repeatable** Quality Control (QC) process,
- continuously check for geographical **data quality**,
- advise on possible **inconsistencies** or needs,
- take immediate actions to **correct anomalies** over and over.

Apart from being a tool for Quality Control, it provides support in order to determine LPIS areas that need to go under revision or update.

The aim of this work, and the issues raised during its development, shouldn't be treated as a document describing the specific image processing techniques and/or Information Technology tools, rather it should be a spur for discussion on the methodologies and workflow needed to formalize a repeatable and assessable process for Quality Control.

In addition this work produced a software tool that has to be seen as a framework allowing to define the Quality Control process and to "plug-in" the different algorithms that might be required due to different landscapes.

2. QUALITY

Quality has always to be defined within a context, having in mind four major concepts:

1. Quality has to refer to a specific "target", e.g. the objective we want to measure quality about
2. Quality applies to specific "objects" to be measured
3. Quality implies the presence of comparable objects, which quality level is known upfront, known as "reference objects"
4. Quality implies the knowledge of existing bias on measurements, also known as "tolerance".

In our case, and thinking of the LPIS context, the four concepts become:

1. Target – topology and land-use
2. Objects – homogeneous Polygons derived from the LPIS (Regions)
3. Reference Objects – updated layers (new orthophotos, new satellite images, certified vectorial, etc.) on a determined Region
4. Tolerance – known tolerances given by GIS algorithms, GPS, legislation, knowledge of territory.

Looking at the figure 1, you can see the four concepts applied to LPIS (look at the yellow area).

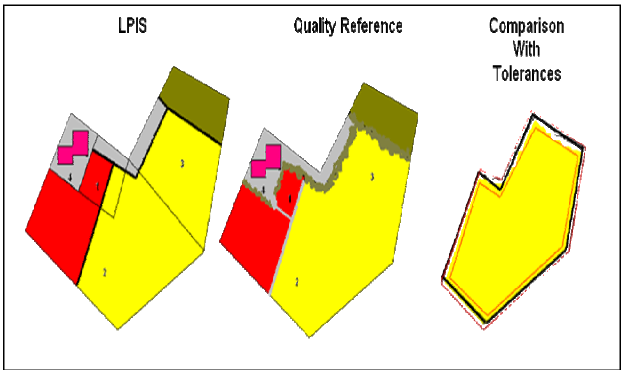


Figure 1. Target, Object, Reference and Tolerance

3. REGIONS

Since the Member States have different type of "objects" registered in their LPIS, meaning that the Reference Parcel can be registered at a different level (Agricultural parcel, Farmer's block, Physical block, or Cadastral parcel), we introduced the concept of Region (usually it is very similar to Farmer's block).

Looking at figure 1, one of the regions is identified by the yellow area. In the LPIS the region can be registered with a different number of reference parcels (yellow area on the left), which has to be compared with a reference object representing the land-use (yellow area in the centre).

The Region is therefore defined as follows:

- A Region is a homogeneous polygon derived from Reference Parcels, according to one of the types specified for LPIS;
- Homogeneous Polygon means a continuous polygon by crop group, or land use.

A Region can be derived from Physical Blocks, through subdivisions, or from Agricultural Parcels through unions. Farmer's block represents a good balance.

4. TOPOLOGY ANOMALIES

Some anomalies can be found and corrected with deterministic algorithms at the topology level. This is required in order to avoid comparing objects which have "geometry" problems (figure 2).

Main anomalies in this field are represented by:

- Overlaps
  - Reference Parcels (RP)
  - Land use polygons
- Discard or rectification:
  - RP not fully classified
  - RP adjacent but not touching (holes, slivers)

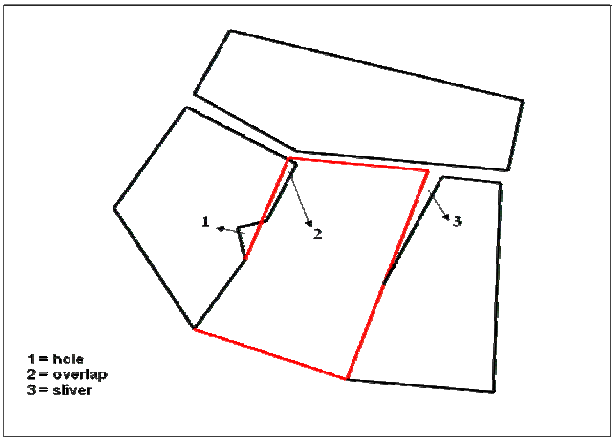


Figure 2. Topology Anomalies

5. TRAINING OF THE SYSTEM

As explained in paragraph "2. Quality", it is always necessary to know exactly the characteristics of certain areas, which will be used as a reference to determine the quality of the objects in the LPIS.

At the same time, it is possible to use a certain number of these reference regions to train the system.

If we think of a country which might have very different landscapes, it will be better to choose a certain number of "meaningful areas", representing "at best" the local landscape.

It's known that image processing algorithms work best on limited areas. Working on a wide area causes, in fact, the features to be undiscoverable due to measurable values being hidden by “average” calculation.

Therefore the system gives the possibility to define multiple reference objects to be used for comparisons, each representing a certain area.

The best number and size of this areas have been the subject of a recent “Scientific and technical Report” of the JRC named “Land Parcel Identification System – Anomalies’ Sampling and Spatial Pattern”.

Once the reference areas are determined, they will almost remain unchanged throughout the years, and only a recurrent update will be needed above these areas, without the need of a full reference objects revision.

6. THE PROCESS

Now that we have defined all the elements that will be used to determine the quality of the LPIS, we can review the process needed to prepare the data, and the process needed to assess the quality.

The following steps constitute the overall process:

1. Prepare the reference objects by homogeneous landscapes
2. Train the system on the reference objects
3. Set the proper tolerances for quality control
4. Run anomalies check and corrections on topology
5. For each Region
    a. Intersect RP with existing and validated data sources
    b. Apply image processing and pattern recognition algorithms
    c. Apply segmentation algorithms
    d. Apply geometric algorithms based on tolerances, including rectification
    e. Use inference algorithms based on training to determine land classification
    f. Compare to reference objects applying tolerances
    g. Produce quality indexes or reports

While steps 1 to 4 were explained in previous paragraph, we can specify the steps contained in 5, which bring to the determination of a quality index, or to a list of areas where certain anomalies are probable.

We start from a set of Reference Parcels contained in the LPIS (figure 3).

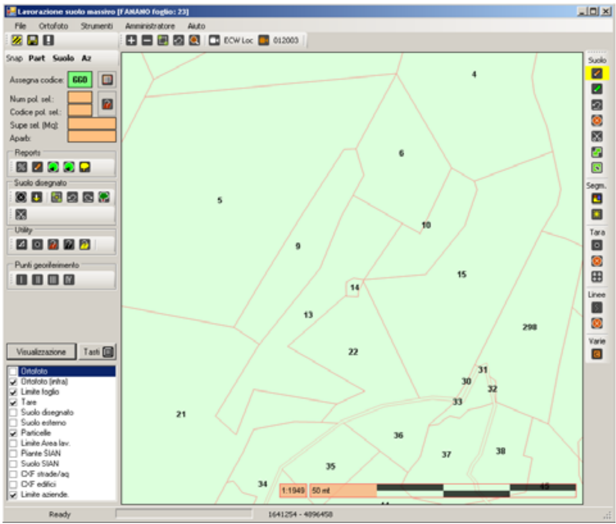


Figure 3. Reference Parcels

The next object will be the Region under investigation (figure 4) which can be a mixed imagery/vector object to be provided to the Quality Control System.

Figure 4. Region under inspection

Step 5.a uses, as a basis, the existing certified layers, like roads, buildings, vineyard cadastre, and hydrography layers, to determine known areas that were assessed through other procedures (figure 5).

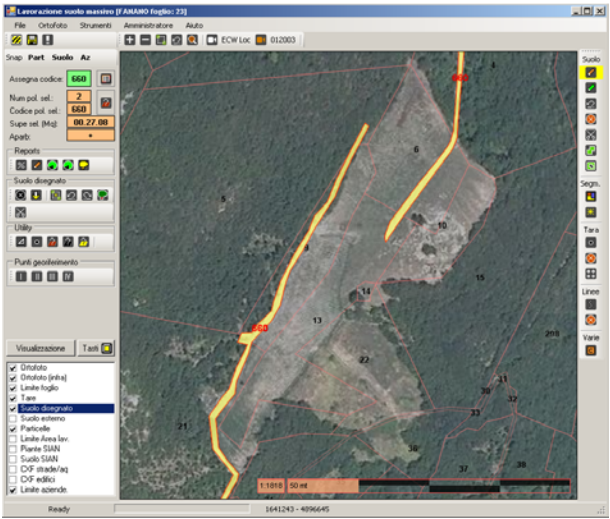


Figure 5. Intersecting Region with certified layers

Step 5.b uses as a basis existing image processing algorithms to determine some known patterns within the Region under inspection.

Among these algorithms we used Oliarea and Olicount (figure 6), plus a proprietary algorithm for vineyards (figure 7).

Figure 6 – Oliarea and Olicount

Figure 7 – Other image processing algorithms

Step 5.c consists of a set of image processing algorithms to segment areas according to the characteristics of the Region (figure 8).

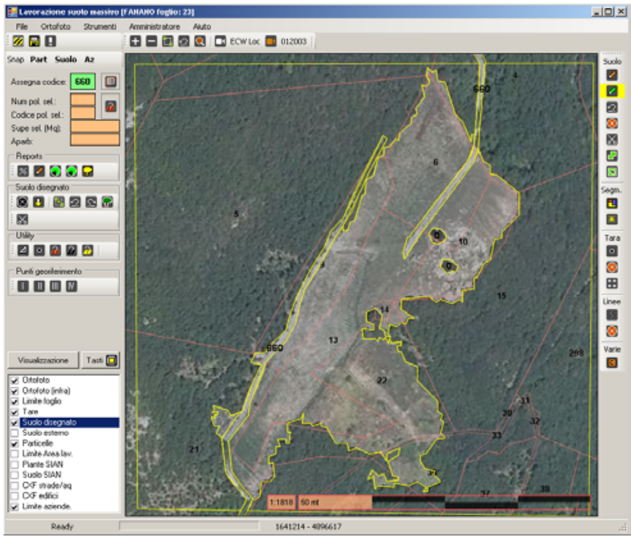


Figure 8- Segmentation

Step 5.d compares the original polygons and the segmentation result in order to resolve any discrepancies that might be considered computational errors, or provides a list of anomalies to be solved manually (figure 9).

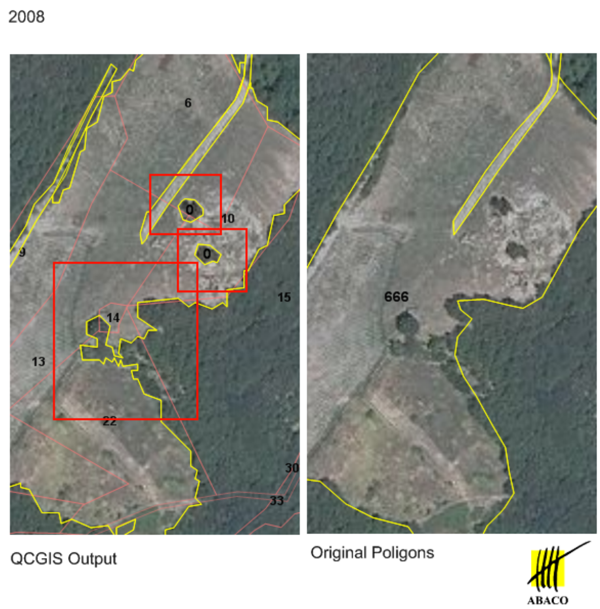


Figure 9. Rectification with tolerances

Step 5.e tries to do an automatic classification (figure 10), using the knowledge of the system (see par. 5. Training of the System).

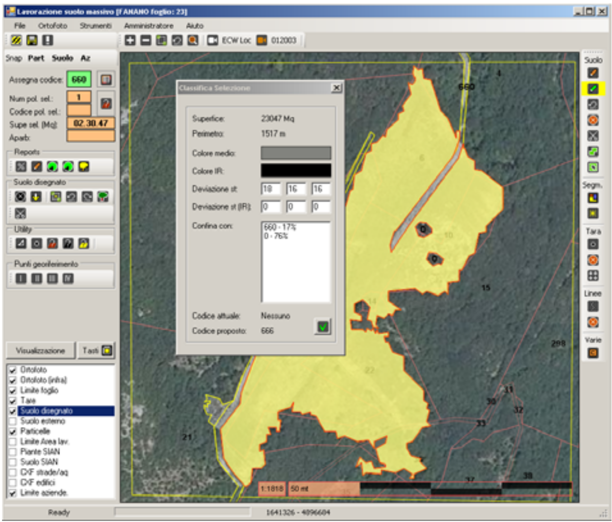


Figure 10. Automatic classification

With step 5.f, finally a comparison with the Reference Objects will provide a simple quality index or a list of anomalies, which will be used to take further actions, like the decision to run an update of the LPIS layers.

All the algorithms used can be substituted or integrated using a simple plug-in mechanism.

7. AUTOMATIC CLASSIFICATION

Probably the most interesting process resides in the algorithm that determines automatically the class of a given area.

The training process is intended to create a series of Markers, specific to a Region, which are then used to calculate a Fitness function. This function is the core of the heuristic algorithm that determines the likelihood of the claimed use against the known use.

Markers depend on the type of information available and can span from RGB values of orthophotos to landscape attributes.

The first definition of the Fitness function, for the purpose of the project is described hereafter. The definition of the function is subject to enhancements in the following versions of the software.

$$Fitness_{Region}(X) = \sum_{i=1}^{n} \frac{|RefMarker_{Region,i} - Marker_{Region,i}(X)|}{weight_{Region,i}}$$

where:

- $RefMarker_{Region,i}$ is a numeric indicator representing knowledge of features in a certain landscape
- $Marker_{Region,i}(X)$ represents a feature indicator of a Region X
- $weight_{Region,i}$ represents the importance of a feature

The Fitness function is then used on a Region to determine possible anomalies.

$$\forall \text{ A}, Marker_{Region,i} \in \text{subset(LPIS)}$$
$$\text{if } |\text{Fitness(A)} - \text{Fitness(B)}| > \text{Tolerance}$$
$$\Rightarrow \text{Possible Anomaly}$$

where:

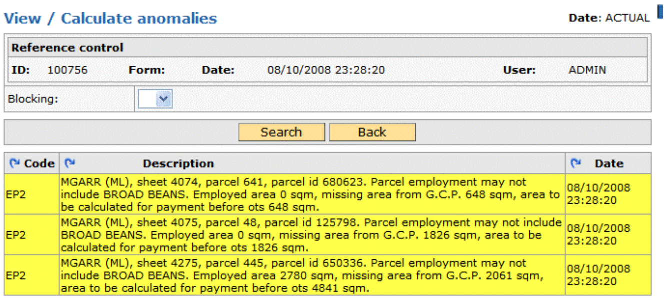
- A = LPIS Homogeneous Region
- B = Reference Area
- A geometrically equivalent to B

A simple case of the above is:

$$\forall \text{ A} \in \text{subset(LPIS), if LandUse(A)} \neq \text{LandUse(B)}$$
$$\Rightarrow \text{Anomaly}$$

8. INTEGRATION WITH THE IACS

This process, can be repeated several times producing detailed reports (figure 11).


View / Calculate anomalies — Date: ACTUAL

Reference control

ID: 100756 Form: Date: 08/10/2008 23:28:20 User: ADMIN

Blocking:

Search Back

Code	Description	Date
EP2	MGARR (ML), sheet 4074, parcel 641, parcel id 680623. Parcel employment may not include BROAD BEANS. Employed area 0 sqm, missing area from G.C.P. 648 sqm, area to be calculated for payment before ots 648 sqm.	08/10/2008 23:28:20
EP2	MGARR (ML), sheet 4075, parcel 48, parcel id 125798. Parcel employment may not include BROAD BEANS. Employed area 0 sqm, missing area from G.C.P. 1826 sqm, area to be calculated for payment before ots 1826 sqm.	08/10/2008 23:28:20
EP2	MGARR (ML), sheet 4275, parcel 445, parcel id 650336. Parcel employment may not include BROAD BEANS. Employed area 2780 sqm, missing area from G.C.P. 2061 sqm, area to be calculated for payment before ots 4841 sqm.	08/10/2008 23:28:20

Figure 11. Example of report

Also it can be easily integrated within an existing IACS (figure 12), in order to perform repeated checks during the year.

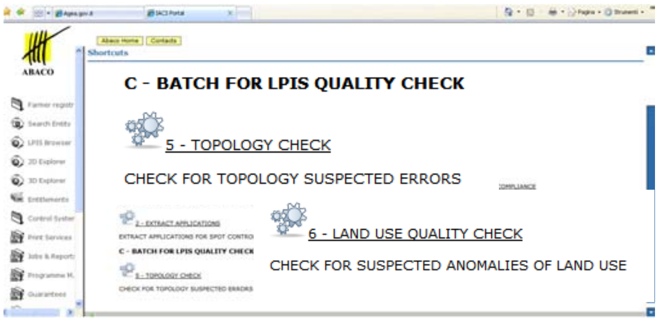


Figure 12. Integration with Control procedures of IACS

9. CONCLUSIONS

An integrated system has been built to supply for qualitative opinion on:

- topology properties of geometrical elements stored in the LPIS (reference parcels and land-use)
- parcels extension recognized as "actually used"
- accuracy and level-of-update of the land-use classification, compared to any information source available (orthophotos, satellite images, vector information, etc.).

The system either reads directly from any LPIS using standard spatial architectures, or it works on datasets extracted from any existing LPIS.

The features and outcomes of the system include:

- Access configuration to existing spatial data sources, including existing LPIS

- Configurability of anomalies to check, together with parametrization and tolerances
- Sample extraction and/or definition for the knowledge management information base and rules
- Interactive tests
- Switch between different datasets to be checked
- Automated report of anomalies found (customizable)
- Statistical analysis on anomalies distribution.

Behind the scenes, a series of well-known and heuristic approaches, are responsible to provide an immediate vision on LPIS data quality. Among them:

- Image processing
- 2D and 3D spatial analysis
- Sequential and comparative algorithms
- Topology analysis with anomalies recognition (holes, overlaps, unused stripes, etc.)
- Land-use analysis with historical comparison
- Automated spatial segmentation
- Automated spatial correction
- Automated unification
- Pattern matching.

10. REFERENCES AND SELECTED BIBLIOGRAPHY

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11. ACKNOWLEDGEMENTS

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Plenary session 4: Review of the 2008 CwRS campaign

IMAGE ACQUISITION STRATEGY: REVIEW OF 2008, PLAN FOR 2009 AND FUTURE CAMPAIGNS

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KEY WORDS: Control with Remote Sensing, image acquisition budget, CAP area based subsidies, on-the-spot checks

ABSTRACT
Since the mid 1990s, remote sensing images have been used by Member States (MS) every year to check farmers'claims for agricultural subsidies. As from the 2005campaign, Very High Resolution (VHR) satellite optical imagery has been used to a large extent (more than 120,000 km^2 per year) by most MS. As a result, a budget of about 6M€ has been allocated every year by DG AGRI for the purchase of satellite images. In 2008, for the first time the amount of imagery requested by MS exceeded by 1M€ the available budget. This paper describes the strategy used to meet the 2008 image budget, the consequences of this strategy on the 2008 campaign and the measures adopted for future campaigns.

1. INTRODUCTION

The use of remote sensing for the control of area based subsidies claimed under the Common Agricultural Policy (CAP) has been recognized since the early days of the 1992 CAP reform. In effect, the 1992 Council regulation authorized MS to "use remote sensing to determine the area of agricultural parcels, identify crops and verify their status" (cf. Art 8 of Reg. 3508/1992). Actually the 1992 reform, which shifted from production based to area based subsidies, was adopted partly due to the possibilities offered by (satellite and aerial) remote sensing for checking field areas, since the Commission at that time, on the basis of experience gained on existing aids based on area, had a fear that fraudulent claims could be difficult to control (Jacquot, 1998).

In the early years of the 1992 reform, remote sensing was considered as a new and complex technique. Therefore, in order to give access to this technique to all MS, the Commission decided to finance both the satellite imagery requested by MS for their control and part of the interpretation work. In 1994, the funding of satellite remote sensing imagery was laid down in regulation 165/1994. The acquisition and purchase of satellite imagery on behalf of the MS was managed by DG AGRI up to the 1998 campaign and then transferred to the JRC. At this time, a budget of 1.6 - 1.7 M€ was necessary for the acquisition of High Resolution (HR) imagery; the acquisition of aerial photos being the responsibility of MS themselves.

With the expansion of the European Union (EU) from 12 MS in 1994 to 27 MS in 2007 and the development of remote sensing, in particular of Very High Resolution (VHR) satellite imagery[1], the budget allocated by DG AGRI for the purchase of imagery has increased from 1.5 M€ in the early years to 6.5M€ in 2008 and 2009. At the end of 2007 it became clear that MS requests for imagery for 2008 would exceed for the first time the budget available. Therefore, drastic measures had to be taken to meet the budget and a model was devised in order to distribute the available image budget among the MS.

The objective of this paper is to describe the strategy adopted to meet the budget for the 2008 campaign, to review the consequences of this strategy and to present the measures adopted for the following campaigns.

2. BUDGET REQUESTED BY MS FOR THE 2008 CAMPAIGN

As for every campaign, in autumn 2007 MS requests for imagery for the 2008 campaign were collected by the JRC.

Type of imagery	# of zones requested	# of windows or km^2 (VHR)	Budget (k€)
HR	256	758[2] (3 windows / zone)	2,620
VHR	280	180 000 km^2	3,970
VHR back up	134	106 000 km^2	1,060
SAR back up	12	36 windows	30
Total			7,680

Table 1. summary of MS <u>requests</u> for imagery for the 2008 campaign.

[1] By VHR imagery, it is meant imagery with a ground sampling distance (GSD) of the order of 1m (typically 0.5 to 3m) whereas HR imagery is characterized by a GSD of the order of 10m (typically from 5 to 30m).

[2] The number of HR windows does not include the 111 autumn & winter 2007 images (taken on the 2007 budget) but includes the same number of autumn & winter 2008 images (as a hypothesis since MS requests for the 2009 campaign were not known yet)

These requests totalled 7.7 M€, i.e. 1.2 M€ above the budget already approved by DG AGRI for 2008 (see table 1). Therefore some reductions to MS requests had to be made. Moreover, it should be stressed that the 180,000 km^2 to be acquired by the prime VHR sensors (i.e. Ikonos and Quickbird) exceeded the maximum capacity estimated by the VHR image providers.

3. STRATEGY TO MEET THE 2008 BUDGET

In order to meet the 2008 budget, two strategies were possible:
(1) Reduce the number of images requested by MS asking more than their “share”, i.e. requesting a % of the total EU budget significantly higher than their % of the total area checked with RS;
(2) Target the reductions on images considered as “less necessary” for the control.

Although MS requesting more than their “share” can be identified by plotting the % of budget requested with respect to the total budget versus the % of area checked with respect to the total area checked for each MS (see figure 1), this option was not considered appropriate at the end of 2007 since no maximum image budget per MS had been defined. Fixing such a maximum for each MS would require some model taking into account parameters such as the number of farms checked with RS, the CwRS methodology employed, the average farm size…

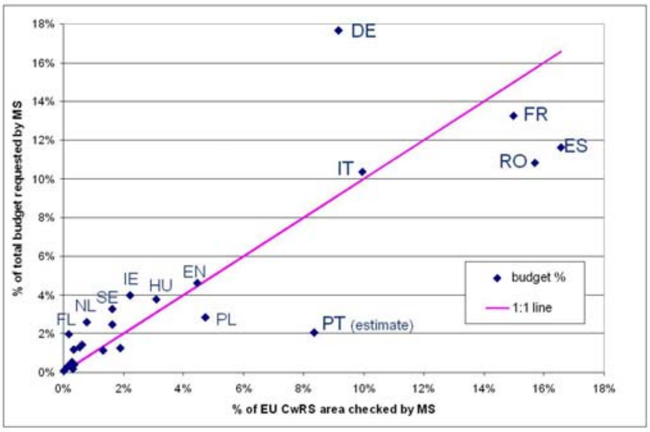

Figure 1. Budget requested by MS for the 2008 campaign versus area checked with RS by the same MS expressed as % of the total image budget and the total area checked with RS. DE clearly appears above average due to a high request of VHR data (31,000 km^2 / 180,000 km^2) whereas PT is below the 1:1 line as it did not request any VHR data.

The reductions were therefore targeted towards images or windows considered as less crucial for CwRS, i.e. HR and VHR back up images:

All MS requesting three HR images over the spring-summer period were allocated only two HR images, i.e. the HR window overlapping the VHR window was cancelled; the impact of this measure was thought to be low as the HR image is often redundant with the VHR (multispectral) image programmed over the same period. However, since VHR sensors on average need a longer window than HR sensors to cover a zone, there was a risk that the VHR image would be acquired too late with respect to the optimal acquisition date (e.g. one month after the end of the cancelled HR window). In this case a multispectral image would be missing over a key period (due to the late acquisition of the VHR image), so it was decided that MS should have the possibility of requesting a suitable HR image, provided such an image could be found in the archive of HR image providers.

As regards the back up of the VHR prime image, the whole strategy was reviewed: up to the 2008 campaign, MS had indicated the zones for which they needed back up VHR imagery. However experience had shown that back up imagery was hardly ever used so it was decided to reduce the number of back up images requested by MS. Furthermore, in order to manage the acquisition of back up imagery more effectively, a more flexible system was introduced:

- Firstly, it was decided that the zones to be backed up would be selected by the JRC on the basis of the feasibility study supplied by the VHR image providers.
- Secondly, back up programming of these zones would be cancelled as soon as the VHR prime image had been acquired (i.e. the back up window would be closed); as in previous campaigns any back up image acquired before or on the same day as the VHR prime image would still have to be purchased.
- Thirdly, the opening of the back up windows would be delayed by 10 days with respect to the VHR prime window. This would allow the VHR prime sensors to acquire some zones and subsequently focus back up effort on zones not yet covered by the prime sensors.
- In case the VHR back up selected had only the PAN band, a multispectral “HR” image over the same window, preferably Spot 5 (10m) or Formosat 2 (8m) would be programmed on request of the MS.
- HR SAR back up was cancelled completely since, with the entry into force of SPS and the limited number of claims for coupled aids, it was no longer considered useful for the controls.

As a result of this strategy, the requested image acquisitions were adjusted to meet the available budget of 6.5M€ (see Table 2). The main reductions were the following:

- 0.5M€ on the VHR back up imagery; instead of the 1M€ requested, a lump sum of 0.5 M€ was allocated to back up; this amount corresponded to 40 zones covered with VHR Pan and HR data simultaneously, or 65 zones with VHR Pan only data;
- 0.6M€ on HR images: for 13 MS, the number of HR windows over the spring-summer period was reduced from 3 to 2 and for one (PT) from 5 to 4. As a result the total number of planned HR windows decreased from 758 to 598, i.e. an average of 2.4 windows per HR zone as compared to 3 in the initial request.

Type of imagery	# of zones requested	# of windows or km^2 (VHR)	Budget (k€)
HR	252	598 (2.4 windows / zone)	2,030
VHR	276	178 000 km^2	3,920
VHR back up	40 – 65		550
SAR back up	0		0
Total			6,500

Table 2. Adjusted budget for the 2008 campaign as it was presented to DG AGRI and the MS at the end of 2007. There is a reduction of 2000 km^2 in the VHR imagery following the decision by Italy to drop four zones.

Moreover, one MS (Spain) requested to move the VHR window from spring 2008 to autumn winter 2007-2008 over zones predominantly covered with olive and almond trees so as to improve the discrimination between these two types of trees. This strategy could save up to 11,400 km^2 of VHR data from the 2008 budget, hence releasing the corresponding budget for back up.

Further adjustments were later made in early 2009 following the precise definition of zones by MS and the results of the feasibility study performed by VHR image providers. The main changes were the following: Poland dropped 10 of its 40 zones (-2000 km^2); Spain had 6 zones successfully covered with autumn-winter VHR acquisitions (3400 km^2); For Germany, two zones had to be directly programmed with back up sensors as the prime VHR image providers estimated that they could not acquire them (-2700 km^2); Denmark changed its control strategy i.e. moved from a control based on VHR and HR images to a method based only on one VHR image (at the same time, it defined two additional zones for 1000 km^2 more).

At the Kick-off (KO) meeting of the 2008 campaign held on 3-4 April 2008, the final plan was to acquire 164,000 km^2 of VHR prime data (264 zones for 3.64 M€), 47,000 km^2 (56 zones for 0.86M€) of back up imagery and 594 HR images over 244 zones (2.0M€).

4. OUTCOME OF THE 2008 CAMPAIGN

The outcome of the 2008 campaign is shown in table 3. Due to bad weather conditions during the summer, not all planned images were actually acquired[3]. Only 5.2M€ from the 6.5M€ budget was spent for the 2008 campaign.

	Planned HR / VHR images	Acquired HR / VHR images	Budget (k€)
HR	594	538 (campaign 2008)	1,500
VHR	164,000 km^2	154 000 km^2	3,100
VHR back up	47,000 km^2 (56 zones)	35,000 km^2 (41 zones, 29 HR)	600
Autumn 2008	111 HR	74 HR + 3 VHR	300
Total			5,500

Table 3. Comparison between the planned acquisitions at KO 2008 and the actual acquisitions at the end of the 2008 campaign. The 300 k€ budget for autumn 2008 imagery is based on acquisitions planned in October 2008 (74 HR + 3 VHR) while the plan made in autumn 2007 is in the 1st column.

To summarise, the 2008 campaign started with a request exceeding the budget by 1.2M€ and ended with a carry over of 1.3M€. Of this 1.3M€, 300 k€ were planned to be used for autumn / winter HR and VHR acquisitions for the following campaign, which leaves 1M€ under-spent with respect to the plan at the KO meeting (540, 260 and 200 k€ were saved from the VHR, VHR back up and HR planned budgets respectively). In hindsight, the restrictions imposed on MS (in particular on HR imagery) were not necessary. However, at the time of planning image acquisitions, the rate of failures was assumed to be zero because the current rules do not allow the JRC to plan for more images than can be covered by the budget; in other words "overbooking" is not allowed by the financial regulations.

5. STRATEGY FOR THE 2009 AND FUTURE CAMPAIGNS

Following the difficulties encountered in the 2008 campaign, it was decided for the future to:

- Collect MS requests for following campaigns in July of each year so as to be able to inform MS of possible budget cuts in September[4] (i.e. by November it is usually too late for MS to request extra budget from their own financial authorities, should the need arise).
- Re-establish the second HR window over spring-summer. Due to poor weather conditions over some zones, the early spring (typically April) HR image was not acquired and the VHR window (typically planned over May June) was acquired at the end of June or early July. This lack of multisprectral image between January and early July 2008 made crop recognition difficult, which is a problem for checking coupled payments, aids related to the Rural Development Plan (RDP) and some cross compliance measures (e.g. crop rotation, nitrate directive). In order to avoid as much as possible redundancy with the VHR image, this second HR image could be cancelled in case of successful acquisition of the VHR multispectral image.
- Devise a model allocating a maximum budget per MS, so that each MS knows the maximum amount it can request as a function of the number and type of remote sensing checks it plans and the farm characteristics (see below).

In order to prepare the 2009 campaign and avoid as much as possible budgetary problems as encountered in the 2008 campaign, a meeting between JRC and DG AGRI was held in July 2008. During this meeting, DG AGRI informed JRC that the 2009 image budget had already been fixed to 6.5M€ early in 2008. However there was a possibility to use the entire remaining budget from 2008 for the 2009 campaign, i.e. not only the amount needed for autumn imagery, provided that the image (bulk) orders were made before 1st January 2009. For the 2009 campaign, this meant an extra 1M€ could be available for ordering imagery in early 2009 - typically between January and March - before the release of the 2009 budget by DG AGRI. In some previous campaigns, this budget release had occurred as late as early April, which had impacted on (southern) MS that were ready to start their OTS checks early in spring.
Furthermore, DG AGRI indicated that an increase of the image budget could be considered for checking cross compliance and RDP measures, provided that these checks were based on sound and cost effective methods. It was up to the JRC to inform MS of the possibility to request additional images or zones for such checks, to verify which GAECs or RDP measures could be checked with remote sensing (Loudjani, 2008) and to collect as early as possible MS wishes for the 2010 campaign (the 2010 budget was to be decided in early

3 For instance in Ireland, due to this exceptional weather two zones had no 2008 VHR data at all and four had TerraSAR X data programmed in emergency at the end of July (i.e. VHR SAR back up of 1m for 2 zones and 3m for the other 2).

4 However, experience from 2009 showed that it was difficult for MS to formulate their requests for imagery before the end of one campaign since at this time they do not know the rate of OTS checks for the following campaign.

2009). By the end of 2008, only Italy had expressed a request for extra zones and images dedicated to cross compliance and RDP checks.

6. MODEL OF BUDGET ALLOCATION

In addition to the above mentioned measures, a model for allocating a maximum budget per MS was devised. It was felt that such a model might be needed if the amount requested by MS exceeded the available budget and if critical imagery was affected by budget cuts.
To establish such a model, the idea was to “predict” the image costs for each MS in 2007 and 2008, using the following explanatory variables:

- the amount of direct aid received by each MS;
- the number of RS checks
- the average farm size,
- the CwRS methodology i.e. the percentage of control zones with HR imagery.

Only two campaigns (2007 and 2008) were considered since the number of MS was constant at 27 and also because MS CwRS strategies had stabilized over these last two years following the entry into force in 2005 and 2006 of the 2003 CAP reform.

The amount of direct aids received per MS (i.e. the national ceilings as found in Annex VIII of Reg. 1782/2003 amended by Reg. 1156/2006) was taken as a potential explanatory variable with the idea to allow a higher image budget to MS benefitting from higher CAP funds. In other words, the idea was to allow some proportionality between the amount of aid distributed by a MS and the maximum amount of images allocated to that MS. On the other hand, MS receiving a relatively low share of the CAP funds but having many claims to check could also justify a high request of imagery. This is considered by taking as explanatory variable the number of RS checks. However farm size (and ideally parcel distribution pattern around the main farm buildings) should also be taken into account since checking a farm of several hundreds of ha requires more km^2 of (VHR) imagery than a farm of a few ha as shown by figure 2.
By multiplying the number of RS checks by the average farm size, a new variable denominated “claimed area checked with remote sensing” was obtained and used as potential explanatory variable. The CwRS methodology was also partly taken into account through the percentage of HR zones (i.e. zones checked with VHR and HR imagery) within a MS (this percentage ranges from 0 for MS using only VHR imagery to 100% for MS using VHR and HR imagery for all zones).

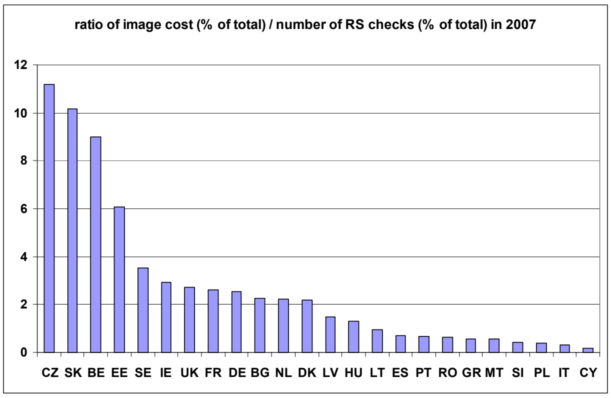

Figure 2a. Ratio of image cost per MS (in % of the total image cost) to the number of RS checks per MS (in % of the total number of RS checks) for the 2007 campaign.

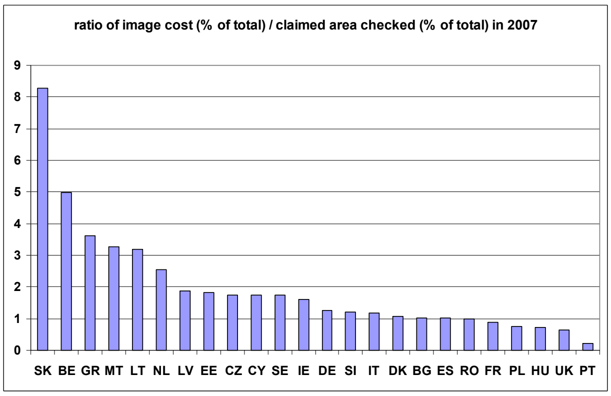

Figure 2b. Ratio of image cost per MS (in % of the total image cost) to the claimed area checked with RS (in % of the total claimed area checked with RS) for the 2007 campaign.

In figure 2a, high ratios are due to MS asking a higher percentage of the total image budget than their percentage of RS checks (e.g. CZ asked 3% of the image budget to check 0.3% of the claims checked with RS). Such a high ratio could be explained by the average size of the farms checked in the control zones (145 ha for CZ versus 2 ha for CY; these are the two extremes for 2007) or by the MS sampling strategy (e.g. BE samples the claims falling inside its control zones in order to improve its risk analysis whereas other MS may check all the claims falling inside their zones to maximize the use of the imagery). When the number of RS checks is replaced by the claimed area checked with RS, i.e. the number of RS checks x average size of the controlled farms, the “ranking” of MS may change: CZ and CY end up with the same ratio of 1.7 while SK and BE still remain with a high ratio; for BE, this is due to their sampling strategy; this could also be the case for SK where the average farm size derived from the summary statistics is of 28 ha whereas the average claim for SK is of 127 ha).

Ordinary least squares linear regression was used to predict the image cost at MS level for campaigns 2007 and 2008 as a function of the potential explanatory variables for these same campaigns. Three MS / years were not taken into account in performing the regression:

- PT 2007 and 2008 as PT did not request any satellite VHR data and was therefore not considered as representative of all MS (moreover the PT data on the number of RS checks and average farm size were estimates based on previous campaigns);
- DE 2008 due to its opposite behaviour, i.e. its very high request (nearly 17% of the total budget).

The best model was obtained by taking the logarithm of all variables:

$$\text{Ln(image\_cost in €)} = 0.512 \times \ln(\text{claimed area checked with RS in ha}) + 0.203 \ln(\text{amount of aid in M€}) + 4.592$$

Table 4 shows the statistics corresponding to this model which explains 91% of the variations in image costs (R2 = 0.914).

Figure 3 shows the predicted image costs versus the actual cost per MS for campaigns 2007 and 2008 while figure 4 shows the model residuals, i.e. the difference between the actual cost and the cost predicted by the model for each MS and campaign. On average, the difference between the requested image budget and the predicted one was around 50,000€ for campaigns 2007 and 2008. Exceptions are PT which could have claimed 200,000€ more of (VHR) imagery and Romania in 2007 and Germany in 2008 which exceeded by 200,000 and nearly 500,000 € their respective image budgets.

Model	Unstandardized coeff.		T	Sig.
	B	Std. error		
(constant)	4.593	0.512	8.973	0.000
Ln(aid)	0.203	0.054	3.731	0.001
Ln(claimed area checked)	0.512	0.066	7.734	0.000

Model	Sum of squares	df	Mean square	F
Regression	63.510	2	31.755	224.177
Residual	5.949	42	0.142	(Sig. 0.000)
Total	69.460	44		

Table 4. Coefficients and ANOVA of the selected model.

In practice, such a model could be used to give MS an order of magnitude of the image budget they can request.

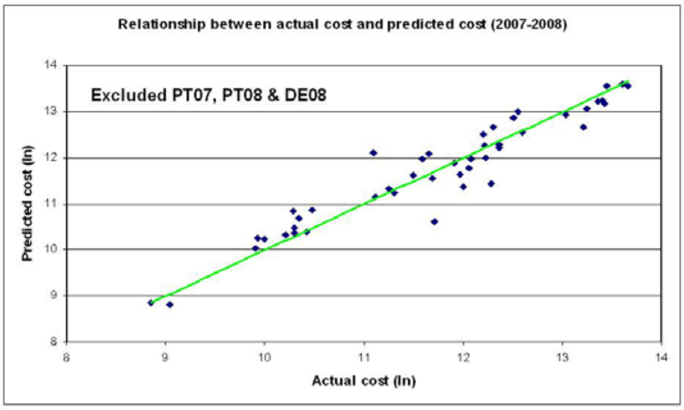

Figure 3. Actual image cost (logarithm of cost in €) versus image cost (logarithm of cost in €) predicted by the model per MS for campaigns 2007 and 2008 (1:1 line in green).

7. CONCLUSIONS

The 2008 CwRS campaign was an exceptional campaign as regards the management of the image budget for various reasons: for the first time in some 10 campaigns managed by the JRC, the MS requests exceeded by far the available budget allocated by DG AGRI. As a result, restrictions on certain images had to be imposed upon MS. At the end of the campaign, due to poor weather conditions, 1.3M€ resulted in not being spent. In order to improve the management of the image budget for future campaigns, a number of measures were adopted:

- VHR back up will be decided by JRC on the basis of the feasibility study of VHR image providers and flexibility will be introduced into the management of back up images in order to focus satellite resources on zones that may need back up;
- The carry over of a campaign will be fully utilised for the following campaign, which will allow for sudden increases in image requests and for imagery to be ordered in winter and early spring before the release of the campaign budget. An alternative to increase the use of the budget could be to allow MS to define additional zones in the course of the campaign if the rate of OTS checks has to be increased significantly following the identification of a particularly high rate of anomaly.
- A model has been devised to predict the maximum image budget to be allocated to each MS as a function of the number of RS checks, the average claimed area of a farm and the amount of CAP funds received by the MS, should such a solution become necessary.

Moreover, extra budget might be allocated specifically for checking cross compliance or RDP measures, if the control of such measures proves to be sound and cost effective using RS imagery.

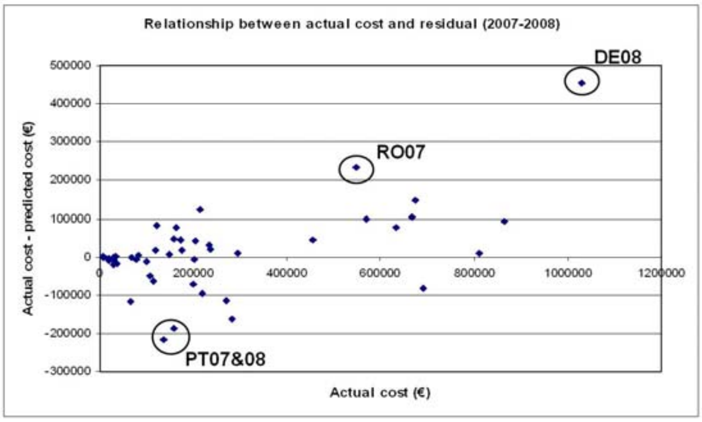

Figure 4. Residuals, i.e. difference between the actual and the predicted image costs as a function of the actual image cost in € per MS for campaigns 2007 and 2008.

8. ACKNOWLEDGEMENTS

We would like to thank David Grandgirard for his support in the search for the best model for allocating image budget to MS and Maria Erlandsson for providing the data on the outcome of the 2008 campaign.

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Technical session 1: New sensors, potential applications

GEOEYE-1, A NEXT GENERATION SATELLITE FOR THE CWRS CAMPAIGN

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ABSTRACT

On September 6th, 2008 GeoEye Inc. launched its GeoEye-1 satellite which is now the world's highest resolution and most accurate commercial imaging satellite. GeoEye-1, equipped with the most sophisticated technology used in a commercial satellite system, offers unprecedented spatial resolution by simultaneously acquiring 0.41-meter panchromatic and 1.65-meter multispectral imagery. The high geospatial accuracy of GeoEye-1 imagery combined with its high agility and collection capacity is expected to become a valuable asset for the JRC CwRS campaign. In this paper, Eurimage – part of the Telespazio Group, exclusive distributor of GeoEye-1 imagery in Europe and North Africa, with also non-exclusive rights in most of the rest of the world – will discuss technical and operational details of the sensor and provide an overview of GeoEye products, methods of operation and multi-sensor capabilities, accompanied by image samples, focusing especially on the constellation capacity and its ability to meet the requirements of the CwRS campaign.

1. INTRODUCTION

Following the great success of the IKONOS satellite, the first 1-m resolution optical satellite for commercial use, GeoEye Inc – the company created after OrbImage Inc acquired Space Imaging Inc in 2005 –launched on September 6th 2008 from the Vandenberg AF Base on a Boeing Delta II launch vehicle its newest optical satellite for Earth Observation, GeoEye-1.

From the very beginning, the plan for this satellite was to build an advanced instrument having all the operational requirements that GeoEye biggest customer and satellite co-financier (the US Government National Geospatial Agency, NGA) was requesting. Three technical requirements were especially important from the beginning: a very high resolution (the highest possible on the commercial market, or even better), a very high standalone geolocation accuracy (for accurate mapping in remote areas) and a very high daily imaging capacity (especially suited for large mapping projects).

In addition to that, because of the new US policy on data with very high resolution (i.e. below 82 cm) and in order to significantly increase the satellite collection efficiency and the overall VHR data availability to all potential users, GeoEye decided to change slightly its old IKONOS operation model. It moved away from the so-called ROC (Regional Operating Centre) network of uplink/downlink stations, which also fully owned the data they were tasking and acquiring, to a more US-centralized approach. This approach would allow better control as well as more integration and less competition among the different strategic partners on a worldwide basis.

However, the continued importance of having strong local partners has moved GeoEye to finalize new exclusive commercial agreements with big local players in the market of remote sensing, through the development of a new network of so-called CRA (Commercial Regional Affiliates) partners. To this end, GeoEye has selected Telespazio SpA (a Finmeccanica / Thales company based in Italy) as the new GeoEye CRA for Europe and Northern Africa. This exclusive commercial agreement gives the Telespazio group – which is composed of different companies working all over Europe, including GAF/Euromap in Germany, Aurensis in Spain, GEOS and Eurimage in Italy – the possibility to commercially supply on an exclusive basis GeoEye-1 Satellite Products to all customers in Europe and North Africa, thanks also to a tasking and production facility to be placed in Europe. Through the same CRA Agreement Telespazio has also been granted non-exclusive distribution rights to customers located in most of the rest of the world.

In addition to the GeoEye-1 CRA agreement, GeoEye and Telespazio entered also into a similar agreement for the IKONOS data acquired starting from January 1st, 2009. This agreement grants Telespazio the exclusive rights to commercialize IKONOS Products in Europe and North Africa, the only company in this area authorized to directly task the satellite, downlink the data, process and distribute the images. Telespazio has implemented this tasking right through a service agreement with European Space Imaging (EUSI), that will operate its station on behalf of Telespazio.

After a period of commissioning, on February 5, 2009 GeoEye announced the SCO (Start of Commercial Operations) of

GeoEye-1 satellite products, followed a few days later, on February 20, 2009 by the NGA certification of the GeoEye-1 products, giving the system Full Operating Capability (FOC).

2. TECHNICAL CHARACTERISTICS

The GeoEye-1 satellite has been built to have more than 7 years of operational life, thanks also to the fact that it has enough fuel for 10 years of operations. It is a high-orbit sun-synchronous satellite, having a sensor that allows the simultaneous acquisition of a high resolution panchromatic image and a 4-band multispectral image (blue – green – red - near infrared). The main technical characteristics of the GeoEye-1 satellite are summarized in Table 1 and Figure 1 below.

Orbital characteristics	
Launch date	6 September 2008
Orbit height	684 Km
Equatorial crossing time	10:20 AM
Revisit (50 cm GSD, at 40° latitude)	3 days
On-board solid state recorder	1 Terabit
Imaging characteristics	
Swath width (at nadir)	15.2 Km
Daily capacity (Pan only)	700,000 Km^2
Daily capacity (Pan + MS)	350,000 Km^2
Geopositional accuracy	5 m CE90%
Sensor characteristics	
Imaging sensor bit depth	11 bit
Panchromatic sensor	
GSD (at nadir)	41 cm
Bandwith	450 – 800 nm
Multispectral sensor	
GSD (at nadir)	1.65 m
Bandwith (blue)	450 – 510 nm
Bandwith (green)	510 – 580 nm
Bandwith (red)	655 – 690 nm
Bandwith (near infrared)	780 – 920 nm

Table 1. GeoEye-1 technical characteristics

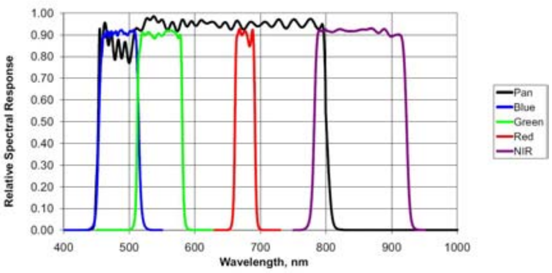


Figure 1. GeoEye-1 spectral response

The GeoEye-1 satellite is flying exactly on the same orbit as the IKONOS satellite, but with a 180° phasing. This configuration allows the maximum revisit of the GeoEye constellation of 2 VHR satellites, allowing serving in the quickest way every need related to emergencies and intelligence needs.

All GeoEye-1 products will anyway not be delivered at full resolution, but subsampled to 50 cm resolution (Pan) or 2 m resolution (MS). This is due to a US Government regulation. This product resampling still allows the GeoEye-1 satellite to provide more information in its images compared to a satellite which has a native GSD of 50 cm at nadir. In fact, up to a viewing angle of about 26°, GeoEye-1 images are originally acquired with a resolution better than 50 cm.

One of the most important characteristics of the GeoEye-1 satellite is its very high geopositional accuracy, which is the best available on the market so far. The 5 m CE90% geolocation accuracy (excluding topographic distortions and considering nadiral acquisitions) is achieved through the use of state-of-the-art technologies previously flown only on USG intelligence satellites. This technology includes high accuracy star trackers from Ball Aerospace, Monarch GPS receivers and Litton Scaleable Inertial Reference Units (SIRU) Gyros. First tests done by GeoEye show how the 5 m CE90% geolocation accuracy has been achieved at SCO, and actually in most cases it is even better than expected, as it can be seen in Figure 2.

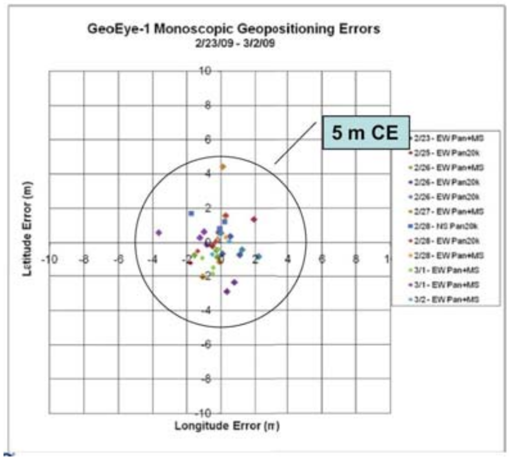


Figure 2. Results of GeoEye-1 independent accuracy tests during CAAP

3. GEOEYE-1 OPERATIONS IN EUROPE

In the new GeoEye CRA scheme, all the operations linked to satellite control are centralized in the US, in order to maintain the level of control required by the US Government licence to operate a satellite with a resolution better than 82 cm. This means that the uplink of commands to the satellite as well as the downlink of its raw compressed acquisitions is done directly from the GeoEye US stations (Dulles, Virginia and Thornton, Colorado) or from a network of fully automated remote terminals in polar areas (Tromsø, Norway; Barrow, Alaska; Troll, Antarctica), figure 3.

Figure 3. GeoEye-1 Ground Stations Network

In the GeoEye-Telespazio CRA Agreement, it is foreseen that Telespazio will buy from GeoEye and operate a GeoEye-1 Imaging and Processing Facility (IPF). This facility will allow Telespazio to receive the raw compressed data acquired by the satellite from the US a few hours after the acquisition, and to process and deliver them to Telespazio customers. In addition to this activity, the most important aspect of the IPF is related to satellite tasking. Through the use of a Collection Planning System (CPS) based on the latest technology of AGI/STK and ad-hoc modules developed by OrbitLogic, the IPF operators will be able to plan the best collections, optimizing the commercial needs of Telespazio with the latest local weather forecasts to avoid clouds. The only difference with the old, similar model used by IKONOS ROCs, is that the IPF has no satellite uplink capacity, and therefore the collection plan needs to be finalized about 30-45 minutes before the satellite pass, in order to send it to GeoEye in the US, where it will be integrated with other orders (if possible) and uploaded to the satellite.

The GeoEye-Telespazio CRA Agreement grants Telespazio a certain percentage of top priorities for the GeoEye-1 orbits over Europe and North Africa. During the orbits where Telespazio has top priority rights, the collection plan optimized by Telespazio using the CPS at the IPF, cannot be changed by any other order or customer.

Telespazio has decided to locate its GeoEye-1 IPF inside the DLR facility of Neustrelitz (Figure 4), in Northern Germany. The station will be operated by the people of EUROMAP and GAF, which are Telespazio controlled companies, with the support of DLR. DLR will also support the IPF operations using the experience and tools developed by the DLR/DFD at their station in Oberpfaffenhofen.

Figure 4. The DLR facility of Neustrelitz

The GeoEye – Telespazio CRA Agreement allows Telespazio to serve its customers also with new acquisitions made by the GeoEye-1 and IKONOS satellites outside Telespazio imaging territory. This task will be carried out directly by GeoEye, using the on-board memory of the satellites, and Telespazio will distribute the products generated from these acquisitions.

4. GEOEYE-1 FOR THE CWRS CAMPAIGN

In order to present JRC with an overview of the potentialities of the GeoEye-1 satellite to be used as a primary source of images for the Control with Remote Sensing (CwRS) campaign of MARS (Monitoring Agricultural ResourceS), Telespazio, with the support of Eurimage and GeoEye, has run some initial acquisition simulations. It has been decided to focus on Spain, and use the 2008 distribution of control sites that can be seen in Figure 5.

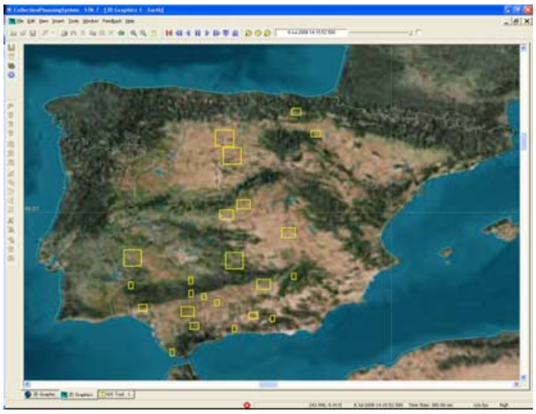


Figure 5. Distribution of 2008 control sites in Spain

The 2008 Spanish sites considered were 23, ranging from 2,000 Km^2 to 200 Km^2, and having an overall surface of 16,300 Km^2. The GeoEye-1 simulation showed that, using only 5 passes (27-29 June, 2-5-8 July) the satellite is able to make a first complete coverage of all the sites. Figure 6 shows the sequence of 5 passes used to accomplish this excellent result.

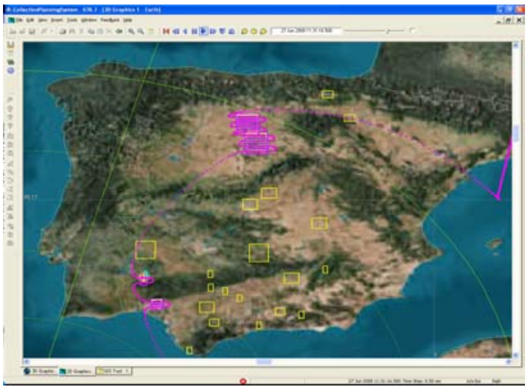
This acquisition sequence means that in only 12 days the GeoEye-1 satellite can acquire a very large number of distributed sites, maintaining also a viewing angle better than required (all images acquired at 57°–90°, JRC requirement is 50°–90°). It must be also noted that, in order to acquire the 16.300 Km^2 of the 2008 Spanish sites, the GeoEye-1 satellite in the end has acquired almost 25.000 Km^2, considering the overlap between adjacent strips and the so-called unordered area around the sites resulting from the 15,2 Km swath.

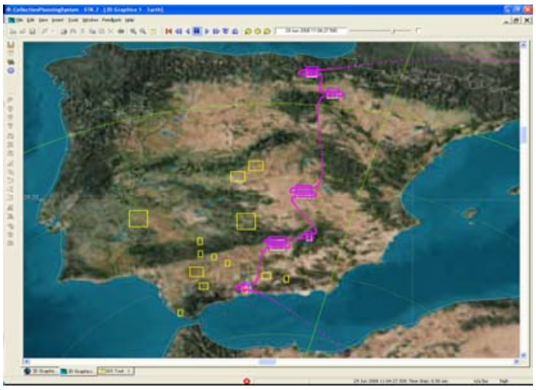
Of course such a simulation does not take cloud cover into account, but if we even consider that we might need 3 times as many satellite passes to get good cloud coverage, still the GeoEye-1 satellite is able to accomplish such a large coverage within the normal requested acquisition windows, which are about 6 weeks.

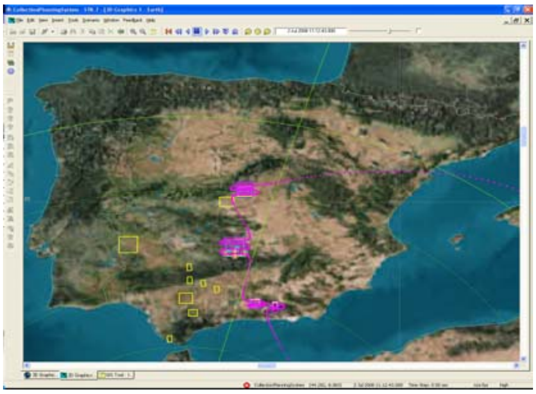
5. FIRST TEST RESULTS

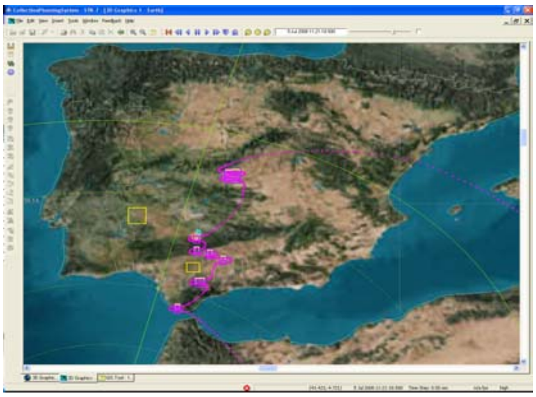
In order to validate the GeoEye-1 Products and verify their accuracy and processing procedures, Telespazio has been able to provide JRC with 2 test acquisitions made before SCO. The 2 images were acquired over the test site of Mausanne (southern France) and were acquired during the same pass of January 27, 2009 but with different geometry (elevations of 83° and 61°). The products were delivered with Geo™ Processing level, which is a standard 2A processing level with the presence of Rational Polynomial Coefficients (RPCs). Both products were delivered as Bundle (i.e. Panchromatic at 50 cm resolution and Multispectral files at 2 m resolution, separately), but JRC has also the option to order Pan-sharpened Colour Products at 50 cm resolution.

The first preliminary results achieved on the Orthocorrection of these GeoEye-1 images, using differential GPS Ground Control Points (GCPs) and a DEM derived from the ADS40 aerial camera, are very interesting and confirm to us the very high accuracy of the GeoEye-1 satellite. In particular, considering that these are Products acquired and processed before SCO, and therefore not yet fully compliant with GeoEye final specifications, we observed that using only four well-distributed GCPs, the final ortho accuracy seems to be below one pixel. Of course we will wait for the final results of the rigorous JRC evaluation of these products, but the preliminary results we are having seem to be very good.









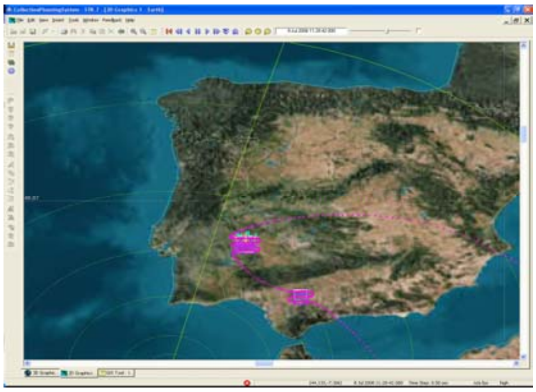


Figure 6. Sequence of 5 GeoEye-1 passes needed to fully acquire the 2008 Spanish sites

It must be added that right now the processing was done using the IKONOS RPC model of Erdas and PCI, as the GeoEye-1 model has not been released yet by the major Image Processing software vendors. Anyway the IKONOS model seems also to work with GeoEye-1 products very well, thanks to the fact that the image format of the two GeoEye satellites is absolutely identical.

6. CONCLUSIONS

In this paper we describe the main technical and operational characteristics of the new GeoEye-1 satellite from GeoEye, which is exclusively distributed in Europe and North Africa by the Telespazio group. Thanks to the unique characteristics that make it the most advanced optical satellite available now on the market, the GeoEye-1 satellite is surely one of the best imaging tools to use for the JRC CwRS Campaign. The Telespazio group is working very closely with JRC to assure that the GeoEye-1 satellite can be used with success, starting already with the 2009 CwRS Campaign.

It should be noted that the Telespazio GeoEye-1 IPF at Neustrelitz will not be operational in time to carry out the activities for the 2009 Campaign, and therefore GeoEye Inc. has committed itself to supporting Telespazio and JRC in the best way, tasking the satellite over Europe to best acquire the 2009 control sites that JRC will dedicate to the GeoEye-1 satellite.

In the following Figures 7 and 8 we will show some screenshots of 50 cm GeoEye-1 Colour images of the Mausanne test area, showing the level of detail of this sensor, and giving a clear evidence of its potentialities for the JRC CwRS Campaigns.

Figure 7. Overview of the Mausanne test area in natural colours (RGB=321) and False Infrared colours (RGB=432)

Figure 8. Full resolution detail in natural colours (RGB=321) and False Infrared colours (RGB=432)

Technical session 2: Image processing, data serving

PROVIDING ACCESS TO TERABYTES OF EARTH OBSERVATION DATA – INFRASTRUCTURE, SERVICES, AND LICENSING

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KEY WORDS: data services, data policy, data curation, image catalogue, image archive, earth observation data, licensing terms

ABSTRACT
The Joint Research Centre (JRC) of the European Commission stores large amounts of low, medium, high and very high resolution earth observation data in a heterogeneous manner. The scientific units within the JRC are the users of these data. An internal project called Community Image Data portal (CID) has been set up to rationalize the situation. One of its main activities is to implement and maintain a core repository with catalogue, processing and dissemination services.
Access to the earth observation data and their usage are mainly governed by the various licensing terms and conditions imposed by data providers. Therefore the CID project is also involved in defining these terms and conditions mainly through the set up and management of framework contracts. These contracts shall take into account data policy definitions laid down by various initiatives in the spatial data domain.

1. INTRODUCTION

A large amount of earth observation (EO) data is stored at the Joint Research Centre (JRC) of the European Commission by numerous scientific units in a heterogeneous manner. An internal project called Community Image Data portal (CID) has been set up to deal with this situation and address the requirements of the research community. An emphasis has been placed on the implementation of data services and data curation, while at the same time complying with restrictions based on intellectual property rights (IPR).

Earth Observation Data at the JRC

In order to get an overview of the usage of satellite remote sensing (SRS) data at the JRC, a survey (Åstrand, P) took place in December 2006 – January 2007. The objectives were to make an inventory of existing satellite data and future requirements; to obtain an overview of how data is acquired, used and stored; to quantify human and financial resources engaged in this process; to quantify storage needs and to query the staff involved in image acquisition and management on their needs and ideas for improvements.
From this survey, it appeared that by 2007 an annual 15 person-years spread over 20 projects were placed on image acquisition and data management for a global expenditure on SRS data of 7.2 M€. At that time, the total amount of image data stored was 55 TB with an estimated increase to more than 80 TB by the end of 2008.
With respect to the data itself, a wide variety of platform/sensors of all spatial resolutions are used at JRC: mostly MeteoSat, NOAA AVHRR, Spot Vegetation, Seawifs, MERIS, Modis, Aster, Landsat, Spot, IRS, Ikonos, Quickbird, Eros, ERS, Radarsat. The total amount of datasets was estimated in 2007 to be 650000 Low Resolution (LR) images, 50000 Medium Resolution (MR) images, more than 12000 High Resolution (HR) images, and more than 500000 km² of Very High Resolution (VHR) imagery.
The data are stored in many different file formats, projections and processing levels. Furthermore, several types of licences determine data usage.

Requirements from JRC Earth Observation Data Users

During the survey JRC scientific officers expressed a strong interest in the set up of a service at JRC level operated by the CID project which would offer a Long Term Archive including a central catalogue, common storage repository with backup facility, access to data via file-based protocols, and FTP for download. In addition, data access should be possible via protocols defined by the Open Geospatial Consortium (OGC), namely the Web Map Service (WMS) and the Web Coverage Service (WCS).
Besides these general requirements, emphasis was placed on the one hand on the possibility for users to add custom metadata about their data and, on the other hand on the reliability of the service as some users are running operational services such as crop monitoring for yield estimates over Europe or forest fire monitoring. In addition, long term archiving also requires thorough conception and implementation of data curation principles.

Data Licensing Issues

Access to the EO data and their usage are very much governed by licensing terms and conditions imposed by image data providers. Therefore acquisition and management of EO data needs to address these issues to provide the best possible data access mechanisms to the user community.

2. DATA CURATION

Definition

The definition of data curation handled by CID is the one by P. Lord: "Data curation is the activity of managing and promoting the use of data from its point of creation, to ensure it is fit for contemporary purpose, and available for discovery and reuse. For dynamic datasets this may mean continuous enrichment or updating to keep it fit for purpose."
Archiving is "a curation activity which ensures that data is properly selected, stored, can be accessed and that its logical and physical integrity is maintained over time, including security and authenticity."
Preservation is "an activity within archiving in which specificitems of data are maintained over time so that they can still be accessed and understood through changes in technology" (Lord, P).
CID is involved in each of the data curation sub-activities defined above as the data workflow in place largely demonstrates.

CID Data Workflow

The complete CID data workflow can be divided into four steps as shown in Figure 1.1. CID does not always manage the acquisition or preprocess the data it is archiving. As a result, the workflow can be simplified as in Figure 1.2 or even become minimal as in Figure 1.3.

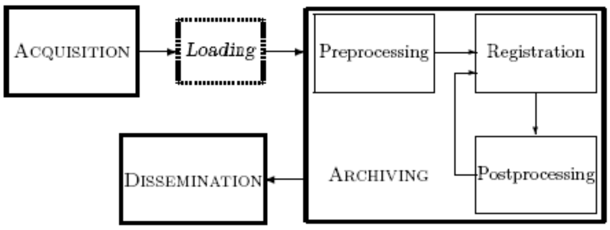

Figure 1.1. CID data workflow

CID manages several framework contracts for the *acquisition* of satellite imagery from various sensors such as DMC, Eros, Quickbird, GeoEye, SPOT, etc. Large parts of the image archive managed currently have been acquired based on them.
Common licensing conditions apply to all data purchased through these framework contracts.

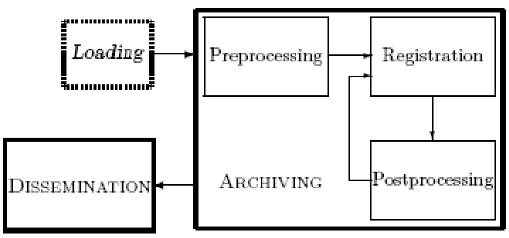

Figure 1.2. Simplified data workflow

Acquired data is *loaded* into the archive for future reuse and dissemination by means of a dedicated application usable by any JRC staff.
The *archiving* activity is a complex process which goes far beyond simply copying files onto a disk space. Briefly, we can identify three steps:
• Preprocessing: This optional step consists of orthorectifying automatically raw satellite data for which archiving has been requested.
• Registration: This step consists of (a) copying the loaded data, possibly with related preprocessed data, to a specific location on the disk storage, (b) referencing them and their metadata in a catalogue and (c) setting file system permissions accordingly. Some metadata can be automatically extracted depending on the type of data being loaded.
• Postprocessing: This step comprises all processes applied to registered data to prepare them for dissemination. Based on the type of data being processed, it includes computing image histograms; creating and referencing previews, ecw files, virtual datasets, etc.

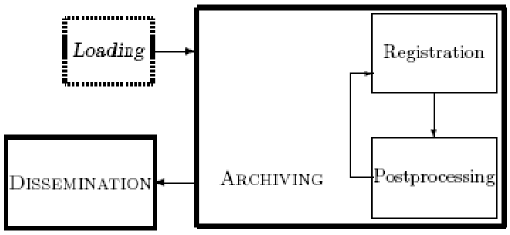

Figure 1.3. Minimal data workflow

The *dissemination* activity is the visible part of the CID portal. Data can be searched for via a web interface or via a CSW compatible client. They can be previewed online using the web search interface. According to their credentials, users with an account on the portal can access data via various view and download services. Registered users from the JRC may simply prefer to access data directly from their computer through file system protocols. Users have a fine control over the data access services through their personal account on the CID portal.
Data preservation is guaranteed by various checks and monitoring systems, dedicated backup strategies and system redundancy ensuring consistency and reliability of data and data services.

3. COMMUNITY IMAGE DATA PORTAL

System Architecture

All systems have been set up in High Availability in order to meet user requirements for reliability with minimal downtime and to be in line with the concept of a Long Term Archive. All services are implemented as master/slave or in load balancing (Fig 2). The underlying hardware is located in a data centre with secured power supply, redundant network connections and internet access.

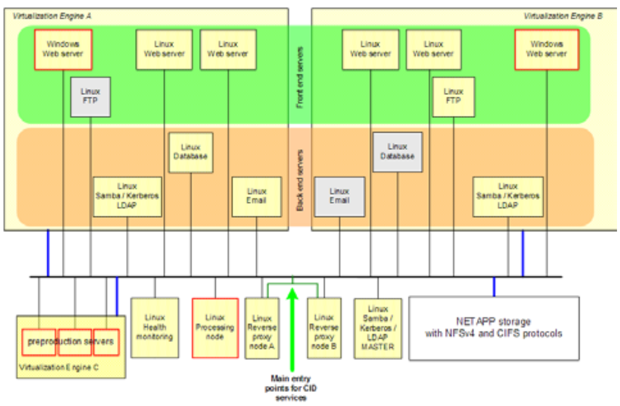

Figure 2. CID system architecture

One of the requirements of the network security team has been to place all CID systems in a dedicated network container (half class C subnet) isolated from other JRC networks and accessible only through a reverse proxy supporting HTTP/HTTPS/FTP.

In order to reduce the number of interfaces towards the external IT environment we set up redundant DNS, NTP, email servers to be used by all machines within the CID subnet. These servers are then communicating with servers outside the CID subnet.
Accessing data via CIFS and NFS with identical permissions for both protocols requires the use of NFSv4. Therefore providing file based access to the data required setting up a Windows Domain Controller for CIFS, Kerberos for NFSv4 and a LDAP user directory for both. The file servers are provided by the Network Attached Storage from NetApp.
In order to keep the running costs low and to facilitate commissioning of new servers as needed for end-user services (web or ftp servers) we decided to use virtual servers. Core base services such as DNS, NTP, Windows Primary Domain Controller, Kerberos Admin and one Kerberos Key Distribution Center rely on physical machines as they prove to be more reliable than virtual ones.

CID Portal – an Online Image Catalogue

The main entry point for users who want to search for images in the CID catalogue is the CID Portal Web application (http://cidportal.jrc.ec.europa.eu/imagearchive, see Fig. 3). The interface which is available to the public, permits searching the archive for images based on various filter parameters, such as platform, acquisition date, image resolution, geographic area, etc. Data matching the search criteria are listed with their metadata and can be previewed via image thumbnails.

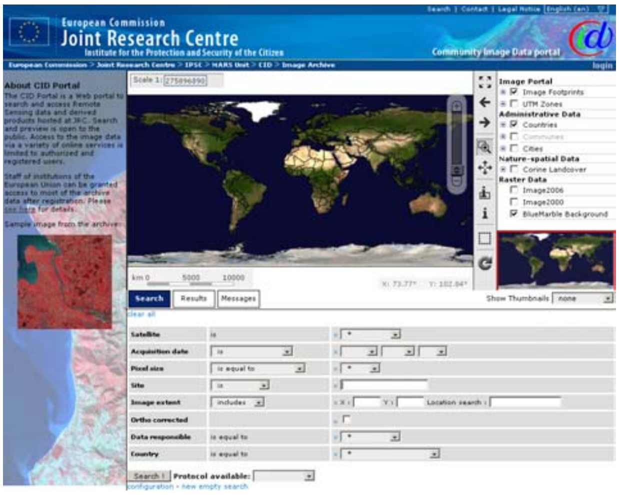

Figure 3. CID Image Portal Web application

Since large parts of datasets are covered by restrictive IPR's, any further in-depth access to the datasets requires authorisation and hence a user registration.
The authorisation granted to users is based on:

- Platform / Sensor
- Acquisition date
- Location
- Licence covering the data
- Protocol requested

After having logged in and depending on their credentials and privileges, authorised users can view the images or load them into various applications via HTTP based view services and HTTP or FTP based download services. Users inside the JRC network are also able to access the data via standard file system mechanisms. Figure 4 shows the options offered to an anonymous user and Figure 5 shows the options offered to a user with full access to the dataset.

Figure 4. Services offered to an anonymous user

Figure 5. Services offered to a user with full access

Data Services

One of the main goals of the image portal is to provide different types and levels of services to scientific users, public authorities, and to the public in general. Following INSPIRE (Directive 2007/2/EC) principles, the portal provides discovery, view and download services. The level of access to data and metadata offered by those services depends on the restrictions intended by data IPR and the user roles.

Discovery Service

In addition to being able to search and discover images interactively via the image portal Web application, data discovery is also possible via an OGC compliant Catalogue System for the Web (CSW) run by GeoNetwork, an open-source web-based metadata catalogue software. The implemented profile for this discovery or catalogue service follows ISO 19115/19139 specifications and is compliant with the INSPIRE Metadata Implementing Rules (Commission Regulation 1205/2008).

Dissemination Services

The dissemination services comprise the View and Download Services as defined by Inspire. CID provides several services for each category. Most of them can be customized through the use of portfolios which are then added to the profile of any user logged in the CID Portal.
The View services provided are displayed in a browser with zoom and pan functionalities, ECWPS (ecwp over HTTPS) and WMS. The Download services provided are FTP and WCS.

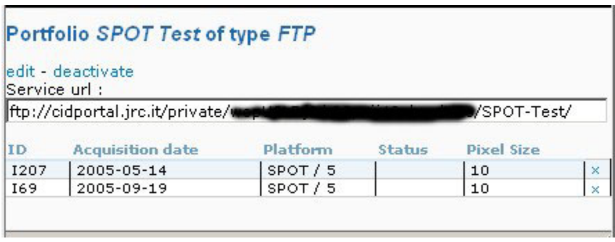

Figure 6. Example of an FTP portfolio management interface

The portfolios provide the user with the ability to (dis)activate and organize his access to the datasets he needs in the most convenient way for him. For example, in order to access a dataset via FTP, a user can place it in a subdirectory of his choice under his FTP personal account (Figure 6). In a similar way, a user can manage access to datasets via WMS and WCS through the matching portfolios. In this case, options related to the protocol used are offered such as the supported output CRS, resampling algorithms and file formats. This approach permits also secured access to non-public data via protocols like WMS or WCS that do not contain authentication mechanisms in the protocol specifications. Data access service via file system protocols includes the possibility to define virtual file structures for the datasets based on the search results which facilitates the access to the datasets in which users are interested. Figure 7 shows the interface used to define a virtual file structure which would associate the search "QB over France" to the directory *QB_over_France* with the datasets placed in a directory structured defined as Acquisition year > Site name > dataset (Figure 8).

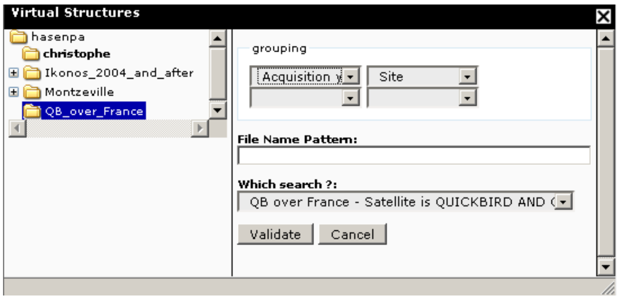

Figure 7. Definition of a virtual file structure

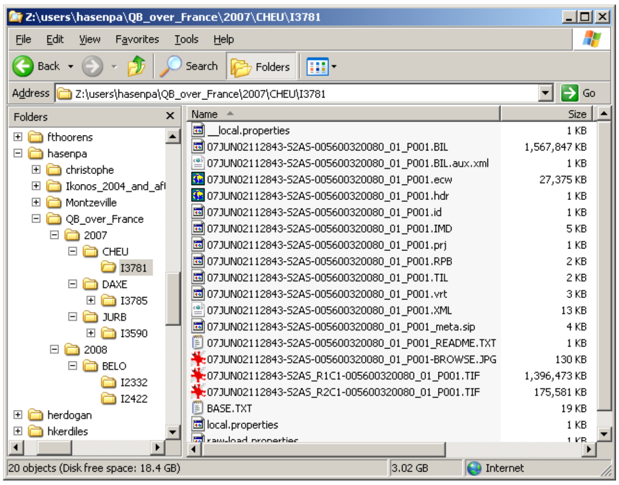

Figure 8. Structure of a virtual file structure

Processing Services

Imagery data from a number of satellites, e.g. SPOT, Landsat, IRS, are automatically processed and orthorectified during data import into the archive. This is achieved by image geo-registration towards a reference dataset accessed via WMS protocol. Currently Image2000 or GLCF Landsat data are used as input references. The limitation for processing higher resolution imagery, e.g. from Ikonos or Quickbird satellites, is the availability of publically accessible ortho reference data via WMS. The automated orthorectification will be provided soon as a processing service available to JRC users who want to rectify raw satellite data without storing them directly in the CID portal archive. The implementation is following the OGC specification for Web processing Services (WPS).

4. LICENSING

Data Licensing Terms and Conditions at JRC

Within any data portal authentication and authorisation services permit or deny a specific user to access data or their related metadata contained within the repository. Such services (permissions) are ruled by the licensing Terms & Conditions (T&C) governing the data set being accessed, which in turn are a result of a data policy where different factors play an important role depending on ownership. (Fig. 9).

Fig. 9. The ownership triangle (GENESI-DR FP7, © G.Schreier, K.D.Missling, DLR, 2009)

The JRC, as a research body of the European Commission, has to fulfil tasks within the development, implementation and monitoring of policies and related activities as defined by the EC Treaty and subsequent Community legislation. To fulfil these tasks the JRC needs to share data through services (e.g. discovery, view, download), via mechanisms such as the Community Image Data portal, with other EU institutions and bodies; with their contractors, their grant holders, public authorities and with research and academic organisations.

Upon request, sharing may also be granted for humanitarian and development purposes by international organisations and non governmental organisations.

It is therefore imperative for the JRC to negotiate adequate licensing T&C in their Framework Contracts (FCs) to govern permitted data usage. JRC annual expenditure on such commercial EO data covered by FCs is approximately as much as 8 M€. However, other JRC data are non-commercial, with coarser resolution, where data sharing and re-use rules are simpler, but not trivial:

Low/medium resolution data is mostly free of charge, or at a production cost (e.g. NASA, or ESA Category 1), but not always possible to distribute directly to any user without permission from the data provider.

High resolution data: some of coarser resolution data is free of charge, or at production cost (e.g. Landsat). Such data can be free of charge if used for specific research collaboration/benchmark tests, but otherwise relying on commercial T&C.

Very High Resolution data can be free of charge for specific research collaboration/benchmark tests, but otherwise it will always follow commercial T&C.

Image Data Policy

Image Data Policy can be summarised as the set of rules to develop technological, political, scientific and socio-economic benefits for the original owners of the EO data sets, the operators of the archive and distribution facilities, for the users of the datasets, for the political entities supervising on a European and National level the development and use of EO data, and for the general public.

Data policy can also be defined as the set of technical and legal approaches establishing a data access and pricing regime (dependent on the particular context e.g. owner, processing level, type, user, usage, etc.) capable of increasing the advantages of a community (social, economic and environmental wealth deriving from the data usage). Image Data Policy can also be viewed as the result of the application of the support of technological and legal disciplines to the ownership triangle (Fig. 9), in order to guarantee the monetary value, the strategic advantage and the security concerns of the referred data set (GENESI-DR: Data Archiving and Dissemination Policy).

In order to define adequate licensing T&C in the JRC Framework Contracts it is important to look at the main initiatives through Europe and worldwide, such as the GMES (Global Monitoring for Environmental and Security), GEO/GEOSS (Group on Earth Observation/Global Earth Observation System of Systems), and INSPIRE (Infrastructure for Spatial Information in the European Community). The JRC's intention is to follow the consensus as much as possible, especially the position on the INSPIRE Directive, Infrastructure, and Data Sharing as this becomes accepted by the Council of the EU, and by the Commission (COM(2006)51).

5. CONCLUSIONS

Setting up an image archive with discovery, view and download services is a step forward to identify, access, and use earth observation data at JRC and Commission level. Standardized protocols will facilitate access to data and metadata available in the archive and are in line with the principles of spatial data sharing initiatives as INSPIRE.

Access to data requires a clear and transparent definition and management of licensing issues. The JRC is looking at the above-mentioned licences and is establishing conditions according to data and service sharing principles for the T&C in future framework contracts.

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Technical session 3: Guidance on area checks, 2009

VALIDATION AND CERTIFICATION OF THE AREA MEASUREMENTS SYSTEMS IN THE LIGHT OF THE COMMON AGRICULTURAL POLICY

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KEY WORDS: on-the-spot checks, GNSS, validation, certification, area based subsidies

ABSTRACT

Since the beginning of 2008, Members States are obliged by Article 30(1) of Commission Regulation (EC) No 796/2004 to provide proof of quality of the tools/methods used in the annual control process of the area based subsidies. Using reliable equipment giving reproducible results within defined statistically predictable limits is of benefit for all the stakeholders: farmers, national administration and the European Commission. In order to evaluate reliability and precision of GNSS receivers in area measurements, tests should be made under different conditions, using the same settings and the method of measurements as used in the control process. In order to guaranty a standardised approach in these tests, measurement validation scheme, based on the ISO 5725 norm, has been designed. Member States can assure the quality of the area measurements required by the Regulation by using one of the two ways: validation tests or by buying certified instruments. The principles of the validation and certification processes of the area measurements systems in the light of the Common Agricultural Policy are presented in this paper.

1. INTRODUCTION

Since the beginning of 2008, Member States are obliged by Article 30(1) of Commission Regulation (EC) No 796/2004 to provide proof of quality of the tools/methods used in the annual control process of the area based subsidies in the frame of the direct support schemes.

The Joint Research Centre is recognized as the technical advisory body at the Community level providing the scientific advice and technical know-how to support a wide range of EU policies.

The first tests of the GNSS receivers were run by the JRC in the early 1990's. The need of development of a standardised testing approach of the area measurements system was recognized already in 2002, when a trial validation test based upon the collection of repeated measurements of a football pitch was run for the first time. Since then, the area measurements validation scheme has evolved on the basis of the experience of the JRC and several Universities.

The principles of the validation and certification processes of the area measurements systems in the light of the Common Agricultural Policy will be presented in this paper.

2. AREA BASED SUBSIDIES

The Common Agricultural Policy (CAP) is a system of European Union agricultural subsidies and programmes that represents over 40% of the EU's budget, i.e. €41.1 billion in 2009.

The agricultural expenditures cover two main areas, so-called 'pillars'. Pillar 1 covers market and income support - 73.3% of the agriculture expenditures in 2009 and includes direct payments to farmers and continuing market-related subsidies under the common market organisations such as buying of products into public storage, surplus disposal schemes and export subsidies. Pillar 2, which is not of the main interest here, covers rural development.

The administration bodies responsible for executing payments to the beneficiaries are the paying agencies. Before any payment is made, all aid applications are subject to the administrative checks, including cross-checks with other data where this is considered appropriate, in order to verify the eligibility of the aid applications.

Moreover, in case of the area based subsidies the area eligible for payments should be confirmed by the on-the-spot checks, e.g. for Single Payment Scheme (SPS) and Single Area Payment Scheme (SAPS) a sample of at least 5% (in practice 6.7% in 2008) of the applications is controlled annually.

3. CHECKS - TAKING DECISION

According to the statistics of the European Commission in 2008 in total more than 680.000 applications were the subjects to checks either with remote sensing techniques or on-the-spot. During these checks the area eligible for payments is determined. In the process of verification whether the application was correct or not (was under- or over-declared), two values have to be compared: the area declared by the applicant and the area found on-the-spot by the inspector.

Technically, when comparing two values a tolerance may be used[5]. In outline the technical tolerance defines the permissible

[5] In some of the Member States the technical tolerance applied is equal to 0, means no tolerance is used.

limit of variation in the measurements obtained with an instrument and can be expressed as variety of statistical parameters at different confidence levels.

Commission Regulation (EC) No 796/2004, art. 30, defines the technical tolerance as a buffer of maximum 1.5m applied to the perimeter of the agricultural parcel.

In case of the technical tolerance applied in the control of the application for area-based subsidies, a term of reproducibility limit of the measurements at the 95% confidence level, expressed as a buffer on perimeter, has been proposed as most appropriate by the JRC. The reproducibility limit expresses the maximum absolute difference between two measurements taken under reproducibility conditions (with probability of 95%). In other words, the difference between any two measurement results obtained by different operators with comparable methods/tools (the same variance of the results would be obtained with the methods/tools), in 95% of the cases, should not be greater than the value of reproducibility limit. The value of the reproducibility limit depends on the tool (hardware, software and settings) and the method of the measurements used, and should be assessed in an empirical way and expressed as a buffer on perimeter.

4. TOOLS AND THE TECHNICAL TOLERANCES

For remote sensing controls performed using the optical satellite or aerial ortophotoimages, the precision of the area measurements is related to the ground sample distance (GSD) of the image. The rule of thumb stating that the technical tolerance to be applied when using remote sensing control methods is defined as a factor of 1.5 multiplied by the GSD and perimeter of the agricultural parcel (1.5 x GSD x perimeter). Recent results of the internal tests of several new sensors run by the JRC seem to confirm the validity of this rule of thumb.

In the case of the on-the-spot checks performed with the GNSS equipment, there is no simple rule to derive the technical tolerance, since the quality of the results depends on several issues like: hardware, software, settings and method of measurements.

The accuracy in *point positioning* and accuracy of the *area measurements* should be clearly distinguished here as they are very often confused.

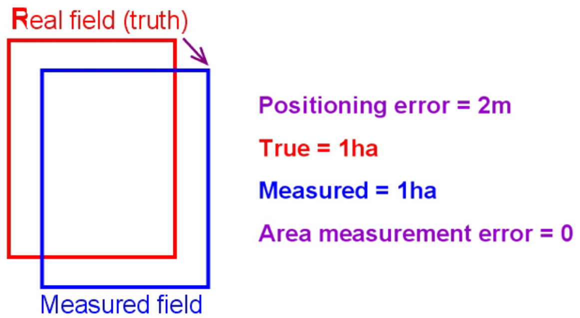

Figure 1. Outline of the certification process

In the theory it is possible that the area estimation will be very accurate in a presence of positioning errors of several meters (See Figure 1.). This is only possible if the positioning error of the measured position is constant (shift) all along the perimeter of the field, and is very rare in practice.

In most cases the manufacturers usually give only statements on the positioning accuracy of the measurement system, for example CEP[6] or RMSE(95%)[7] in point positioning. Generally the accuracy of the GNSS devices in the area measurements is not tested by manufacturers.

A wide range of GNSS equipment is used for the on-the-spot checks, starting with low-cost devices like Garmin GPS 60 (~170€), through advanced GIS data collectors (several thousand €), up to the high-precision surveying instruments that cost over €10 000.

For several years the default value of 1.25m times the perimeter has been recommended to be used as the technical tolerance in the control process when code GNSS technique was used, regardless of the quality of the equipment used. Taking into account the increasing performance of the GNSS, easily accessible correction signals and the variety of more and more sophisticated and precise measurement systems available on the market, this value seems to be outdated and too general.

Article 30 of the Commission Regulation (EC) No 796/2004 states that the "agricultural parcel areas shall be determined by any means proven to assure measurement of quality at least equivalent to that required by applicable technical standard, as drawn up at Community level." In other words, the Members States should prove, that the measurements systems used during the on-the-spot checks meet the quality requirements defined by the maximum tolerance allowed to be used: a buffer of maximum 1.5m applied to the perimeter of the agricultural parcel.

Moreover, the Community level technical standards, i.e. the recommendations of the JRC, state that depending on the quality of the measurement system, settings and the method of the measurements, an *appropriate* technical tolerance should be used.

For the sake of simplification, a classification of the devices in 5 different classes has been proposed (see Table 1.). The classification is based on the values of the reproducibility limits (R) of the area measurements estimated in the validation process. Depending on the class that the measurement system falls into, different values of the buffer width to be used to compute the technical tolerance are proposed.

Class of the measurement system	R – reproducibility limit of the area measurements expressed as a buffer on perimeter [m]	Technical tolerance proposed – buffer width to be multiplied by the perimeter [m]
better than 1.50m	(1.25 - 1.5]	1.50
better than 1.25m	(1.0 – 1.25]	1.25
better than 1.00m	(0.75 – 1.0]	1.00
better than 0.75m	(0.5-0.75]	0.75
better than 0.50m	<0.5	0.50

Table 1. Technical tolerance depending on the reproducibility limit of the measurements.

5. AREA MEASUREMENT VALIDATION SCHEME

Using reliable equipment giving reproducible results within defined statistically predictable limits is of benefit for all the stakeholders: farmers, national administration and the European Commission.

6 CEP - Circular Error Probable - 50% of the data points fall within a circle of this radius centered on truth. Values stated as CEP apply to horizontal accuracy only.

7 RMSE(95%) - 95% of the data points occur with this distance of truth. It should be expressed clearly whether the accuracy value refers only to horizontal or to both horizontal and vertical.

Farmers should to be treated justly and equally, therefore the use of measurements systems of proven quality by the administration when taking decisions on the amount of subsidies granted, is of their interest.
It is also in the interest of the national administration as their decisions could be disputed in front of the court and are subject of many audits. Non-compliance of the elements of the subsidies distribution system with the European Regulations can result in high penalties if recognized by the auditors from the European Commission. For the manufacturers and system providers, certification of their products can also benefit by giving proof, usable in court, of the accuracy of the area measurements that could be stated in the technical specification of the devices.

In order to evaluate reliability and accuracy of GNSS receivers in area measurements, they should be tested under different conditions, using the same settings and the method of measurements as used in the control process.

In order to assure a standardised approach in these tests, the measurements validation scheme, based on the ISO 5725 norm, has been designed. Both types of the measurements methods, i.e. area measurements on orthoimages and with the GNSS receivers, can be validated with the proposed scheme. There will be several differences in the test design related mainly to practical issues, like the number of parcels in the test, number of repetitions of the measurements etc. This paper will focus on the validation of the GNSS receivers for area measurements.

According to the principles of the validation scheme, the measurement system should be tested on several fields with different border characteristics (e.g. open horizon, dense forest, single trees, etc), different shapes and sizes. The sets of measurements should be taken using different GNSS satellite constellation, i.e. at different times of the day. The data resulting from the test should be assessed according to the statistical approach presented in the ISO 5725. The final value of the reproducibility limit of all the measurements expressed as a buffer can be cross-checked with the thresholds presented in Table 1. in order to derive the appropriate technical tolerance to be used with the validated system.

5.1. Design of the test site

The test site should be representative for the operational environment (region/country) of the tool and include several fields, e.g. 5 or more, with variable: size, shape, conditions of the horizon: open or obstructed, for example by tree canopy.. The borders of fields should be clearly marked, e.g. by coloured wooden pegs, easily recognizable and comfortable for walking. The area of the fields should be surveyed with high precision instruments, like surveying instruments or RTK measurements, and kept unknown for the operators collecting data with the tested tool.

5.2. Schedule of the measurements

In the validation scheme, a single measurement of a field is called a *repetition* and it is assume that the GNSS satellite constellation is stable during collection of the successive repetitions. Several repetitions taken in short intervals of time create a *set of measurements*. The sets of measurements should be collected with different GNSS satellite constellations. In the other words, for each field the repetitions should be collected as fast as possible, but a time-distance should be kept between different sets of the measurements. It is recommended to collect at least 8 sets of measurements consisting of 4 repetitions per field. An example of the schedule of the measurements designed for 3 operators on 6 parcels is presented in Table2. Each of the three operators will repeat the proposed sequence of the measurements 3 times (3 runs), means measure each parcel 12 times.

Order of the collection of the data in one run per operator

Operator 1	Operator 2	Operator 3
A (cw, acw, cw, acw)	B (cw, acw, cw, acw)	C (cw, acw, cw, acw)
B (cw, acw, cw, acw)	C (cw, acw, cw, acw)	D (cw, acw, cw, acw)
C (cw, acw, cw, acw)	D (cw, acw, cw, acw)	E (cw, acw, cw, acw)
D (cw, acw, cw, acw)	E (cw, acw, cw, acw)	F (cw, acw, cw, acw)
E (cw, acw, cw, acw)	F (cw, acw, cw, acw)	A (cw, acw, cw, acw)
F (cw, acw, cw, acw)	A (cw, acw, cw, acw)	B (cw, acw, cw, acw)

Schedule of runs:

	Day 1	Day 2
Run 1	8:00-12:00	
Run 2	13:00-17:00	-
Run 3	-	10:00-14:00

Table 2. Example of the data collection schedule designed for 6 parcels and 3 operators.

5.3. Data collection

The measurements should be acquired using exactly the same settings and measurement protocol as is applied in the operational use of the device. The data collection should be well documented, so that each single result (area and the vector) is fully traceable with respect to operator, date and time and other related factors. Measuring in both clockwise (cw) and anti-clockwise (acw) direction will help to identify potential systematic errors related for example to left/right handed operators. It is advised to take notes of at least: field ID, operator ID, time of measurement, area, perimeter, direction and any extraordinary behaviour of the device.

5.4. Statistical processing of the data

Statistical processing of the data should be started with detection of the outliers. Grubb's and Cochran's tests for outliers are recommended in ISO 5725 to identify stragglers and outliers within data sets and between them. However, any other statistical tests capable of that are acceptable.

Furthermore dependence of the errors on different factors, like: operator, set of measurements, direction, size of the field, type of field (open/obstructed horizon), should be analysed by using analysis of variance (ANOVA).

After confirming the absence of significant bias in the measurements, the reproducibility standard deviation and the reproducibility limit (R) of the measurements, expressed as a buffer on perimeter, should be calculated for each field. In absence of significant difference between the values of the reproducibility limit computed for all the fields, an arithmetic mean of the reproducibility limits should be considered as the final result of the validation test.

5.5. Results of the validation and the technical tolerance

The appropriate technical tolerance of the tested tool can be derived by comparison of the final value of the reproducibility limit (R) with the values presented in Table 1.

6. CERTIFICATION VS. VALIDATION

The differences between the certification and validation process, together with their advantages and disadvantages should be underlined here. Both deliver the required proof of the quality of the area measurements, thus are suitable for the needs of the national administration.
In short, a validation can be understood as a part of a certification process. A typical overview of the certification process is outlined in Figure 2, below. For comparison, an example of the validation process is presented on Figure 3.

In the process of the certification of devices, the JRC provides the recommendations for testing, in other words is an accreditation body. A certification body proposes a test plan, in accordance with the JRC guidelines. This test plan is verified and quality assured by the accreditation body (the JRC) and the certification body is announced as recommended.
The certification body should in turn contract with a test laboratory, which operates under their control and supervision, to undertake tests and produce data through equipment testing. These data will be analysed to produce results, which will, following the review and evaluation by the certification body, lead to certificate publication, again on the web. The certification mark is regarded as an evidence for legal claims so the liability risks are minimized, also by the limited warranty issued by the certification body.

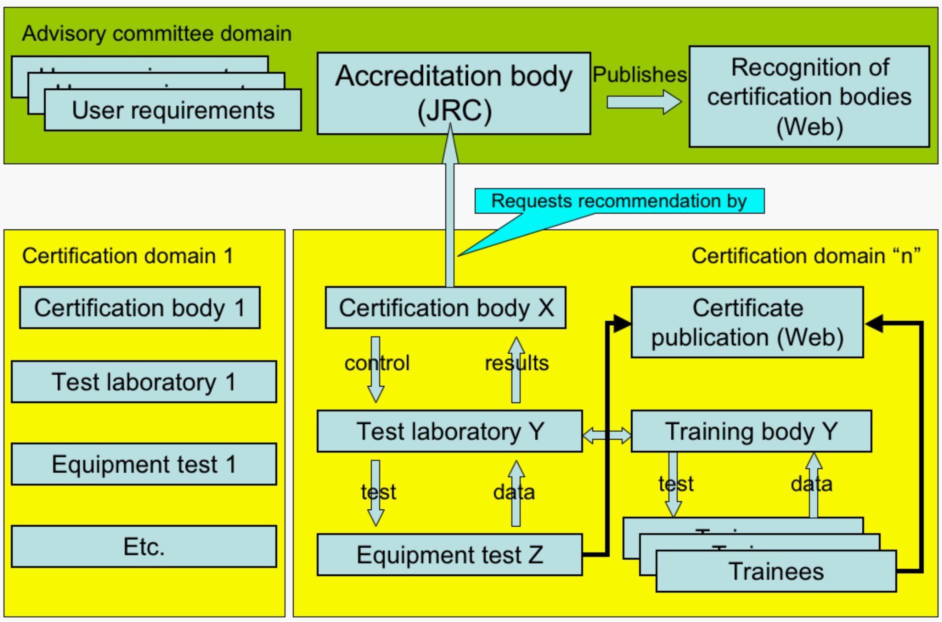

Figure 2. Outline of the certification process

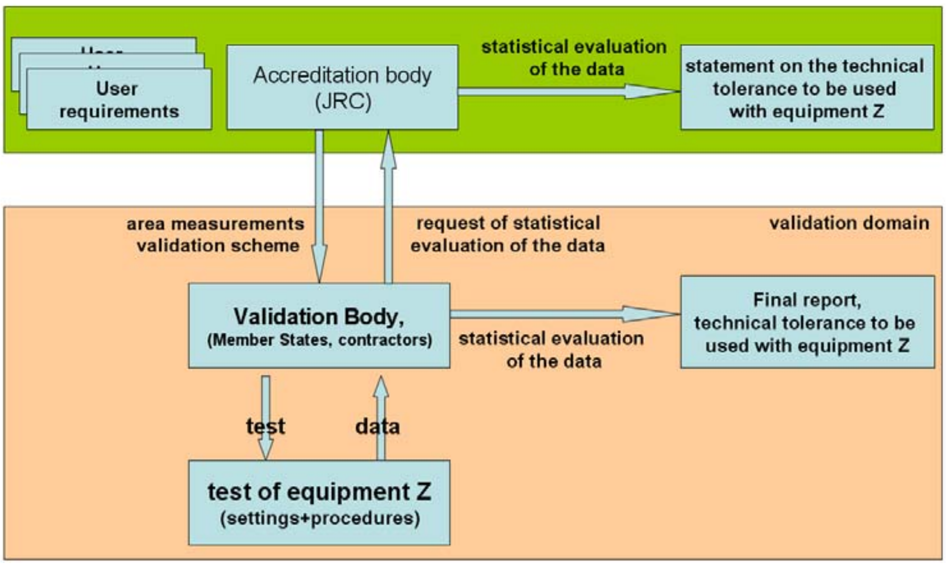

Figure 3. Outline of the proposed validation process

The certification process is more formal and involves more parties (e.g. licensed test laboratory) than the validation process thus it is more suitable for the manufacturers or equipment providers.
In the process of validation of the instruments, the stakeholders like Member States or the contractors responsible for performance of the on-the-spot controls can test the devices on their own, following the JRC guidelines.
The JRC can assist in the first phase of the validation tests: designing of the test site and in scheduling the measurements. After collecting the data, the validating body can process statistically the data or ask for assistance of the JRC in order to derive the final value of the technical tolerance to be used when using equipment Z for the area measurements.

7. CONCLUSIONS

The principles of the validation and certification processes of the area measurements systems in the light of the Common Agricultural Policy have been presented in this paper together with the background and the rationale of the development of the area measurements validation scheme.

Member States can assure the quality of the area measurements, as required by the Regulation, by using one of the two ways presented above: validation tests or by purchasing a certified instrument. Both ways are equally good as they use the same, standardised principles and should lead to the comparable conclusions on the precision of the tested tool in area measurements.

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Technical session 4: Farm Advisory Systems

CROSS COMPLIANCE AND THE FARM ADVISORY SYSTEM IN THE REPUBLIC OF SLOVENIA

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Chamber of Agriculture and Forestry of Slovenia

KEY WORDS: Common Agricultural Policy (CAP), Cross compliance (CC), Farm Advisory System (FAS), advising

ABSTRACT

The Chamber of Agriculture and Forestry of Slovenia (CAFS) has been authorized to provide advising on cross compliance. The Chamber was established by law in 2000; part of CAFS is the public agricultural advisory service which also carries out cross compliance related tasks. In November 2006, CAFS was authorised by the Ministry of Agriculture, Forestry and Food to carry out training courses for farm advisors allowing them to attain full competence in cross compliance counselling. Due to that fact we can start talking about Farm advisory system in Slovenia as defined in Council Regulation (EC) No 1782/2003 (chapter 3, article 13).

CAFS headquarters are in Ljubljana, the public agricultural advisory service tasks are coordinated by the Agricultural Advising Section at CAFS employing 18 agricultural experts. CAFS has established 8 agricultural and forestry institutes carrying out field operations of agricultural advising. The public agricultural advisory service is employing 310 agricultural advisors in total. The staff structure within the public agricultural advisory service is as follows: 8 heads of departments, 179 common agricultural consultants, 78 consultants and 45 specialists for agricultural families' and complementary activities advising.

1. HISTORICAL BACKGROUND

The beginnings of farm counselling in Slovenia go back to the end of 19th century when the establishment of agricultural companies and cooperatives allowed farmers to receive advice and improve their knowledge of farming and breeding. Agricultural experts, who also served as advisors to farmers, were employed by local cooperatives after the Second World War.

Expert aid to farmers was abolished in 1960 and was only resuscitated in 1972 with the return of cooperatives and the establishment of the Agriculture Extension Service. The service operated on the following three levels: The Centre for Agriculture Extension (first level) first operated at the Slovenian Agricultural Institute and later at the Association of Cooperatives. Regional specialist (second level) farm advisors were located in the regional agriculture and livestock institutes, while cooperatives housed farm advisors and organisers of production (third level). The service was free-of-charge for the members of cooperatives. The number of employees in the centre increased to 450 and the service was financed by the state, the municipality and the cooperative, which all paid for a third of the costs.

The service was thoroughly reorganised in 1990 when the Farm Advisory Service was set up by a decision of the Agriculture, Forestry and Food Committee of the Socialist Republic of Slovenia. The newly-established agency operated on three levels: the departments for agriculture counselling at the regional farming and breeding veterinary institutes (fieldwork and specialists) and as part of the Slovenian Agriculture Extension Administration which was a body within the Agriculture, Forestry and Food Ministry (MAFF).

Nowadays the Farm Advisory Service of Slovenia is organised within the framework of the Chamber of Agriculture and Forestry of Slovenia (CAFS).

The Chamber of Agriculture and Forestry Act was adopted in June 1999, and the first CAFS elections were held in 2000. The Farm Advisory Service obtained its legal status with the constitution of CAFS.

2. CAFS MEMBERS

2.1. Members And Membership Fee

- Chamber Members are divided into two subgroups: natural persons and legal entities
- Around 112.000 natural persons and approximately 1.200 legal entities are members of the Chamber.
- The membership fee is determined once per year for the past year.
- The total income of membership fee for 2008 was 2.350.000 EUR.

2.2. Members – Natural Persons

- Membership is compulsory for those that generate more than € 167 of cadastral income. Annually they pay 4% of their cadastral income, but no less than € 8.35 lump-sum payment.
- Members who have pension and disability insurance as farmers pay € 8.35 annually.

2.3. Members – Legal Entities

- Owners of agricultural lands and forests pay 4% of cadastral income.

- Legal entities engaged in agricultural activities pay 1.53% of profit.
- Legal entities, registered for agriculture as their principal activity, pay 0.2% of incurred depreciation and calculated salaries.

3. CAFS STRUCTURE

The Chamber head office is in Ljubljana. The Chamber is headed by an elected president and a director, who is appointed to office. Head office is divided into nine divisions where there are 58 employees:

- Agricultural Advisory Service Division,
- Animal Husbandry Division,
- Forestry Division,
- Legal Affairs Division,
- Financial Division,
- General Affairs Division,
- Coordination of Elected Bodies Division,
- European Affairs Division
- Public Relations Division.

The employees of the Chamber head office:

- direct and coordinate the activities of specialist and other advisors from 8 regional offices,
- organise education classes,
- prepare and draft material for advisors and farmers,
- communicate with national bodies responsible for the system – the Ministry of Agriculture, Forestry and Food, the Ministry for Environment and Spatial Planning, the responsible payments agencies as well as monitoring bodies and inspectorate.

CAFS has established 8 agricultural and forestry institutes carrying out field operations of agricultural advising, covering complete state territory (figure 1). The public agricultural advisory service is employing 310 agricultural advisors in total. The staff structure within the public agricultural advisory service is as follows: 8 heads of departments, 179 common agricultural consultants, 78 consultants and 45 specialists for agricultural family based holdings and complementary advising activities.

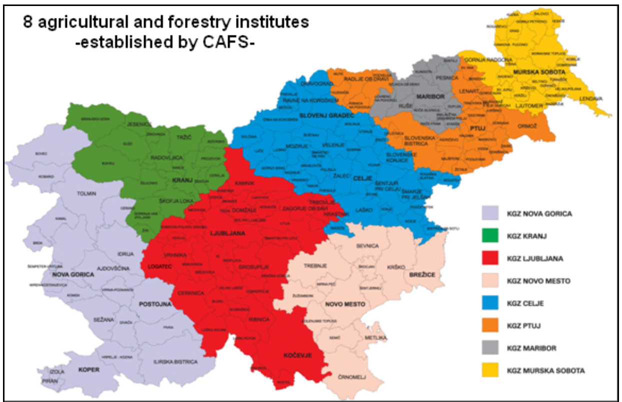

Figure 1. Eight agricultural and forestry institutes established by CAFS

4. WHAT DOES THE CHAMBER (CAFS) OFFER TO ITS MEMBERS?

The CAFS:

- Represents Members' interests.
- Provides free technical aid in agricultural, forestry, legal and economic consultancy.
- Informs members of current issues in agriculture and forestry (free monthly bulletin "Zelena Dežela").
- Informs the public on current problems in agriculture, forestry, fishery and rural development.
- Promotes agriculture, forestry, fishery and rural areas, (participation on fairs, organisation of congresses, events, round table discussions, etc.).
- Provides co-ordination among public services in agriculture and in selection and control in animal husbandry.

Most of Slovenian farmers are members of CASF. A large number of farm advisors (310 in total) are in contact with some 70.000 farms each year. They help farmers to maximise profit making full use of both EU and national income support schemes. Advice is given in five basic subject areas (crops, stockbreeding, farm accountancy and management, direct marketing, building and techniques) and farmers are encouraged to take advantage of all opportunities whether they are on-farm or off-farm.

Because of its wide knowledge and huge experience the farm advisory service also plays an important role in advising the Ministry of Agriculture, Forestry and Food in the preparation of legislation and in its implementation.

5. FUNDING FARM ADVISORY SERVICE (SINCE 2006 ALSO FAS)

The service is mainly funded from the national budget and through its other income (for example founding from EU projects,) according to a submitted yearly plan (figure 2). The Farm Advisory Service of Slovenia drafts yearly plans of activities which are approved by the government. The approved programme of activities serves as a basis for the implementation and the funding.

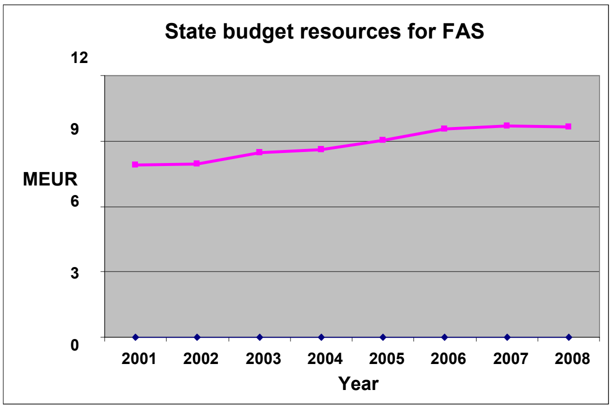

Figure 2. Sources for funding the public farm advisory service in Slovenia

6. FUNDING BASIC TASKS AND ACTIVITIES

The tasks in the field of agriculture counselling, defined in article 90 of the Agriculture Act (Official Journal RS No 51/06) are primarily:

- Counsel on technological, economic and environmental aspects of farming,
- Counsel and aid in drafting development plans for agricultural holdings,

- Counsel and aid in carrying out agricultural policy measures,
- Counsel and aid in organising and maintaining of breeding and producing organisations as well as other forms of association of workers in agriculture,
- Counsel in agriculture and agriculture-linked legislation.

Apart from the tasks that are set forth in law, the Farm Advisory Service also carries out tasks and activities necessary for the implementation of the Common Agricultural Policy in Slovenia and serves as support for farmers and the agro-food industry in their drive to the common European market.

7. CROSS COMPLIANCE

Advising on cross compliance is one of the main priorities of the Farm Advisory Service in Slovenia. The existing farm advisory service allows for a quality and efficient counselling service in the area of cross compliance. In November 2006, The Ministry of Agriculture, Forestry and Food authorised the CAFS to carry out training courses for farm advisors allowing them to attain full competence in cross compliance counselling.

The cross compliance requirements were first published in the Republic of Slovenia in the Official Journal RS No 21/05 within the Regulation on statutory management requirements and good agricultural and environmental practices for farming. In November 2006 the Ministry of Agriculture, Forestry and Food authorised the CASF to carry out training courses for farm advisors allowing them to attain full competence in cross compliance counselling. Therefore, training farm advisors had become one of its main tasks. Due to that fact we can start talking about Farm advisory system as defined in Council Regulation (EC) No 1782/2003 (chapter 3, article 13).

In the year 2006 all farm advisors attended a special course on cross compliance, reflecting the additional professional knowledge to be attained in advising on cross compliance. The participants included all field-farm advisors and advisors of farmers' families and supplementary activities, and specialist advisors. The course lasted three days and was repeated three times during November and December 2006; it was followed by a test of the knowledge acquired for advising farmers on cross compliance. The total number of advisors that participated in this special educational course was 288: 93% of the total number of farm advisors in Slovenia (310).
The training concerned the following categories:

- Overview of EU legislation,
- Overview of Slovenian legislation,
- A detailed presentation of the Regulation on statutory management requirements and good agricultural and environmental conditions for farming (OJ RS No 21/2005),
- System of sanctions,
- Reasons behind the creation of individual requirements and possible consequences for the environment, public and animal health, food safety and animal welfare if the requirement is not met,
- Implementing the requirement on the farm level, possible adjustments of procedures,
- Self-checking.

The course was followed by a test examining the knowledge acquired for advising farmers on cross-compliance. The test performance was monitored by a special committee designated by MAFF, with one member from CAFS. Each advisor received a certificate (granted by MAFF) to confirm their qualification. This educational initiative allowed for in-depths specialist treatment of issues linked to meeting the demands of cross compliance and searching for suitable solutions.

7.1. What has been done?

MANUAL
In order to orient farmers in the necessary direction in considering cross compliance requirements the "Manual for meeting cross compliance requirements" has been prepared by FAS and other experts and financed by MAFF. The contents of the guide are designed to allow farmers to see clearly how to implement the procedures required for meeting individual cross compliance requirements and how to prevent infringements.

The guide was delivered to most Slovenian farmers during the subsidy campaign in spring 2008 (65.000 pieces).

ONE TO ONE on the farm APPROACH
In the annual work plan for 2008 it was planned that each licensed farming consultant should visit and advise 29 farms. Despite the fact that there is not a lot of interest amongst farmers, advisors visited and advised nearly 4000 farms in 2008, which means approx. 50% of the work plan. Already in 2007, 485 farms were visited for the same purpose.

- In principle, farmers make a request on their own to examine their farms with a consultant. For this purpose, farm advisors use a special form and the procedures are uniform as they are set out in a protocol.
- Farm advisor needs to use a protocol to write the report that is sent back to the farmer.
- Data is archived for statistics that is stored by the farm advisor and are inaccessible to control services

Project	Working hours	Working hours (%)	Working hours (for purpose of CC)	Working hours (for purpose of CC) in %
1. Carrying out technological and economic measures to boost the farms' competitive ability	191.288	28,8	21.393	11,2
2. Promoting supplemental and additional income	46.820	7,1	2.215	4,7
3. Implementing the agricultural policy measures	352.577	53,1	52.095	14,8
4. Associating and creating connections in the countryside	45.181	6,8	556	1,2
5. Other projects and activities	27.760	4,2	1.053	3,8
TOGETHER (FAS)	**663.626**	**100**	**77.312**	**11,6**

Table 1. Implementation of tasks in 2008 (source: Chamber of Agriculture and Forestry of Slovenia, 2008)

METHODS used to provide advice to farmers
In the aim of advising farmers, the methods used within the FAS include: courses, seminars, lectures for farmers and their families, individual consulting, professional articles published in different journals, co-editing of agricultural broadcasting for

TV and radio, practical demonstrations, workshops, excursions, website, publication of on-line information, etc.
An overview of data from the annual FAS report is shown in table 1. Also in 2008, agricultural advisors spent 4760 working hours for the purpose of own education on the cross compliance contents. In these courses they got acquainted with new developments. In addition, within its system the CAFS has appointed an expert group involved in the coordination and preparation of legal regulations on CC issues. Via the coordinators system all field advisers are shortly informed of all the news and changes. Additionally, in the context of the public agricultural advisory service an intranet site has been put in place.

In the first half of this year (2009), MAFF and CAFS will carry out a follow-up course for agricultural advisers who have already obtained the certificate for advising on CC and a comprehensive course for the consultants who have not yet obtained the certificate (newly employed).

8. EVALUATING, MONITORING THE EFFICIENCY

Quantity data are collected regularly. It is obligatory for each advisor to report daily. Reporting, monitoring and evaluating the activities of the Farm Advisory Service of Slovenia is performed with software that allows for simultaneous overview and analysis of the efficiency of the programme implementation. Moreover the programme enables the drafting of a quality annual report on the activities of the Farm Advisory Service of Slovenia, submitted to the Ministry of Agriculture, Forestry and Food. The software also allows an overview of the market activities of the service in the areas of individual institutes and on the national level.

Feedback is collected from advisors regularly. Farmers also have the opportunity to express their opinion. Via the CAFS regional units (13) and the branch committees (60) (elected farmers' representatives) and other Chamber authorities, farmers' opinions are forwarded to the Chamber office where they are collected and answered by the Agricultural Advising Section. Initiatives and questions are also conveyed through the agricultural and forestry institute councils, whose members are also farmers. Initiatives are also collected through MAFF.

9. CONCLUSIONS

The farm advisory system in place in Slovenia functions very well: in addition to all other parameters which speak in favour of the existing system (historical background, territorial coverage, technical and infrastructural facilities), it is necessary to highlight the confidence of Slovenian farmers in advisors, which is a result of hard work in the past. The farmers perceive the public agricultural advisory service as an indispensable part of agriculture. By introducing an already functional system it was achieved a reduction in costs but, most of all, an adequate quality of advising on cross compliance.

Technical session 5: Cross Compliance

ARE REMOTE SENSED DATA USABLE FOR CROSS COMPLIANCE AND AGRI-ENVIRONMENTAL MEASURES CHECKS?

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KEY WORDS: Remote sensing, GAEC, AEM, control, Risk Analysis

ABSTRACT
The paper analyzes the use and potential use of Remote Sensing (RS) data for checking cross compliance (in particular GAECs) and RDP claims. A rapid overview of requirements and standards already checked by some Member States is made. Then, a screening of other elements that could possible be identified (GAEC requirement, Environmental SMR (Statutory Management Requirements) and Agri-Environment Measures-AEM) is done. Despite the need of results quantification, proposals are made on how to use this information in the frame of cross compliance check. Thus, it can either be use to ease the work of controller during the field check. Member States may also use the imagery to locate all suspicious parcels (possible specific infringement) and use this information for risk analysis purpose. Finally a discussion is done on the possible impact of the use of RS for Cross Compliance check both on the image acquisition and CwRS strategies.

1. INTRODUCTION

Before the CAP reform (2003) Remote Sensing imagery was used to check land eligibility and the consistency of farmers' declarations. It was requested to photo interpreters to check, for each declared parcel, its area and its land use.
With the CAP Reform, farmers' subsidies do not depend anymore on production but it is required to maintain the land in Good Agricultural and Environmental Condition (GAEC) and to respect a number of European laws (SMR). Some of them are linked to environmental aspects (Nitrate Directive, Habitats, Water protection …). As a result, a wide range of new elements have to be checked at parcel level and/or farm level. These elements are linked to topics like soil erosion, soil structure, maintenance of soil cover, maintenance of landscape features …
Assuming that some of the requirements or measures could be visible on RS imagery, between 2005 and 2007, the European Commission has given the possibility to Member States to require and test the use of RS imagery, especially for the GAEC checks. The main scopes were to define: which requirements, measures could be detected? Which methods could be used to do so? Would it be possible to quantify the results? How can we valorise the use of RS imagery (direct check, risk analysis support …)?
The elements provided in this presentation mainly come out from the results of theses tests and from the different workshops and conferences organised by the JRC where these topics have been presented and discussed.

2. WHAT CAN BE DETECTED AND HOW?

The list provided hereafter is mot exhaustive but is to illustrate the wide range of requirements, measures that can be spotted and methodologies used to detect them.

2.1. Direct Visual Interpretation Using One Image

In such case, there is no specific image processing to identify the specific element.

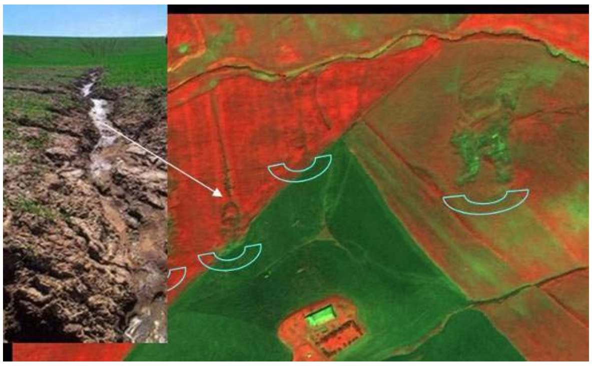

Figure 1. Soil erosion marks visible on a QuickBird VHR image from May 2005, together with a corresponding photography taken on the field

Figure 2. Ashes of burnt stubbles visible on a Ikonos VHR image

The element is identified, recognised visually by the photo interpreter. As example, one can cite soil erosion marks (Figure 1), evidence of stubbles burnt (Figure 2), or presence of ‘unwanted’ vegetation (Figure 3).

Figure 3. Example of a parcel presenting several areas presumably covered by ‘unwanted’ vegetation (Ikonos VHR image)

One has to note that, apart from few cases such as burnt areas that can be visible on HR images, only VHR images have the appropriate spatial resolution to discriminate elements we are looking for.

2.2. Comparison of two images (two dates)

In such case, there is also no specific image processing to identify the specific element. One image is used as a reference situation (often an archive image) and it is visually compared to another image (often a current year image) to locate: specific reduced areas, increased areas, removed elements, or new elements. As example, one can cite the retention of landscape features (Figures 4 and 5).

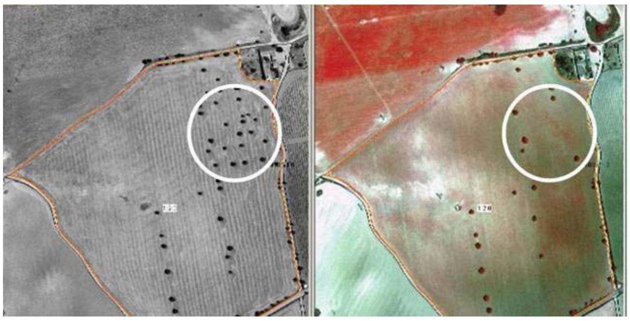

Figure 4. Identification of trees removed by comparing of an archive orthophoto (2003) and an Ikonos VHR image from 2005.

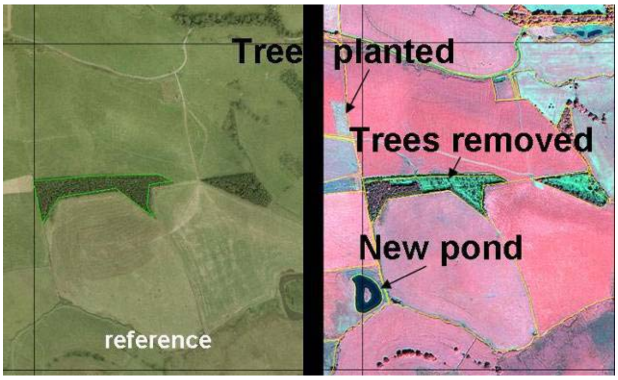

Figure 5. Identification of modifications of landscape features by comparing of an archive orthophoto (UK perspective) and an Ikonos VHR image from 2005.

2.3. Specific image processing

In some cases, some image processing, even rather basic such as image filtering or contrast enhancing, can be done in order to better delineate, discriminate the element we are looking for. See figure 6 for example.

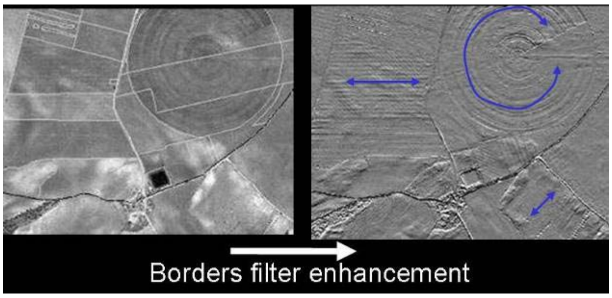

Figure 6. On the right side, result of the ‘borders filter enhancement’ processing of the Ikonos VHR panchromatic image (left side). This process allows to better recognise the direction of crop rows (blue arrows on the right image). This information is very useful for what concerns requirements linked to soil erosion.

2.4. Image combine with other information (layers) in a gis

Remote sensing imagery can be loaded in GIS and combine with other layers in order to check some requirements or in order to locate parcels according to specific environmental zones (vulnerable zones, Natura 2000 sites …).

Figure 7: Example of superimposition of a river network layer on a VHR Ikonos image to automatically check the compliance of a 10 meters width buffer strip of ‘green’ cover along water courses.

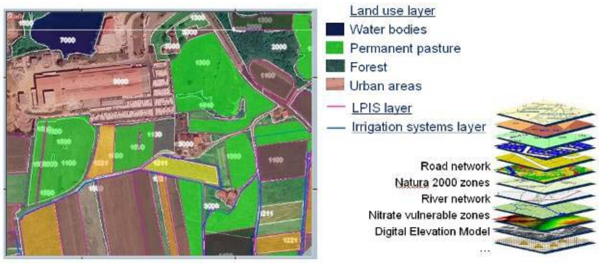

Figure 8. Example of GIS managed by a Member State Administration. Land use and irrigation systems layers are superimposed on land parcels. On the right, examples of other layers that could be useful to superimpose to check some requirements.

See example of check of buffer strip along water courses (Figure 7) or the example of layers gathered in a GIS by a Member State Administration (Figure 8).

2.5. Other elements likely to be checked

Up-to-now, test done using remote sensing images has been mainly dedicated to the check of some GAEC requirements. However, we can reasonably state that some environmental SMR infringements can also be discriminated such as the ones linked to sludge and manure storage, leakage and pollution evidences (see figure 9).

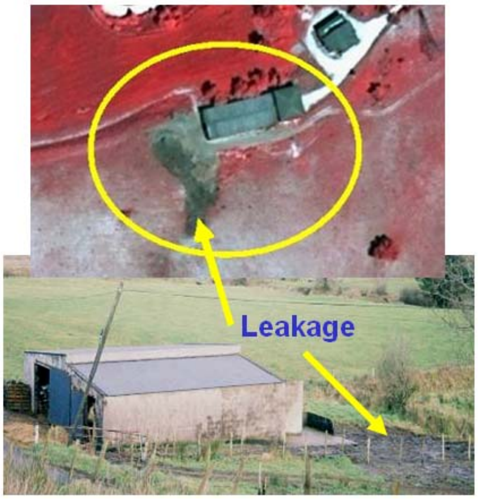

Figure 9. Example of bad (non compliant) manure storage driving to leakage and its location on an aerial photograph.

Issue	Standards	VHR	HR
Soil erosion: Protect soil through appropriate measures	– Minimum soil cover	✓	✓
	– Minimum land management reflecting site-specific conditions	✓	✓
	– Retain terraces ★	✓	
Soil organic matter: Maintain soil organic matter levels through appropriate practices	– Standards for crop rotations ★	✓	✓
	– Arable stubble management	✓	✓
Soil structure: Maintain soil structure through appropriate measures	– Appropriate machinery use ★	✓	
Minimum level of maintenance: Ensure a minimum level of maintenance and avoid the deterioration of habitats	– Minimum livestock stocking rates or/and appropriate regimes ★	✓	
	– Protection of permanent pasture	✓	✓
	– Retention of landscape features, including, where appropiate, hedges, ponds, ditches trees in line, in group or isolated and field margins,	✓	
	. Establishment and/or retention of habitats ★	✓	
	Prohibition of the grubbing up of olive trees ★	✓	
	– Avoiding the encroachment of unwanted vegetation on agricultural land	✓	
	– Maintenance of olive groves and vines in good vegetative condition ★	✓	
Protection and management of water: Protect water against pollution and run-off, and manage the use of water	– Establishment of buffer strips along water courses,	✓	
	– Where use of water for irrigation is subject to authorization, compliance with authorization procedures		

ANNEX III
GAEC referred to in Article 6
★ Optional

Table 1. Standards of the Annex III of the Council Regulation 73/2009 where some elements of the requirements defined by the Member States can possible be distinguished on RS imagery.

In table 1, we have put tick marks for standards of the new annex III of the Council Reg. (EC) N. 73/2009, where some requirements defined by the different Member States can possibly be recognised on Very High Resolution RS imagery and, for some of them, even with High Resolution imagery. One can see that the potential for using RS imagery in the frame of Cross Compliance is rather high

Despite the high potential just illustrated and according to information collected by JRC, use of remote sensing imagery for cross compliance controls has scarcely been used by Member States. This small amount of results is not sufficient enough to quantify the quality of GAEC checks using RS imagery. We do have enough feedbacks from field visit in order to estimate the pertinence of the checks (i.e. number of infringements suspected on images and confirmed or rejected on the field, infringements found on the field and not seen on images …). This quantification step is a keystone to give more credit to the use of RS imagery for cross compliance checks.

3. WHAT CAN BE SUGGESTED?

Despite the need of quality quantification of results, we are convinced that RS imagery can be very helpful in the frame of cross compliance checks. Thus, in two main uses: support office work on dossiers for controllers before the field visit and provide information for CC risk analysis.

3.1. Use Of Rs Imagery For Preparing Systematic Field Inspections

Since images are acquired in the frame of eligibility check, and available, we would recommend taking benefit of these images to check requirements of cross compliance and prepare the dossiers before going on the field. Images could be used to locate parcels with possible infringements and also to document the infringement (e.g. possibly document the extent of infringement: one parcel, several parcels, several farms …). It would possible to make printouts of these infringements so that the controller can use it as piece of evidence to farmers (Figure 10).

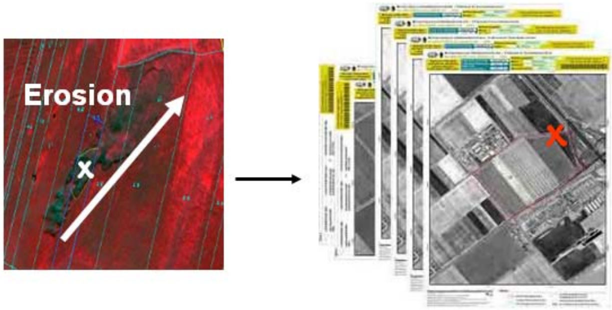

Figure 10. Erosion mark discriminated of RS imagery and extending on four Land Parcels. This can then be printed to be used as piece of evidence for controllers to present to concerned farmers.

Compared to 'classical field inspection' method, we are definitively convinced that this preliminary office work would ease, optimise and quicken the work of controllers on the field by targeting parcels to check and knowing what infringement to look for.

3.2. Use for cross compliance risk analysis

RS data could be used as a support for the risk analysis aiming at selecting the cross compliance sample to be controlled. Assuming a particular GAEC breach is visible on RS data (e.g. bare soil parcels, or burnt or covered with a certain type of summer crop), one could use the imagery to target the risk based sample of parcels to be visited. Also, if a high number of a specific infringement is observed over a geographic area, farmers located in that zones could be put at high risk for this infringement for the following year campaign (Figure 11).

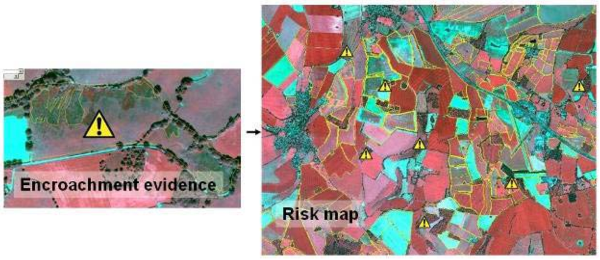

Figure 11. RS imagery used to produce risk map of CC infringement (here encroachment of unwanted vegetation). This information can be used to put farmers located in that zone at high risk concerning that infringement when performing the CC risk analysis.

Up to now this approach has not been used because the regulation did not allow building different samples for the different GAEC: once an application was selected for GAEC checks, all the GAEC of the MS had to be checked whether these were relevant for the farm or not. As from 01/01/2008, MS could design different samples for the different GAEC (groups of GAEC) and could therefore target their risk analysis on a particular GAEC (cf. amended Reg 796/2004). A possible drawback of this approach is that it increases the number of farms to be checked (even if less GAEC are checked at the time of the visit).

4. OTHERS ADVANTAGES OF USING REMOTE SENSING IMAGERY

4.1. Allow to be 'present' all year long

Contrary to the eligibility check, where controls can be performed and grouped during summer, some checks of CC requirements may need to be done at different other periods of the year (e.g. Green cover on a parcel during winter – (figure 12).

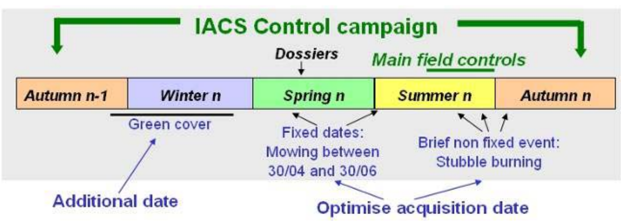

Figure 12: Comparison of the distribution in time of the needs to check eligibility and the needs to check requirements linked to cross compliance.

In this respect, RS data acquired over different time windows may allow to reduce the number of field visits and to target the visits to doubtful or non compliant parcels. That implies that additional images, to the ones acquired for eligibility check campaign, may need to be acquired to check specific requirements. In some cases it may be sufficient to optimise, adjust the acquisition date of images used for the eligibility check so that they can also be used to check specific CC requirements (e.g. to check a compliance at a fixed date – figure 12).

4.2. Allow and ease the access, identification and location of 'objects'

Before the CAP reform, it was necessary to check cropped parcels (cereals, oleaginous, proteaginous), set-aside parcels, pastures and olive trees fields. After the reform, the heterogeneous list of detailed requirements under SMR, GAEC and AEM enlarged the spatial distribution of elements to check (sloppy area, riverside, undeclared area). It also enlarges the range of 'objects' to identify (fire, erosion marks, bushes, trees in lines, isolated trees, ponds … - figure 13).

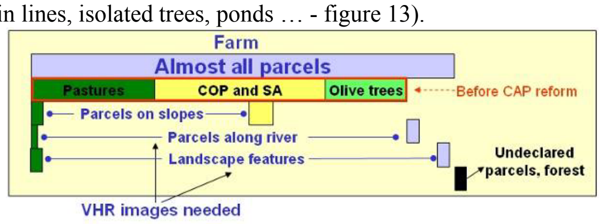

Figure 13. Comparison of 'objects' to be checked in farms before and after the CAP reform

Compared to field check, Remote Sensing imagery allows having a rapid overview of a considered holding and to 'access' to all outer parts of it. However, considering the small size of some objects that need to be identified (isolated trees, 5 meters strips …), it is necessary to use VHR imagery.

5. SOME CONSTRAINTS IMPOSED BY REMOTE SENSING IMAGERY

Up to now, RS imageries have been acquired on zones selected via risk analysis for eligibility check purpose. Due to VHR satellite acquisition constraints, the size of zones is limited to some hundreds square kilometres.

Using RS imagery to check cross compliance will restrict the selection of the cross compliance sample to the RS zones. Budget and technical limitations do not allow acquisition of very large areas. For instance, images acquisition within a week of a whole Country (e.g. to check stubble burning) is not feasible.

Weather conditions (cloud cover) may limit and even prevent the acquisition of images during the suitable periods for specific requirements. It can especially be the case for the check of green cover during winter. Even if we can acquire an image for the winter cover check, evidence based on the imagery alone, i.e. without any field visit with the farmer, may not be sufficient proof of a GAEC breach. Moreover, because the check has to be made at a time where the farmer has not lodged his application, a higher number of checks than the minimum 1% requested has to be targeted. In practice some MS use the winter image of campaign n to identify the farmers to visit for campaign n+1 (case of Germany).

Finally, some GAEC and SMR cannot be checked with RS imagery. It is the case for instance of requirements linked to the Nitrate Directive, or some requirements linked to appropriate machinery use without mentioning obviously all what concerns public, plant, animal health and animal welfare.

6. POSSIBLE EVOLUTION OF IMAGE ACQUISITION AND CWRS STRATEGY

As already mentioned, Member States have not really invested in the possibility to use RS imagery in the frame of Cross

Compliance. It is certainly due to the fact that the know-how and the quantification of the results are still premature. However, if Member States decide to really use it; this may have a significant impact on image acquisition strategy. For instance, except for few cases such as the discrimination of burnt areas, it is necessary to use VHR images to be able to discriminate elements linked to cross compliance requirements. This implies that it would be preferable to acquire at least two VHR images per campaign and per zone instead of only one acquired for the averaged present situation (together with one to two HR images).

Furthermore, if RS imagery is more and more use for CC risk analysis purpose, this could lead to a consistent increase of control zones. Indeed, zones could be more spread over a Member State since some areas would be selected for high erosion risk purpose, others for high encroachment of vegetation risk, others for stubble fire risk, and so on. Depending on satellites technical capacity, this increase of number of zones may imply a reduction of the average size of the zones.

It is presently very difficult to estimate what could be the possible increase of imagery need and costs attached to their acquisition. Several VHR satellites should be launched in the coming years increasing the possibility of 'covering' areas. It is difficult however to know what will be the impact of these new products on the average cost of imagery on the market.

Using RS imagery for Cross Compliance checks would also imply new investments in CAPI (Computer Assisted Photo Interpretation) materials and methods. Photo interpreters have to be trained to recognise the new specific elements or objects. Guidelines have to be produce to provide rules on how to evidence the possible infringements, provide photos of infringements taken on the ground and their correspondence on images. This would also imply to up-date or even re-engineer the software used for the CAPI work.

7. CONCLUSIONS

Following the CAP reform, the scope of the remote sensing images mainly used to check areas and crops declared by farmers could be extended to the environmental issues which is subject for the cross compliance. With the support of the European Commission, several Member States had the opportunity to test the use of RS imagery for cross compliance requirements checks (especially for what concerns GAEC). These tests turned to be very convincing and a wide range of requirements breaches were distinguishable via visual interpretation of images (e.g. soil erosion, encroachment of vegetation, tree removal, tree pruning, maintenance of terraces, poaching …). RS imagery provide strong advantages, compared to classical on-the-field inspection, allowing a fast an exhaustive view of holding and also allowing check of farm during 'unusual' period of control (i.e. check of winter cover).

However, despite these promising results, Member States do not have really invested in that possibility and their request of additional images for cross compliance check is low.

While requiring investments by Member States in recruitment and training of photo-interpreters for such purpose, we are convinced that the use of RS imagery could really help to prepare dossiers in office before going on the field. This would ease and faster the field work. Furthermore RS imagery could be very useful for risk analysis and selection of cross compliance sample. The full adoption of these methods by Member States would then certainly induce significant changes to the present image acquisition campaigns (higher need of VHR images, higher number of controls zones, and reduction of site area). Since it is technically and financially not possible to acquire images over large areas of Member States, this would implies to systematically link the selection of cross compliance sample with the eligibility one.

8. 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, amending Regulations (EC) No 1290/2005, (EC) No 247/2006, (EC) No 378/2007 and repealing Regulation (EC) No 1782/2003

Commission Regulation (EC) No 796/2004 of 21 April 2004 laying down detailed rules for the implementation of cross-compliance, modulation and the integrated administration and control system provided for in Council Regulation (EC) No 1782/2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers, as well as for the implementation of cross-compliance provided for in Regulation (EC) No 479/2008

9. ACKNOWLEDGEMENTS

The facts presented in this paper come out from results of tests done by Member States and from different workshops and conferences organised by the JRC. The author would like to acknowledge the contribution of all concerned Administrations and contractors. He would also acknowledge the support and work of JRC/GeoCAP colleagues and very particularly Vincenzo ANGILERI and Hervé KERDILES.

Technical session 6: New Radar sensors

EVALUATION OF SPOTLIGHT TERRASAR-X IMAGERY AS A SURROGATE FOR VHR OPTICAL DATA

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KEY WORDS: CwRS, Agricultural controls, TerraSAR X, VHR imagery, CAPI

ABSTRACT

The aim of the study was to assess to which extent TerraSAR-X SpotLight data could be used as a surrogate for traditional VHR data. A mosaic of 6 TerraSAR-X SpotLight orthoimages was acquired for the 2008 campaign on the VIRO site located in the Southwest of France. The first objective of the study was to develop an appropriate sampling scheme to test whether SpotLight data could be used to reliably extract agricultural parcels. An area frame sampling approach was adopted using the LPIS as a reference and resulting in a sampling rate of about 13% with two replicates. The SAR and optical imagery was interpreted independently by two experienced photo-interpreters using a simple land cover classification scheme. The agreement between the RADAR and optical interpretation is around 90% for the identification of agricultural parcels. However, the agreement between the 2 data sources is less than 60% for the Identification of agricultural controls related cover types.

The second objective of the study was to test the use of SpotLight TerraSAR-X imagery under operational conditions. To this end a total of 125 farmers dossiers selected randomly were processed out of a total of 399 dossiers for the VIRO sites. The dossiers were processed independently by 2 experienced photo-interpreter, one performing the interpretation under normal operational conditions using VHR and HR optical imagery and the other performing the interpretation by replacing the VHR imagery with the SpotLight data. Nearly 4/5 of the dossiers interpreted with RADAR remain unchanged and 1/5 change from accepted to rejected.

The results obtained suggest that TerreSAR-X SpotLight data could be used as a substitute to optical data, but the level of comfort and accuracy is somewhat less than that of VHR optical imagery. This is because with SpotLight data, the photo-interpreter sometimes fails to distinguish between certain crops, making it difficult to identify accurately parcel boundaries. For instance, this occurs when two summer crops (e.g. sunflower and maize) are adjacent or one summer crop is adjacent to a vineyard. This could be greatly improved if multi-temporal coverage of SpotLight data was available or combined with HR optical imagery. This was tested for areas of overlap between SpotLight Scenes and a resolution merge between the SpotLight and SPOT5 multispectral data. The resolution merge greatly improves the comfort of the photo-interpreter and the ability to identify crop parcels.

1. INTRODUCTION

The Controls with Remote Sensing programme is one of the largest remote sensing programme in the world with several hundreds of satellite image scenes acquired every year for each campaign. Normally, the image acquisition plan relies on the acquisition of VHR (Ikonos, Quickbird or equivalent) imagery during spring and on at least 3 HR images (SPOT XS or equivalent) during the growing season. The main role of the VHR imagery is to identify precisely parcel boundaries, whilst the role of the HR imagery is to identify cover types.

The image acquisition plan is very much constrained by the crop calendar and the strict requirements it imposes makes it sometimes particularly difficult to acquire VHR imagery at the right time period. Therefore, it was thought that the availability of new higher spatial resolution SAR sensor imagery such as TerraSAR X, approaching the spatial resolution to that of VHR optical sensors, should be explored with a view to use the SAR imagery as a surrogate to the VHR optical imagery when not available. The advantage being that the SAR imagery is not affected by cloud cover and that its acquisition can be programmed for the optimum time period in terms of crop development.

The overall aim of the study was to assess whether or not VHR SAR and Terra SAR X imagery in particular, could be used as a surrogate to VHR optical imagery as part of CwRS. To this end, the objectives of the study were the following:

1. to test whether the use of Terra SAR X SpotLight data could be used to reliably extract agricultural parcels, with a view to check to which extent precise parcel boundaries could be extracted from TerraSAR X Spotlight imagery alone
2. to test the use of SpotLight TerraSAR-X imagery under operational conditions using the CAPI software and the TerraSAR X Spotlight alongside the HR optical imagery for a selection of farmers' dossiers following the common technical specifications for the 2008 campaign of remote sensing controls for area based subsidies.

2. PRESENTATION OF STUDY AND MATERIAL

A mosaic of 6 TerraSAR-X SpotLight orthoimages was acquired on the VIRO site located in the Southwest of France to coincide with the 2008 CwRS campaign. This site is located in the south of the Charente Maritime department as shown in figure 1 and was chosen because of its diversity in terms of crop practices with a combination of cereals, summer crops, pasture and vineyards.

In addition to the Terra SAR X ortho-rectified imagery acquired between 15/06/08 and 3/07/2008, the VHR optical ortho-imagery acquired between 27/06/08 and 10/07/08 was used as a basis for comparison. Multitemporal HR optical imagery was also used to fulfil the second objective of this study:

- Autumn HR image : 21 october 2007
- Spring HR image : 4 april 2008
- Summer HR image : 1 july 2008
- Additional Summer HR image : 4 july 2008

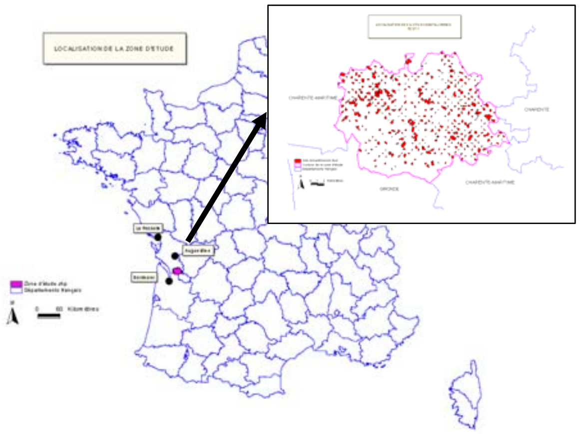


Figure 1. Location of VIRO site

In addition, the following data and software were made available to us by the AUP (French Administration):

- the CAPI software used in France for CwRS (HORUS)
- a sample of around 200 farmers' declarations for the VIRO site
- the corresponding LPIS data.

3. FARMERS BLOCK ANALYSIS

To fulfil the first objective of the study, an area frame sampling strategy was adopted using a randomly aligned systematic sampling approach to extract sample parcels from the LPIS. In total about 13% of the study area was sampled representing a total of 411 farmers blocks. The sample of farmers blocks was achieved by overlaying the LPIS layer with a 1km grid which origin had been randomly selected. All the farmers blocks intersecting with the grid were included in the sample. The operation was repeated to create 2 replicates with a view to switch interpreter between replicate to ensure there were no significant bias between the interpretations.

The photo-interpretation work was carried out as follows:

- Replicate 1: photo-interpreter 1 carried out the photo-interpretation of the RADAR data and photo-interpreter 2 worked on the VHR imagery
- Replicate 2: photo-interpreter 2 carried out the photo-interpretation of the RADAR data and photo-interpreter 1 worked on the VHR imagery

The photo-interpretation work involved the delineation of crop and non crop parcels and if required, the modification of farmers block boundaries. Each parcel was encoded with two attributes, one related to land use and the other to crop cover as shown in table 1.

Land Use Description	Code
Built up area	11
Agricultural parcel	21
Grassland band	22
Vineyard	23
Orchard	24
Bad stewardship	25
Woodland	31
Woodland strip	32
Wide hedge	33
Thicket	34
Water course	51
Pond	52
Non agricultural	61
Difficult interpretation	62
Encroachment on neighbouring parcel	63
Crop Cover Description	**Code**
Pasture	1
Summer crop	2
Winter/Spring crop	3
Bare soil on agricultural parcel / Harvest	4
Vineyard / Orchard	5
Non agricultural	6
Unknown cover	7
Crop growth problem	8
Farmers declaration discrepancy	9

Table 1. Land use and crop cover classification schemes

The level of agreement between the TerraSAR and VHR interpretation is around 90% as illustrated in Figure 2a. This is mainly due to a good agreement between the agricultural parcel class which represents nearly 90% of the overall area from the VHR interpretation. However, the agreement between smaller classes is much worse with particularly a tendency to overestimate the agricultural parcel. This is confirmed by the number of new parcels created during the interpretation: 561 for TerraSAR and 1578 for the VHR imagery, when considering that the default parcel value code is 21 (Agricultural parcel) and that new parcel are likely to be given a different code.

In addition, on smaller classes, it appears to be a confusion between built up areas and woodland, orchards and the non agricultural class, thus illustrating the difficulty to identify these classes on single date RADAR imagery.

This is further confirmed in Figure 2b. where the agreement between optical and RADAR imagery is only slightly greater than 50% for crop cover types. An illustration of the problems encountered in the differentiation of cover types from the single band TerraSAR X imagery is shown in Figure 3.

	ECHANTILLON 1 + 2								OPTICAL										
	Description	**Codes**	**11**	**21**	**22**	**23**	**24**	**25**	**31**	**32**	**33**	**34**	**51**	**52**	**61**	**62**	**63**	**Total**	**Agreement**
	Built up area	**11**	**16682**	8680		500					288	17020		1757	8665		58	**53650**	**31,1%**
	Agricultural parcel	**21**	21227	**25203723**	100089	1546011	10725	83039	22352	127674	64785		4802	5845	186024	12295	106743	**27495334**	**91,7%**
	Grassland band	**22**		20978	**5060**	3845		6136		357				913	3416	3266	1711	**45682**	**11,1%**
	Vineyard	**23**		26082		**282885**	13559		1660	692					766		1263	**326907**	**86,5%**
	Orchard	**24**	1054	2330			**3851**											**7235**	**53,2%**
	Bad stewardship	**25**																**0**	**0,0%**
RADAR	Woodland	**31**	151	12877					**25669**			1635		510				**40842**	**62,8%**
	Woodland strip	**32**	1378	36097	1490	1004		262	20984	**44824**	4145	2797			443	18	714	**114156**	**39,3%**
	Wide hedge	**33**	1286	72915	9021	702	1474	7012	11262	12011	**16397**	581		179	5990	9507	428	**148765**	**11,0%**
	Thicket	**34**		10310		826			13140		2538	**8454**	634	1953	61		161	**38077**	**22,2%**
	Water course	**51**																**0**	**0,0%**
	Pond	**52**		127	267						1080			**11425**				**12899**	**88,6%**
	Non agricultural	**61**	4467	23573		249	2417			650	659	1481		165	**1072**		2096	**36829**	**2,9%**
	Difficult interpretation	**62**	7676	2447		1230									1451			**12804**	**0,0%**
	Encroachment on neighbouring parcel	**63**	169	23323	2287	5927				1235	4073			12	2640		**10045**	**49711**	**20,2%**
	Total		**54090**	**25443462**	**118214**	**1843179**	**32026**	**96449**	**95067**	**187443**	**93965**	**31968**	**5436**	**22759**	**210528**	**25086**	**123219**	**28382891**	
	Agreement		**30,8%**	**99,1%**	**4,3%**	**15,3%**	**12,0%**	**0,0%**	**27,0%**	**23,9%**	**17,5%**	**26,4%**	**0,0%**	**50,2%**	**0,5%**	**0,0%**	**8,2%**	**Overall**	**90%**

(a)

	Echantillon 1 + 2						OPTICAL						
	Description	**Code**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**Agreement**
	Pasture	**1**	**2087465**	482566	412457	718597	166379	126295	36572	324428	20970	**4375729**	**47,7%**
	Summer crop	**2**	599354	**6433871**	817702	674429	842881	114193	29627	661064	33707	**10206828**	**63,0%**
	Winter/Spring crop	**3**	578722	224483	**6460871**	757373	17924	104268	38540	467905	39888	**8689974**	**74,3%**
	Bare soil on agricultural parcel / Harvest	**4**	3183	0	112319	**11521**	821	63	0	0	0	**127907**	**9,0%**
RADAR	Vineyard / Orchard	**5**	14400	1021	1067	11489	**281140**	4172	0	0	1263	**314552**	**89,4%**
	Non agricultural	**6**	122933	10065	21336	20169	26327	**225413**	12009	6052	3457	**447761**	**50,3%**
	Unknown cover	**7**	1318540	939439	393105	556752	524730	115052	**3776**	208028	22921	**4082343**	**0,1%**
	Crop growth problem	**8**	2176	0	71243	10935	0	4015	0	**0**	0	**88369**	**0,0%**
	Farmers declaration discrepancy	**9**	4870	4089	16278	373	5927	8129	0	0	**10045**	**49711**	**20,2%**
	Total		**4731643**	**8095534**	**8306378**	**2761638**	**1866129**	**701600**	**120524**	**1667477**	**132251**	**28383174**	
	Agreement		**44,1%**	**79,5%**	**77,8%**	**0,4%**	**15,1%**	**32,1%**	**3,1%**	**0,0%**	**7,6%**	**Overall**	**55%**

(b)

Figure 2. Agreement between optical and RADAR interpretation at (a) the land use and (b) crop cover level

4. FARMERS' DOSSIERS ASSESSMENT

Although the farmers block analysis described in paragraph 3 is essential to identify the ability of TerraSAR X imagery to be used as a surrogate to VHR optical imagery for identifying land parcel geometry, it was deemed essential to test the use of TerraSAR X imagery under operational conditions by replacing the VHR optical imagery with TerraSAR X data to assess a representative sample of farmers dossiers.

A total of 123 farmers dossiers were selected randomly out of a total of 399 dossiers for the VIRO site. The dossiers were processed independently by 2 experienced photo-interpreters:

- one performing the interpretation under normal operational conditions using VHR and HR optical imagery
- and the other performing the interpretation by replacing the VHR optical imagery with the TerraSAR X SpotLight data as illustrated in Figure 4.

It must be added that the photo-interpreter in charge of the TerraSAR X imagery did not have the VHR optical imagery at her/his disposal.

There were 78% of the dossiers which did not see their status changed by using the RADAR imagery instead of the VHR optical data

Even though the TerraSAR X data often provided supplementary information compared to HR imagery (see figure 4.), 21.6% saw their status change from accepted with VHR optical imagery to rejected with RADAR data. 0.4% of the dossiers changed from rejected with VHR optical imagery to be accepted with RADAR data.

The higher percentage of rejected dossiers is consistent with the results of the farmers block analysis in that the identification of some cover types is more difficult with the TerraSAR X imagery. As a result, photo-interpreters have a tendency to be more conservative, preferring to reject a dossier in the absence of a sufficient level of confidence about the land use/cover types present.

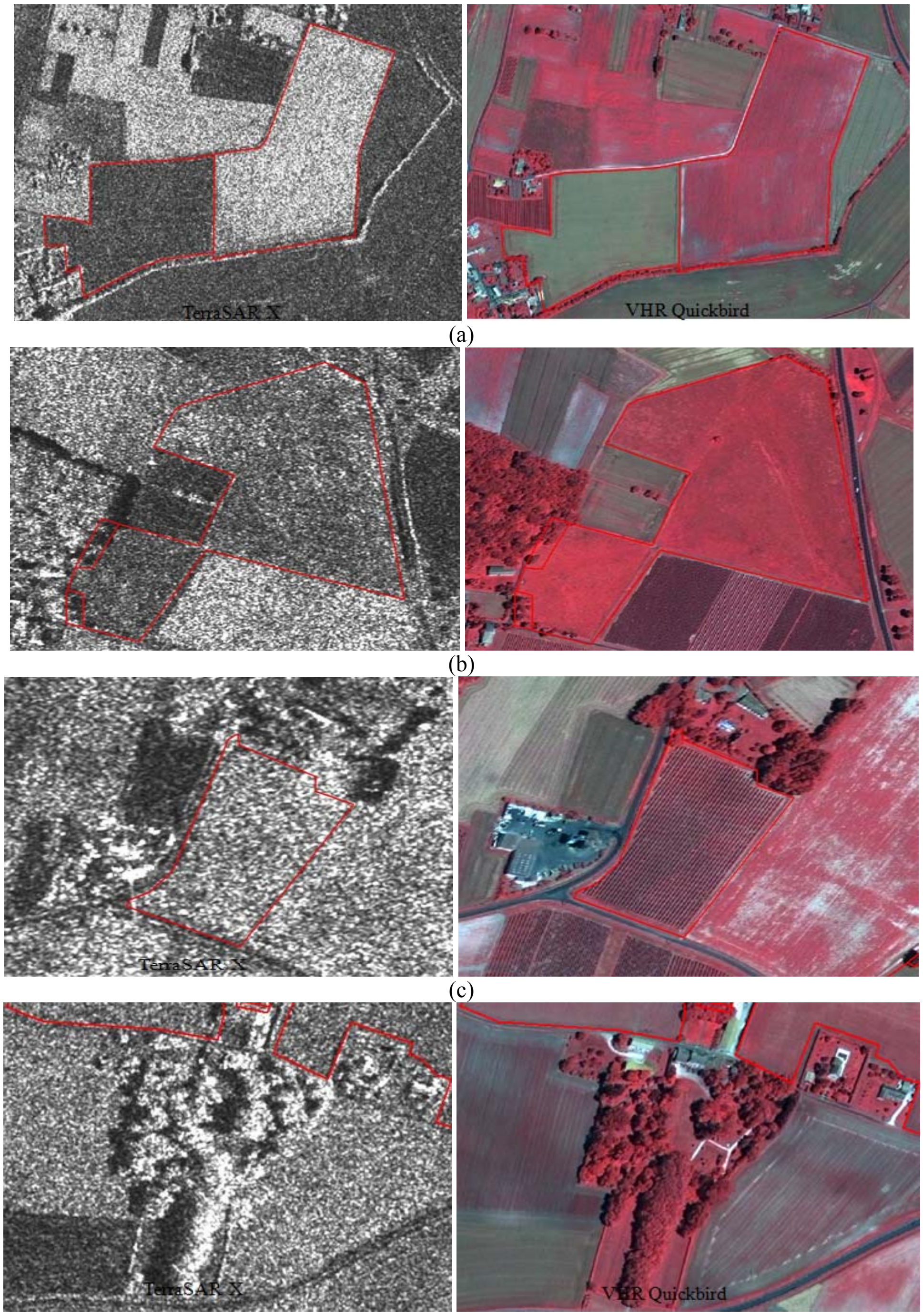


Figure 3. Identification of land use and cover types on TerraSAR X imagery, good discrimination between (a) summer and winter crops and (b) pasture and other cover types, poor discrimination between (c) vineyards and summer crops and (d) built up areas and trees.

5. CONCLUSIONS

The main purpose of this study was to investigate whether TerraSAR X Spotlight imagery could be used as a surrogate to VHR optical imagery as part of the agricultural Controls with Remote Sensing (CwRS) programme.

Analysis carried out at the farmers block level comparing the use of VHR optical versus TerraSAR X Spotlight data highlighted that even though there was a good level of agreement between VHR optical and TerrSAR X spotlight data at the land use level, it is not possible to characterise relevant crop cover types to a level equivalent to that of VHR optical imagery.

When the VHR optical imagery was replaced with single date TerraSAR X Spotlight data under operational conditions, nearly 4/5 of the dossiers analysed came out with the same decision. Of the remaining 1/5, most of the differences were related to a lack of confidence in terms of the cover types present, resulting in a change from accepted to rejected.

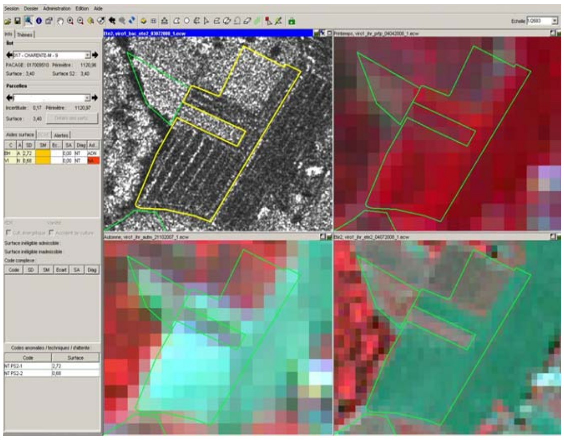
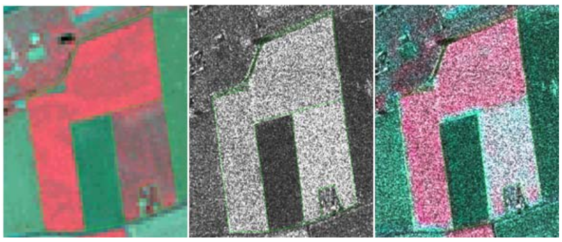


Figure 4. CAPI operational user interface with the TerraSAR X imagery replacing the VHR optical data

Finally, it should be added that comfort issues are crucial for this type of work where visual interpretation is involved. It is true to say that single date RADAR imagery is not as comfortable to look at compared with VHR optical imagery. However, this could be greatly improved if either an resolution merge approach was adopted as shown in Figure 5. below or if multitemporal RADAR coverage was achieved.



(a) (b) (c)

Figure 5. Example of RADAR/optical image fusion with (a) HR Summer optical image, (b) TerraSAR X Spotlight data and (c) optical/RADAR resolution merge image

This was tested for areas of overlap between SpotLight Scenes and a resolution merge between the SpotLight and SPOT5 multispectral data. The resolution merge greatly improves the comfort of the photo-interpreter and the ability to identify crop parcels. There were not enough time between the acquisition of the TerraSAR image scenes to assess the usefulness of the multitemporal RADAR image approach.

Technical session 7: LPIS Geodatabase updating and associated

ASSURING TRACEABILITY: PRINCIPLES OF LPIS MAINTENANCE IN THREE GERMAN FEDERAL STATES USING REFERENCE MAINTENANCE REQUESTS

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KEY WORDS: LPIS, maintenance, request, reference system, update, physical block, traceability, history, Germany, Brandenburg, Mecklenburg-Western Pomerania, Saxony-Anhalt, GAF AG

ABSTRACT

The German federal states of Brandenburg, Mecklenburg-Western Pomerania, Saxony-Anhalt and GAF AG have jointly developed an elaborated system for maintaining LPIS. LPIS is of considerable legal relevance with direct implications on subsidies payments and even penalties. Due to this, a major focus has been on how to control changes to the reference system and how to trace them. The main measures taken include: the four-eyes-principle, a complete history record of each reference object and the integration of a reference maintenance request system, which was introduced just recently.

The four-eyes-principle requires that every change to the reference system has to be approved by a second official. This person is not allowed to edit that respective area himself/herself. On approval, the reference is updated. Therefore, the 'long transaction' methodology based on a specific layer technique, has been introduced.

A complete history of each reference object is maintained. It allows reviewing its versions, including preceding and succeeding objects, which are linked due to splitting or merging operations. All former geometrical and alphanumerical states for any specific point in time can be retrieved. This includes information on the exact period of validity of each reference object and the logging information, e.g. who made the changes and who confirmed it.

The recently integrated reference maintenance request system allows for gathering, processing and controlling change requests for physical blocks and landscape elements. It is an open system, enabling the direct submission and retrieval of change requests via web-service-interface for other applications, like digital farmer declaration or IACS. Another set of requests is triggered on each update to the ortho-photo layer of the system. In the updated workflow, the reference update procedure is always triggered by a maintenance request. Its processing is integral part of the process. The LPIS editor evaluates each request and decides if it constitutes a reference change or if it will be rejected. If the request is successful, the change is made according to the editor's decision. On updating the reference system, the request is automatically closed. External software like IACS can trace the current status of each request.

1. INTRODUCTION

According to the Council Regulation (EC) No 1593/00 and Council Regulation (EC) No 1782/03, every EU member state is obliged to introduce LPIS. In most countries including Germany, LPIS has been introduced prior to 2005. Now the focus has shifted from the implementation to the maintenance work. This includes specific tasks with specific requirements. One main requirement is the traceability of changes to the LPIS. Traceability is of particular importance, when it comes to internal and external audits, such as the ones conducted by the European Commission as well as legal disputes on payments to the farmer.

To fulfil that traceability requirement the logging of LPIS operations alone is not sufficient. Far more system capabilities are required. All requests for an LPIS update need to be recorded. Clear information on the reception, processing and finalisation (validation or rejection) of each change request needs to be stored. Changes have to be confirmed by administrative staff to improve the data quality but also to avoid possible misuse. For auditing purposes, it is required to recall the historic states of the reference system as well as the complete historic successions.

In Germany the LPIS is the responsibility of the existing 16 federal states in Germany, leading to different IACS-GIS solutions. Eight federal states have contracted GAF AG for the development of a custom-made LPIS solution. In order to address the needs of traceability the three federal states of Brandenburg, Mecklenburg-Western Pomerania and Saxony-Anhalt have joined in their development efforts. Together with GAF AG they have developed an elaborate system for maintaining LPIS.

2. COUNTRY FACTS

Brandenburg, Mecklenburg-Western Pomerania and Saxony-Anhalt are all using physical blocks as agricultural reference unit. In total ~250 000 physicals blocks and ~215 000 landscape elements have already been specified. ~15 000 farms are concerned. The total agricultural area is about 3.8 million hectare. All three federal states are using the GAF AG software LaFIS-LFK® for the maintenance of their reference system, while the farmers utilize the AgroView®-CD software to do their declarations and for the generation of digital sketches of the parcels.

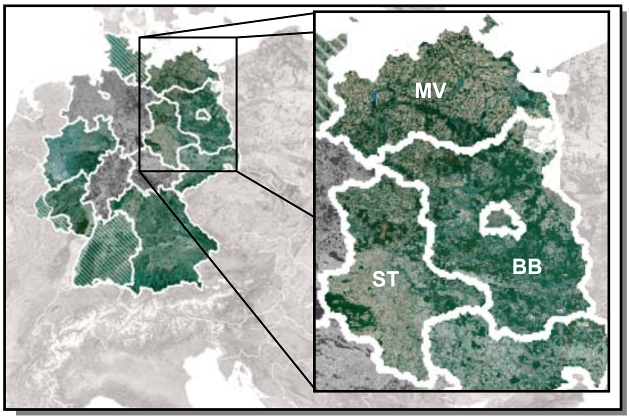

Figure 1. Federal states of Brandenburg, Mecklenburg-Western Pomerania and Saxony-Anhalt

3. PRINCIPLE SOLUTION

The principal solution to assure traceability consists of three main components:

1. Reference Maintenance Request System
2. Four-Eyes-Principle
3. Full Reference Object History

The Reference Maintenance Request System enables the tracking of change request and their processing. The Four-Eyes-Principle guarantees the confirmation of each change to a physical block or a landscape element by a second official. The Full Reference Parcel History stores the information of the different versions of an object including its attributes and geometry and also maintains the predecessor - successor relation among objects.

4. ORIGINS OF REFERENCE MAINTENANCE REQUESTS

To begin with, there are different motivations to issue a reference maintenance request (RMR). A request indicates that a reference object needs to be checked or created at a certain location for a certain reason. This does not mean that each request necessarily leads to a change of a reference object. Various origins of requests have to be integrated:

- Digital Farmer Application
- IACSs
- On the spot controls (OTSC) – Control with remote sensing (CwRS)
- Ortho-photo update

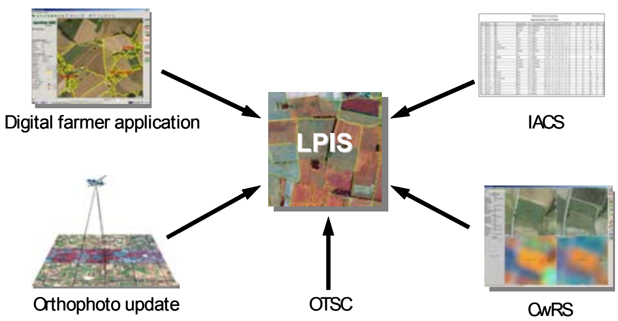

Figure 2. Origins of reference maintenance requests

Furthermore, reference maintenance requests can also be generated within LPIS itself to indicate required changes.

On a technical level, the LPIS system receives its RMRs from the other sources, either via web-services or via the import function. The advantage of web-services is that the full functionality of the RMR-System, including creation, retrieving or changing of RMRs, can be utilised.

4.1. Digital farmer application

In all three federal states, the application for subsidies can be filed digitally with the aid of the GAF AG software AgroView®-CD. In total more than 80% of the farmers have provided this information digitally, covering more than 90% of the total declared area. The declaration procedure requires that the geographic location and extend of the land parcels concerned are sketched. RMRs can either be set manually by the farmer or be created automatically by the software. If set manually, the farmer selects a geographic point and the type of maintenance request he/she likes to issue. Should a declaration record conflict intentionally with the reference (e.g. declaring a larger area than specified in the reference), the RMR will be generated by the software.

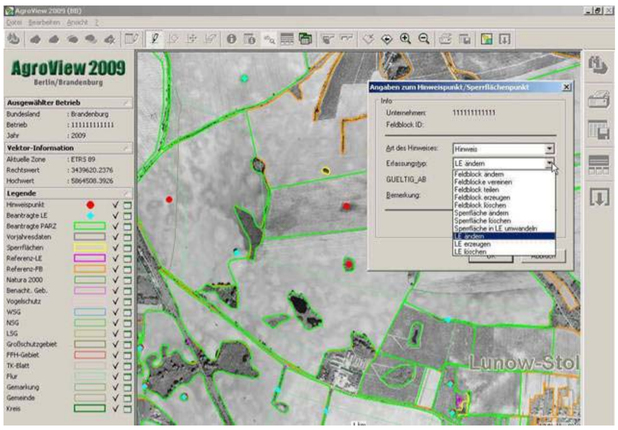

Figure 3. Digital farmer application

4.2. IACS

It is an EU requirement that new observations made during on-site-controls have to be reflected in the reference system. RMRs can now be submitted to the LPIS system via online link with IACS. The reasons for requests originating from the IACS controls can be various. For instance there could be a missing reference object, a conflict in size or an incorrect extend. In case of IACS staff detecting such an inconsistency he/she can submit an RMR via web-service to the LPIS system. The request will then be independently processed by an LPIS editor. The IACS staff member can track the status of the requests from within the IACS system also via online link.

4.3. OTSC - CWRS

Data gathered during on the spot checks and remote sensing controls constitutes another source for RMRs. In both cases, the data is exported from the external systems into the LPIS system. Additionally, vector information based on current GPS-measures or independent digitalisation can also be exported.

4.4. Ortho photo update

The most frequent RMRs are initiated due to an update of the ortho-photo basic layer. Currently, all three federal states are updating approximately every three years the complete ortho-photo coverage. Brandenburg and Saxony-Anhalt are updating one third of the respective provincial area per year, Mecklenburg-Western has just recently started a complete update. RMRs are generated automatically for all physical blocks within the updated area to indicate that a manual check of the object is required. All physical blocks concerned will then be checked. Even if this leads to no changes in the object, the check-up procedure itself is documented as having been executed.

5. PROCESSING REFERENCE MAINTENANCE REQUESTS

Having different origins, all reference maintenance requests are processed within LPIS by editors. They decide independently, if and how the individual request constitutes a change to the reference system.

RMRs are not just means to handle external sources of information. Within LPIS systems, their usage is now mandatory for every single change to the reference system. So far, a change to the reference system could have been done without having received a request, while now a request needs to be issued prior to the change.

Reference maintenance requests have the following main data contents:

- ID of reference object affected
- Standardised type of request
- Additional free description
- User and date of issue
- Origin of RMR
- Status of RMR

On the LPIS map all RMRs are represented with a particular symbol indicating their processing status.

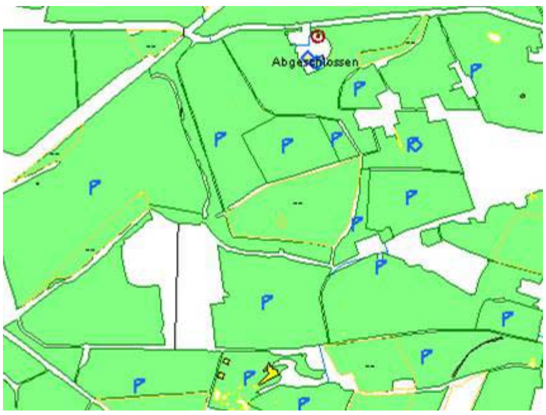

Figure 4. LPIS map with maintenance requests

The processing of RMRs follows a dedicated workflow, as described in the figure below.

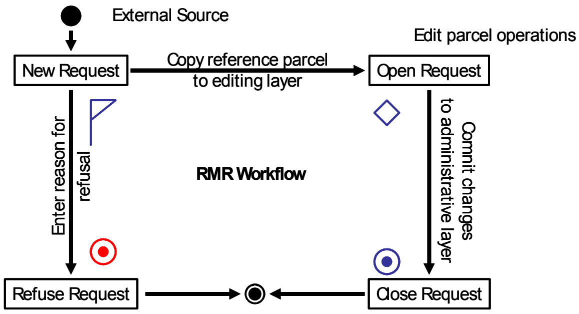

Figure 5. Process workflow of RMRs

Each new request is evaluated by the administrating official on whether to admit a change to the reference object or to reject it. In case of a rejection, the reasoning behind it has to be recorded. The date of processing as well as the user name is logged. The processing ends here. Refusals take place frequently e.g. in case of RMRs generated automatically due to ortho-photo updates. The RMR methodology ensures now the recording of rejected requests including the reason for their refusal.

If the administrating officer decides to open an RMR, the consecutive workflow is linked to the processing of the reference object itself. On opening the reference object, the process status of the RMR will be set to 'editing'. On committing the reference object changes, the RMR is closed as well. Details of this process are also described in the next section on the four-eyes-principle. The RMR methodology now allows for documenting the reasoning behind a reference object change.

6. FOUR-EYES-PRINCIPLE

Apart from the RMR methodology, the second component to assure traceability is the four-eyes-principle. It means that every change made to the LPIS by one editor, has to be confirmed by another administrative officer. Since LPIS is the legal basis for area related payments, every change to the LPIS needs to be authorised. This procedure also aims to maintain the system's integrity and to improve its overall quality. However, this requirement has made the workflow for processing LPIS updates more complex. The confirmation is not made immediately within the same session, but by different staff members at a different location and time. Consequently, the editing process, including the commitment of changes to the reference system, can technically be considered as a 'long transaction', processed in multiple editing sessions. This issue has been solved by separating the reference layer from the editing layer (allowing 'long transaction') and by introducing a dedicated workflow as shown in the diagram in figure 6.

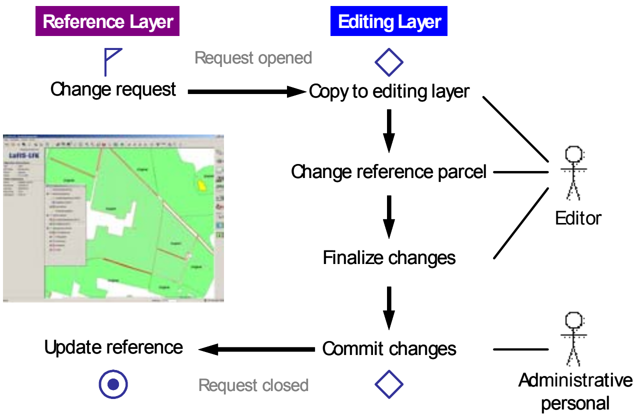

Figure 6. Four-Eyes-Principle workflow

On opening an RMR, the reference object is copied to the editing layer. Thereby the transaction is started. All consecutive actions are logged. The editor makes his/her changes to the object and finalizes them. The finalizing involves a change to the object status. Now another administrative officer checks the changes. He/She can either refuse the changes and hand the reference object back to the editor, or accept the changes being made. He/She is not allowed to make any changes to the object him/herself. In case he/she accepts the changes, the altered object is committed to the reference system, the transaction is finalized, and the reference system is updated. The RMR is automatically closed. While editing, the reference system remains unchanged. However, the reference object's status is changed, to indicate that an update is in progress.

7. REFERENCE OBJECT HISTORY

For each physical block, including landscape elements, a history of consecutive changes is maintained. Information on current and historic objects is maintained in the database. The documentation includes predecessor and successor relationships of objects, as well as the corresponding time stamp indicating the validity period of each object. Historic RMRs are also stored including the information on the corresponding historic object.

Maintaining a history of reference objects in the database, allows for reconstructing the reference system for any point in time. It can be retrieved on the database level or visualized within the maintenance system. Also the corresponding RMRs are shown.

On recording the predecessor - successor relationship, more complex relations due to splitting or joining of objects, can be reproduced. Even when the identification number of an object changes due to an update, the predecessor – successor history enables the identification of previous IDs and their historic succession.

Figure 7 shows a sample of an object history as it is displayed in the LaFIS-LFK® software. The latest reference object is the product of a joining process of two physical blocks. Also displayed is the time stamp (GUELT_VON and GUELT_BIS), indicating the validity of the record. Another view allows overlying graphically all objects of the object history tree showing the changes over time. Hereby, a selection on which objects are shown can be made.

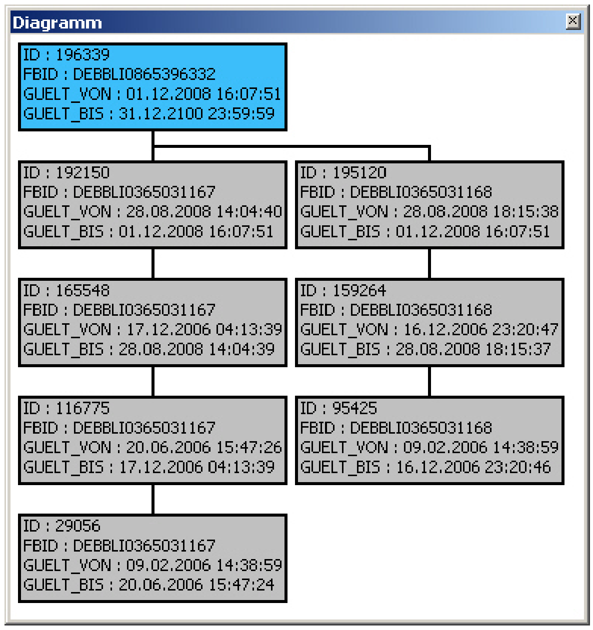

Figure 7. Object history

8. CONCLUSION

After more than 5 years of maintaining LPIS, it has been shown that there is a need for a more sophisticated change management. This article has described an integrated solution, developed by three German states in cooperation with the GAF AG, consisting of a reference maintenance request system, based on a four-eyes-principle and a reference object history. This methodology has already proven its usefulness over the past years. The full scale maintenance request system, as the latest development, is in operation since the beginning of 2009. This enhancement is meant to improve the traceability of changes to the reference system significantly, thus to keep up with the increasing requirements on the LPIS. The LPIS is more and more interlinked, since its maintenance information has its origin in an increasing number of sources. The maintenance request system also integrates these sources on a technical level, thereby assuring efficiency and timeliness of the processing.

9. REFERENCES

Council Regulation (EC) No 1593/2000 of 17 July 2000 amending Regulation (EEC) No 3508/92 establishing an integrated administration and control system for certain Community aid schemes

Council Regulation (EC) No 1782/2003 of 29 September 2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers and amending Regulations (EEC) No 2019/93, (EC) No 1452/2001, (EC) No 1453/2001, (EC) No 1454/2001, (EC) 1868/94, (EC) No 1251/1999, (EC) No 1254/1999, (EC) No 1673/2000, (EEC) No 2358/71 and (EC) No 2529/2001

Poster session

AN AUTOMATIC DETECTION OF SELECTED NON-CONFORMITIES IN THE LPIS

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KEY WORDS: LPIS, update, object extraction, non-conformities, image, DSM, nDSM

ABSTRACT

The Land Parcel Identification System (LPIS) is a spatial database of reference parcels managed by Member States in the context of the Common Agricultural Policy (CAP). This spatial database should be up to date with respect to elements which are ineligible for CAP subsidies. In particular built up areas and patches of trees should be excluded from the maximum eligible area of LPIS parcels. Because the landscape changes continuously (e.g. new buildings and roads appear), Member States need to monitor these changes and to integrate them in the LPIS. That means that usually an ortho-coverage of the country is renewed on average every five years. However the photo-interpretation of this ortho-imagery in order to verify the correctness of LPIS boundaries, and in particular that all ineligible elements are excluded, is time consuming and expensive. Therefore, there is a strong need for the development of automatic methods for detecting LPIS non-conformities.
In this paper an automatic method for detecting buildings and patches of trees on airborne digital ortho-imagery is presented. The method is based on an object oriented approach applied to multi-spectral data in combination with a Digital Surface Model. The preliminary results obtained over two LPIS subsets from a Member State show that 100% of buildings and 90% patches of trees can be detected.

1. INTRODUCTION

The Land Parcel Identification System (LPIS) is a spatial database of reference parcels that Member States (MS) are requested to implement and maintain for managing the CAP subsidies and operational since 2005. This spatial database is used by farmers for declaring their cultivated land and by the administration for checking all claimed parcels; in particular the total area claimed by farmers inside an LPIS parcel should not exceed the maximum area eligible for aid in this LPIS parcel. Therefore it is of great importance that the LPIS should be up-to-date in order to allow the administrations to take valid decisions. This means that the vector / image (not compulsory layer) data that are part of the LPIS must be both up to date and of appropriate accuracy. In order to achieve this objective, MS renew their ortho-coverage on average every five years. The 'millions' of reference parcels boundaries in the LPIS should then be verified by operators through Computer Aided Photo Interpretation (CAPI), which is time consuming and expensive.

The objective of the study is to develop an automatic method for the detection of selected non-conformities in the LPIS system to support a systematic update process on the basis of up-to-date ortho-imagery. According to survey carried out by Grandgirard and Zielinski (2008) the two main sources of anomalies found in the LPIS are: natural landscape features surrounding or included in the reference parcels (forests, hedges, etc.), and continuous anthropogenic features (buildings, roads). Since the building and patches of the trees represent more than 50% of all possible object types causing problems in the LPIS, the work presented in this paper focused on those selected objects. In the new method proposed the image content is used in combination with the digital surface model for object analysis. The preliminary results presented here are based on two subsets of the LPIS dataset from a Member State.

The paper is organized in several sections. Firstly the rationale of the project and the problem statement are defined; secondly the workflow of the method is described; then the methods applied and dataset used are presented. Finally results of the object extraction and potential non-conformities detection within the LPIS database are depicted and conclusions are drawn.

2. RATIONALE

The first concept of the LPIS, as a fully alphanumerical database without any geospatial reference was introduced in 1992 by Council Regulation (EC) No 3508/1992. Later, the idea of a GI oriented system was proposed in order to serve spatial identification of the agricultural parcels (Council Reg. (EC) No 1782/2003, Art 17) in the frame of the Integrated Administration and Control System (IACS). In principle the LPIS provides a unique identification, the location and, through a defined reference parcel system, the maximum area of agricultural parcels. The reference parcel is a basic unit of LPIS and is spatially represented within the database by the polygon geometry of the 'object' boundaries. The 'object' term refers to the agriculture land use function in specific economic aspect – agricultural activity (Sagris *et al*, 2008). As result the definition of the object might become very complex. Moreover, diverse practices exist among the Member States in the implementation of the reference parcel systems (Milenov and Kay, 2006). The reference parcel boundaries can be based on different patterns given by the topographical linear elements, land cover borders and/or land use practices. Where the cadastral parcel is used as reference the boundaries might not match any terrain phenomena. In addition, "the conceptual roles in the LPIS were not extensively documented" (Sagris *et al*, 2008) like in the GIS application of other geographic domains (Jacquez *et al*, 2000) to force boundary type to be well defined.

Considering the above-mentioned constrains, the LPIS is a very complex system to be kept up-to-date, especially, when the lineage of the data used for the creation of the systems and reference parcel type among Member States is considered. The use of archive data (e.g. aerial ortho-photo) or other not error free databases (i.e. cadastre) introduced temporal inconsistency already at the system creation stage. Another important factor is the reference parcel boundaries stability over the time: the agriculture parcel required annual revision of the whole database; the block-based systems (farmer and physical block) are much more stable and cadastre-based systems take advantage of external information supplier.

In principles, the update process of the geographic database ensures that the data is up to date and consistent with the 'real world'. The update process is a very important element of the system maintenance. Several processes might trigger the update of the reference parcel of the LPIS. Firstly, the information provided directly, in the annual life circle, by farmers about the change in the parcel (e.g. land use changed). Secondly, the information collected by inspectors during the controls (OTSC, CwRS) or rising from cross-check with external database. Finally, the periodic (or systematic) solution defined in the long term update strategy linked with data acquisition, i.e. partial update of ortho-coverage (Wirnhardt *et al* 2007), used as the source of information about the change.

As the systematic update on the basis of the ortho-imagery gives a consistent result in the large range of elaboration, in comparison to the other approaches, this approach should be further examined. Nowadays, the preferred image data source for the systematic update has moved towards ongoing developments of airborne digital cameras (Zielinski and Sagris, 2008). As result, additional information (the near infrared channel) became available for photo-interpretation process. According to the results of a survey reported by Zielinski and Sagris (2008) the most commonly used technique for the update of the reference boundaries is based on fully manual photo-interpretation (CAPI). The photo-interpretation is defined as the method of examining images for the purpose of object identification and judging their significance (Colwell, 1960). In other words, a visual inspection, parcel-by-parcel, is performed by an operator in order to detect any failures to meet quality requirements. This creates an evidence of a non-conformity or an anomaly. The anomaly is an observed non-fulfilment of the data to one or several specified requirements, as expressed in the specifications. Non-conformity is a registered discrepancy which exceeds a value pre-defined in the data specification (Sagris and Devos, 2008).

In the LPIS context, an anomaly can be an obvious error, observed when data does not comply with the applicable LPIS model, caused by incorrect mapping or data processing. The terrain dynamic and local changes (i.e. new buildings, roads appeared) that are not introduced in the system, cause anomalies. Potentially a mass of anomalies might be generated when the concept applied to 'real world' changes, for example by a change in policy goals and consequently in the Regulations (Sagris and Devos, 2008).

Nevertheless, in order to understand the actual update needs and to address the problem correctly, the extensive analyses of non-conformities and anomalies in the system have been undertaken. According to the results of the first comprehensive survey concerning the subject (Grandgirard and Zielinski 2008) the natural landscape feature (patch of the trees) and anthropogenic features (buildings) surrounding or containing the reference parcel are detected as the main sources of the anomalies. Therefore, the information about the location of those features might allow verifying the correctness of the data in the system. Fully manual revision of the reference parcel (one by one) is time consuming and expensive, thus there is a great potential for the systematic update methods of the LPIS. The automatic detection of parcels that potentially need to be updated could significantly improve the time efficiency and reduce the cost of the update process.

The work presented in this paper is focused on detecting two most important objects: patch of the trees and buildings that are causing the most frequent anomalies in the LPIS. The author believes that the investigation of potential anomalies might become a powerful instrument to maintain and monitor the quality of the system.

3. WORKFLOW

The workflow of the study is divided into four steps (Figure 1): the first one (marked green) presents the input data, the second (marked orange) refers to the data pre-processing steps used to supply the automatic object extraction (marked blue). The last step in the workflow is dedicated to the potential non-conformities detection in the system (marked red).

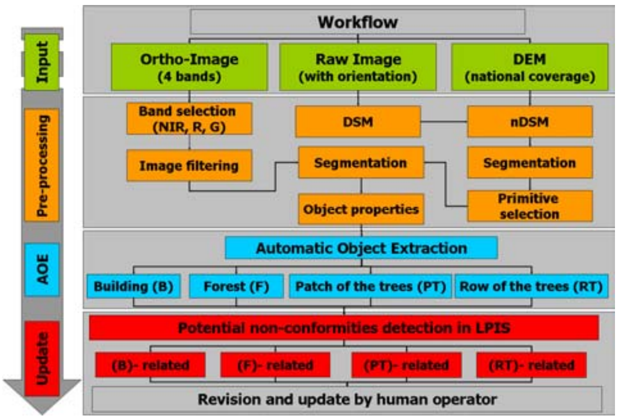

Figure 1 Proposed workflow of automatic detection of potential non-conformities in the LPIS

This workflow is designed to use a standard image dataset collected in the frame of the LPIS project. The raw image data acquired with the digital airborne camera are used for the ortho-imagery generation. In parallel, the same set of raw data is used for the creation of the Digital Surface Model (DSM) by image correlation techniques. The Digital Elevation Model (DEM) is used in order to normalize the surface information obtained from the DSM. The height data are considered as an additional source of information about the objects of interest. The object extraction process is based on the information taken from the ortho-image (further called image) and the normalized Digital Surface Model (nDSM) data. The algorithm applied is described in the next paragraph. The results of the extraction, the vector outlines of the objects, are confronted with the corresponding reference LPIS parcel using standard GIS techniques. The presence of the object of interest (i.e. building) within the reference parcel is recorded as a potential non-conformity. The final result of the detection, including the graphical and statistical information (e.g. number of objects, origin and area), by reference parcel are delivered to the human operator for verification and final update.

4. METHODS

In order to detect patches of trees and buildings on the multi-spectral imagery, the properties of the object have to be described (i.e. shape, size, radiometric response). However, the characteristics are highly variable as a function of the roof material, tree species and also depended on the geographic location and date of image acquisition. All these factors make extraction itself rather a complex task. Therefore in order to limit the number of variables in the extraction process, the common property for both objects is introduced. The height of objects might help to discriminate them from the surrounding objects with similar i.e. radiometric response.

The height information might be derived from various sources but the image correlation results might be the most appropriate for the LPIS, considering the fact that the ortho-coverage is collected anyway for the entire country in most of cases, so there is no need to collect additional expensive data (i.e. with LIDAR). However, the expected quality of the DSM delivered from the image stereo-matching, using image data acquired for the LPIS purpose, is still not comparable with the LIDAR data. Besides, the parameters of the flight projects executed for the LPIS are mostly not dedicated for the DSM creation, so that the expected quality of the surface description might be rather poor. As a consequence, the methods designed to support the object extraction in urban environment which are strongly dependent on height information, might not be useful for that purpose (i.e. Zhang *et al*., 2005). Considering all mentioned facts the utilization of the DSM matching based product or derivative of it, should be used as secondary or additional information in the process.

The first step of algorithm is to limit the area of investigation and focus further elaboration in the subset of image where the objects of interest are foreseen. Here, the hypothesis based on the object properties is used. In order to identify buildings two conditions are used: first the height of the object have to be higher than a value above the ground (variable A – set to 1,5m) - calculated at the basis of nDSM; second, the radiometric response of the object have to be different than the green areas. The latter is delivered by *normalised difference vegetation index* (NDVI) index and indicated by variable B (set to NDVI < 0). For the trees oriented objects the hypothesis is built similarly, the objects concerned have specified heights (A - the same as above) and radiometric response (B - NDVI > 0,3). The two types of data, the nDSM and (NDVI) derived from a multi-spectral image, are used in the segmentation (Haralick *et al.,* 1985) through threshold process driven by the variables (A and B). At the basis of that the potential locations of the objects of interest are created, the primitives (or blobs - an irregular object or part of it, not corresponding to the correct object shape) are separated to the single object and used in the next steps. This part of the algorithm derives the primitives size and location so that in the further steps the blobs can be extracted and treated separately. Next, the image bands (near-infrared, red and green) are delivered to the process of Mean Shift (MShift) segmentation based on *feature space analyses* (Comaniciu and Meer, 2002). The MShift algorithm is a nonparametric clustering technique which does not require a priori knowledge of the number of clusters and does not constrain the shape of it. Shortly, the technique is comprised of two steps: a mean shift filtering of the original image data (in feature space), and a subsequent clustering of the filtered data points. In order to control the MShift segmentation algorithm three parameters are required; the spatial bandwidth *Hs*; the range bandwidth *Hr*; and the minimum segment area *S,* that constrains the minimum area of the resulting segments. In general, the spatial bandwidth determines the resolution in selecting the local maxima density points, so that controls the number of resulting segments. The *Hr* parameter is related to the colour information and determines the granularity of the segmentation.

The segmentation is a crucial step in the automatic image analysis process and along with the object extraction will have a significant influence over the final accuracy of the extracted features. The miraculous segmentation method which segments in a correct way all types of landscape does not exist thus the choice of the most appropriate parameters is important and has a great influence on the segmentation results (Carleer *et al.,* 2005). Therefore, it is necessary to evaluate the performance and optimize the values of the segmentation parameters. The optimization is performed on the basis of empirical discrepancy measures (Zhang, 1996) for each type of objects separately. The statistical approach is used to select the most appropriate segmentation parameters (Hs and Hr). The minimum size parameter (S) is excluded from the investigation because has not a significant influence on the segmentation results. The representative sample of the object with corresponding ground true information are used for the comparison of similarity in sample set and measured by Jaccard index. The sample set consists of segmentation result (achieved using a selected pair of the parameters) and the corresponding true outline of the object (i.e. building). In the iterative process a number of combinations of the parameters are performed. Finally, the statistical analyses are carried out in order to find the pair of the parameters balancing the under- and over-segmentation of the image. Then, the MS segmentation algorithm is applied to the digital airborne data to partition an image subset into a set of non-overlapping regions for which a set of the geometric and radiometric properties are calculated. Additionally, the shadow of the height object (i.e. building) is extracted based on the image insensitivity and geometric properties of the objects, calculating approximate sun elevation and azimuth. This feature is used in the pair with the DSM data to find optimal placement of one object boundary. Next, the segments of the object concerns are selected by the means of the fusion algorithm based on the segments properties (i.e. colour, nDSM, NDVI). Last, the extracted objects are exported to the final vector layer and the geometrical prosperities are calculated.

The algorithm described above is programmed in the IDL® environment and applied on subsets of LPIS dataset.

5. DATASET

The presented method is tested on two subsets of the LPIS database of a given Member State. For each subset sites a set of two ortho-image layers and corresponding vector representations (LPIS) are collected. The first ortho-image layer is only considered as archived data (acquired in the year 2005). The true colour composition image with a 0,5m ground sample distance (GSD) acquired by the airborne analogue camera RC 30 Leica is used as the reference layer for detection of terrain changes.

The second layer, a recent update of the ortho-image acquired in the year 2007 by means of the digital airborne camera Microsoft UltraCam D with a GSD of 0,5m, on which the method is applied. The resampled product to 8 bits per channel with true colour and false compositions is used (Wirnhardt *et al.,* 2007). Further in the process, the advantage is taken of the raw image data with orientation parameters and the DSM is generated using the commercial off-the-shelf software (PCI, 2009) with a 1m GSD. The DEM used in the project for the normalization of DSM is a subset of the national model (Winkler, 2004). The vector data consists of two LPIS reference years (2005 and 2007). The first, archived vector is used with the ortho-image from the same year to serve as a reference for the changes in the terrain. The second dataset (image and vector from 2007) is a subject of investigation. The vector layers are corresponding to the orto-images and presented below. Figure 2 and 5 shows the LPIS 2005 layer overlaid on the 2005 ortho-image and figure 3 and 6 presents the LPIS 2007 layer with the ortho-image based on the Ultracam D acquisition for two test sites respectively.

The selected areas of interest show an interesting example of the significant change of the land cover in the time frame of two consecutive years. Analysing the status of the LPIS in the 2005 year some omission errors might be found. The main build-up areas are excluded, however few buildings (marked by red circles) and partly forested areas are not recognized or update process did not cover this area (Figure 2 and 5). Comparing the situation with the ortho-image, acquired two years later in the frame of systematic ortho-coverage update, the development of the inhabited area and the high vegetation encroachment is noticeable (Figure 3 and 6).Twenty-three and twenty new buildings with infrastructure are built, respectively for the first and second test site. Furthermore, the reference parcel and exclusion boundaries in force remained not changed and required verification and update.

6. RESULTS

The results presented in this paragraph are divided into categories: the object extraction quality assessment and the evaluation of the potential non-conformities identified automatically. The visual representations of the potential non-conformities found in two test sites are presented in figure 4 and 7.

The evaluation consists of a comparison between the automatically found non-conformities and the ground truth (manually collected outlines of the objects). Two quality measures: correctness and completeness (Heipke et al., 1997) are computed for the evaluation purposes. The calculation is performed in two approaches: per object, which gives an idea of the extraction expressed in the number of objects; and per pixel, what is dedicated to evaluation of the quality of the extracted objects. The completeness is expressed by the percentage of the objects that are detected by the algorithm, formula penalised by false negative foundings. The correctness states the percentage of the objects detected by an algorithm that correspond to the real objects; the formula includes the false positive objects.

The range values of both indexes vary from 0 to 1, where 1.0 indicates that the extraction is fully correct.

The results of the evaluation are presented in table 1. The measures express the quality of the objects extracted by presented algorithm. For both sites all the buildings (B) are found correctly, only in the second test site the greenhouse (marked by red circle) is classified incorrectly into the building class (Figure 7) due to radiometric and geometric similarities. Thus, completeness for that class of object is close to 1. The measures calculated per pixel gave worse results because of an incomplete extraction of the single building caused by a light reflection on the roof.

Table 1 The result of the objects extraction process (B-building, T-patch of trees)

	Completeness		**Correctness**	
	per object	per pixel	per object	per pixel
AOI 1				
B	1.00	0.72	1.00	0.69
T	0.90	0.69	0.91	0.72
AOI 2				
B	1.00	0.83	0.97	0.79
T	0.91	0.74	0.95	0.80

The tree related (T) objects are extracted with a satisfactory rate, but the calculations are performed for all objects without distinction between the object sizes (including single trees or object smaller than $100m^2$ for which the rate are much smaller). The lower correctness rate expressed per pixel is less problematic in this application. The final outlines of the objects can be identified and delivered for verification in the final update phase.

In the last part of the method the result of the extraction are superimposed with the LPIS vector data. The verification of presence of the object within the reference area is performed using a standard GIS tools. The trees related objects are filtered applying the minimum area parameter (>0,1ha) to select only the objects concerned in the LPIS update process.

Based on the spatial relation with the LPIS data, the extracted objects are classified on a basis of additional spatial attributes and are shown using different colours in figure 4 and 7. The building outlines are marked in two colours: in orange extracted objects already excluded from the reference layer and in yellow those that are automatically marked as potential non-conformities. Similarly the trees related objects are classified. The green colour represents the objects excluded already from the reference LPIS layer. The areas with potential non-conformities are marked in red. The extraction results show a higher details level than required in the LPIS (min. mapping unit: 0.1 ha), so further development of generalisation process should be developed. However, in this paper all extraction results are presented in order to demonstrate a potential of that method (i.e. in CwRS projects).

7. CONCLUSIONS

The LPIS systematic update processes carried out by Member States are mostly done using manual photo-interpretation method (CAPI) and qualified human resources. The parcel-by-parcel LPIS revision is a possible method of update but also very expensive and time consuming. The automatic method proposed in this paper addresses more than 50% of LPIS anomalies, according to the result of the survey (Grandgirard D., Zielinski R., 2008) of all possible objects types causing problems in the LPIS. The correctness and completeness coefficients of the object extraction were found to range between 90 and 100%. The application of the method might significantly speed up the update process by pointing potential anomalies inside reference parcels.

Figure 2. The state of the LPIS in the year 2005, ortho-image acquired in 2005 overlaid with the reference parcel and exclusions layer (AOI1).

Figure 3. The state of the LPIS in the year 2007, the LPIS layer for the reference year for 2007 overlaid to with up-to-date ortho-image acquired using Ultracam D (AOI1).

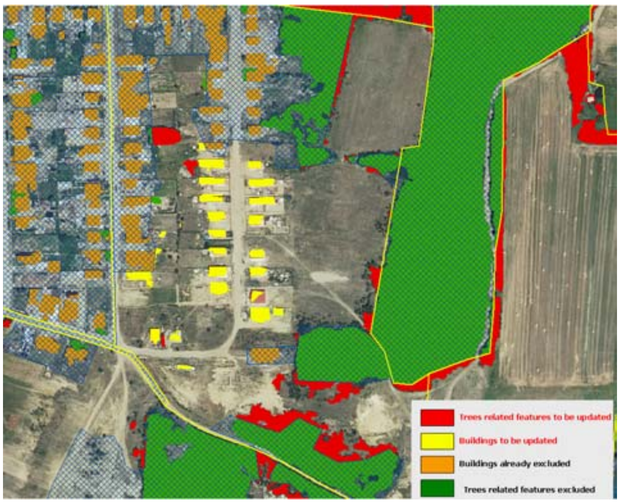

Figure 4. The detection results of potential non-conformities in the LPIS (AOI1).

Figure 5. The state of the LPIS in the year 2005, ortho-image acquired in 2005 overlaid with the reference parcel and exclusions layer (AOI2).

Figure 6. The state in the year 2007, the LPIS layer for the reference yeah 2007 overlaid with up-to-date ortho-image acquired using Ultracam D (AOI2).

Figure 7. The detection results of potential non-conformities in the LPIS (AOI2).

The human operator would have to update only the boundaries of the parcels indicated as potentially incorrect by the algorithm instead of screening of the LPIS database parcel-by-parcel. That would significantly reduce the time needed for the systematic update thus lower down the costs. Additionally, the importance of update for every parcel might be evaluated on the basis of several attributes resulting from the object extraction process, given per reference parcel: object types, number of objects within one reference parcel, total area, etc.

However, high correctness and completeness coefficients of the object extraction are the crucial component of the proposed workflow. The usage of a combination of image and height information with a strict regime applied in the selection of segmentation parameters has proven to show promising results. Additional parameters (e.g. texture) for object extraction could be investigated in order to improve the robustness of results.

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Conference Programme

Wednesday 3/12		
8:30 – 10:00	**Registration, stand set-up**	
	Linhart Hall **sessions with interpretation**	
	Conference opening session	
10:30 – 11:15	Milan Pogačnik, Minister, Ministry of Agriculture Forestry and Food, Slovenia Stephan Lechner, Director, Institute for the Protection and Security of the Citizen, JRC, European Commission	
	Plenary 1	
11:15 - 12:30	• Introduction to the conference (Simon Kay, JRC) • Geoinformation and CAP implementation in Slovenia (Alenka Rotter, MAFF, Slovenia)	
12:30 – 14:30	**Buffet Lunch**	
	Plenary 2 **Keynote speeches**	
14:30 – 16:00	• Keynote invited speaker: GIS & Auditing: from Tsunami to money laundering, (Egbert Jongsma, Project manager, Knowledge Center GIS & Audit, Netherlands Court of Audit) • The CAP Health check – outcome (Jean-Jacques Jaffrelot, Head “Direct Support” Unit, DG Agriculture and Rural Development, European Commission)	Parallel in foyer: Poster demonstrations
16:00 – 16:30	**Coffee break**	
	Plenary 3 **Land Parcel Identification System**	
16:30 – 18:00	• Current status of LPIS, future approaches for QC and benchmarking (Wim Devos, JRC) • Status of LPIS implementation in Croatia (Zdravko Tusek, Ministry of Agriculture, Croatia and Pavel Trojáček, EKOTOXA) • QC LPIS: an automated system for LPIS Data Quality Control (Fabio Slaviero, Abaco Group) • LPIS update by remote sensing techniques (Anders Forsberg, Swedish Board of Agriculture and Erik Pettersson, Visimind AB)	Parallel in foyer: Poster demonstrations
20.00 - 24.00	**Reception at club Bachus Center**	

Thursday 4/12		
	Linhart Hall **with interpretation**	**Kosovel Hall** **no interpretation**
	Plenary 4: Review of the 2008 CwRS campaign **Restricted to National/Regional Administrations**	**Technical 1: New sensors, potential applications**
09:00 – 10:30	• Summary statistics analysis (Andrew Rowlands, JRC) • Image acquisition CwRS 2008 (Maria Erlandsson, JRC) • The use of TerraSar-X and Non LPIS datasets to deal with the absence of optical imagery (Tom McHugh, ICON) • Image acquisition strategy: review of 2008 plan for 2009 and preparation for 2010 (Hervé Kerdiles, JRC)	• GeoEye-1, a next generation satellite for the CwRS campaign, (Axel Oddone, Eurimage) • RapidEye, Multi-Temporal Imagery With 5 bands In 5m: A Key Resource In Agricultural Monitoring (Frederik Jung-Rothenhäusler, RapidEye) • Orthorectification of KOMPSAT-2 as potential source of data for the CwRS campaigns (Stefana Popova, ReSAC) • Leica's 3rd Generation of Airborne Sensors – features & benefits for environmental applications (Arthur Rohrbach, Leica Geosystems)
10:30 – 11:00	**Coffee break**	
	Plenary 5: On-the-spot check preparation, **Restricted to National/Regional Administrations**	**Technical 2: Image processing, data serving**
11:00 - 12:30	• The Common Technical Specifications, 2009 (and 2010) (Hervé Kerdiles, JRC) • Deduction of ineligible areas: thoughts and proposals for 2009 (Hervé Kerdiles, JRC) • Use of Pan image only for the CwRS (Pavel Milenov, JRC) • A Mobile System for on the Spot Checks (Anders Lind, Västra Götalands län, SE)	• Benchmarking the WorldView-1 and EROS B sensors for use in the CwRS programme (Joanna Nowak, JRC) • Image Connect web access to worldwide satellite aerial data (Bruno Biagini, Eurimage) • Providing access to terabytes of Earth Observation data - infrastructure, services, and licensing (Paul Hasenohr, JRC) • How web services and geo-collaboration tools could help MARS community? (Emmanuel Mondon, ERDAS)
12:30 - 14:30	**Buffet Lunch**	

	Linhart Hall with interpretation	Kosovel Hall no interpretation
	Technical 3: Guidance on area checks, 2009	**Technical 4: Farm Advisory Systems**
14:30 – 16:00	• Guidelines for measuring vineyard parcels in the context of Reg. 479/08 and 555/08 (Hervé Kerdiles, JRC) • Calculation of vineyard grubbing-up area in Spain (Fernando Ruiz, Tragsatec, ES) • Results of validation tests on imagery (Joanna Pluto Kossakowska, JRC) • Results of GNSS test (Aleksandra Sima, JRC)	• Status of the Farm Advisory System in the Member States (Vincenzo Angileri, JRC) • Cross compliance and the Farm Advisory System in the Republic of Slovenia (Igor Hrovatič, Chamber for Agriculture and Forestry of Slovenia, SI) • Orthoimage and LPIS and their further use in a holistic approach (Walter H. Mayer, ProGIS) • Precision agriculture techniques in relation to Cross Compliance and FAS (Tamme van der Wal, Portolis)
16:00-16:30	**Coffee break**	
	Technical 5: Cross Compliance	**Technical 6: New Radar sensors**
16:30 – 18:00	• Remote Sensing and GAEC (Philippe Loudjani, JRC) • Issues on eligibility (land cover, land use) – a standardised approach (Wim Devos, JRC) • GIS as a support tool for increasing the IACS efficiency, especially for GAECs and eligibility OTS checks (Lucie Savelkova, SAIF, CZ)	• Multi-source remote sensing integration: VHR SAR and Optical data for extraction of agroenvironmental parameters (Livio Rossi, Agrisian) • TerraSAR-X in support of CwRS – High geometric quality by automated image processing (Thomas Schrage, Infoterra) • Case study on TerraSAR-X use within CwRS campaign on test sites in Czech Republic (Lukas Brodsky, GISAT) • Evaluation of SpotLight TerraSAR-X imagery as a surrogate for VHR optical data (Jean-Paul Gachelin, SIRS)
19:00 – 20:00	**Guided tour of Postojna Caves**	
20:30 – 23:00	**Conference dinner at Jamski dvorec at Postonjska jama**	

Friday 5/12		
	Linhart Hall **sessions with interpretation**	
	Technical 7: LPIS – Geodatabase updating and associated guidance	
09:00 – 10:30	• Testing the LPIS Core Conceptual Model in practice (Grega Milcinski, CosyLab) • The Revised Guidelines for Best Practice and Quality Control of Ortho Imagery (Dimitrios Kapnias, JRC) • Assuring Traceability: Principles of LPIS maintenance in three German Federal States using reference maintenance requests (Stefan Scherer, GAF AG) • Review of the GeoCAP Web tools for online data exchange and support (Pavel Milenov, JRC)	Parallel in foyer: Poster demonstrations
10:30 – 11:00	**Coffee break**	
	Plenary 6: Closing session	
11:00 – 13:00	Keynote speaker: Application of laser scanning Lidar data for land cover classification, Prof. Krištof Oštir (Scientific Research Centre, Slovenian Academy of Sciences and Arts) Panel debate: Should we check Cross Compliance with Remote Sensing? - Inconsistencies, scientific view and audit reality; - From theory to practice; - Simplification of management; - Cost, effectiveness, efficiency; Scientific Committee report – proceedings selection and awards for best presentation, poster and software demonstration Closing speeches: Branko Ravnik (Director General, Directorate for Agriculture, MAFF, Slovenia) Jacques Delincé (Head of Agriculture Unit, JRC)	
13:00 – 14:30	**Buffet Lunch**	

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