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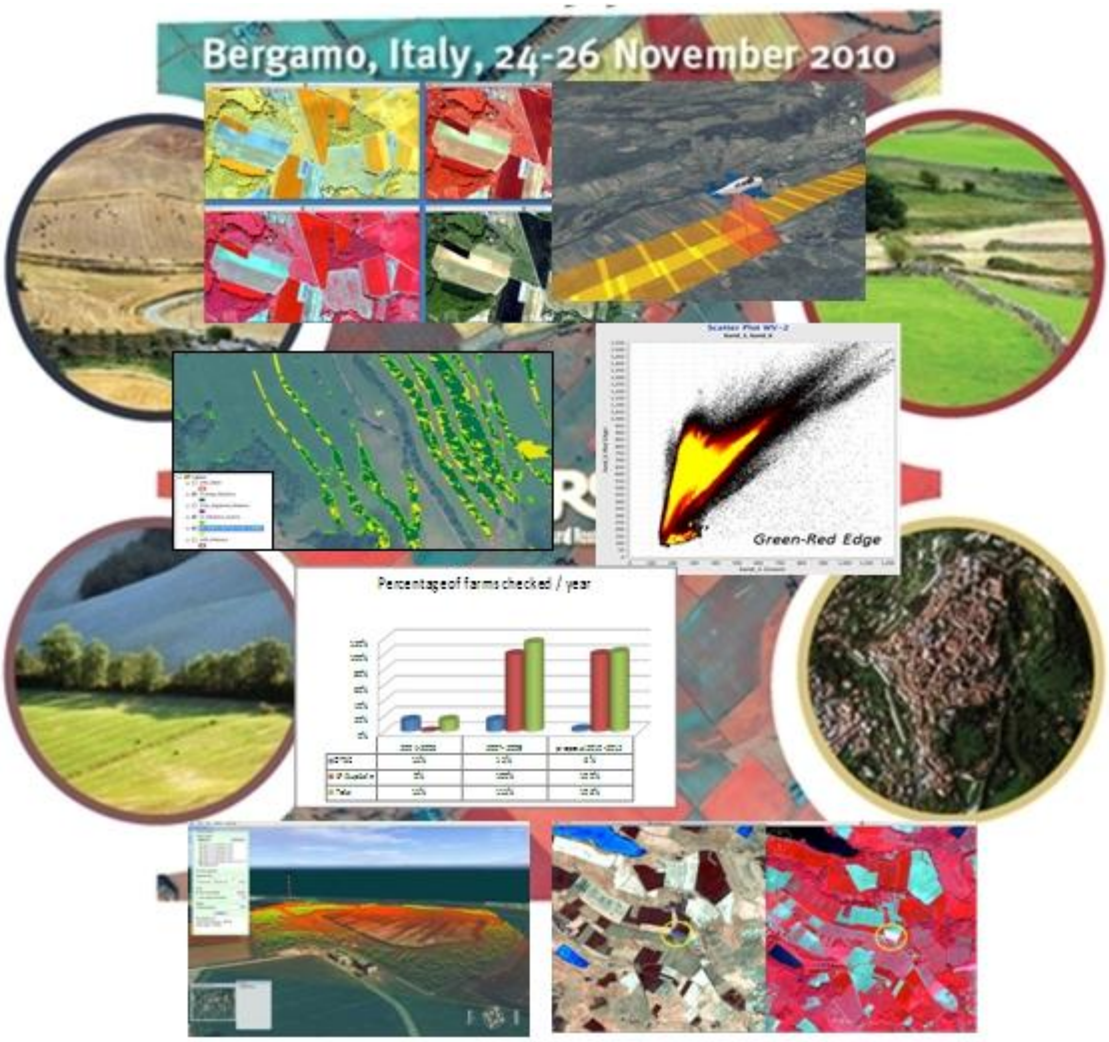
# Geomatics in support of the Common Agricultural Policy

## Proceedings of the 16th GeoCAP Annual Conference, 2010
## Centro Congressi Giovanni XXIII, Bergamo 24th-26th November 2010

**Edited by: Kadim Taşdemir, Philippe Loudjani, Vincenzo Angileri, Beata Hejmanowska, Cozmin Lucau, Pavel Milenov, Csaba Wirnhardt, and Paolo Pizziol**

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## Contents:

# Conference Abstract

The 2010 Annual Conference was the 16th edition. The conference entitled ‘Geomatics in support of the CAP’ was held in Bergamo and organised by the GeoCAP action of the Joint Research Centre (Ispra, Italy) alone. The conference covered the 2010 Control with Remote sensing campaign activities and ortho-imagery use in all the CAP management and control procedures. There has been a specific focus on the Land Parcel Identification Systems quality assessment process.

The conference was structured over three days – 24th to 26th November. The first day was mainly dedicated to future Common Agriculture Policy perspectives and futures challenges in Agriculture as well as overview of 2010 CwRS campaign. The second was shared in technical parallel sessions addressing the following topics: i) LPIS Quality Assurance and geo-databases features; ii) New sensors, new software, and their use within the CAP, and iii) Good Agriculture and Environmental Conditions (GAEC): control methods and implementing measures. The last day was dedicated to the GPS validation process and to the conclusions of the conference.

The presentations were made available on line, 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.

# Acknowledgments

We express our gratitude to Paolo Pizziol (JRC) and to the staff of the 'Centro Congressi Giovanni XXIII' of Bergamo for the sound organization and smooth development of the conference. We are grateful to presenters for agreeing to submit their work as papers, as well as to the review committee for contributing their valuable time at the meeting to select those presentations most suitable for publication.

# Peer review process and committee

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

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

***Best presentation**:* Albert Domingo Roigé (Gencat) et al. with the presentation “Innovation in on-the-spot checks with aerial photographs; UAV and dynamic publication of orthoimages”

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

- **Ms. Joanna Czapla,** Ministry of Agriculture and Rural Development, Poland
- **Mr. Geoff Groom,** National Environmental Research Institute, AU, Denmark
- **Mr. Arno Krause,** Alterra, Netherlands
- **Ms. Alenka Rotter,** Ministry of Agriculture, Forestry and Food, Slovenia
- **Mr. Pascal Schichor,** European Space Imaging, Germany
- **Mr. Ferdinando Smania,** AGEA, Italy
- **Mr. Robert Stein,** EFTAS Fernerkundung Technologietransfer GmbH, Germany
- **Mr. Kadim Taşdemir,** MARS, EC Joint Research Centre, Italy

# INNOVATION IN ON-THE-SPOT CHECKS WITH AERIAL PHOTOGRAPHS:

## *UAV AND DYNAMIC PUBLICATION OF ORTHOIMAGES*

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**ABSTRACT**

The completion of on-the-spot checks of the direct support schemes for farmers provided by Commission Regulation (EC) No 1122/2009 is crucial with respect to deadlines; costly on resources and presents a complex task every year. The results obtained in the present campaign 2010 during which several technological innovations in remote sensing and geomatics have been incorporated are presented in this paper. The use of unmanned aerial vehicles (UAVs), as well as new tools of dynamic publication of orthoimages, accessible by means of the protocol OGC WMS (Web Mapping Services of Open Geospatial Consortium), provide us with aerial photographs, at low cost, between 2 and 8 weeks after their capture. The images, with 25 and 12,5 centimetres/pixel resolution, are highly appropriate for carrying out on-the-spot checks in zones with diversity of cultures and parcels of small dimensions which are common in the Mediterranean area. Photo interpretation allows us to greatly reduce the periods and costs of the completion of checks. The performance of our technical personnel is multiplied by ten in relation to traditional in the field checks.

**KEY WORDS:** IACS, on-the-spot checks, aerial image, DMC, UAV, ortoXpres

## 1. INTRODUCTION

Technological advances in various areas constantly provide opportunities to improve the complex task of on-the-spot (OTS) checks on land receiving agricultural subsidies established in the European Commission Regulation 1122/2009. In the Government of Catalonia Department of Agriculture, Livestock, Fisheries, Food and Environment (DAAM) several of these advances have been implemented in order to develop an efficient alternative for carrying out the checks by remote sensing (RS) through photo-interpretation of recent aerial photographs with the following objectives:

- The reduction of check completion time.
- The reduction in costs of OTS checks.
- The promotion of the use of new technologies and the use of geomatics in the agrarian sector.
- The simplification in the documentation of the procedure.
- The guarantee of rigour, objectivity and quality in the checks.

## 2. MATERIALS AND METHODS

### 2.1. Orthophotographs and dynamic publication

The Catalunya Cartographic Institute (ICC) provides a public service in which aerial photographs are published on-line and orthorectified on demand and are accessible from the platform OrtoXpres (www.ortoxpres.com). The orthorectification carried out with the primary aero-triangulated images stands out because of its limited margin of error in the positioning obtained (generally less than the size of 1 pixel) and for the prompt availability of the images (6-8 weeks after the photographs are taken). The photographs are obtained by using a DMC sensor carried by the ICC's own Cessna Caravan (Figure 1); the majority belongs to the Pla Cartogràfic de Catalunya, are available for free for public use and have a resolution of 25 cm/pixel. Specific aerial photographs with a resolution of 12.5 cm/pixel are also available and reasonably priced for the inspection of wood crops (trees) for which species identification is necessary. The IT applications on subsidy checks access the geoservice of ortoXpres through the OGC WMS protocol.

**Figure 1.** ICC Cessna Caravan B208 airplane (left) and DMC sensor (developed by Zeiss / Intergraph Imaging) for obtaining images (right).

### 2.2. Unmanned Aerial Vehicles (UAV)

Additionally, an UAV services company, which is developing its own platforms (www.catuav.com), has been contracted for the procurement of aerial photographs. For several years its ATMOS model (Figure 2) with electric motorisation has been tested, validating its operational capacity, flexibility, reliability and the quality of the images provided.

During the development period, the current capability of these platforms and the rapid evolution of its capacities (autonomy, speed, operational radius, stability, automation, security, etc) have been noted which leads us to believe that in the near future, it could become a regularly used tool, as long as reasonable regulations which do not restrict its operational capacity are established.

**ATMOS 5**
Electric motorization
Wingspan: 1.800 mm
Weight: 1.300 g
Payload: 500 g
Cruise speed: 45 km/h
Max. speed: 75 km/h
Autonomy: 90 min
Range: 20 km

**Figure 2.** Image of the ATMOS 5 UAV and its characteristics.

### 2.3. Quality and availability of aerial images

The high resolution of the images allows verification of the crops and the agronomic conditions, guaranteeing maximum rigour in the results of the checks (figure 3). The land parcels which cannot be checked with absolute certainty from images are visited on the field. Surface calculations are carried out from the most recently approved and available orthophoto-graphs (1 year) which are seen simultaneously in a synchronised window.

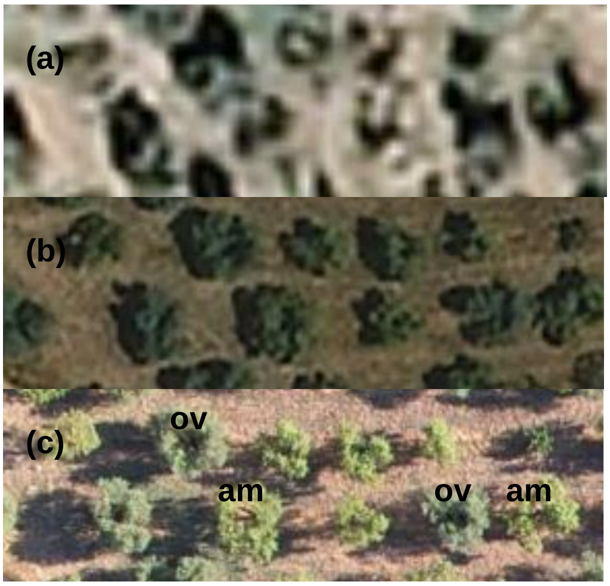


**Figure 3.** DMC images (a) 50 cm/píxel, (b) 25cm/píxel and (c) UAV 12.5 cm. In the 12.5 cm resolution image, olive (ov) and almond trees (am) are easily distinguishable.

In Figure 4, flight expeditions carried out by the Cessna Caravan (1) and with the UAV (2) are in green. The completed orthophotographs obtained with the DMC are available at the end of the year (A), but can be seen through ortoXpres after triangulation only 6 to 8 weeks after the flight (B). They could also be available in 1 or 2 weeks (C) directly orthorectified from the nominal flight data (direct orientation). In case of the UAV, the orthophotos are available in the week after the flight (D).

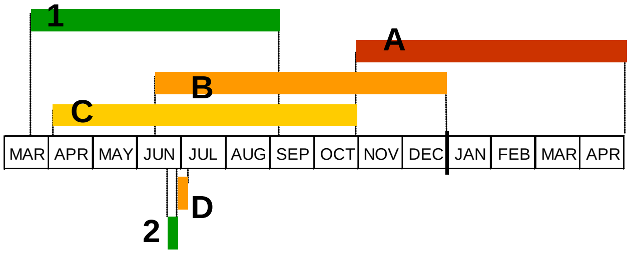


**Figure 4.** Comparative graph of flight expeditions and availability of corresponding images.

### 2.4. Management Tools

One of the keys to the success of the implementation of the new methodology lies in having achieved the integration of recent images into our management and control model and their incorporation into previously developed tools: specifically, communication between LPIS "Croquis" programme and the IT application of control management (CON) (Domingo-Roigé and Marco-Sanz, 2007). Images are accessed through this programme, checks on selected subsidy inquiries are made and the results made known.

### 2.5. Sample checks for the 2010/11 campaign.

Of the 2010/11 OTS checks, 37% were carried out in the field, 54% by RS with satellite images and 9% with the new methodology of aerial imaging (DMC + UAV).

**Table 1.** Sample checks of land use carried out during the 2010/2011 campaign

| TERRITORY | SELECTED AID APPLICATIONS | ON-THE-SPOT CHECKS | | |
|---|---|---|---|---|
| | | TRADITIONAL | SATELLITE IMAGES | AERIAL PHOTOGRAPHS |
| Barcelona | 236 | 236 | 0 | 0 |
| Girona | 150 | 150 | 0 | 0 |
| Lleida | 2.049 | 349 | 1.700 | 0 |
| Tarragona | 345 | 219 | 0 | 126 |
| Terres de l'Ebre | 350 | 200 | 0 | 150 |
| CATALONIA | 3.130 | 1.154 | 1.700 | 276 |

### 2.6. Check zones and images used

Two areas were selected for checks using aerial photographs:

1. *Delta del Ebro*, in the far south of Catalunya, predominantly rice fields.

2. *Alt Camp*, predominantly hazel nut, olive, almond and carob trees (Figure 5).

In both zones, (*Delta del Ebro* and *Alt Camp*), two 20x20km windows were selected with images supplied by the ICC. As well as this, in Alcover, a sub-zone of *Alt Camp* a sample of land parcels were flown over by UAV. Also, a window of 30x30km in Lleida, characterised by its farming of dry and irrigated cereals along with olive trees and nuts, was selected for RS with satellite images (Figure 5).

Types of aerial images used:

1.In the Delta del Ebro, PNOA images 25 cm/pixel.

2.In Campo de Tarragona, two types of images were used:

- DMC at 12.5 cm/pixel (ICC).
- UAV at 12.5 cm.

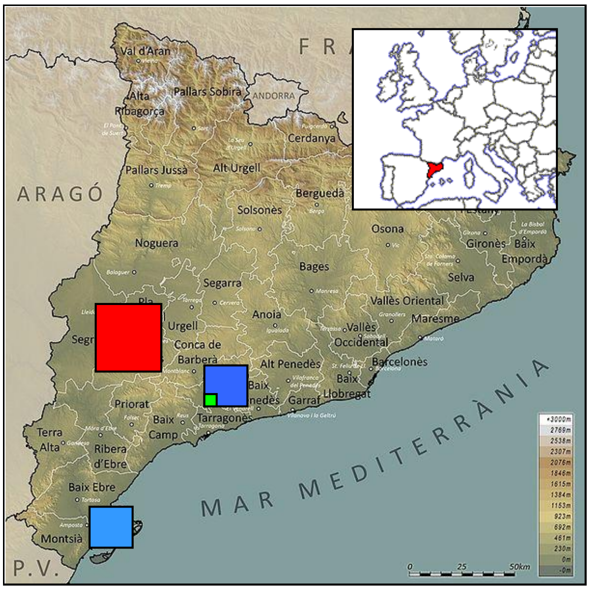


**Figure 5**. Check zones by RS with satellite images and aerial photographs:

- Satellite image (*Lleida*)
- Aerial photography ICC 25 cm (*Delta del Ebro*)
- Aerial photography ICC 12.5 cm (*Alt Camp*)
- Aerial photography UAV 12.5 cm (*Alcover-Alt Camp*)

**Table 2.** Types of images and sources used in each zone

| SOURCE | SPATIAL RESOLUTION | BANDS | ZONE |
|---|---|---|---|
| ICC (DMC) | 25 cm | RGB+IR | Delta of Ebro |
| ICC (DMC) | 12,5 cm | RGB+IR | Alt Camp |
| UAV | 12,5 cm | RGB | Alcover (Alt Camp) |

## 3. RESULTS

Comparative studies of the time invested, implementation schedule and costs of each method with the objective of evaluating efficiency, have been made.

### 3.1. Time performance with different methodologies

A reduction of 90% in the time dedicated to OTS checks, compared to the methodology of visit in the field, based on the data of the last 4 available years (2007-2010 – both included) has been recorded. (Table 3)

**Table 3.** Time invested per farmer

| | On-the-spot checks | | |
|---|---|---|---|
| | Traditional (In the field) | Remote Sensing | |
| | | Satellite images | Aerial photographs |
| **Campaigns** | **2007-2010** | **2007-2010** | **2010** |
| **Farmers/year** | **995** | **2.331** | **276** |
| **hours/farmer *** | **12,27** | **1,03** | **1,2** |

### 3.2. Improved lead-time of on-the-spot checks

The workloads of the different methodologies can be seen in the calendar in Figure 6. A huge reduction in the time needed has been achieved by carrying out checks using aerial photographs. The time needed for carrying out the checks under the traditional system is shown in yellow (1): 4 months from initiation to finalisation. RS by satellite imaging takes 3 months to process the images, evaluate the checks and to obtain the initial results (in purple (4)). Between 5 and 6 weeks are then needed to manage and resolve difficult checks to be revised. (lilac (5)). However, checks carried out with aerial photographs require only 3 weeks for the collection and analysis of the images (dark green (2)) and a further 3 weeks for the evaluation of the results (light green (3)). As can be seen, a significant reduction in the length of the resolution process has been achieved.

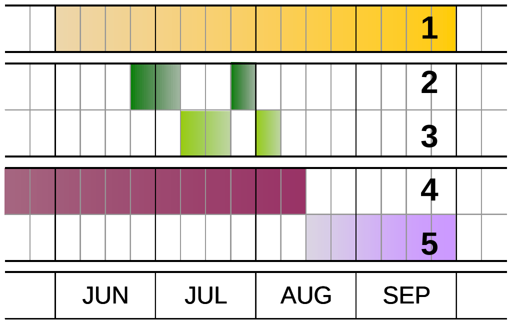


**Figure 6.** Distribution of workload under the different methods

### 3.3. Comparison of cost estimation per parcel

In the study assessing the estimated cost (in euros per parcel) a considerable cost reduction with the OTS checks carried out by RS with aerial photographs can be seen. The cost is half compared to that of RS with satellite imaging and one third of the cost of traditional OTS checks in the field (Table 4).

**Table 4.** Estimated cost per parcel under the different checking methods.

| Type of control | Cost € / parcel |
|---|---|
| **Traditional in the field** | **10,3** |
| **With satellite images** | **7 *** |
| **With aerial photographs** | **3,5** |

**cost met by DAAM.*

## 4. CONCLUSIONS

OTS checks by RS with aerial photographs allow the elimination of a large part of in the field checks, resulting in the simplification of management processes, a reduction in costs and an extraordinary increase in performance. Other aspects in which added value is implicitly provided by the method include:

- Checks can be repeated under the same conditions guaranteeing the proper supervision of the results and ensuring the proper use of European funds.

- A synoptic view of the parcel is provided
- Checks are independent on climatic and orographic factors.
- Data and altitude flight expeditions can be adapted to various typologies of crops.
- Disruption to farmers is minimised.
- Management is simplified and expenses are reduced (fuel costs, paper)
- Employee satisfaction is improved and occupational risks are lessened

Crucial points to be considered are:

- Training in the use of the new methodology and use of tools is required.
- Slight risk of dependency on the image suppliers in terms of complying with delivery terms and image quality.

Finally, in light of the results obtained, the OTS checks for the forthcoming campaign need to be considered in terms of:

- Increasing the number of checks carried out with aerial photography
- Maintaining the number of checks carried out with satellite imaging
- Considerably reducing the number of traditional checks. A certain number of OTS checks under the traditional system will always be necessary in order to complete the sample and for the cross compliance checks (GAEC) and agro-environmental measures.

## 5. REFERENCES

A. Domingo-Roigé, V. Marco-Sanz (2007). Integration of the SIGPAC maintenance in the management and control of area based aids in Catalonia. Geomatics in support of the Common Agricultural Policy. *Proceedings of the 13th MARS PAC Annual Conference,* 2007.

EC JRC, Monitoring Agricultural Resources Unit webpage, http://marswiki.jrc.ec.europa.eu/wikicap/index.php/On_the_spot_checks

EC JRC, Monitoring Agricultural Resources Unit webpage, http://marswiki.jrc.ec.europa.eu/wikicap/index.php/CwRS

# NEW SPECTRAL DATA AVAILABLE FOR THE CONTROLS IN AGRICULTURE (CWRS) AND FOR VEGETATION MONITORING:

## *A FRENCH EXPERIENCE ON THE POTENTIAL BENEFITS IN USING WORLDVIEW-2 NEW BANDS*

*Guido Peroni, Jean-Paul Gachelin, Marilyn Saint-Pol, Valerie Legoff, Franco Fontanot, Christophe Sannier*

SIRS, Systémes d'Information à Référence Spatiale

**ABSTRACT**

New spectral data recorded by the sensor on board of the recently launched WorldView-2 satellite is regarded as carrying very promising additional information for better detection and discrimination of agricultural and other vegetated features. If confirmed, the new information could greatly help the computer aided photo-interpretation (CAPI) and other activities related to the annual controls of farmers' claims with remote sensing (CwRS), possibly including the monitoring of some GAEC/agri-environmental measures. The test was performed over one of the French sites selected for the CwRS 2010 campaign.

**KEY WORDS**: VHR optical sensors, WorldView-2 satellite, Red Edge band, Vegetation Indices, EO vegetation monitoring, CAP's agricultural subsidy controls, CwRS.

### 1. INTRODUCTION

The WorldView-2 (WV2) satellite, launched from Vandenberg Air Force Base in California, on October 8, 2009 and orbiting the Earth at an altitude of 770 kilometres, was declared operational on January 4th 2010. It is carrying on board an Earth Observation sensor system collecting images at 46 cm resolution (GSD at nadir) in panchromatic mode (though resampled to 50 cm for all non-US Government customers) and at 1.84 metres in 8-band multi-spectral mode (resampled to 2 metres for all non-US Government customers).

The multi-spectral collection system contains series of detectors sensitive to the 4 standard colour bands (blue, green, red, near-IR-1) plus 4 additional new colour bands called: Coastal, Yellow, Red Edge, and Near-IR-2. See Table 1 for technical details on respective spectral bands limits and wavelength central values [23].

**Table 1:** WorldView-2 spectral bands

| Spectral band name | Spectral band limits (5% pass) (µm) | Spectral band centre wavelength (µm) | Spectral band effective bandwidth, $\Delta\lambda$ (µm) |
|---|---|---|---|
| Panchromatic | 0.447 – 0.808 | 0.632 | 0.2846 |
| *Coastal* | 0.396 - 0.458 | 0.427 | 0.0473 |
| *Blue* | 0.442 – 0.515 | 0.478 | 0.0543 |
| *Green* | 0.506 – 0.586 | 0.546 | 0.0630 |
| *Yellow* | 0.584 - 0.632 | 0.608 | 0.0374 |
| *Red* | 0.624 – 0.694 | 0.659 | 0.0574 |
| *Red Edge* | 0.699 - 0.749 | 0.724 | 0.0393 |
| *NIR 1* | 0.765 – 0.901 | 0.831 | 0.0989 |
| *NIR 2* | 0.856 - 1.043 | 0.908 | 0.0996 |

(source: DigitalGlobe®, Inc, ©Copyright 2010)

Concerning the organization of the sensor's recording system (see Figure 1) [23], the WorldView-2 focal plane is composed by 50 panchromatic staggered Detector Sub-Arrays (DSAs), and two sets of 10 MS, staggered Detector Sub-Arrays (DSAs). The two sets of staggered MS arrays are positioned on either side of the Pan array, one for the MS1 bands (MS1: NIR1, Red, Green, Blue), and the other for the MS2 bands (MS2: Red Edge, Yellow, Coastal, NIR2). Each DSA contains four parallel rows of detectors, each with a different colour filter. Each detector pitch size for the PAN is 8µm, while for the multispectral bands, it is 32µm. The full width of the panchromatic band is composed by 35,420 pixels while it is 8,881 pixels for each multispectral band.

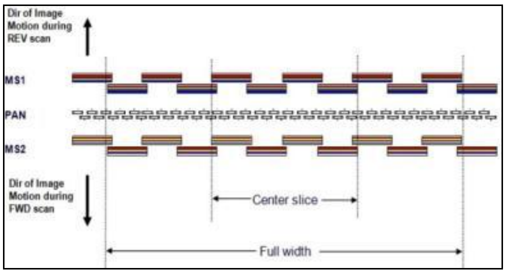


**Figure 1.** Overview of the organization of focal plane on WorldView-2 satellite (not in scale)
(source: DigitalGlobe®, Inc, ©Copyright 2010)

### 1.1. Rationale for the test

Ground features in or bordering agricultural parcels claimed by the farmers for their annual declaration (agricultural subsidies foreseen by EU's Common Agricultural Policy), which result in problems in their interpretation based on the current satellite images, were at the centre of SIRS proposal to the Joint Research Centre (JRC) and to the French National Administration (ASP) to explore the potential of the new spectral data recorded by the WV2 satellite.

The main goal was to verify if innovative ways of using band colour composites and new band combinations could facilitate the photo-interpreter in identifying specific occurrences happening on the ground. That could be of great importance to support the local authority in confirming or rejecting the farmer claim over that parcel without necessarily requiring verification on the ground. This kind of activity is performed in each EU member state by CwRS (Control with Remote Sensing), in order to comply to the rules expressed by IACS (Integrated Administration and Control System) that is the EU system responsible to administer payments under the common agricultural policy.

### 1.2. New spectral bands for vegetation detection

The idea of testing alternative colour composites in CAPI using WV2 new bands was derived from the assumption that at least two of new spectral bands on WV2 satellite (Red Edge and Yellow band) are considered particularly sensitive to the vegetation and its conditions (see Figure 2). Moreover, another new band, Near-IR-2, covers a zone of the electromagnetic spectrum traditionally regarded as very suitable for vegetation monitoring.

However, while in the case of Red Edge and Yellow bands the advantages in using the new information appeared evident from the start, we could not find, in our specific case, much difference in the information retrieved from NIR-2 and NIR-1. Therefore, for question of consistency with usual operational activities, it was decided to use only the more traditional NIR-1 band in our test.

Regarding the last remaining new band "Coastal", the part of electromagnetic spectrum covered by it does not present in principle, any specific characteristic that could be exploited for vegetation detection/monitoring. Nevertheless, the band was tested for possible integration in alternative combination with other new bands or for atmospheric corrections.

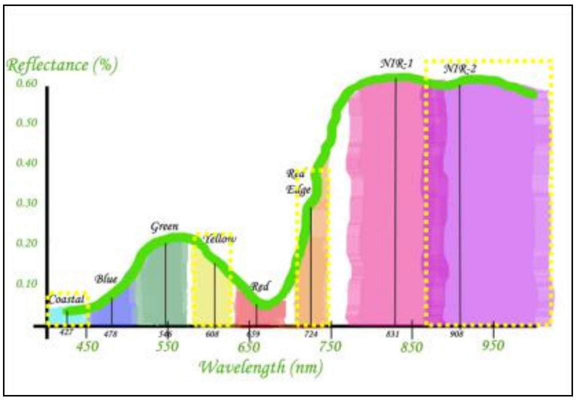


**Figure 2.** Vegetation spectral signature and relative position of the eight WorldView-2 multi-spectral bands

### 1.3. Red Edge

The importance of the information derived from the part of the electromagnetic spectrum so-called Red Edge is amply demonstrated in the scientific literature and publications. The data derived from this area is considered very informative for vegetation monitoring, not only for species localization and discrimination but also for more in depth determination of single plant physiological or health conditions. The reason of such vegetation sensitivity is related to the fact that the vegetation spectral signature presents a very characteristic sudden increase in reflectance in this part of the spectrum (that is situated between red and near infrared bands, see spectral plot in Figure 2). As a consequence of this rapid rise, even small changes in canopy foliage content, senescence or development problems are sufficient to produce visible shifts in the slope, position and its degree of inclination.

The main reason of this sudden increase in reflectance, which determines this characteristic steeply sloped region of the vegetation reflectance curve (between about 690 nm and 740 nm), is caused by the transition from high chlorophyll absorption (occurring in the visible part of the spectrum region and in particular in the area occupied by the red band) and the leaf scattering mechanism that is the principal responsible for the high reflectance values occurring in the near-infrared area of the spectrum.

### 1.4. Vegetation Indices

In general, vegetation indices (VIs) are combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation [24]. The sudden increase in reflectance occurring between red and near-infrared can be exploited numerically by differentiating or subtracting the information derived from these two bands located at the extreme of such steeply sloped part of the vegetation curve.

Out of the numerous VIs that can be found in the literature, the Normalized Difference Vegetation Index (NDVI) is considered one of the most useful and most frequently used VIs due to its simplicity and robustness [18]. NDVI is defined by the following equation:

$$\mathrm{NDVI} = (R_{NIR} - R_{RED}) / (R_{NIR} + R_{RED}) \qquad (1)$$

NDVI values range between -1 and 1 with green vegetation generally identified with values between 0.2 and 0.8 [1; 18].

NDVI is successfully used in different part of the world having extreme variety of vegetation conditions. However, in the presence of dense vegetation, when the Leaf Area Index (LAI) is high, NDVI can saturate. Presence of saturated pixels is occurring when the difference in reflectance between Red and NIR is becoming very significant. To avoid such kind of situations, the use of alternative bands is suggested. The most interesting results in our experience are obtained by the replacement of the Red band with the Red Edge. So, in our test we have calculated a "$\mathrm{NDVI}_{RE}$" that is differing from the usual NDVI only by adopting the Red Edge band instead of the Red (see example in Figure 3).

According to Gitelson [2] the $\mathrm{NDVI}_{705}$ *capitalizes on the sensitivity of the vegetation red edge to small changes in canopy foliage content, gap fraction, and senescence*. $\mathrm{NDVI}_{705}$ is defined by an equation similar to the NDVI:

$$\mathbf{NDVI_{705}} = (R_{750} - R_{705}) / (R_{750} + R_{705}) \qquad (2)$$

As for NDVI, the value of the $\mathrm{NDVI}_{RE}$ ranges from -1 to 1 and the common range for green vegetation is between 0.2 and 0.9 [24]. However, it must be stressed that the Red Edge central value on WV2 is not actually positioned at 705 nanometres as considered by Gitelson and other investigators as the most appropriate reference central position for the band. The Red Edge band on WV2 is in fact centred at 724 nanometres (see Table 1). At the time of writing, we had not found any documentation explaining if pure scientific justifications or more economical or technical limitation were the reasons for selecting the central values of the WV2 new bands in the locations as expressed in Table 1.

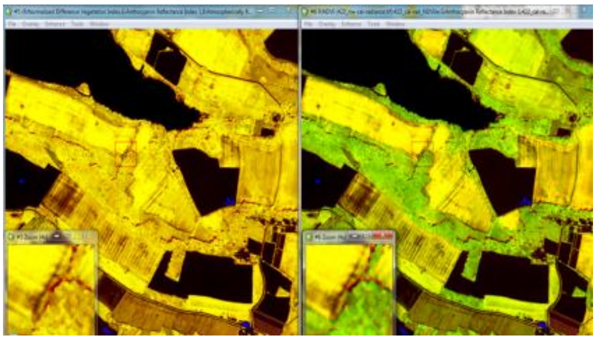

**Figure 3.** Comparison of colour composites using synthetic bands derived from VIs. **Left:** using "classical" NDVI (NIR and Red); **Right:** using $NDVI_{RE}$ (NIR and Red Edge).

## 2. TEST PROCEDURE AND PHASES

The test was performed over one of the French sites already selected to be checked by the Controls with Remote Sensing in 2010. However, the test activity could not start before termination of the control operations since both ASP (the National Administration in France responsible for the agricultural controls) and SIRS' CAPI experts were deeply involved in finishing the regular CwRS activities.

The test started with a preliminary image analysis, which involved checking the quality of the raw data. It was followed then by some image processing including the image ortho-rectification. Further image analysis then focused on the selection of band combinations considered the most promising and so to be tested under CAPI.

This second image analysis was then followed by further image processing steps, which included the pan-sharpening of the multispectral bands selected for CAPI test using the higher spatial resolution details derived from the panchromatic band. The test clearly demonstrated the fundamental importance of producing the pan-sharpening operation before performing visual interpretation. Even in the presence of extremely interesting new spectral information provided by the new bands in WV-2, this spatial processing enhancement must be still regarded as the most advantageous support given to the photo-interpreters in CAPI (see conclusions and recommendations at Section 4).

After pan-sharpening, the central testing phase of CAPI could start. The photo-interpretation was performed by two expert operators using a similar methodology that SIRS operationally employ during its annual controls. In parallel to the CAPI test, the image was subjected to additional spectral analyses aiming at discovering alternative procedures for further exploiting the potentials of this new type of satellite imagery.

### 2.1. Image analysis and Processing

Before starting the actual image analysis, a search was performed in the literature and among the scientific community looking for reference material and publications suitable to guide our methodological approach (see full reference list at the end of document). The image was then fully analysed focusing on its radiometric characteristics, calculating the most important statistics relative to each band. Bands histograms were produced and compared.

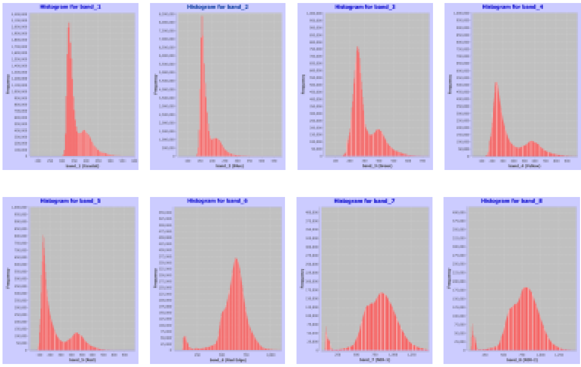

**Figure 4.** Histograms for all 8 bands

Looking at the histograms for the different bands (Figure 4), we can clearly see some group of bands showing histograms with similar shapes. For instance, the histogram of Coastal (band_1) looks very similar in shape to the one for Blue (band_2) with the only major difference being that Coastal minimum values start only at about 300 (DN) comparing to about 140 for the Blue. This difference is probably caused by a higher rate of atmospheric aerosol scattering mechanisms affecting the shorter wavelength of the Coastal band compared to the wavelength of the Blue.

Green, Yellow and Red bands make another group with a very similar histogram shape, though it should be noticed that the range values for Yellow band seem better spread out and reaching higher values (about 900) comparing to the max of 650 and 750 respectively for the Green and the Red band.

Last group holding similar histograms includes the Red Edge (band_6), the NIR-1 (band_7) and the NIR-2 (band_8). While the curves of the two infrared bands look almost identical in shape (both observing dynamic range and frequencies), the Red Edge shape looks slightly different (rather compressed) and having a dynamic range reaching maximum values at a lower level comparing to the other two bands (Red Edge max values are about 1,000 compared to the max values, 1,200, of the two NIR bands). As mentioned earlier (Section 1.4), the higher reflectance values found in the NIR bands could determine saturated pixels when subtracted/differenced with the very low level of reflectance values that are characteristics of the Red band (as it can occur when adopting the traditional NDVI formula). The more moderate maximum values reached by Red Edge band can mediate this gap making the difference with NIR more manageable. That is why a different NDVI, where the Red band is replaced by Red Edge ($NDVI_{RE}$), was suggested and tested. Further bands comparisons were then undertaken checking the degree of correlations amongst the different bands via spectral plotting.

Scattering plots, as shown in some examples below, can quickly show which bands have a higher level of correlation than others. If two bands have a very high/positive level of correlation, they are holding very similar spectral information and so not so useful to be combined in colour composites. For instance, in our case we have identified two couple of bands having a high level of correlation: Coastal-Blue and NIR1-NIR2 (see Figures 5 and 6). Other pair of bands (Yellow-Red and Green-Yellow) had more moderate level of correlations (see plots in Figures 7 and 8).

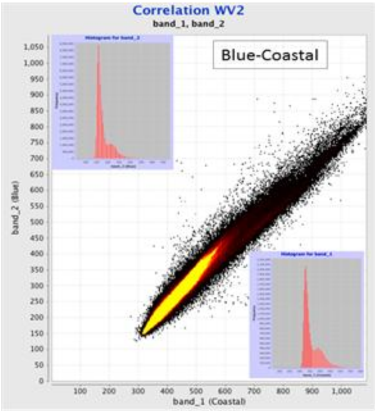


**Figure 5.** Scatter plot showing correlation between Coastal and Blue.

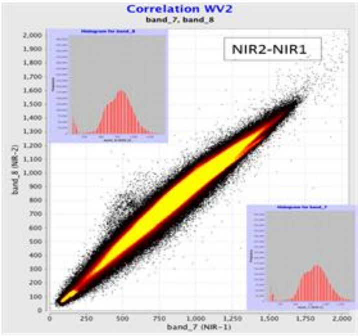


**Figure 6.** Scatter plot representing Near-IR-1 and Near-IR-2 bands (the high correlation is described by the linear diagonal feature starting almost at the origin).

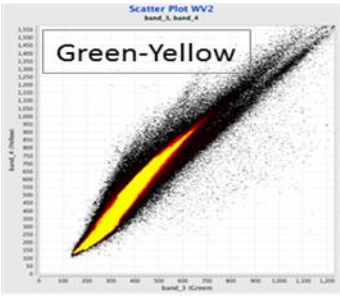


**Figure 7.** Scatter plot showing moderate correlation between Yellow and Red band

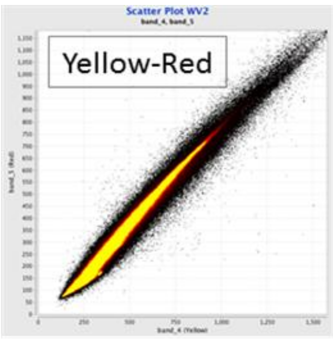


**Figure 8.** Scatter plot showing moderate correlation between Green and Yellow band

Finally, the bands that showed the lowest degree of correlation were Yellow with Red Edge and NIR with either Red or Red Edge (see Figures 9, 10, and 11)

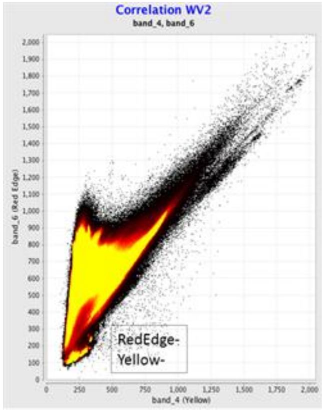


**Figure 9.** Scattering plot for Red Edge and Yellow band

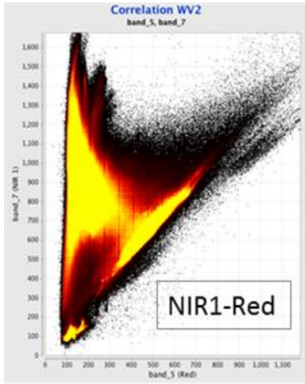


**Figure 10.** Scattering plot for NIR-1 and Red bands

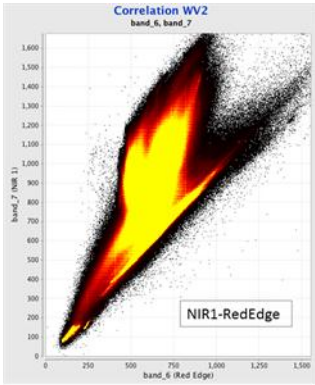


**Figure 11.** Scattering plot for NIR-1 and Red Edge band

The results from this kind of comparisons permitted the identification of bands holding significantly different information, and, as a consequence, better suited at being combined to produce colour composites (RGB). In fact, mixing higher decorrelated bands should provide a wider range of colour palettes facilitating the visual identification of subtle features in the image.

Different colour combinations (RGB) were therefore proposed and subsequently compared. Overall, the best visual results were provided by the use of NIR-1 as red channel, Red Edge as green and Green as blue. In particular, when compared with the traditional False Colour Composite (NIR1; Red; Green), it appeared immediately evident its advantage that various details within the vegetated features becoming more visually detectable by the adoption of the Red Edge (see comparable examples in Figure 12, respectively the images at top and bottom left).

Another interesting combination was composed by Red Edge as red channel, Yellow as green and Coastal (or Blue) as blue channel (see image at top right of figure 12). However, in particular after the pan-sharpening step, this new RGB combination was not showing any significant advantages comparing to the classical NIR-Red-Green apart from the rather useful information derived from Red Edge (but which was still more evident in the previously mentioned NIR-Red Edge-Green combination).

Another alternative RGB band combination demonstrating interesting results during the test was the use of Red Edge band as Red, Yellow band as Green and Coastal band as Blue (image at bottom right of Figure 12). This RGB combination was found visually appealing especially in comparison to the traditional “true” colour composite (Red-Green-Blue). However, the high level of aerosol scattering that appears compounding the ground reflectance signal recorded by the Coastal band could severely limit its operational adoption in CAPI due to the significant level of uncertainty related to the correct interpretation of its spectral signal. Nevertheless, it must be emphasized that the presence of the Yellow band in different variations of “true” colour composites appears producing rather visually attractive results. Therefore, in addition to red edge (see conclusion and recommendation below), the yellow band could also become an interesting asset for possible future integration within CAPI.

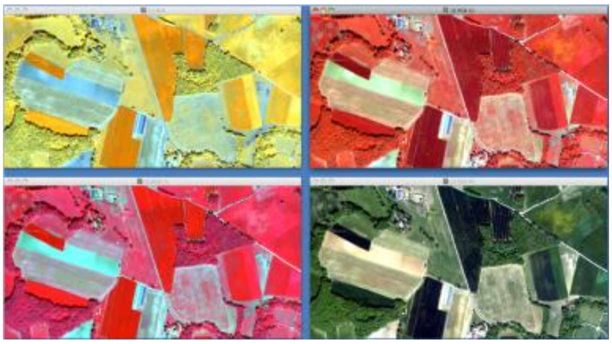

**Figure 12.** Comparison of different band colour composites (RGB). **Top left:** alternative FCC, NIR1-RedEdge-Green; **top right:** alternative FCC, RedEdge-Yellow-Coastal; **bottom left:** “traditional” FCC: NIR1-Red-Green; **bottom right:** alternative True Colour Composite, Yellow-Green-Coastal.

***Vegetation Indices and synthetic colour compositions (RGB):*** The spectral analysis phase of the test then carried on with the calculation of various **VIs**, with or without integrating the Red Edge band. First, all the spectral bands required correction and calibration for atmospheric influences. Atmospheric correction was performed using the ancillary data made available by the image provider and with the appropriate tools available in ENVI. Then, we could start to calculate different VIs. The results were visually compared (see Figure 13), also with the help of masking operations in order to highlight any special capability to detect hidden features. Finally, synthetic colour bands were derived from the VIs and combined in order to produce colour composites.

### 2.2. CAPI Implementation

The CAPI phase, at the centre of the testing effort, consisted in performing a classical photo-interpretation of land cover/use using a simplified nomenclature (see list of classes in Table 2).

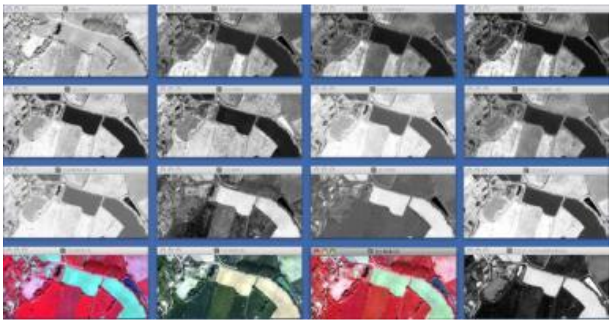

**Figure 13.** Visual comparison of the results after calculation of various Vegetation Indices. The colour images at the bottom are, respectively, NIR1-Red-Green, Red-Green-Blue, and Red-Edge-Yellow-Green.

The CAPI test started with the selection of a suitable sampling area. The sample was composed by a number of îlots (French name identifying an agricultural block of parcels owed and/or cultivated by the same farmer) selected according to a random function performed within ArcGIS. In addition to these îlots selected randomly, it was then decided to include in the sample also all the îlots being contiguous or contained within a buffer zone created around the water courses. That procedure required the preliminary digitations of all water courses included in the site.

**Table 2:** CAPI classes (nomenclature)

| Désignations (FR) | codes | Description (EN) |
|---|---|---|
| Bâti /chemin / route | 11 | Impervious |
| Céréales à paille | 211 | Winter cereals |
| Colza | 212 | Rape |
| Culture de printemps | 213 | Spring crop |
| Culture d’été | 214 | Summer crop |
| Sol nu | 215 | Bare Soil |
| Prairie/Gel | 221 | Pasture/set aside |
| Bande enherbée le long des cours d’eau | 222 | (green) buffer strip along water courses |
| Vignes | 231 | Vineyards |
| Vergers | 232 | Orchard |
| Accident de culture / retard de levée | 241 | Crop late in development or with problems |
| Défaut d’entretien | 242 | Maintenance issues |
| Anomalies déclaratives | 243 | Declaration anomaly |
| Zone boisée non éligible | 311 | Not eligible forested area |
| Alignement d’arbres | 411 | Trees in line |
| Bosquet | 412 | Group of trees |
| Haie | 413 | Hedge |
| Talus | 414 | Embarkment |
| Fossés | 415 | Ditches |
| Bande enherbée | 416 | Green buffer strip |
| Cours d’eau | 511 | Water course |
| Plan d’eau | 512 | Pond,lake, etc |
| Couvert indéterminé | 600 | Undetermined cover |

As result of the sampling operation, 649 îlots were selected, representing 15% of the total number of îlots declared within the zone in the 2009/2010 campaign. The sample represented in surface about 36% of all declared agricultural land. The French National Administration (ASP) actively supported the test activities and made available to SIRS all the necessary reference data indispensible for performing the photo-interpretation (in particular providing the vector data related to LPIS, the local administration boundaries, the limit of the selected CwRS zone, local topographical maps in raster format and others geo/tabular data).

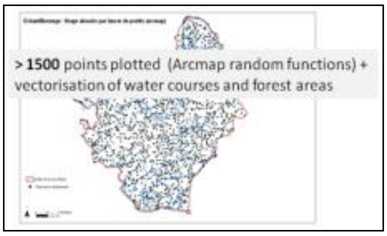


**Figure 14.** Points randomly plotted with ArcMap

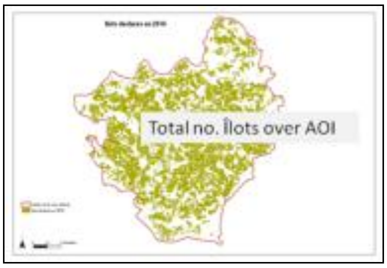


**Figure 15**. îlots over zone

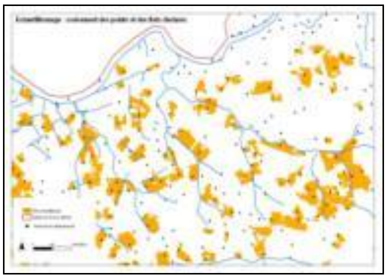

**Figure 16.** Matching îlots and random points

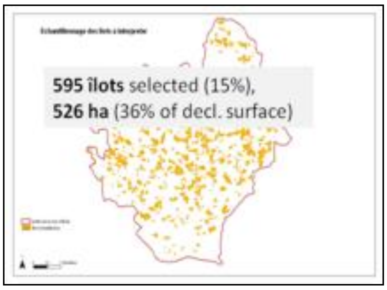


**Figure 17.** Selected sample

As mentioned earlier, the photo-interpretation has followed similar principles and methodology currently in use during the normal controls (CwRS). It involved the detection of crop types that were growing on the agricultural parcels under observation including possible interpretation/evaluation of their phenological status. This activity was performed using a series of multi-temporal dataset of HR (high resolution) satellite imagery. In addition to that, a more accurate analysis of the parcels management, including the identification of specific topographic occurrences, was performed using the single VHR (very high resolution) imagery made at disposal (in our case the WV2 image) and an archived ortho-photograph (coming from the LPIS).

In order to make the test rigorous and valuable for possible future operational utilisation, two "blind" CAPIs were performed, both performed by the same team of SIRS CwRS expert operators. The first one (CAPI 4**),** used the "traditional" band combination in WV2 (NIR1-Red-Green) as it was made available by JRC for the operational controls (already pan-sharpened). This first photo-interpretation effort was then followed by another photo-interpretation (CAPI 8) where the traditional band combination for the WV2 image was then replaced by the new colour combination, previously selected according to the results of the previous described image analysis phase.

The images used in **CAPI 4 bands**:

- 1 image VHR: - 28 April 2010: WV2 pansharpened (0.5 m) RGB: 7-**5**-3
- 3 images HR:
  - 11 April 2010: SPOT 5 XI (10 m)
  - 20 May 2010: SPOT 4 XI (20m)
  - 06 July 2010: SPOT 4 XI (20 m)
- 1 orthophoto archive (PAN), 2004

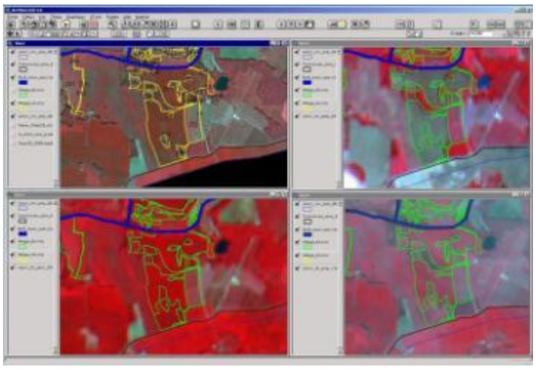

**Figure 18.** Visualization of CAPI 4 screen

Images used in CAPI **8 bands**:

- 1 image VHR: - 28 April 2010: WV2 pansharpened (0.5 m) RGB: 7-**6**-3
- 3 images HR :
  - 11 April 2010: SPOT 5 XI (10 m)
  - 20 May 2010: SPOT 4 XI (20m)
  - 06 July 2010 : SPOT 4 XI (20 m)
- 1 orthophoto archive (PAN), 2004

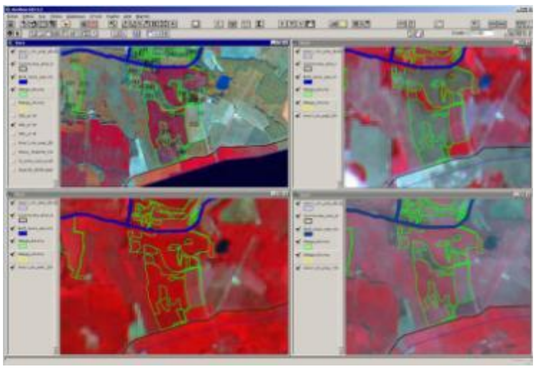

**Figure 19.** Visualization of CAPI 8 screen

## 3. RESULTS

### 3.1 CAPI results (confusion matrix)

Comparing quantitatively the results derived from the 2 separate efforts of (blind) photo-interpretation, the overall conclusion is that we do not find any significant difference between the 2 CAPI efforts (see complete confusion matrix below, where CAPI 4 on x axis and CAPI 8 on y).

**Table 3.** Confusion matrix

| codes | 11 | 211 | 212 | 213 | 214 | 215 | 221 | 222 | 231 | 232 | 241 | 242 | 243 | 311 | 411 | 412 | 413 | 414 | 415 | 416 | 512 | 600 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 28.45 | | | | | | | | | | | | | | | | | | | | | | 28.45 | 100% |
| 211 | | 946.54 | | | | | | | | | 15.26 | | | | | | | | | | | | 961.8 | 98% |
| 212 | | | 110.61 | | | | | | | | | | | | | | | | | | | | 110.61 | 100% |
| 213 | | | | 97.69 | | | | | | | | | | | | | | | | | | | 97.69 | 100% |
| 214 | | | | | 1290.58 | | | | | | | | | | | | | | | | | | 1290.58 | 100% |
| 215 | | | | | | 97.61 | 0.23 | | | | | | | | | | | | | | | | 97.84 | 100% |
| 221 | | | | | | | 1681.13 | | | | | | | | | | | | | | | | 1681.13 | 100% |
| 222 | | | | | | | | 19.05 | | | | | | | | | | | | | | | 19.05 | 100% |
| 231 | | | | | | | | | 19.6 | | | | | | | | | | | | | | 19.6 | 100% |
| 232 | | | | | | | | | | 647.92 | | | | | | | | | | | | | 647.92 | 100% |
| 241 | | 36.66 | | 0.4 | | | 6.5 | | | | 86.76 | | | | | | | | | | | | 130.32 | 67% |
| 242 | | | | | | | 5.87 | | | | | 55.28 | | | | | | | | | | | 61.15 | 90% |
| 243 | | | | | | | | | | | | | 22.09 | | | | | | | | | | 22.09 | 100% |
| 311 | | | | | | | | | | | | | | 0.14 | | | | | | | | | 0.14 | 100% |
| 411 | | | | | | | | | | | | | | | 0.47 | | | | | | | | 0.47 | 100% |
| 412 | | | | | | | | | | | | | | | | 10.38 | | | | | | | 10.38 | 100% |
| 413 | | | | | | | | | | | | | | | | | 29.95 | | | | | | 29.95 | 100% |
| 414 | | | | | | | | | | | | | | | | | | 4.87 | | | | | 4.87 | 100% |
| 415 | | | | | | | | | | | | | | | | | | | 1.53 | | | | 1.53 | 100% |
| 416 | | 0.26 | | | | | | | | | | | | | | | | | | 29.13 | | | 29.39 | 99% |
| 512 | | | | | | | | | | | | | | | | | | | | | 7.54 | | 7.54 | 100% |
| 600 | | | | | | | | | | | | | | | | | | | | | | 10.65 | 10.65 | 100% |
| | 28.45 | 983.46 | 110.61 | 98.09 | 1290.58 | 97.61 | 1693.73 | 19.05 | 19.6 | 647.92 | 102.02 | 55.28 | 22.09 | 0.14 | 0.47 | 10.38 | 29.95 | 4.87 | 1.53 | 29.13 | 7.54 | 10.65 | 5263.15 | |
| | 100% | 96% | 100% | 100% | 100% | 100% | 9926% | 100% | 100% | 100% | 85% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | | 99% |

In fact, out of a total number of parcels identified within the sample, 98.76% were assigned to same land use both in CAPI 4 (WV2 image using the classical FCC) and CAPI 8 (replacing Red with Red Edge in the FCC derived from WV2 image). Looking at the details, (see inset below) we can see that the only classes where some discrepancies have been quantitatively noticed were: "Winter Cereals", "Spring Crop", "Bare Soil", "Pasture/Set Aside", and "Crops Late in Development".

| | 11 | 211 | 212 | 213 | 214 | 215 | 221 |
|---|---|---|---|---|---|---|---|
| 11 | 28.45 | | | | | | |
| 211 | | 946.54 | | | | | |
| 212 | | | 110.61 | | | | |
| 213 | | | | 97.69 | | | |
| 214 | | | | | 1290.58 | | |
| 215 | | | | | | 97.61 | 0.23 |
| 221 | | | | | | | 1681.1 |
| 222 | | | | | | | |
| 231 | | | | | | | |
| 232 | | | | | | | |
| 241 | | 36.66 | | 0.4 | | | 6.5 |
| 242 | | | | | | | 5.87 |

In particular, the class "Crop late in development/with problems" (that means parcels presenting cropping zones with growing difficulties) seems clearly more easily detectable by using the Red Edge spectral information compared to the use of the traditional Red (see example in Figure 20).

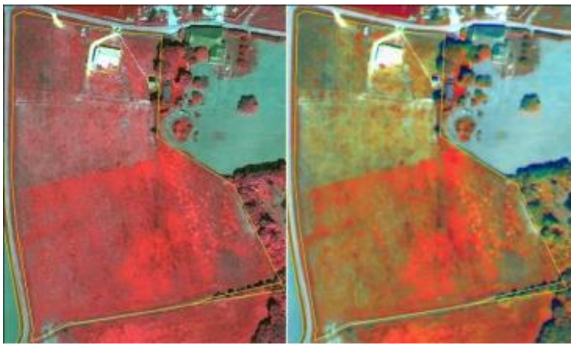

**Figure 20.** Example of an agricultural parcel showing the areas affected by problems, which are more easily detectable when using Red Edge (right image) than when using the classical Red band (left image).

**Table 4.** Comparison of the two CAPI results

| Description | codes | CAPI 4 | CAPI 8 |
|---|---|---|---|
| Impervious | 11 | OK | OK |
| Winter cereals | 211 | 96% | 98.40% |
| Rape | 212 | OK | OK |
| Spring crop | 213 | 99.60% | OK |
| Summer crop | 214 | OK | OK |
| Bare Soil | 215 | OK | 99.80% |
| Pasture/set aside | 221 | 99.30% | OK |
| (green) buffer strip along water courses | 222 | OK | OK |
| Vineyards | 231 | OK | OK |
| Orchard | 232 | OK | OK |
| Crop late in development or with problems | 241 | 85.00% | 66.60% |
| Maintenance issues | 242 | OK | 90.40% |
| Anomaly in declaration | 243 | OK | OK |
| Not eligible forested area | 311 | OK | OK |
| Line of trees | 411 | OK | OK |
| Group of trees | 412 | OK | OK |
| Hedge | 413 | OK | OK |
| Embarkment | 414 | OK | OK |
| Ditches | 415 | OK | OK |
| Green buffer strip | 416 | OK | 99.10% |
| Pond,lake, etc | 512 | OK | OK |
| Unknown cover | 600 | OK | OK |

### 3.2. General impressions from the CAPI experts

The two SIRS experts have both expressed positive comments in the use of WV2 colour composites that include Red Edge as it provides better detection of possible within field differences especially during crop development (see Figure 21).

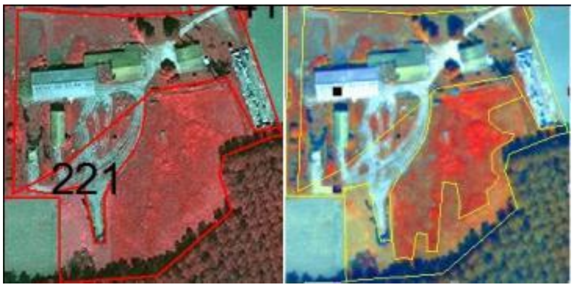


**Figure 21.** The use of Red Edge (right image) allows an easier delineation of areas affected by problems

According to the experts, also the presence of wet zones (for example in parcels cultivated with grassland, pasture, etc.) seems to be better detectable when using Red Edge spectral information. They also added that the Red Edge band appears rather useful even to discriminate different forest species.

However, for one of the important goals that SIRS and ASP wanted to verify during the CAPI test, which is the possibility to gain supplementary details within the shadow areas, suitable results were not achieved as hoped. In fact, during the analysis of satellite imagery for the agricultural controls, the shadow of trees near water courses generally prevents a comfortable validation regarding the presence (or absence) of a green buffer zone around water courses or the precise identification of field margins (as requested by new rules). For such contexts, the introduction of Red Edge in the colour composite alone has not provided the desirable success in the CAPI test to overcome this particular problem, in comparison to the spectral information already provided by traditional bands.

### 3.3. Further Image Analysis

In addition to provide a new band combination to be tested in CAPI for possible rapid integration in future CwRS operational activities, we decided to perform further analyses on the new imagery in order to verify if the new spectral information could be exploited for photo-interpretation using less traditional methods (band colour composites). After some unconvincing results using the Principal Component analysis and automatic classifications, we focused our attention on the calculation of alternative vegetation indices and their possible combination for visualization purposes (for CAPI).

So, in addition to the classical NDVI and $NDVI_{RE}$, already explained earlier, some additional VIs had been calculated. The VIs giving the most interesting results were:

Soil Adjusted Vegetation Index (SAVI) [3, 22]:

$$SAVI = (R_{NIR} - R_{RED}) (1 + L) / (R_{NIR} + R_{RED} + L) \quad (3)$$

According to Huete [3], optimal L values differ according to different vegetation density, but L=0.5 was suitable for a wide range of conditions.

Enhanced Vegetation Index (EVI), whose equation is [4]:

$$EVI = 2.5 (R_{NIR} - R_{RED}) / (R_{NIR} + 6R_{RED} – 7.5R_{BLUE} +1) \quad (4)$$

Normalised Pigment Specific Difference Index (NPDI) [5]:

$$NPDI = (R_{800} – R_{470}) / (R_{800} + R_{470}) \quad (5)$$

Chlorophyll Indices (CIs), whose equations are [6]:

$$CI_{green} = (R_{NIR} / R_{GREEN}) – 1 \quad (6a)$$

$$CI_{red\ edge} = (R_{NIR} / R_{RED\ EDGE}) - 1 \quad (6b)$$

CIs are used to calculate the leaf chlorophyll concentrations.

Plant Senescence Reflectance Index (PSRI) [7, 24]: *"The Plant Senescence Reflectance Index (PSRI) is designed to maximize the sensitivity of the index to the ratio of bulk carotenoids (for example, alpha-carotene and beta-carotene) to chlorophyll. An increase in PSRI indicates increased canopy stress (carotenoid pigment), the onset of canopy senescence, and plant fruit ripening. Applications include vegetation health monitoring, plant physiological stress detection, crop production and yield analysis"* (from ENVI User Guide, [23]). Its equation is

$$PSRI = (R_{680} – R_{500}) / R_{750} \quad (7)$$

Index value ranges from -1 to 1 (green vegetation is usually between -0.1 and 0.2).

Anthocyanin Reflectance Index 2 (ARI2) [8, 24]: *"The Anthocyanin Reflectance Index 2 (ARI2) is a reflectance measurement that is sensitive to anthocynanins in plant foliage. Increases in ARI2 indicate canopy changes in foliage via new growth or death (changes in Green absorption relative to Red, indicating leaf anthocyanins). The ARI2 is a modification of the ARI1 which detects higher concentrations of anthocynanins in vegetation"* (from ENVI User Guide, [24]). Its equation is

$$ARI2 = R_{800}[(1 / R_{550}) – (1 / R_{700})] \quad (8)$$

This index ranges between 0 to more than 0.2 (green vegetation generally between 0.001 and 0.1).

Due to lack of sufficient time at disposal, the results of such VIs analyses, though promising, were not considered satisfactory enough at the time of interruption (the work was presented at November's CwRS Conference). So we could not derive any practical suggestion aiming at their direct integration in the CAPI operations.

Further work would need to be performed in order to advance and complete such tests and to verify, for instance, whether the adoption of alternative VIs for creating synthetic bands for producing enhanced colour combination is feasible. This area is full of promises but it would require further analyses and verifications before confirming their practical use.

**Figure 22.** Combination of Vegetation Indices (RGB) versus False Colour Composite. **Left:** ARI2-$NDVI_{RE}$-$ARVI_{RE}$-Co.; **Right:** classical FCC (RGB): NIR1-Red-Green.

**Figure 23.** Combination of Vegetation Indices (RGB) versus True Colour Composite. **Left:** Veg. Index combination (RGB): ARI2-$NDVI_{RE}$-$ARVI_{RE}$-Co. **Right:** "enhanced" TCC (RGB): Yellow-Green-Coastal (all bands previously enhanced)

## 4. CONCLUSIONS

In summary, in quantitative terms the test did not highlight any significant differences for CwRS purposes (CAPI) in the adoption of Red Edge comparing with the use of the traditional Red. However, both CAPI experts have confirmed the qualitative advantages in replacing Red with Red Edge. The higher degree of decorrelation between the bands Green and Red Edge comparing to the traditional Green-Red (Figures 24 and 25), as mentioned earlier, provides a wider range of colour spectrum facilitating the visual interpretation of features.

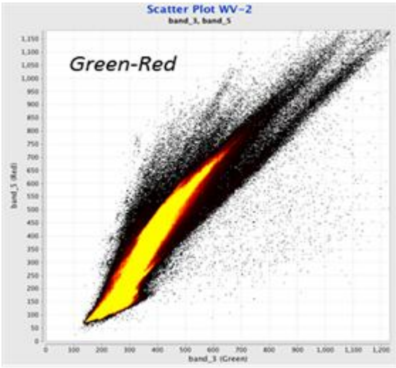


**Figure 24.** Moderate level of correlation between Green and Red

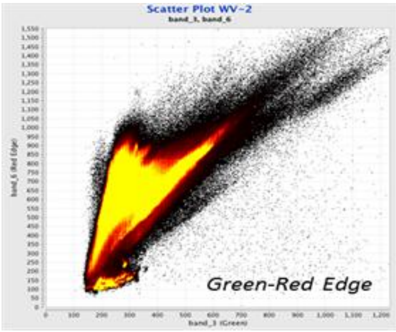


**Figure 25.** Low level of correlation between Green and Red Edge

In conclusion, we can summarise that, as expected, the new bands on WV2 provide significant supplementary information comparing to the traditional multi-spectral bands.

The new Red Edge band appears to be the most significant, in particular for enhancing vegetation phenological differences that are not visible using traditional bands.

However, the test also confirmed how pan-sharpening WV2 data remains the most important requirement for CAPI (that is spatial resolution still to be regarded as more critical factor than spectral resolution, see representative example in Figure 26).

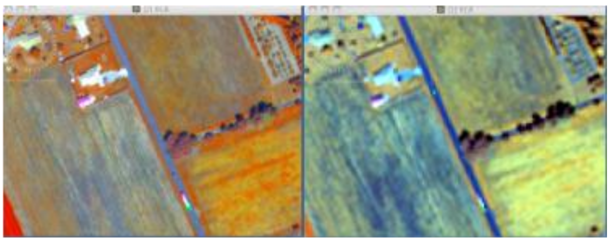

**Figure 26.** Comparison pan-sharpened with multi-spectral data (same band combinations: NIR-1, Red Edge, Green). On the left: image pan-sharpened, on the right: original multi-spectral.

Being pan-sharpening such a critical factor, we also want to underline possible issues regarding consistencies in the pan-sharpening results when using different algorithms (see example in Figure 27).

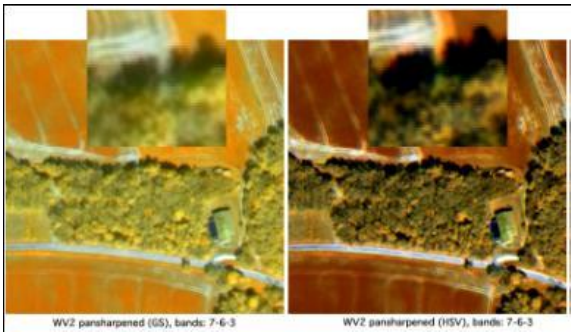


**Figure 27.** Visual comparison of results after pan-sharpening using different algorithms (same band combination: NIR-1, Red Edge, Green)

The use of vegetation indices, in particular incorporating the Red Edge band and the creation of band combinations from them (see an example at the bottom left image of Figure 28) seems to give very promising results. However, more investigations are required to confirm their potential.

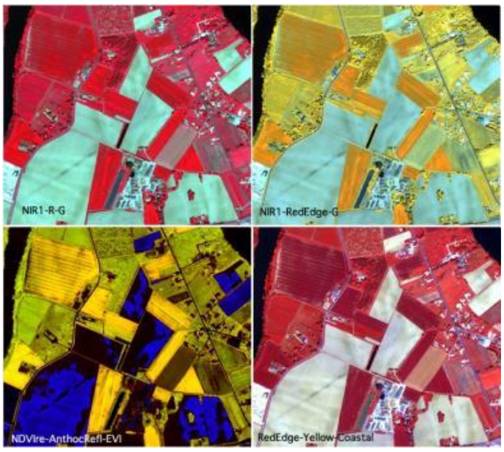


**Figure 28.** Visual comparison of different colour band combinations (RGBs). The image at bottom left is composed by synthetic bands (derived from vegetation indices)

Finally, few practical recommendations for future CwRS derived from the test results:

1) Provide, whenever feasible, WV2 full data as standard (8+1 original or 8 already pan-sharpened)

2) If the full provision of 8/9 bands is not feasible, it is strongly suggested the replacement of Red by Red Edge

3) For question of consistency, the image already pan-sharpened (which remains essential for facilitating photo-interpretation) should be provided as standard by the image provider. Alternatively, the pan-sharpening operation could be performed independently in each MS by the contractor/national administration provided that follows same specific instructions proposed by JRC

4) In order to take full advantage of the high sensitivity demonstrated by some new bands for vegetation detection and monitoring (i.e.: Yellow and Red Edge), it is suggested to move the opening of WV2 acquisition windows for CwRS towards vegetation growing season (May-July).

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# ENHANCING AND USING THE LPIS AS A LAND KNOWLEDGE SYSTEM: AN EXAMPLE OF USING LPIS DATA FOR RISK ANALYSIS AND GAEC CONTROLS

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**ABSTRACT**

Since 2006 Abaco has invested in the field of IACS-related technologies, working together with real users in order to apply several techniques available in the IT industry, with a focus on the spatial data included in IACS systems. The Land Parcel Identification System (LPIS) is the container of the spatial information which can be used to properly locate and quantify the agriculture land; often the LPIS limits its potential to payments schemes support. Currently many LPISs contain other relevant information that, together with historical information recorded during the years in the overall IACS, can be used as a knowledge system which provides a full understanding on the land, relevant for the sustainable agriculture development. So, when used in conjunction with IACS information, or previous year's control outcomes, the LPIS can be efficiently used for effective risk analysis, and to support cross-compliance inspectors for GAEC controls. When used like this, the number of people contributing to updating the information grows, with the positive effect to optimize control costs, enhance the quality of LPIS data, and provide a source for knowledge.

**KEY WORDS:** LPIS, IACS, 3D, GAEC, Risk Analysis, Land Management, Greening the CAP

## 1. INTRODUCTION

The LPIS (Land Parcel Identification System) and the ICS (Integrated Control System) are two of the IACS' (Integrated Administration and Control System) main systems required by the CAP Regulations to identify land and to control the claimed parcels. The LPIS is, underneath, based on GIS technologies whose high technical development rate offers the possibility to use this container to store more and more information on land phenomena, including the current agricultural and environment conditions.

The ICS uses GIS techniques to check for the eligibility and correctness of payments, while recording on-the-spot checks results. Such recorded information, together with advanced spatial data analysis techniques, enable people to use these features in order to perform additional Land Management tasks, such as a comprehensive risk analysis, aiming better knowledge of the territory, effective controls, and a better definition of "greening" policies.

So to say, we are studying the possibility to avoid limiting the IACS only for the purpose of taking the measures necessary to satisfy those transactions financed by European funds that are actually carried out and executed correctly, or to prevent and deal with irregularities. In addition, we would like to extend the use the information gathered for a better understanding of the agricultural land conditions.

## 2. IACS CONTEXT

Information collected during the different processes required to deal with CAP subsidies are entered into the IACS by several actors. For the purpose of this study we are focusing mainly on the information entered in the LPIS and the ICS (Figures 1 and 2), while considering ancillary information that might be collected within other modules, like the Farm Registry.

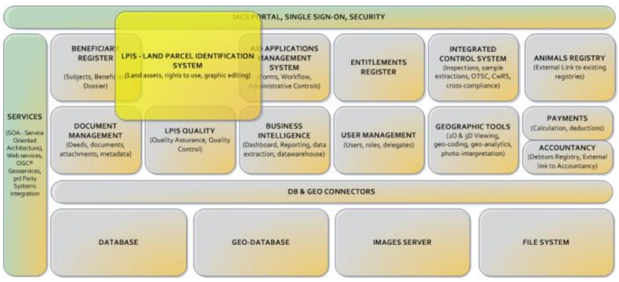


**Figure 1**. LPIS within the IACS

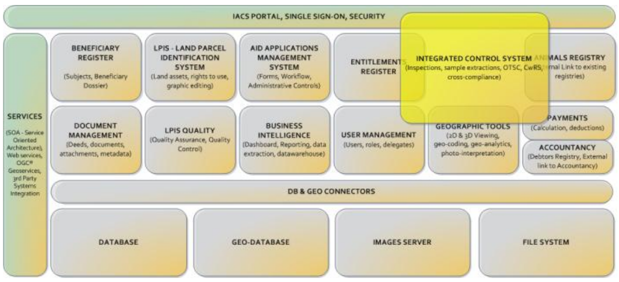


**Figure 2**. ICS within the IACS

## 3. EXTENDING THE LPIS

Extending the LPIS for controlling environ-mental and agricultural conditions requires the extension of the definition of the Reference Parcel to a more general concept – the one of the Spatial Unit. The Spatial Unit is also a concept described in the ISO 191xx standards on Land Management: "a single area (or multiple areas) of land or water, or a single volume (or multiple volumes) of space".

Within the CAP, the above elements are frequently referred as terrain features which are seen as eligible or ineligible in the context of subsidies payments. The new terrain elements (Figure 4) which can be added to the LPIS, as it happens within other GIS projects, are for example:

- Buildings;
- Water features;
- Roads;
- Non-agricultural land;
- Landscape features.

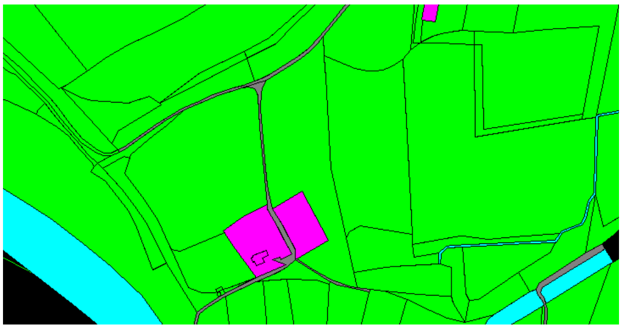

**Figure 3.** Full mapping of features

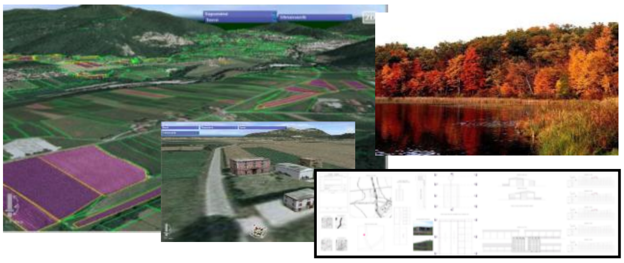

**Figure 4.** Examples of Spatial Units

An LPIS custodian should consider therefore the possibility for a country-wide mapping of Spatial Units, like some Member States already do, since the GIS technology behind the LPIS enables this possibility and because these data are usually already available. Identifying the Spatial Units should not only be done as a pure exercise, but also for the EU requirement of informing the farmers regarding possible irregularities during the claim process.

It has to be noticed that collecting more information is also required by EU Reg. 73/2009 Art. 6 which, with regards to the GAEC, states that Member States shall define, at national or regional level, minimum requirements for good agricultural and environmental condition on the basis of the framework established in Annex III, *taking into account the specific characteristics of the areas concerned, including soil and climatic condition, existing farming systems, land use, crop rotation, farming practices, and farm structures.*

Moving from Reference Parcels to Spatial Units provides the possibility of getting a Land Management Information System (LMIS) which can be enriched by other internal/external systems and that, through spatial analysis, becomes source for additional information. The resulting data model (Figure 5) can be therefore queried through standard spatial tools.

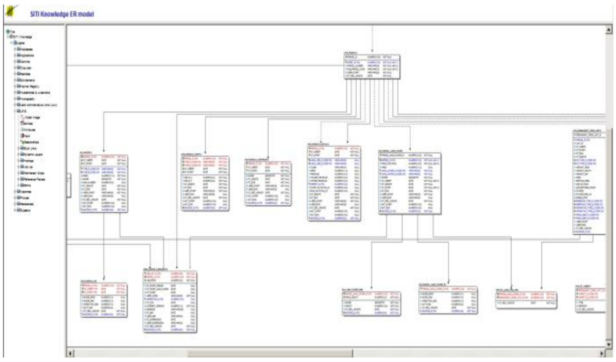

**Figure 5**. Land Knowledge Data Model

## 4. ENVIRONMENTAL RISK ANALYSIS

Once the LPIS is extended, then it is possible to extract risk information by following a simple reasoning:

- **From** the Land Knowledge Data Model
- **Using** Business and Location Intelligence
- **Determine** Key Risk Indicators
- **For each** Agricultural Holding
- **Considering** historical GAEC and SMRs.

Basically from the extended LPIS, based on a continuum of Spatial Unit plus information layers and through spatial techniques, it is possible to determine the punctual risk (Key Risk Indicators) for each agricultural holding when conducting its activities and related also to the respect of GAEC. We then built a software solution having in mind two basic applications:

- Farm Advisory System (FAS) – (FAS – Art.12 Reg. 73/2009) – also with the aim of providing information to the agricultural holdings regarding the possible risks and their obligations under GAEC and SMRs;
- Risk Analysis – defining suitable criteria for the PA in order to select high-risk holdings for cross-compliance checks (Art 4, 5, 6, 22 Reg. 73/2009, and the Nitrate Directive).

GAEC requirements can be found within the Annex III of EU Reg. 73/2009; for the purpose of this study we considered, among others the following requirements:

- **Erosion**
  - Terrain structure, texture, and land use;
  - Terrain slope and morphology;
  - Water infrastructures and industrial facilities;
  - Rainfall indexes.
- **Wildlife-Habitat Maintenance**

- Land use;
- Landscape features;
- History of crop plans.

- **Water protection and maintenance**
  - Water infrastructures and industrial facilities;
  - Hydrography (including underground water).

## 5. LPIS: NEW DATA AND ENGINE

For having enough information to determine relevant indexes, we started collecting/refining additional data, like:

- Digitisation of Spatial Units that are not CAP Reference Parcels (e.g. we cover 100% of the land with additional spatial elements);
- Classification of Spatial Units in Arable Land, Terraces, Settlements, Road, Water, etc. ;
- Identification of Landscape features, registering them onto the Land Cover layer;
- Classification of buildings linked to spatial units and assigning the type "settlement" (stables, tanks, paddocks, manures, etc.);
- Registration of the crop plans;
- Adding roads and water networks.

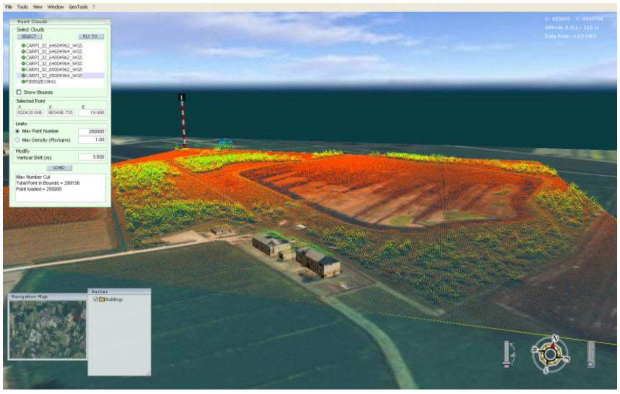

**Figure 6.** Mixing information layers

Apart from the above information and taking advantage of the GIS behind the LPIS, we collected a series of information layers to perform spatial analysis. Most of these layers were available from external systems managed by different authorities (the list refers to Italy):

- Map of chemical analysis (regional DB) ;
- Map of natural and artificial wells (province DB) ;
- Water basins and water network (regional DB) ;
- Map of rainfall indexes;
- Past GAEC and SMRs assessed areas (from OTSC feedback) ;
- Permanent crop registries (e.g. vineyards, olives, orchards, etc.).

We therefore did a detailed work on the LPIS database aiming to the use of GIS integrated spatial operators. The LPIS server engine was then enhanced to provide advanced 2D and 3D libraries, to be called by several procedures, and providing results related to specific environmental conditions.

Among the enhancement we added functionalities to calculate in real-time 3D attributes from polygons in conjunction with the DTM/DSM:

- Altitude AMSL (Above Mean Sea Level);
- Polygon slope;
- Polygon orientation;
- Polygon 3D area.

Within the new engine we added the possibility to determine the buffer areas of Spatial Units of certain types (for example water courses) and expected GAEC buffer strips by spatial intersection. A further operation has been done to find, through proximity analysis, areas with a high likelihood for GAEC controls. The resulting set of data provides therefore:

- Minimum Safety Areas;
- Vulnerable Reference Parcel boundaries touching special Spatial Units (for example junkyards), or possibly ineligible field margins.

For the purpose of agricultural holding risks, a set of functionalities to merge/split reference parcels according to homogeneous characteristics has also been introduced. This was necessary to extend the analysis beyond the specific Reference Parcel (RP) type used in the LPIS. Among others, the extended functionalities include:

- Merging Agricultural Parcels into Farmer's blocks for the analysis of whole agricultural holdings, and vice versa;
- Merging RPs to Physical blocks according to permanent features layers;
- Finding hillsides with homogeneous slope;
- Recognizing Reference Parcels adjacent to water course, or crossed by roads.

Other LPIS engine features include the possibility of obtaining dynamic attributes through intersection with other GIS layers (point, line, polygons). This helped to find:

- RPs which include wells;
- RPs which lay within constrained/protected areas;
- RPs which are crossed by water elements (especially artificial ones).

## 6. RISK INDICATORS

Once the information has been collected and the enhanced LPIS engine has been installed, we began to define a model to calculate environmental risk indicators by agricultural holding. The risk indicators are a result of the overall information stored in the IACS system. Their purpose is to conduct an effective risk analysis needed either to optimize Member State's controls of agricultural holdings, or to prepare a farmer's personalized informational report on GAEC requirements. Such indicators are not intended as precise anomaly or infringement detection, they are instead an accurate element to be used during control sample selection, or to suggest best agricultural practices.

We started determining the following set of indicators:

- Erosion Risk Indicator
- Nitrate Water Pollution Risk Indicator
- Olives and Vineyard Abandon Risk Indicator
- Landscape Features Negligence Indicator
- Zootechnical Overload Risk Indicator
- Animal Waste Sustainability Indicator

### 6.1. Erosion risk indicator

The Erosion Risk Indicator derives from our studies on drainage basins adapted to a couple of algorithms which are described in literature.

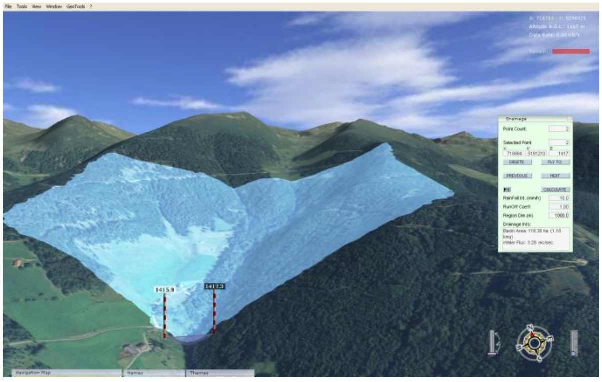

**Figure 7.** Erosion Area

The first is based on the **Revised Universal Soil Loss Equation** (**RUSLE**):

$$A = RKLSCP \qquad (1)$$

where R is rainfall erosivity factor, K is the soil erodibility factor, L and S are the topographic factors, and C and P are the cropping management factors. The soil erodibility factor K can be approximated from a nomograph if this information is known. The LS factors can easily be determined from a slope effect chart by knowing the length and gradient of the slope. The cropping management factor (C) and conservation practices factor (P) are more difficult to obtain and must be determined empirically from plot data. They are described in soil loss ratios (C or P with / C or P without).

The second is based on **the Gavrilovic Method:**

$$W_p = \pi P F_w K_t \sqrt{K_z^3} \qquad (2)$$

where P is rainfall average yearly precipitation, $F_W$ is drainage area in km$^2$, $K_t$ is temperature coefficient and $K_z$ is the erosion coefficient. $K_t$ is $\sqrt{0.1 + \frac{T}{10}}$ where $T$ is the average yearly temperature (°$C$). $K_z$ can be estimated through land use tables or approximated with the formula $K_z = K_y K_t K_x (K_o + \sqrt{F_{sl}})$,

where $F_{sl}$ is the average slope of the basin (%), $K_y$ is the soil erodibility coefficient, $K_x$ is the soil protection coefficient, and $K_o$is the erosion and stream network coefficient.

### 6.2. Nitrate water pollution risk indicator

In this case we choose a deductive method to raise the attention on critical agricultural holding size, related to likelihood of using waste and sludge as organic fertilizers**.** Critical areas are found on the basis of proximity to water course or basins of an agricultural holding (proximity means internal and/or in the vicinity).

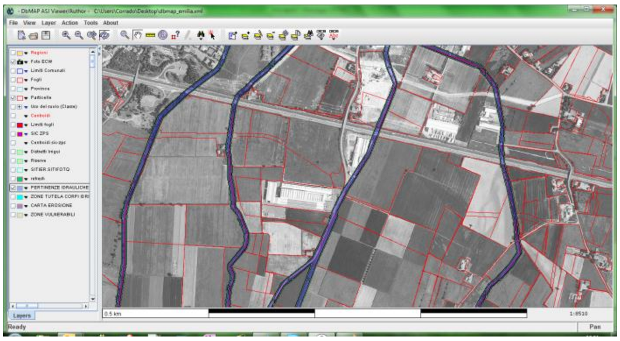

**Figure 8.** LPIS with water courses

The vulnerable area is determined through a parametric buffer strip and it is then compared to the total arable land. There will be a risk when the ratio is higher than a specified percentage threshold. The Nitrate Water Pollution Risk Indicator can be adjusted with a coefficient when the agricultural holding has also livestock.

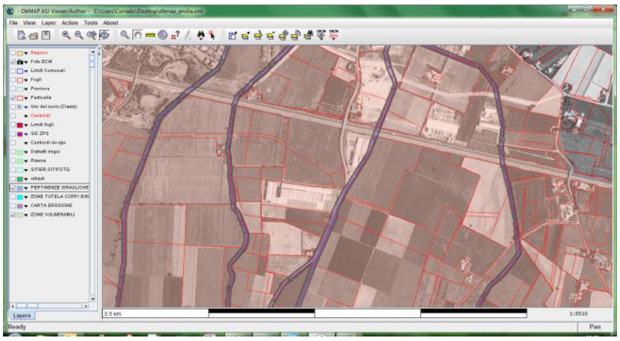

**Figure 9.** Nitrate vulnerable area (in pink)

### 6.3. Olives and vineyard abandon risk indicator

This Indicator uses a deductive method only for the purpose of sample extractions. It is based on the assumption that there is an abandon risk when these types of permanent crops represent a minimal portion of the agricultural holding cultivated area, or when they are below the minimum size required to provide a subsidy income.

The indicator is calculated using the following information:

- Comparison of the farm holding's total cultivated area with the olives (or vineyard) cultivated area
- Information gathered from the IACS related to open administrative proceedings (for example production claims)

A holding has a risk if the ratio between the olives (or vineyard) cultivated area and total cultivated area is below a defined percentage.

### 6.4. Landscape features negligence indicator

This indicator is determined in a way similar to the previous one. It shows the likelihood of maintenance negligence when the features size is considerably large when compared to the Utilized Agricultural Area, or considerably small when compared to the Agricultural Holding size.

The indicator is calculated using the following information:

- Comparison of the total farm holding cultivated area with the landscape features area.

A holding has a risk if the ratio between the landscape features area and the total cultivated area is below a defined percentage.

### 6.5. Zootechnical overload risk indicator

Determining an accurate zootechnical indicator is more complex, since it should be based on information available only outside of the LPIS realm. Since we were not intended to get into the heart of the actual management of the agricultural holding, we choose to limit the study to a qualitative indicator on the zootechnical overload and on the tolerability of soil. Basically we were not considering the presence of manure heap or fertilizing habits.

**Figure 10.** Zootechnical load areas

The indicators are calculated using the following information

- Organic fertilizers balance: nitrate demand, from the annual crop plan, corrected with soil analysis, and determining the waste production, expressed as fertilizing power. This takes into account also the type of animals and the type of waste;
- Adjustment based on the Nitrate Water Pollution Risk Indicator.

The above are, again, risk indicators which will not be enough to determine SMRs, but at least providing likelihood. The model is anyway expandable.

### 6.6. Animal waste sustainability indicator

This indicator should be determined in a way similar to the previous one, and it is still under study. When the size of livestocks is comparably higher than the Utilized Agricultural Area, a risk of sustainability is possible.

The indicator is calculated using the following information:

- Comparison of the total farm holding size with the number of animal heads.

Among practices of farmers, waste could be given to other farmers, therefore this indicator still represent a risk factor. A holding should have a risk if the ratio between the number of animal heads and the total cultivated area is within a defined factor.

## 7. CONCLUSIONS

The "extended LPIS" has been designed to integrate spatial analysis tools and to establish a flexible framework to define a number of risk indicators.

The architecture enables the definition of more indicators that are currently under study with selected users. The applications are numerous, but initially it is intended to achieve two main results:

- Effectiveness of On-The-Spot Checks, using a better risk analysis;
- Farm Advisory System.

All the new tools and techniques can be applied and provide tangible results. The new functionalities, together with additional datasets, therefore can now be used to enhance the importance and usability of LPIS information.

Using an extended LPIS as an integrated component of the IACS can be the source for important knowledge, so that the Member States can use the risk indicators to perform better sample selections with Risk Analysis, reducing costs and being effective in land controls. Furthermore, Member States can now provide the farmers with useful information to comply with EU Directive and Regulations on cross-compliance, avoiding financial corrections, while improving the land quality.

## 8. ACKNOWLEDGMENT

We thank the R&D department of Abaco which gave the possibility to make it real. The researchers of the company were able to transform ideas into real and usable tools.

## 9. REFERENCES

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WikiCAP - Statutory management requirements - http://marswiki.jrc.ec.europa.eu/wikicap/index.php/Statutory_management_requirements

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Abaco DbMAP 3D http://www.abacogroup.eu/pdfview/DbMAP_3D_EN.html

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# AN OBJECT BASED APPROACH ON THE DETECTION OF LANDSCAPE FEATURES IN THE CZECH REPUBLIC

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**ABSTRACT**

Retention of landscape features is a requirement for good agricultural and environmental conditions (GAEC). Landscape features can be mapped at a national level but this is a huge task and only applied in a few Member States (MS). Automation of this mapping process is therefore an attractive alternative. A classification based upon Geographic Object Based Image Analysis (GEOBIA) is developed on a WorldView II satellite scene and focus on woody landscape features. The selected feature attributes and their sequential use in the classification are expected to be stable and transferable to an extended classification program using similar VHR datasets. A reference data set with visual digitized polygons is applied in the accuracy assessment. The initial result demonstrates that the classical assessment of accuracy should be extended. It is useful to take into account not only overlap but also the adjacency of the classification results with the reference. A simple buffer function already increases the overlap from 51% to 71%. An update of the reference set is required to judge the GEOBIA results correctly.

**KEY WORDS:** LPIS, GAEC, Landscape Features

## 1. INTRODUCTION

Landscape features in agricultural environment are related to local historical agricultural practices. They are also under strong influence from recent developments in agricultural management in the given context of the landscape with specific geo-morphological properties and ecological conditions. Although they receive this impact from modern agricultural management, their development and seasonal change is still closely linked to natural processes such as *succession, climax and senility* in vegetation development stages.

### 1.1. DSR analysis

The biotic and abiotic components of landscape features are subject to a variety of processes which can be scrutinized under the concept "driving force-state-response" (DSR) (Piorr, 2003). The mapping of landscape features delivers first a set of polygons with existing area occupation in hectares. This is just a part of the DSR analysis. The state itself might not be sufficient to evaluate the condition of landscape features. Also field observations and local historical knowledge can define the background of pressure and the expected system response. The final result should be an estimation of expected change in area of landscape features and a confirmation of change in a multi temporal analysis. The mapping process is an essential part of the total concept. The detailed DSR analysis could serve adaptations in landscape management in favour of landscape feature retention.

The retention of landscape features is a requirement for good agricultural and environmental conditions (GAEC). The removal of landscape features is considered a breach of GAEC. Changes related to maintenance practices and recovering from (minor) damage can be considered a part of the landscape features biological dynamics. It is crucial to evaluate if the damage is irreversible or not. Natural processes of vegetation succession often can re-establish themselves on the damaged parts. Gradual damage (for example stone-terraces and stone-walls due to weathering and erosion) is an inherent part of this abiotic landscape feature but this is not triggered by active removal and thus does not breach GAEC. However, without interference, a serious deterioration of these abiotic landscape features can be expected. For more fragile biotopes, especially related to the hydrology of the terrain, extra attention might be required. Irreparable damage related to species extinction should be avoided.

Overall gradual deterioration of landscape features is common but often at a slow pace. Even when GAEC limitations are respected and removal of landscape features is avoided, in the long run only active interference in the support of landscape features guarantee their long-lasting existence. They linger in an environment where their functions diminish in relationship with the scale of operations of modern agricultural production techniques. Because landscape features retention and habitat preservation are frequently linked, the assumption on habitat loss requires an in-depth evaluation. Local (incidental) habitat loss in itself might not have enormous impact in the landscape as a whole. This is related to the scale of the lost area compared to existing compensation in the neighbourhood, where a balance between succession, climax and biotope-senility is still intact and seeding or re-population from the neighbourhood remains possible. The mapping process of landscape features focused on inventory delivers the "state". A multi temporal mapping process can deliver areas of change and can assist in answering the urgency of landscape management measures required and describe the driving forces and response of the system.

### 1.2. VHR satellite imagery in monitoring

For inventory purposes, the national orthophotomap is the only homogeneous imagery with complete coverage as well as sufficient details, whereas VHR satellite imagery is rarely able to cover the country of MS as a whole within the timeframe needed for the inventory. This might be subject to change in the near future. The monitoring process however does not require a complete national coverage per season on a fraction of the cost of inventory. The VHR satellite imagery can offer the required area details in a cost efficient manner. An additional (semi) automatic mapping process would make cost effectiveness possible. Within the context of this study, the landscape features which are within the reference parcels of the land parcel identification system (LPIS) are taken into considerations. This might be a limitation for a good insight in the potential of natural recovery processes, because the regional natural context of the agricultural fields can have considerable influence on reconstruction of landscape features. Due to the reference restrictions within the LPIS only, this study is limited to landscape features only within this LPIS mask.

Diversity is a core characteristic of landscape features, which is the reason for a difference in the national description among MS. Moreover, landscape features show diversity inside the MS itself and can therefore be described only in general classes. In some of the MS a specific mapping of the landscape features has already taken place. One existing example is created in the Czech Republic, which offers a unique reference data set. Therefore this paper is developed around a case study from the Czech Republic. The test case has been developed for a WorldView II scene (2010) over the area of Brunthal in the Moravian-Silesian Region (Cz). The paper describes the Czech categorization of the landscape features and their focus on woody vegetation in Section 2.1. The woody vegetation can be detected due to their cast-shadows which develop typical textural feature attributes in panchromatic data as explained in Section 2.2. More details of the datasets and methodology are described in Section 3. For the accuracy assessment, a subset is chosen for more detailed evaluation in Section 4.1 and the confusion matrix presented in Section 4.2. The summary of discussion and conclusions are given in Section 5.

## 2. TEXTURAL CHARACTERISTICS OF THE LANDSCAPE FEATURES IN THE CZECH REPUBLIC

### 2.1 categories of landscape features

The landscape features definition differs among MS. For the Czech Republic, they are classified:

*A. balk / grass strip of land that may include woody vegetation (i.e. trees and bushes) and stone walls; used against water and wind erosion.*

*B. terraces (may include woody vegetation)*

*C. grass strip in Thalweg, that may include woody vegetation*

*D. group of woody plants with at least 2 woody plants; area under 2000 m2; cannot be part of a forest*

*E. tree row with at least 5 woody plants*

*F. solitary trees with a projected crown of at least 8 m2; cannot be part of any of the previously defined LF*

The term "woody" is used frequently in the definitions of landscape features. This is partly due to the effects of natural forest succession which remains a strong biological process available within the agricultural domain under natural conditions in the Czech Republic. A reduction on intensive land use therefore stimulates the natural effect of tree growth in an environment where sufficient seeding is available. This can be considered the case for the large majority of the Czech countryside. With an absolute minimum of landscape management, forest succession is a likely development even in cases when alien plant invasions might be the cause of delay in forest succession. Prove of ongoing succession can be found during fieldtrips in the test site area.

Besides the habitat functions of woody landscape features, they also play an important role in erosion prevention. Severe erosion, which even prevents further forest succession is unlikely in the landscape of the Czech Republic and can better be mapped using slope and aspect of the terrain as the basic indicators over the 2-dimensional VHR imagery or in combination with it.

### 2.2 Vegetation succession and textural image characteristics

The biophysical properties of "woody" plant communities produce a characteristic appearance in all very high resolution panchromatic imagery. This is expressed as high textural areas related to cast-shadows. Additionally, the reflective properties in the infra-red part of the spectrum for vegetation, which is neighbouring the cast-shadows, highlights the contrasts between adjacent (relative small) image objects in segmented imagery. The sensitivity of the panchromatic band of VHR satellite sensors for infrared light makes the registration of spectral discontinuities possible. The bio-physical background of image-texture is the plant-community competition for light. For most agricultural crops, the light competition is similar to pioneer (annual) plant communities. In landscape features, on the contrary, perennial plants are likely to dominate and create cast shadow situations with contrast. Agricultural land with annual plants expresses a more homogeneous appearance in imagery. In addition gramineae communities under grazing compete for other factors than light and appear less textured. The homogeneity is scale dependent but is even stronger when agricultural management practices take place with machines or when grassland are under strong grazing influences. Basically, the separation of annual versus perennial flora can be made by a standard classification for all VHR imagery based on texture calculations, which in the majority of the cases allows splitting agricultural crops from biotopes with less annual disturbances.

The typical characteristics of the woody part of the landscape features can be calculated by textural properties (solely on-screen) but also emphasized in additional artificial texture images. To express texture inside imagery, a large variety of algorithms are available. They range from simple standard deviation of the pixels within a moving window up to so called "Haralick features" which are based upon grey level co-occurrence matrices (Steinnocher, 1997). Characteristic for the large amount of texture calculations and image derivatives are their redundancy. This requires a selection by the producer. For this case study, the textures derived from "edgeness" have been chosen. The core of this feature attribute is a selection of all pixels that are falling out of a two sigma range inside a moving window technique. The pixels that exceed two sigma within the moving window represent strong spectral discontinuities inside an image. They are often related to edge pixels of image objects. Due to the sharp contrast between vegetation and cast-shadows, the pixels at the edge of this contrast are highlighted. As the contrast also exist in infrastructure and urban fabric, an additional separation for plant communities is required based upon the difference in red light absorption and infrared reflection. Especially the larger variance of the red band for infrastructure and build-up areas differs from the lower variance of red in vegetation communities. This characteristic is even functional with low chlorophyll activity and therefore independent from the growing season. The textural feature is fast to be calculated and remains a stable and transferable property of shadow casting vegetation (Wężyk , de Kok ,2005, Wężyk et.al, 2004).

Due to the homogeneous nature of the vast majority of annual plant communities in agricultural parcels, including perennial gramineae under grazing, any strong texture is likely to be related to a landscape feature inside the LPIS. Because the landscape features in the Czech Republic are related to vegetation and hydrological properties, the textures caused by infrastructure and (archeological) constructions are not taken into account in this study.

The developed method for classification based upon texture should be so robust that it can be applied throughout the country without the need for samples. A master rule set (Tiede et. al., 2010) would be made available which gives a strong assistance in the inventory as well as nearly fully replace the monitoring with an automatic approach. The exact role of the automatic input needs to be fine-tuned in the mapping process.

## 3. DATASETS AND METHODOLOGY

### 3.1. Details on the datasets

A WorldView II scene from 9 June 2010 with area coverage of around 440km² around Brunthal (Cz) was used as the basic scene (see Figure 1). Cloud cover is less than 5%. The image has 8 spectral bands and 1 panchromatic band. Based on the panchromatic band, 2 artificial edge images were created to assist in the texture map calculations. The Ministry of Agriculture provided a dataset with polygons of the Landscape Features in the Moravian-Silesian Region (Cz). Imagery from a digital camera was used in the fieldtrip to document the ground truth conditions. The oblique imagery is linked to a camera based GPC receiver for integration into GIS programs.

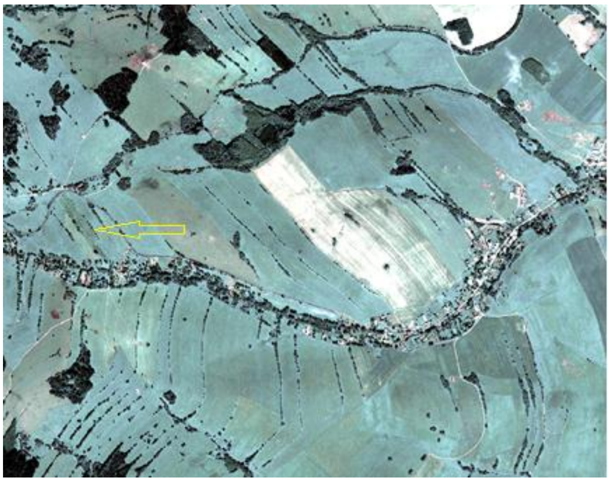

**Figure 1** A color composite (RGB) ± 6 KM² from the Brunthal region (CZ) The yellow arrow indicates an almost not distinguishable Christmas tree plantation (compare also Figure 2).

### 3.2 Methodology

The core of the work was the setup of a process tree which sequentially classifies the satellite scene. The sequential process lines should be based upon a set of feature attributes preferably those which are stable and transferable and therefore can be applied to a whole range of satellite scenes from the same sensor. Initially it might appear that landscape features are in general darker in the colour composites (see Figure 1). A textural analysis is also sensitive to the relatively bright areas in the colour composite. In a texture map constructed from panchromatic band divided by the edge imagery (edge pixels exceeding two sigma, see Section 2.2 and Figure 2), the sensitivity for all textures can be illustrated. A yellow arrow in Figure 1 points to a four hectare field with young Christmas trees. Initially the field appears considerably brighter (in Figure 1) than the woody landscape features and shows similarity in spectral composition with other areas with grass and herbaceous cover. In the texture image in Figure 2, this young plantation area is different and darker, more similar to the textures from forest and woody landscape features.

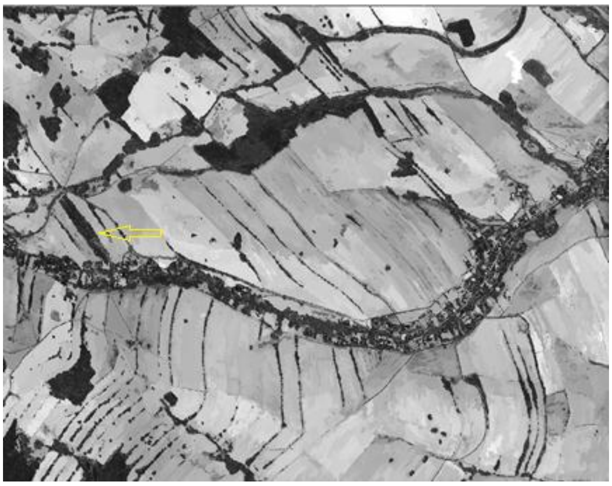

**Figure 2**. Visualization of the crucial feature attribute *"Texture based upon edgeness" (Panchromatic band/ Sum of dark and bright edges)*, for the same image area in Figure 1. Dark for woody features and other strong textured infrastructure, bright for more homogeneous agricultural fields.

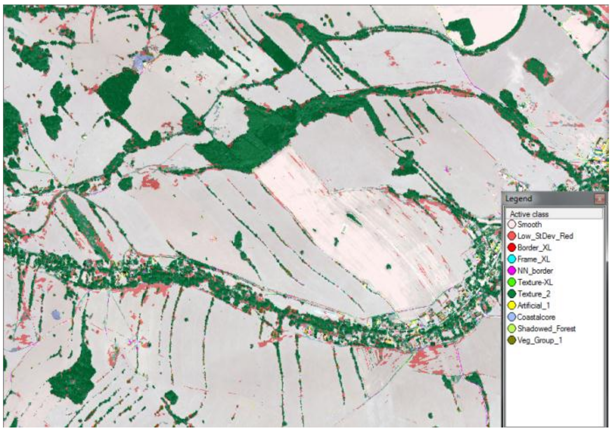


**Figure 3.** An initial categorization with a legend showing producer categories used to export so called "user classes" in the final stage. The category "*Texture 2"* in this legend dark-green delivers the large majority of the candidates for the final user class woody landscape features.

The sequential classification of image objects produce intermediate steps of initial categories of image object which are not visible in the final classification result. Categories have functional labels according to their feature attributes. A producer category is oriented towards its characteristic feature attributes. For example a category label "high-NDVI value, strong shadow component" can end up in the users class "Forest".

Figure 3 displays an intermediate classification result with producer categories. These different categories are subject to discussion among image analysis experts and do not immediately facilitates producer-user interactions. The categories however are pinpointing to the reasons for overlap in practical user classes. In Figure 3, the most important category is "Texture 2". Based upon spatial rules, additional categories are partially added to arrive at the final stage of user-class woody landscape features. The strong link between producer categories and feature attributes allow producers to compare categories from different sources. The aim is to develop a master protocol which describes a set of categories in their relative standardized behaviour towards feature attributes. A classical category consists of image objects with relative high NDVI value which is related to the user-class vegetation. The same case exists for the response to textural features in vegetation with a considerable shadow component.

## 4. ASSESSMENT ON EXPERIMENTAL RESULTS

The preliminary results over the whole satellite scene reveals a large gap between total hectares in the reference set versus the outcome of the GEOBIA classification with 51% overlap. Before concluding that GEOBIA produces commission errors, a subset of 535 Ha was chosen, where it was evident that GEOBIA classification has correctly identified more landscape features than the reference set.

### 4.1 Assessment of a detailed subset

Although conclusions from the detailed subset cannot be transferred completely to the 440 KM² area, some typical deviations can be noticed and regarded to be valid for the total scene. The reference data is much more generalized than the initial output of the GEOBIA classification. It would be useful to apply a generalization to the GEOBIA results before a quality assessment takes place.

The terrain height differences play a role in the visual interpretation, whereas they are not incorporated into the GEOBIA analysis. Due to the standard approach of analysing parts of the MS in a campaign mode, very rarely applying satellite stereo imagery, it is unlikely DSM, DTM and nDSM incorporation becomes an important part in the landscape feature mapping with VHR satellite data.

Another conclusion from the detailed subset, valid for the complete scene, is the general fragmentation of the GEOBIA results compared with the reference data. This is an extra argument to add a generalization step to GEOBIA results.

### 4.2. The Kappa value and the confusion matrix

The complete LPIS area is 17.863 hectare. From this area a merely 82,79 ha is digitized in the reference set and GEOBIA delivers a 96.30 hectare total area of landscape features. However, only 42.55 ha is in the overlap with the reference representing just 51% of overlap zone. The GEOBIA classification requires 1,15 hours per tile of 20.000*20.000 pixels (10 *10 Km) on a standard PC.

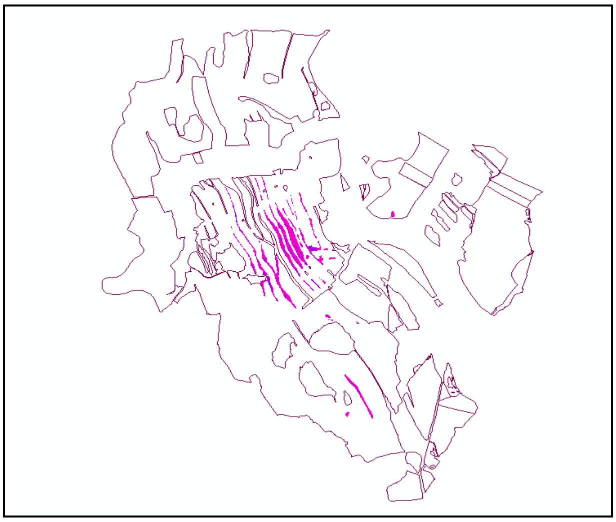

**Figure 4.** The reference polygons on 534.80 Ha subset of LPIS parcels with 12.32 Ha of landscape feature displayed in magenta.

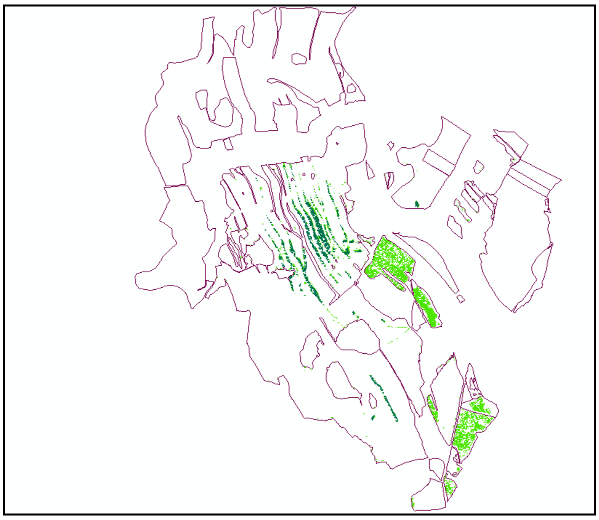

**Figure 5.** The result of the GEOBIA analysis in green, with darker green showing the confirmation of the reference area from Figure 4.

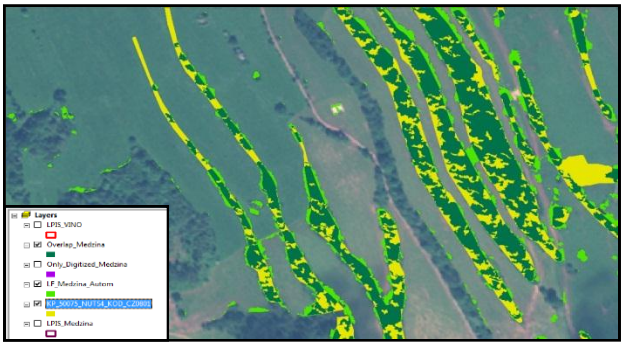


**Figure 6.** Details from Figures 4 and 5 with an additional colour composite in the background. The green areas are detected using a GEOBIA approach where dark green visualizes the confirmation with the reference. The rest of the reference data is displayed in yellow. Only areas inside the LPIS mask are classified.

**Table 1.** The confusion matrix for the detailed subset.

| vertical ; Automatic classified (in Ha)↓ | Tv Observed | Ta Observed | Total |
|---|---|---|---|
| Textured and contrasting vegetation (=Tv) | **7.98** | **17.67** | 25.65 |
| Non textured smooth (agricultural) areas (=Ta) | **4.34** | **504.81** | 509.15 |
| Total | 12.32 | 522.48 | 534.80 Gt |

If the GEOBIA objects directly connecting the overlap zone are taken into account the adjacency-related area of result and reference increases with an additional 34.82 Ha. This would imply that 93% of the result and reference can be interpreted as spatially related (overlap **plus** adjacency). This would matter if adjacency is considered equally important as overlap. However this is not the standard way to evaluate results. Starting with an overlap of 51% and adding a buffer zone of 2,5 meter would bring the overlap zone to 71% for the total 440 KM². This already expresses the spatial proximity between result and reference. Once a GEOBIA result has an overlap with a reference zone, the missing reference can be assumed not to be randomly distributed within the map but likely to be neighbouring the resulting polygons. This can be confirmed in Figure 6 where yellow reference areas are neighbouring the dark green overlap zones.

For a first assessment, a standard procedure is applied to the detailed subset analysis, with two classes in the 535 ha subset (see Figures 4 and 5). The dataset is split between textured vegetation and homogeneous agricultural area. Table 1 shows the confusion matrix for the GEOBIA subset-result and reference using Tv (textured vegetation) and Ta (agriculture) observed versus classified. The values of the 535ha subset (from Figure 5) result in a 0.40 Kappa value. Producing the off-diagonal values for 535 Ha is feasible by re-evaluating the reference set. In this particular case the non-registered texture vegetation in the WorldView II image does give correctly an extra 17.67 Ha in the result. The reference shows here the omissions, which can be visually confirmed in the WorldView II image. In case the reference set would be adapted to the visual inspection of the satellite image, the 17.67 Ha would be moved to the diagonal and added to the Tv observed/Tv result (7.98 + 17.67) which would lead to a 0.92 Kappa. However this change can be applied to the subset alone but reconstruction of the complete reference set (more than 440KM²) with updated imagery is not considered a part of this study.

## 5. DISCUSSION AND CONCLUSIONS

The assessment is promising but incomplete. For an improved assessment, first an indicator that includes the factor adjacency of the reference set with the result needs to be designed. Further, a re-evaluation of the reference might be required on a selected sub-set and based upon the same WorldView II scene used in the automatic classification. A thorough increment of the Kappa from 0.40 for an updated reference set is likely, based upon the detailed findings in the subset. However conditions for the imagery used in the reference set cannot be retrieved nor can it be concluded if the reference has an omission due to its creation in those older datasets (Orthophoto, pre-2009) where WorldView II image is just recording a new situation. Producing further the off-diagonal values for 440 KM² requires a re-evaluation of the reference polygons being assigned to textured vegetation but actually overlapping smooth agricultural fields as well as missing woody vegetation due to temporal changes and updated imagery.

A defendable position on incorporating the importance of adjacency in the assessment is applying a 2,5 meter buffer around the GEOBIA results. This already increases into a 71% overlap zone with the reference. Overlap is related only to the diagonal of the confusion matrix and supports the statement that the 0.4 Kappa value alone shows an incomplete assessment. For a practical application the established results might be too low for making a decision on incorporating GEOBIA classification directly into a final product. However, for assisting the mapping of landscape features at a national level the 71% overlap is encouraging and the GEOBIA procedure can be assigned a role within the total chain of production.

Creating a 1:10.000 map of landscape features is a visual interpretation task which cannot be replaced by an automatic approach at the moment. The computer aided mapping of landscape features using GEOBIA can reduce the production time and facilitate delineation issues. It is necessary to calculate this time saving factor in a pilot project. This is recommended as the next step.

## 6. ACKNOWLEDGMENT

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# LPIS UPDATE: A WAY TO SIMPLIFY AND IMPROVE THE CONTROL PROCEDURES

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**ABSTRACT**

The complete revision, or, as it is now commonly addressed, the "refresh" of the Land Parcel Identification System (LPIS), has been recently executed in a number of different Member States. In Italy the project has been carried out in the years 2007-2009 on the entire national territory. The results of the project brought to the recovery of all undue payments on claims for the same reference period. In 2010 a new 3-years project for a complete update of the LPIS information based on new aerial imagery has been started. As a result of this methodology, since 2007, geospatial controls have been carried out on 100% of the claims, providing the highest level of safety to EU funds. For this reason, provided the respect of some specific constraints, Italy considers there is scope for a reduction of the annual rate of on-the-spot checks (OTSC) to 1% within a new methodology more efficient and cost effective for Member States, EU services and farmers.

## 1. INTRODUCTION

Since the first definition of the Integrated Administration and Control System (IACS), in 1992, two basic types of control have been required:

1. *administrative controls, based on IT tools and executed in alphanumeric databases on 100% of the annual claims*
2. *geospatial controls – On The Spot Checks (OTSC) – executed by means of remote sensing or GPS tools and limited to smaller percentage, around 5% of claims*.

The limitation of the amount of OTSC was due to technical and economic constraints.

In the last years, the context of application of the controls required by IACS has radically changed. Common Agriculture Policy (CAP) reform of 2003, with the introduction of the Single Payment Scheme (SPS) and the decoupling of payments from production, has brought to remarkable simplification in geospatial control methodologies. In Italy, where more than 95% of claims are paid on decoupled claims, most of the geospatial controls require only a photo-interpretation based on a simple eligibility profile.

Progress in GIS and remote sensing technologies has made possible, and economically feasible, the definition of methodologies for LPIS maintenance on large areas in short time. Most of LPIS are now stored in spatial databases, accessed online via web applications or web services, and managed by means of automatic or assisted CAPI tools which have reduced the burden of manual photo-interpretation activities.

Furthermore the newly introduced quality framework provides an effective assessment methodology to evaluate the accuracy of the LPIS so that a control on 100% of geospatial information can be considered of the same level of confidence of alphanumeric controls.

The purpose of this paper is therefore to promote a discussion for an overall review of the IACS control which should achieve a substantial reduction on the amount of traditional OTSC.

## 2. ITALIAN LPIS SYSTEMATIC REFRESH (2007-2009)

In the years 2007-2009 Italian LPIS has been completely *refreshed.* The specifications and the methodology applied has been the same defined for the photo-interpretation of eligibility on decoupled aids in OTSC.

The entire national territory has been controlled, resulting in a new homogeneous layer where the classification of agricultural land was not limited from cadastral boundaries but based on a "land cover map" approach. Special attention has been paid to the identification of all ineligible areas (woods, artifacts, water surfaces, …). The work has been carried out using digital orthophotos at nominal scale 1:10.000 and working scale between 1:2.000 and 1:3.000. Minimum mapping elements has been defined for any class The new classification has been based on 3 major groups that can be identified as: not agricultural land cover (A), agricultural land cover (B), agricultural land use (C) where data has been derived from previous registry data.

At the end of the technical work, new LPIS data has been used to recover all undue from the respective claims so that, from the point of view of IACS control scheme and the safeguard of EU funds, we can assume that Geospatial controls has been applied on 100% of claims instead of the required 5% controlled by means of OTSC.


**Figure 1.** Extract from refresh project photo-interpretation

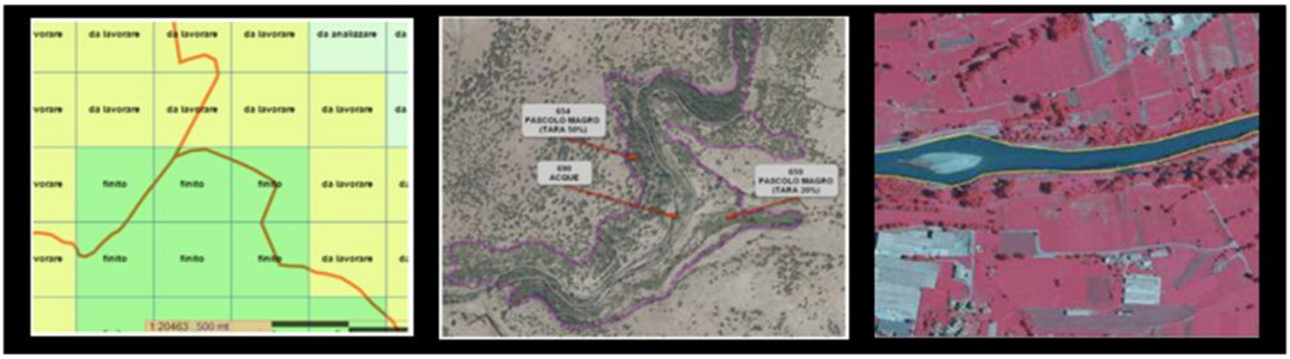


**Figure 2.** Refresh update project: tiled photo-interpretation (left); new specifications for semi-natural habitats (middle); higher classification level for water courses (right).

## 3. LPIS UPDATE CYCLE (2010-2012)

From year 2010 a new 3-years LPIS update cycle has been started on the entire GIS database. The main characteristics of the project are:

- A vector-raster calibration procedure has been defined to avoid "fake" land cover modification deriving only from the differences in the reference data (orthoimagery).
- An higher level of precision for the identification of natural or semi-natural habitats (mixed land cover classes–pro rata eligibility – i.e. pastures)
- New parameters, including lower surface threshold, has been defined for "small not eligible elements".
- Specification has been introduced in order to be compliant to European Commission (EC) Regulation 436/2009 on vineyard classification
- A specific task for the identification of specific landscape elements as terraces, hedges, buffer strips, has been included
- Higher classification level for classes as woods and water has been defined.

LPIS update will cover the entire national territory, and the technical specification will be the same of those applied in OTSC under the controls with remote sensing (CwRS) methodology. As in the previous 3-years cycle, the results will be used to investigate over eventual undue payments. We can therefore assume that 100% of the claims will be controlled each year by means of geospatial information as well as with alphanumeric cross checks.

## 4. COST-BENEFIT ANALYSIS

In order to take a deeper look into the matter, a cost-benefit analysis has been carried out for which the following assumptions have been done:

1. In the period 2004-2006 traditional OTSC were partially executed on the basis of CwRS methodology with a high rate of field survey while since 2007 100% of control has been carried out on the basis of CwRS.

2. LPIS full refresh on the entire national territory for the period 2007-2010 and OTSC rate at 5%.
3. LPIS update on the entire national territory and a proposal of reduction of OTSC rate to 1%.

The interpretation of the results (Figures 3 and 4) shows the growth of the overall costs deriving from the update of the LPIS (in a 3 year cycle) added to the costs of traditional OTSC. Moreover the LPIS update methodology itself can already provide the geospatial control on 100% of uncoupled claims, so traditional OTSC don't really provide any reasonable higher guarantee to EU funds, but are just a duplication of expenses to the MS.

A 1% level of OTSC might instead be enough to check coupled aids (now limited to a small percentage of the total), and as an integration of the LPIS quality framework.

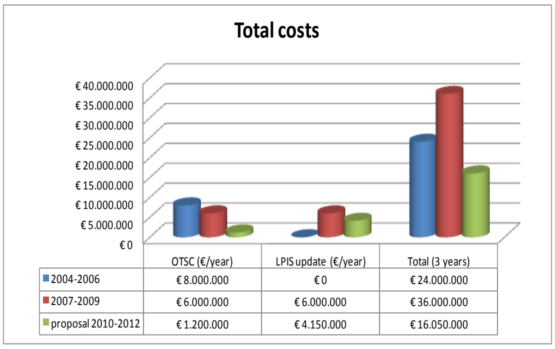


**Figure 3.** General Reduction of cost of controls

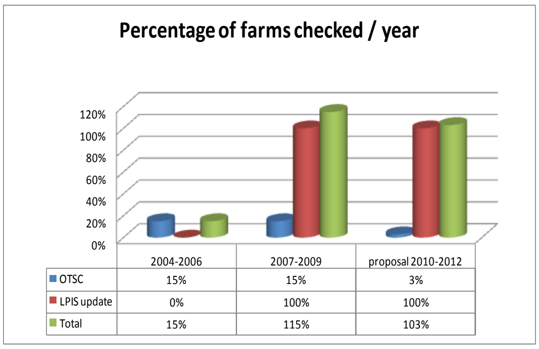


**Figure 4.** Avoid redundancy of controls

So the proposed reduction could provide:

- ✓ Benefit to MS: Significant reduction on the cost of controls - Italian scenario in saving between 10% to 33 % with respect to traditional OTSC – no redundancy of controls
- ✓ Benefit to EU funds: controls applied to 100% of farms in the 3 years period instead of 5% per year

## 5. PROPOSED ACTION

The proposal is therefore, from claim year 2011, to amend article 30 of Commission Regulation No 1122/2009 in order to allow MSs to choose an alternative methodology to perform the controls on geospatial information of IACS and a consequent reduction of OTSC from 5% to 1%.

This option should go under specific defined conditions, as:

- ✓ Limited to the controls on SPS decoupled claims – eligibility checks (maintenance of present percentages on coupled aids and cross compliance)
- ✓ Having in place an operating procedure, compliant to CAPI OTSC requirements, ensuring the effective control of geospatial information for the entire national territory on the basis of an appropriate scheduling
- ✓ Correct execution of LPIS quality measurements according to article 6 of Commission Regulation No 1122/2009 with special regard to the effectiveness of update processes
- ✓ Perform of retroactive recovery of undue payments as requested by present regulations.

The proposed methodology for OTSC SPS controls can be an efficient and cost effective solution either for Member States, for EU institutions and for European citizens, having the effect of improving the quality of farmers' declarations therefore reducing the percentage of anomalies and consequent sanctions.

# USING VERY HIGH RESOLUTION SAR PRODUCTS FOR RISK MAPPING OF NEW GAEC STANDARDS

*Filippo Britti, Roberto Ligi, Livio Rossi, Giulio Monaldi*

SIN-AGEA: Italian Agency for Agriculture Subsidy Payments

**ABSTRACT**

Starting from the already acquired findings about the processing of high resolution SAR satellite in 2009, new tests with encouraging results have been performed within the existing JRC –Italian Agency -AGEA technical collaboration agreement. The research work is focused on Reg. EC 73/2009 GAEC standards requirements, particularly for individuating both winter vegetation coverage on sloping parcels with crops or natural grass and different landscape elements, such as hedge-rows/trees, grouped/isolated trees, ponds, etc. Test and methodology experimentations involving classifications, aimed at a semi-automatic work for detecting possible areas in infringement (e.g. sloping and not vegetated) and extended layers of existing landscape elements, to be overlaid on national land parcel identification system (LPIS) and monitored during control phases. The final goal will be the creation of coherent information layers to be added on national LPIS, supporting the Administration to monitor GAEC issues, locate landscape features, support risk analysis, manage the shift from I to II Pillar, keeping down both costs and working time.

**KEY WORDS:** SAR, VHR satellite, SAR data processing, CAP, Cross-Compliance, landscape features, winter crops, agro-environment, feature extraction, subsidy controls.

## 1. INTRODUCTION: FROM 2007-2008-2009 TEST ACTIVITIES IN COLLABORATION WITH JRC TOWARDS 2010 EXPERIMENTATIONS

The AGEA (Italian Agency for Subsidy Payments), experience on Very High Resolution (VHR) Synthetic Aperture Radar (SAR) started by the end of 2006, through test campaigns in agreement with JRC MARS Unit. Knowledge was gained on X-Band SAR[1], especially for agriculture controls (CwRS), Cross-Compliance (agro-environmental measures) analysis, and, above all, thematic mapping capabilities and geomatic issues, using TELAER airborne system.

In summary, from the technical point of view, the experimentations on TELAER X-Band SAR flights have led to following conclusions:

- On flat areas: thanks to the regular fields' geometry and the relief absence, good accuracy can be obtained both from the geometric and the thematic point of view.
- On flat - hilly areas: some geometrical problems and some detection concerns occur (e.g. the tree crowns can present major extension in canopy) for land cover /eligibility capacity
- On hilly areas: with complex morphology, high gradient slopes/aspects create sometimes severe deformations and problems in features detection especially when using standard DEM which appears not having adequate resolution.

Based on these results, AGEA-SIN made a pre-operational feasibility study for CwRS using Satellite VHR SAR data over several test areas selected inside 2008 annual control samples. COSMO-SkyMed VHR SAR data were tested as:

- Back-up solution when optical data are not available due to partial or total cloud cover
- Possible tool for detection and monitoring of complex agronomic patterns (herbaceous or permanent crops)
- Multi-temporal information source for crops detection (linked to payment associated to specific crops)
- Possible support for Cross-Compliance policy, especially for detection of GAECs (Good Agricultural Environmental Conditions) infringements such as erosion, water stagnation, pastures maintaining, etc.
- Multi-temporal information source in rice areas (North Italy paddies), also aimed at using optical-SAR packages on international agronomic/food scenarios.

As an additional analysis, woodland mapping was investigated, with the purpose of contributing to environmental safeguards, $CO_2$ fluxes monitoring and renewable resources management. Results are given below:

- From the geomatic point of view, the measured geometrical mismatch behaviour was clearly in line with our expectations (see in Figure 1), and through an accurate selection of the acquisition parameters it will be possible to get as an output 3m of RMSE with Spotlight-2 (1m) data without using GCP during the ortho-correction. As Figure 2 shows, encouraging results were obtained for parcels measurement assessment. Good accuracy (especially for flat areas) was calculated. Multitemporal

[1] The TELAER airborne system includes two aircraft equipped by optical, multispectral and hyperspectral sensor and a X-Band SAR. Particularly, the SAR sensor works in the X-Band (the same of the SAR sensor mounted on the COSMO-SkyMed satellites constellation) guaranteeing a ground resolution up to 0.5 m.

analysis enhanced the features recognition but, due to the multi-look (necessary step to compute the interferometric coherence map), the reduction of GSD (Ground Sampling Distance) seems to slightly worsen the accuracy.

- COSMO-SkyMed VHR SAR data interpretation test shows good thematic capabilities, reaching the same outputs of TELAER X-Band Airborne SAR (1m) for both land cover mapping and GAEC infringements on agricultural parcels. Crop maps, obtained using the joined analysis of multitemporal COSMO-SkyMed VHR SAR data series (optical HR data as additional reference), were quite well in agreement with farmers declarations. As expected, an increase of uncertainty was noticed when only crop groups are declared.
- All the agricultural and cultivated parcels and their field boundaries were identified, and, in some cases, depending on the ancillary information, also the belonging crop groups.
- Capabilities of single tree counting (olive, citrus trees … ) were also assessed.
- Good discrimination capabilities between winter and summer crops within the same agricultural pattern were noticed thanks to the clear differences in backscattering measured. Results were positively compared with HR optical data and in situ surveys.
- Concerning permanent crops, COSMO-SkyMed Spotlight-2 data shows good identification capability while, as expected, discrimination of species and variety of permanent crops was impossible due to the absence of spectral signature.
- Soil erosion and creeping, due to the induced soil roughness, are easy to depict by SAR. In the same manner, flat water bodies and water stagnation can be detected due to the low or null backscattering levels of those areas.
- Single VHR SAR images allow to map forestry areas and extract single trees, both isolated and surrounded by scrub (if sufficient big). Clear cuts can also be spotted. For example they appear in clearer colours using the multitemporal false colour composite RGB (ILU or MTC) in Figure 3.

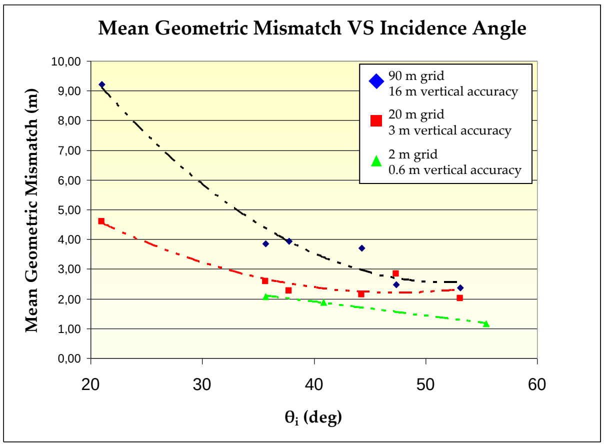


**Figure 1.** Mean geomatic mismatch versus the incidence angle implemented during the data collection for different digital model used during the ortho-correction (without GCP)

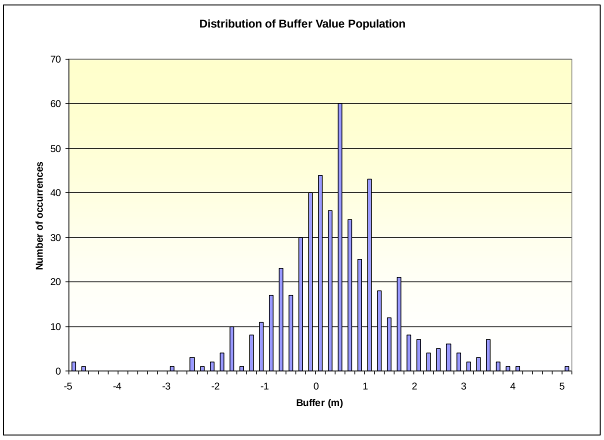


**Figure 2**. Parcels measurement assessment results: distribution of buffer value population

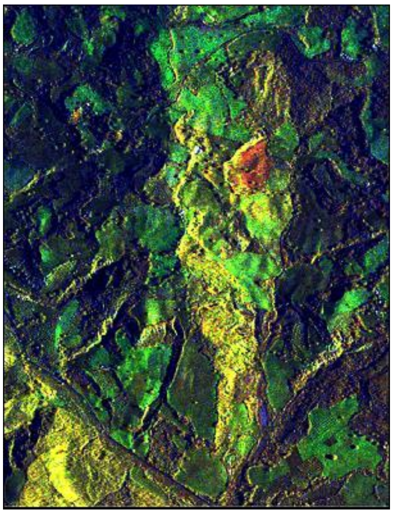

**Figure 3.** COSMO-SkyMed Spotlight-2 MTC image over the Pollino area (08/12/2008-09/03/2009); In red a forest parcel cut

- Very good results are obtained for river beds and alluvial fans monitoring through the analysis of interferometric coherence maps. Clear potentialities in soil or deposit movements were noticed, even concerning useful parameters extraction for Civil Protection.

From the above described results, one can conclude that the joint use of COSMO-SkyMed data with VHR/HR Optical data has strong potential for land monitoring activities, annual or seasonal, and particularly for agricultural and agro-environmental analysis. It also allows the mapping and updating of 'traditional' landscape features (hedge trees, rows, stonewalls, ponds, etc.) enabling to fit the new Cross-Compliance monitoring recommendations. Finally, VHR SAR data appears as the unique back up RS instrument to be used when cloud cover affects optical data.

## 2. 2010 PRE-OPERATIONAL STUDIES FOR CROSS-COMPLIANCE NEW STANDARDS ASSESSMENT

The introduction of new GAEC after the so-called 'CAP Health Check', led to the developments of several experimental activities aiming at the improvement of the agro-environment monitoring and the related controls. Into this scenario, 2010-2012 SIN-AGEA activities, together with the statistical programs of MIPAAF (Italian Ministry of Agriculture, Forestry and Food Policies) and National Rural Network, in agreement with JRC and DG-AGRI, topics having major relevance on soil protection and the related policies were addressed. The aim of this paper is to give a description on the preliminary results obtained during the following studies:

1. Check of the minimal winter coverage over sloping cultivated areas
2. Landscape features geographical extraction and mapping

According to what previously written, the above mentioned analysis is based on the usage of VHR SAR data coming from the Italian constellation of four (now operative) satellites COSMO-SkyMed.

### 2.1. Winter Coverage check

Referring to the Standard 1.2 (soil erosion) of Reg. EC 73/2009 to individuate the winter coverage of sloping arable parcels with crops or natural grass, the study was based on test and experimentations through (semi) automatic classification systems, in support to photo-interpretation of possible parcels in infringement (sloping and not vegetated), via VHR SAR data and derived products.

The final aim is to set-up an operational service able to detect cultivated lands with bare soil during winter period. This would help to locate and trigger rapid field visits only on farms/parcels flagged at risk of infringement. It will thus help the Administration to reduce costs and duration of controls. The selected acquisition mode was COSMO-SkyMed HImage, allowing a high spatial resolution (3-5m), greater area coverage (40 x 40Km up to 40 x 1000/2000 Km) and, above all, a good mosaicking capability.

The core of the developed methodology is based on interferometric coherence. After a preliminary assessment based on single image exploiting (Figure4) in which it was possible to note the high sensitivity of the sensor to surface roughness and moisture, the following analyses were based on the use of short term interferometric series.

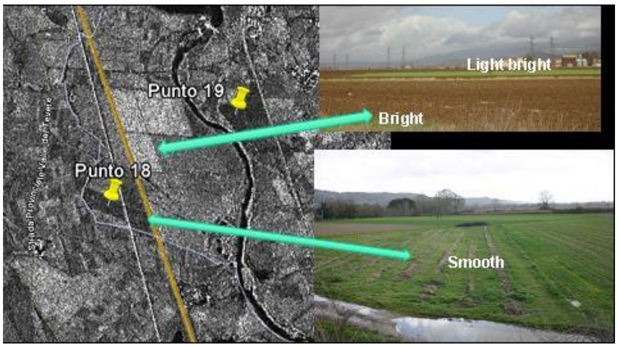


**Figure 4.** Comparison of single COSMO-SkyMed Spotlight-2 data with rapid field visit data collections.

Thanks to the COSMO-SkyMed constellation, the revisiting period of the system is noticeably reduced, giving the user the possibility of generation of short term interferometric couples, up to one day of time-interval. In addition, taking into account X-Band amplitude and phase, through this short time interferometric series it is possible to generate false colour composite RGB images based on the following colour-code:

- RED : Master backscattering map (calibrated SAR detected amplitude image related to the first acquisition)
- GREEN : Slave backscattering map (calibrated SAR detected amplitude image related to the first acquisition)
- BLUE : Interferometric coherence between first and slave)

This added value interferometric multitemporal product, depending on the scenario of acquisition and, above all, the interval time within Master and Slave acquisitions allows:

1. enhanced change detection through the production of specific RGB image called Coherent Change Detection (CCD) Image;
2. thematic mapping through the production of specific RGB image called MultiTemporal with Coherence (MTC) image (Figure 5).

From the acquisition point of view, in the first case a high time interval will be required between the acquisitions. For the second case, in order to "use" the different land cover classes and features behaviour along time as additional information for thematic extraction, short time interval should be selected to avoid the occurrence of changes causing misinterpretation.

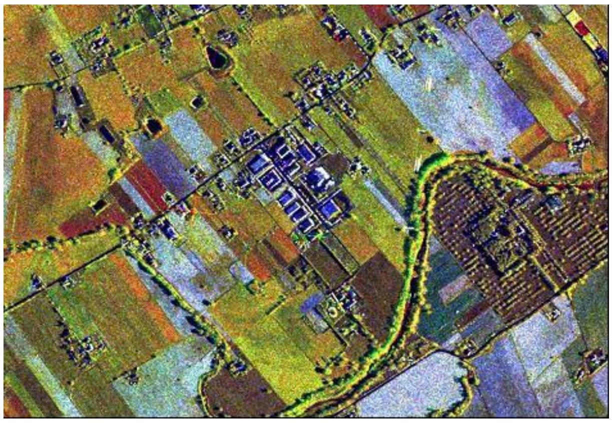

**Figure 5.** COSMO-SkyMed Spotlight-2 MTC over the Macerata area (17/11/2008 - 27/12/2008)

Based on the above assumptions, on MTC images, bare soil or poorly vegetated areas will be characterized by:

- high or low backscattering depending on the surface roughness (thus indicating possible plowing or flattening activities),
- high or low coherence depending on the level of vegetation on the soil (i.e. in X-Band, due to the short wavelength used -3 cm- vegetation cover induces incoherence, even within one day interferometric couples).

**Figure 6.** Test areas and footprints of the images retrieved from winter 2009-2010 archive acquisitions

In order to test this methodology, several images regarding different regions in Italy (see Figure 6) were retrieved from our archive, processed and analysed. In order to make a preliminary validation of results, winter optical images acquisitions were planned and collected.

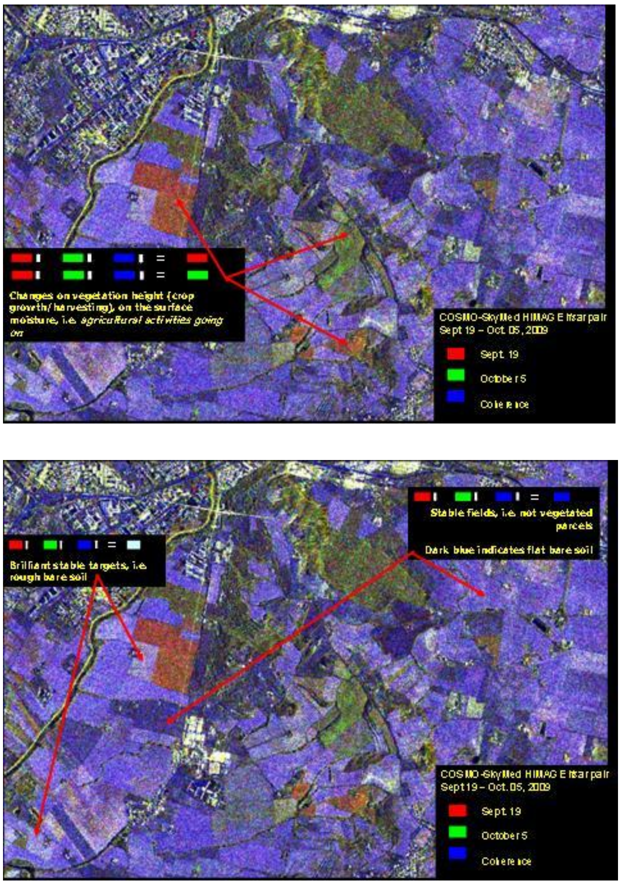


**Figure 7.** COSMO-SkyMed HImage MTC over the Marche Region area (19/09/2009-05/10/2009) produced to check winter coverage.

Once the COSMO-SkyMed HImage MTC was coregistered, suspected unvegetated fields were identified through visual photointerpretation and compared to the one observed on optical GeoEYE-1 image used as reference. Due to the temporal distance within SAR and optical acquisition (due to cloud cover problems) a "doubt" class was introduced during validation to take into account fields that could be unvegetated during SAR acquisition and vegetated during the optical one. As a result (refer to Table 1):

- 350 fields flagged on optical reference
- 307 fields detected through CSK-MTC image:
    - 138 approved
    - 169 doubt
    - 43 missing

**Table 1**. Reference classification matrix used for results quality assessment

| | | COSMO-SkyMed Himage (18 December 2010) | |
|---|---|---|---|
| | | *Coherent* | *Uncoherent* |
| **GeoEYE-1 Groundtruth (07 April 2010)** | *Partially Vegetated* | ***Doubt*** Bare Field | ***Vegetated*** approved |
| | *Vegetated* | ***Wrong*** Bare Field | |
| | *Unvegetated* | ***Approved*** Bare Field | ***Missing*** bare field |

**Figure 8.** Coregistered COSMO-SkyMed HImage MTC (02/12/2009-18/12/2009) and optical ground-truth reference GeoEYE-1 (07/04/2010).

As a conclusion, the coherence layer improves the detection capability of the class of interest and, through the usage of MTC image, no particular photo-interpretation experience is required. Of course the more the ancillary information are available (accurate digital elevation model of the area for precise geocoding and sloping area detection, LPIS parcel boundaries…) the more the reliability of the application is guaranteed.

Future developments:

- Prototypal product chain test over bigger area (a full province) using rapid field visit and, hopefully, coeval VHR optical data for quality check.
- Definition of a semi-automatic procedure for coherent (i.e. bare soil or poorly covered by vegetation) fields detection.

### 2.2. Landscape Features detection

Reg. EC 73/2009 also requires agro-environmental landscape elements identification (such as hedge-rows, hedge-trees, grouped or isolated trees, ponds, etc…) and can possibly lead to their digitalization. Landscape elements maintenance aims at biodiversity enhancement, soil conservation and flora/fauna protection. A test campaign was set up to validate different methodologies developed for semi-automatic classification of such features from VHR SAR data.

In this case, the aim is to support the future creation of coherent information layer to be added in the Italian LPIS-refresh, helping the Administration to locate elements, improve risk analysis and improve the management of Pillars I and II, keeping down costs and working time. Here again, the COSMO-SkyMed HImage mode was selected to optimize at the same time ground resolution, area coverage and mosaicking capabilities.

Two different types of landscape features were selected for the preliminary assessment:

- Fields separators (hedge-rows, hedge-trees)
- Lakes, water reservoir and ponds

*Fields Separators* – as it is possible to see in Figure 9, these features are clearly depicted on SAR images, since they are:

- aligned with a well-defined texture with respect to the surrounding

- 'brilliant' (high canopy volume reflection)
- surrounded by dark SAR shadows (increased by the selected acquisition geometry)

Starting from these facts, an automatic algorithm for brilliant aligned features surrounded by shadows was developed. The core of the proposed methodology is based on image filtering for brilliant and dark features enhancement and a subsequent step of image filtering based on the "Hough" transform for linear features detection and vectorization. Four different steps may be followed (see Figure 9):

- Image filtering
  - Gamma-Gaussian filtering for speckle noise reduction
  - Enhancement of bright and dark features
- Bright features extraction
- False alarm and shadowless features removal
- Data vectorization

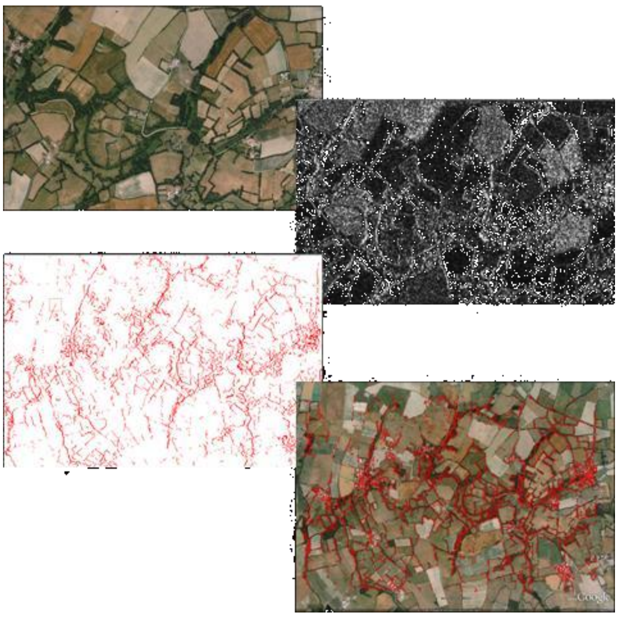

**Figure 9.** Test on Vendée area (France): field separators extraction through automatic procedure based on COSMO-SkyMed HImage single data. Optical reference (Google Earth database), CSK-HImage data (14/08/2010); field separators layer is automatically extracted, and superimposed on the optical reference.

As observed in Figure 9, the preliminary feasibility study shows encouraging capabilities in elements extraction. Future developments will be based on:

- algorithm optimization
- test over areas characterized by complex morphology
- test with higher level products, like MTC

*Lake, water reservoir and ponds* – as in the case of landscape features, the first step was to identify how the feature of interest appears on the SAR image. As it is possible to see in Fig. 10, inland water bodies are characterized by:

- Low backscattering value and variance (due to the extremely flat surface and improved by the acquisition geometry implemented)
- Typical form-factor

Starting from these assumptions, two extraction procedures were developed and tested:

1. Fully automatic procedure

- Image over segmentation
- Target classification through
  - Minimum area size
  - Shape factor
  - Backscattering variance and values range

2. Semi-Automatic procedure

- Image over segmentation
- Algorithm training based on
  - Water reservoir samples selection
  - False alarm samples selection
- Target classification through backscattering variance and values range

An additional common step based on shadows false alarm removal was used for both procedures.

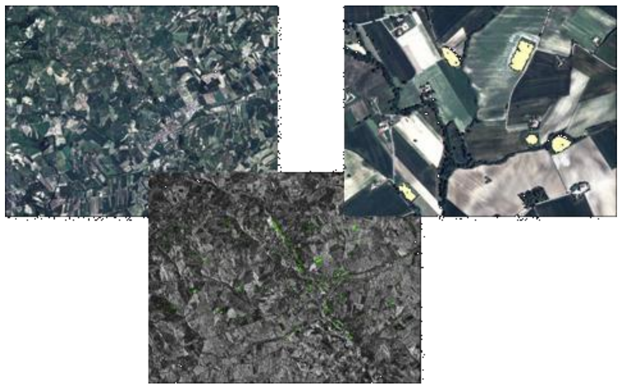

**Figure 10.** Test over Macerata area: semi-automatic lake and water reservoirs extraction through COSMO-SkyMed HImage single data. Optical reference (2010 AGEA OrthoPhoto), CSK-HImage data (30/12/2009), superimposition of the extracted layer of lakes and water reservoirs and optical reference.

**Table 2.** Assessment of automatic and semi automatic procedures for water reservoir and lakes.

| Procedure | Time for procedure execution | Additional step manual effort | Extraction performances | Missing features | Additional notes |
|---|---|---|---|---|---|
| automatic | 30' | | 71% (27/38) | Water reservoir and | all the reservoir bigger than |
| Semi-automatic | 15' | 1h 30' | 76% (29/38) | lakes smaller than | 350 SqM were correctly |

As shown in Table 2, preliminary results show good capabilities of semi-automatic inland water reservoir extraction (this procedure guarantees better performances and less manual editing during the last additional step). Of course automatic procedure can be noticeably improved by ad-hoc developments. Future activities will be on:

- Fully automatic algorithm development and optimization in order to reduce false alarm and improve lakes detection
- Performances improvement by better acquisition geometry selection (pre-defined angles)
- Usage of Coherent Multitemporal Image (MTC) in order to enhance feature extraction
- Shadows effect removal by radargrammetric acquisition couples

## 3. CONCLUSIONS

SIN-AGEA tests, with the fundamental collaboration of Agriculture Minister and National Rural Network, are directly addressed to the identification of the best methods and the relative benefits and cost for managing the entire agri-environment territory, offering:

- Suitable tools for a complete and continuous land monitoring
- Useful risk analysis for GAEC sampling definition and extraction
- Better targeted area aids controls

This paper shows recent developments concerning the new GAEC standards controls through different remotely sensed data. Going deeper, keeping and following the analysis carried on since 2007, pre-operational feasibility study based on the usage of COSMO-SkyMed VHR SAR data were carried on.

In synthesis:

- COSMO-SkyMed 4 satellites constellation, thanks to its guaranteed product delivery at high coverage and high resolution, represents a suitable tool also for operational activities in agro-environment monitoring.
- Coherent multitemporal analysis shows encouraging capabilities for bare soil (or poorly covered by vegetation) detection, allowing an easy procedure for winter cover checks.
- Good capabilities in landscape features extraction were also obtained. Of course, the use of SAR coherence information can noticeably increase the performances of the system (but with the overall cost of the chain)

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# UNCERTAINTY OF LPIS DATA OR HOW TO INTERPRET ETS RESULTS

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## ABSTRACT

During the last few months there was a lot of activity focused towards assessing the quality of LPIS data. However, do we actually know which quality we are measuring? When we get good or bad results, are we aware what is the reason for those? Is it a non-accurate control layer? Or is it the interpretation? Thresholds? We will try to analyse all steps of the LPIS data production – starting with the aerial photography acquiring, processing, digitization and field measurement. For each of these, error margin will be estimated. In that way we should be able to calculate a technical/random error margin of a specific LPIS polygon. By comparing this value to the ETS results the systematic effects should remain. These are the errors the administration can reduce by improving their processes; the technical errors are pre-defined by a selection of e.g. reference parcel or a reference layer. With the result of this exercise we will, hopefully, be able to get a general idea about what the ETS results tell about the LPIS quality. We will also describe some ideas about improving it.

**KEY WORDS:** LPIS, Area uncertainty, ETS, data quality

## 1. INTRODUCTION

In the past year the LPIS community was trying to assess the state of quality of LPIS data by performing Executable Test Suite (ETS) [3]. We believe that this is very good idea in general as it is most important to be aware of the data quality. By understanding the quality, one is able to proceed with steps to improve the system, which not only results in better quality but also improves efficiency and reduces problems.

However, in order to understand the quality of the LPIS data we have to analyze all the processes which influence it, starting with gathering the base data (aerial photography, digital elevation model…), digitization, interpretation etc. Only proper analysis of these processes will allow us to understand the theoretical limits of the data quality. Then we will be able to line up some useful decisions.

Mr. Brian Klinkenberg from the Department of Geography at the University of British Columbia states in one of his lectures: “Often little is known of the input data quality, and far too much is assumed about the output quality.” We decided to try to assess the quality of input data, which should result in understanding the output quality. We focused on those parameters, which influence the accuracy of LPIS area, as the area is the basis for most of agriculture-related EU payments. The side result of this exercise is a comparison between theoretical estimates of achievable data quality and the demands from ETS testing and other legislation.

## 2. THEORETICAL BACKGROUND

During preparation of this article we have spent several months working on theoretical background, mostly analysing different statistical models and preparing theoretical simulations about area uncertainty. However, we focused here on the results of the analysis more than on the theory itself. For those who are interested in mathematical models on this topic, we have prepared quite extensive supplementary material [1], available at Sinergise’s website for download, and also includes the results of our test cases, simulations and some other topics.

## 3. AERIAL PHOTOGRAPHY

LPIS acquisition usually begins with aerial photography (combined with digital elevation model). This is the basic dataset and there are some legislation-based rules, which should ensure proper administrative control of the gathered data. The two most important ones are: the rule from 1782/03 that the level of details should be at least 1:10.000 and the MARS Wiki advice that the dataset should not be older than 5 years. Member states usually also define the absolute position error specification-RMSE 1m. However, none of these specifications ensures the area accuracy. To assess the current estimate of the area-related error of the orthophoto, we often came to an answer that “the relative position error is important for the area, not absolute and that relative position error is 0 due to correlation of data on the parcel-level”. We were not really satisfied with this answer. It might be true that the relative position error is very small but it cannot be 0. To better understand the errors of aerial photography (and satellite images) we have to understand the process of data acquisition.

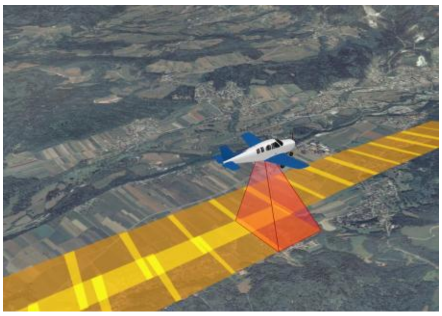

**Figure 1.** Aerial image acquisition

The aerial imagery is usually taken by airplane flying at low altitudes, taking several images in a row (Figure 1). These images are later post-processed, ortho-rectified and overlaid on top of a digital elevation model of the area. The procedure is complex and even though there are several processes in place to ensure the quality of the data, it is not possible to avoid the errors completely, even those which affect the area accuracy:

- errors in digital elevation model,
- image transformation errors,
- deformation of optical lenses, and
- other human-performed errors.

It is correct that most of these errors are correlated on the small-scale but we were not able to get any exact information about this correlation. Therefore we tried to analyse the data which are collected during assessment of absolute position error. Figure 2 shows the vectors of absolute position errors on two neighbouring sheets of aerial imagery. The scale is larger than parcel-level (the nearest two measurement points were 300 m apart) but one still notices that the correlation is not that obvious.

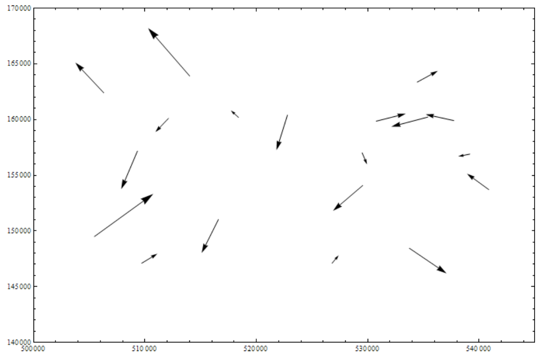


**Figure 2.** Absolute position error vectors after ortorectification

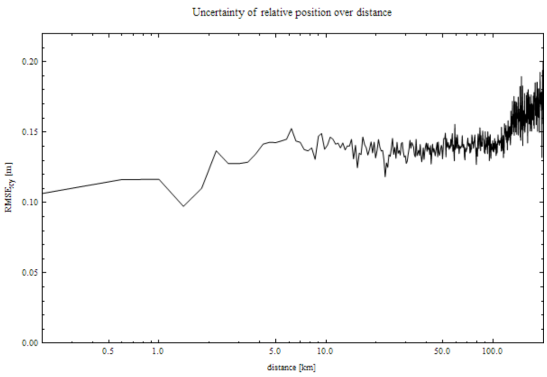


**Figure 3.** Difference between error vector pairs in correlation with their distance

To analyse the correlation we show a difference of all error vector pairs in Figure 3. There is one thing not clear from this chart – that the correlation is strongly dependent on the distance between two error vectors. Therefore we cannot simply dismiss relative position error on the parcel-level (e.g. distance of 100 m). As mentioned, we were not able to find any proper research about relative position error but we came with some estimation:

- the relative position error is probably in the range of one pixel size (e.g. 0.25 – 0.5 meters with recent orthophotos),
- the error is strongly related to the terrain structure – it will be much bigger in the hilly areas, where the terrain is very dynamic, than on the flat areas,
- the error is especially significant at the borders of flat and steep areas, where the steepness of the terrain changes,
- the effect on area is highest with very long narrow parcels,
- the angle of the photography.

How does relative position error affect the polygon area? It is easiest to show this by assuming that every point (e.g. vertex) of the polygon can be shifted away by some random amount in random direction. Therefore a perfect rectangle (black) can be in reality significantly different (red, pink, blue in Figure 4):

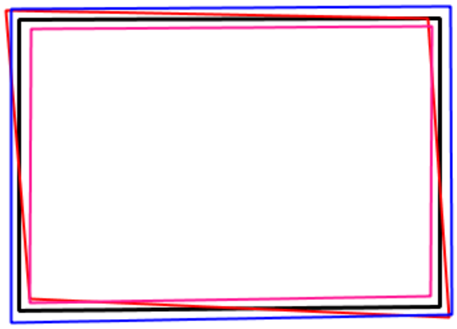

**Figure 4.** Different representations of a black rectangle due to relative position error

To estimate the area uncertainty as a result of relative position error we have simulated thousands of possibilities of such random small movements of rectangle border points for three representative shapes – a square (the most perfect rectangle), long polygon (ratio between width and height 1:10) and very long polygon (ratio 1:30). Such long polygons are quite common in some member states such as Slovenia.

We notice that the relative area uncertainty, shown in Figures 5 and 6, is very significant for small and long polygons. Note that the area uncertainty will be larger when using satellite images instead of aerial photography due to their lower resolution.

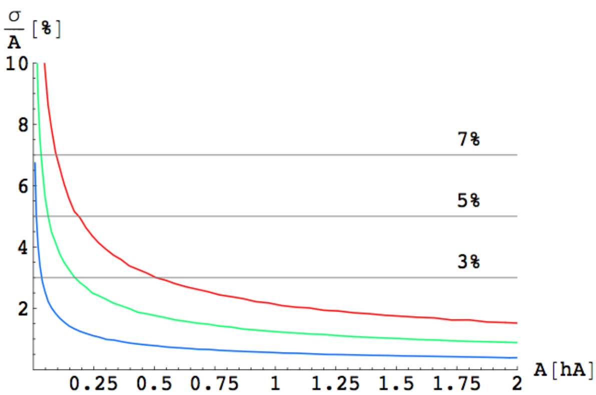


**Figure 5.** Relative area uncertainty due to relative position error (0.2 m) for three shapes - square (blue), long rectangle (green), very long rectangle (red)

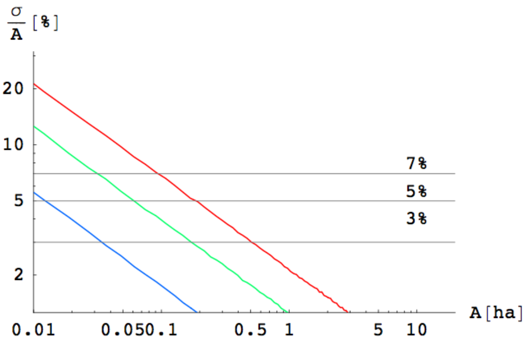


**Figure 6.** Relative area uncertainty due to relative position error (logarithmic scales)

## 4. DIGITIZATION

LPIS related procedures recommend digitization of the polygons between scales 1:1.000 and 1:2.000 (also dependent on the aerial images resolution). However, Figures 7 and 8 show that this might not be accurate on some occasions.

**Figure 7.** LPIS parcel in the scale 1:1500

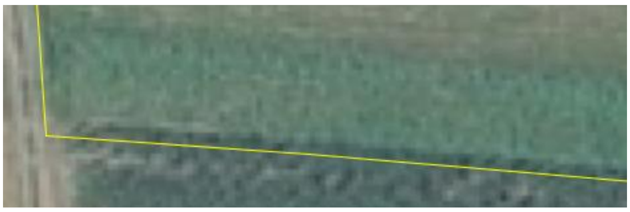

**Figure 8.** LPIS parcel in scale 1:350

We notice that the parcel is not digitized accurately but this is not clear when observing at the scale of 1:1.500. From this example we can assume that digitization cannot be perfect following up-to-date guidelines. To analyse this effect we did a simple test. We generated a set of polygons and asked several users to draw their borders on two scales (1:1.000 and 1:2.000). Afterwards we have joined all results in one image, shown in Figure 9.

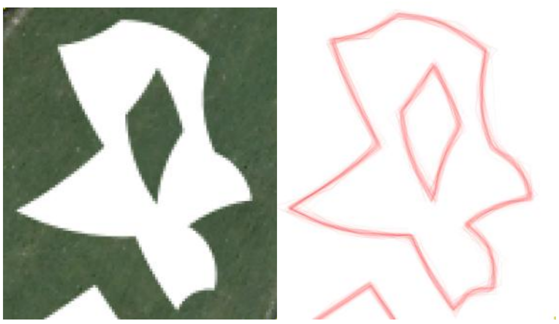

**Figure 9.** An example polygon and its digitization result.

It is clear that the border is not exact even though the polygon is a white shape on the greenish background so the borders are as clear as possible. What happens is that the users are not able to digitize accurately due to several reasons:

- the mouse pointer moves a bit while pushing the button,
- the screen resolution makes it difficult to exactly define even the "clear" borders (that was even more obvious when the shape was red which was perceived by some users as "radiating" and thus larger),
- people's sight is not able to see that accurately,
- some users are simply more precise than others.

From our experiment the digitized border was approximately 1 meter wide (non-accurate). In China there was a much larger experiment performed where the users were asked to digitize sharp angles [7]. Their results showed a RMSE of 1.58 pixels. Depending on the scale of digitization this can range between 0.45 (1:1.000) to 0.9 meters (1:2.000).

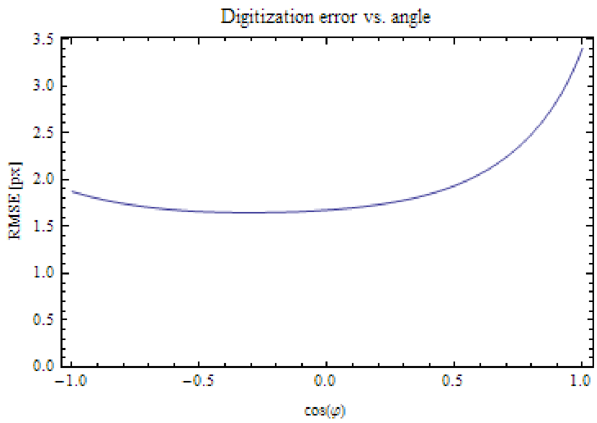


**Figure 30.** Digitization error in pixel positions depending of the angle which was digitized.

Using the result of this exercise we have repeated simulation of the area uncertainty of different shapes and sizes of polygon. We have treated digitization error as random/non-correlated – this means that the users would in some occasions click left of the border and on other occasions right of the border.

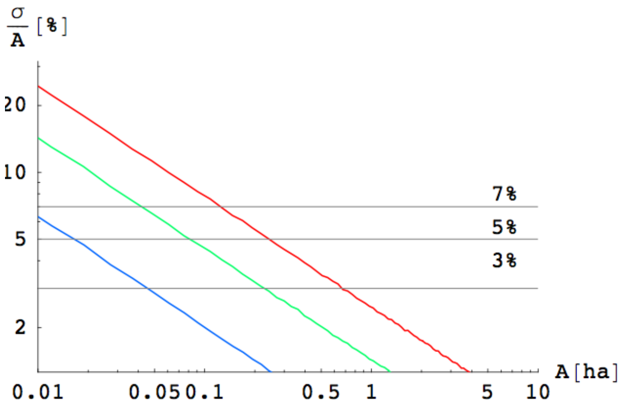


**Figure 11.** Relative area uncertainty based on combined error - 0.2 m for aerial imagery and 0.4 m for digitization

Comparing the chart in Figure 11 to the previous one in Figure 5, we notice that the uncertainty lines are shifting right, which means that the error is growing for all shapes of polygons.

## 5. INTERPRETATION

The third set of errors users are doing is due to uncertain interpretation of polygon borders. Note that there are two types of interpretation errors – wrongly understanding the rules, methodology or image and thus wrongly attributing, for example, an illegible land as legible. The other type is wrong interpretation due to unclear borders. This can happen due to non-sharp image, patch of trees on the border, steep areas, etc. We will be focusing only on the latter as it is not easy to solve it by education and training.

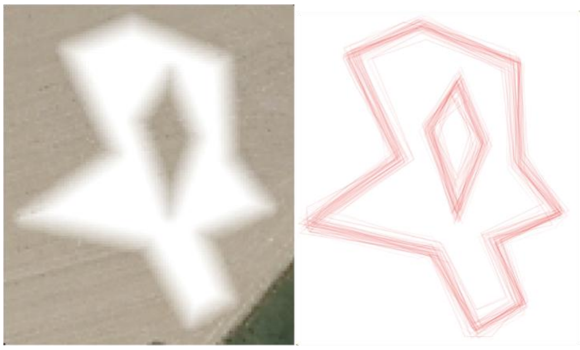

**Figure 12.** Digitization of a polygon with blurry border

We notice two things. The joined border is much wider than the one in Figure 9 (4 m compared to 1m). What is even more important is that the interpretation error is correlated. The users were, based on their character, digitizing only the "inner" perceived border or the "outer" one or somewhere in between. This correlated mistake significantly increases the area uncertainty. We notice that the uncertainty is larger than 3% even for 1 ha large square parcels and 17 ha for very long parcels (Figure 13).

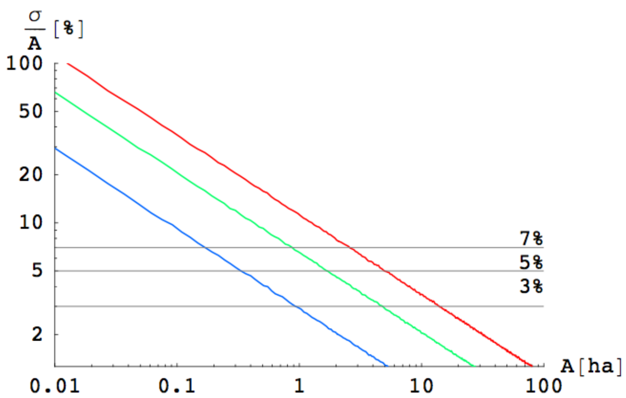


**Figure 13.** Area uncertainty of the combined error - random aerial imagery and digitization ones (0.2 and 0.4 m) and correlated interpretation error (1m)

## 6. PERFORMING ETS (OR CWRS)

The ETS procedure requires blind digitization of a set of polygons and comparison of their areas to those from LPIS. The procedure is very similar to the procedures performed during Control with Remote Sensing (CwRS). However, when performing this task, the users are producing the same set of errors as described earlier. They cannot avoid them. Actually, by using the satellite imagery with lower resolution the errors are even bigger.

When they are comparing the area from initial digitization to those from ETS they are comparing two erroneous results, in worst case scenario one result is smaller than the "proper" area and the other is bigger, thus making the difference of these two measurements even more significant. We performed a simulation of such cases and derived the uncertainty of the difference of two results. We have taken into account the same parameters as before for first measurement (0.2 m for aerial, 0.4 m for digitization and 1 m RMSE for interpretation) and a "best case" for the second measurement (0.4 for imagery as we would use satellite imagery with lower resolution, 0.4 for digitization, same as before, and 0 for interpretation, as these users would be perfect interpreters).

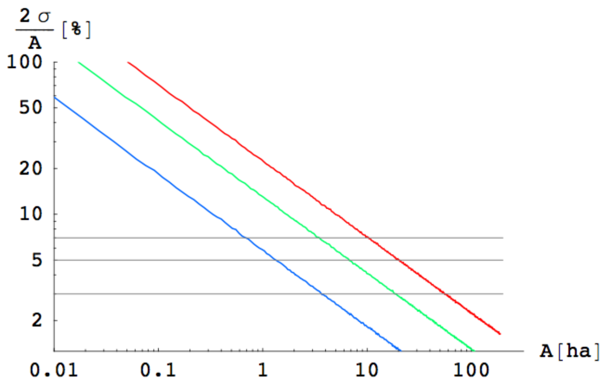


**Figure 14.** 95% confidence interval of difference uncertainty of two area measurements, similar to performing ETS

Note that we have charted the "95% confidence interval" at this point (Figure 14), contrary to RMSE (root mean square error) in earlier charts. This is to have results comparable to those from ETS methodology where only 5% of measurements are allowed to be outside of the thresholds. In order to have a better overview of the numbers, let us put some cases in the table (more examples are available in supplementary material [1]).

**Table 1.** Area uncertainty examples

| | | Area uncertainty (%) | | | diff (%) |
|---|---|---|---|---|---|
| **ha** | **shape** | **DOP** | **DOP+ DIG** | **DOP+DIG +INT** | **ETS** |
| **2** | **Square** | 0.4 | 0.9 | 3.9 | 4.0 |
| | **Middle** | 0.9 | 2.0 | 8.9 | 9.1 |
| | **Long** | 1.5 | 3.4 | 15 | 16 |
| **0.5** | **Square** | 0.8 | 1.7 | 8.0 | 8.1 |
| | **Middle** | 1.8 | 3.9 | 18 | 18 |
| | **Long** | 3.0 | 6.7 | 31 | 31 |

The uncertainty of measurement is pretty significant, especially compared to allowed thresholds for ETS testing (3% for parcels larger than 1 ha, 5% for those between 0.2 and 1 ha and 7% for those bellow 0.2 ha). We have to ask ourselves how relevant the overall ETS results are if the measurement itself produces much larger errors than they are allowed. Note that these uncertainties are related only to small "technical" errors and are not related to the "real" errors, such as cheating, methodological problems of LPIS maintenance process in some member states, out-dated data, etc. – the errors which the ETS should really focus on.

## 7. POLYGON AREA UNCERTAINTY

All of the above mentioned results were calculated using simulations with large number of cases and trying to identify some specifics (using Monte-Carlo method). However, we can calculate exact area uncertainty of any polygon (not only rectangles) using the following equations:

- area error produced by independent point position error, calculated as

$$\sigma_A{}^2 = \frac{\sigma^2}{4}\sum_{i=1}^{N}(y_{i+1} - y_{i-1})^2 + (x_{i+1} - x_{i-1})^2 + 2\,\sigma^2. \tag{1}$$

- area error produced by correlated offset from the true boundary, calculated using

$$\sigma_A = \sigma_s\sqrt{l^2 + 3\,(N_{\text{out}} - N_{\text{in}})^2\,\pi^2\,\sigma_s{}^2} \tag{2}$$

Using these two equations we have built a tool TopoCheck [2], which allowed us to compare the theoretical area uncertainty, based on the shape of the polygon and initial parameters (relative position error, etc.) with the results of ETS testing.

## 8. LESSONS LEARNED

*a) Spatial imagery error:* We are using spatial imagery (aerial and satellite) for many years already as a basis to measure the area of agriculture parcels. However, we do not have good information about the relative position error – the aspect of image data accuracy that affects area measurement. We should put more focus into analysing the quality of these data.

*b) Shape of the polygon:* We are aware that small parcels (smaller than 1 ha) are problematic from the point of area uncertainty. However, we should include additional attribute of the parcel – how long they are. The calculations show that very long parcels are problematic even though they have large area. Note that we should not focus only on rectangle-like parcels when determining their length. There are other shapes, which have a high perimeter/area ratio, mostly due to exclusions, such as the one in Figure 15.

**Figure 15.** An example of a large (1 ha) parcel, which looks normal but is quite long based on perimeter area/ratio

*c) Digitization guidelines:* In our tests we have digitized polygons on two scales – 1:1.000 and 1:2.000 and the area accuracy has been significantly better on the scale of 1:1.000. Therefore we recommend digitizing at larger scales (1:1.000 - 1:750). Another thing we have noticed is that the results are much better when there were a lot of points taken for a specific polygon. This might be counter-intuitive as the line looks nicer (more straight) if there are only two points taken for it. However, due to digitization errors, the area accuracy is much worse. We recommend recording a polygon point every 3-5 meters even for straight lines. It might be useful to use image recognition tools to correct small digitization mistakes (e.g. "snapping" the line to raster imagery line).

*d) Area uncertainty awareness:* All the stakeholders of IACS system should be aware of the area uncertainty, which comes from small technical errors. It might be useful to use precision-based styling to represent the uncertainty of each point or line (Figure 16).

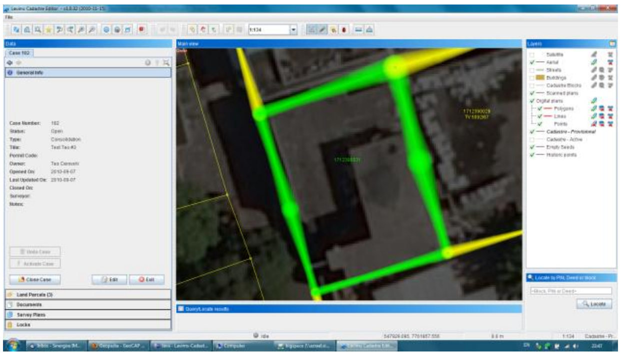

**Figure 16.** Precision based styling

*e) Hard thresholds are problematic:* IACS regulations are full of different thresholds – tolerances, penalty limits, ETS limits. Additionally, many of these eligibility tests are made on the level of individual parcel. However, we learned that the uncertainty itself could be bigger than the allowable thresholds in many cases, which causes many problems to the administration and farmers and brings additional work.

To demonstrate this problem we have calculated area uncertainty using TopoCheck [2] on all LPIS parcels in Slovenia (Figure 17). 19.7 % of all parcels had the area uncertainty larger than allowed by ETS limits (3/5/7 %, depending on the area size). This fact might look dramatic. However, when calculating the total area uncertainty of all parcels (not just mentioned 19.7%) it would affect only 0.002% of total area – a number which is not significant on IACS scale. The reason for this lies in the fact that Slovenia has a lot of small and long parcels and thus a large number of relatively significant over- and under-declared areas. But it is only significant when comparing individual parcels. When comparing the effect on the whole, the number is irrelevant.

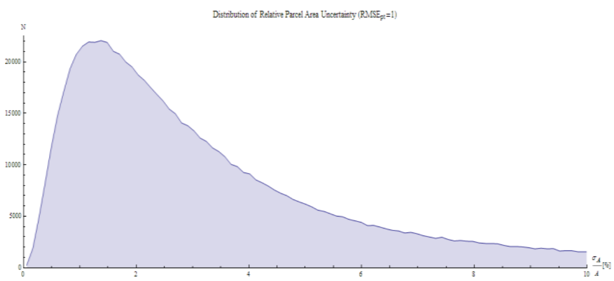


**Figure 17.** A number of parcels (Y axis) with specific relative area uncertainty (X axis)

## 9. CONCLUSIONS

All of the above discussed simulations and models are only theoretical models, based on assumptions which are not exact. Therefore the results should be treated with caution. However, these theoretical models show some problems, which can be observed also in practice. While performing ETS testing several member states have found many problematic cases, which are "faults" by ETS standards but cannot be attributed to any systematic error (e.g. old imagery, non-educated users, cheating) – they might fall in the category of technical errors which are related to what we have been researching.

Another important point we have noticed is that by performing ETS we are multiplying the initial technical error by 1.4 (or even more in the case of lower resolution imagery). It might be wise to reconsider the ETS techniques and allowed limits to compensate this error. One might also reconsider observing absolute errors instead of relative errors, since absolute errors can be directly compared to a value of wrongfully distributed funds. Then we should be able to decide about the further course of actions. For example, if errors are larger than 3% but they only account to several hundred EUR it is not practical to spend several thousand EUR to perform on-the-spot checks.

The legislation should be focused on improving the general accuracy of the system – member states should be motivated to have as detailed imagery as possible and most up-to-date data. However, at the current state, by being accurate, one also finds lots of small (and probably non-important) errors. This fact should not cause problems to the member states. It should not point them in the directions of using non-detailed data solely to be able to use larger tolerances and thus not find these small errors. It should do the opposite – congratulate the effort and reduce the amount of controls required.

## 10. REFERENCES

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# AGENDA

## 16th GeoCAP Annual Conference: Geomatics in support of the CAP
## Centro Congressi Giovanni XXIII, Bergamo, Lombardy, Italy, 24-26 November 2010

### Day 1 (24 November 2010)

| | |
|---|---|
| 11.00-13.00 | Registration |
| 13.00-14.00 | Buffet Lunch offered by |
| **Plenary 1**<br>**SALA OGGIONI (with translation EN/FR/DE/IT)**<br>**(chair: Jean-Jacques JAFFRELOT, DG AGRI/ Co-chair: Philippe LOUDJANI, JRC)** | |
| 14.00-14.15 | Opening Session - Conference Program (Philippe LOUDJANI, JRC) |
| 14.15-14.30 | **PA-1**: Welcome speech by the Dr Massimo BANDERA, Assessor for environment and ecology of Bergamo's Municipality |
| 14.30-15.00 | **PA-**2: Direct payments and landscape features (Ansa Norman-PALMER, DG AGRI) |
| 15.0-15.30 | **PA-3**: The GAEC standards relevant for eligibility of land to direct payments (Aymeric BERLING, DG AGRI) |
| 15.30-16.00 | Coffee Break offered by |
| 16.00-16.25 | **PA-4**: Review of Image Acquisition campaign 2010 (Eugenio GERVASINI, JRC), |
| 16.25-16.55 | **PA-5**: Overview Campaign 2010 – outline 2011 (Hervé KERDILES, JRC) |
| 16.55-17.15 | **PA-6**: Future of the CAP (Jean-Jacques. JAFFRELOT, DG AGRI ) |
| 16.00-18.15 | Bilateral Meetings CID -Image providers<br>SALA STAMPA |
| 19.15 - *** | Welcome Cocktail offered by |

## Day 2 (25 November 2010)

| | | |
|---|---|---|
| | **Parallel session 1**<br>**SALA OGGIONI (transl. EN/FR/DE/IT)**<br>**LPIS Quality Assurance and geodatabases features**<br>**Chair: Henrik FRISS**<br>**Co-chair: Wim DEVOS, JRC** | **Parallel session 2**<br>**SALA ALABASTRO**<br>**New Sensors, new software, and their use within the CAP**<br>**Chair: Rob Postma, SpotImage**<br>**Co-chair: Pär Johan ÅSTRAND, JRC** |
| 09.00-10.00 | **P1-1**: Findings of the 2010 LPIS workshop in Copenhagen and resulting modifications to the ETS methodology (Wim DEVOS and Pavel MILENOV, JRC) | **P2-1**: EROS C – an introduction to the new sensor of ImageSat (Rani HELLERMAN, ImageSat) |
| | **P1-2+3:** ETS-results from 4 different LPIS-systems, Marcel MEIJER (Dutch Ministry of Agriculture, Nature and Food Quality LNV) | **P2-2**: SPOT - Assured Mission Continuity (Charlotte GABRIEL-ROBEZ, SpotImage) |
| | Cont'd | **P2-3**: New Generation of Leica Airborne Imaging & LiDAR Sensors - Features & Benefits for Airborne Monitoring (Arthur ROHRBACH, Leica Geosystems AG) |
| 10.30-11.00 | Coffee break offered by ABACO | |
| 11.00-11.30 | **P1-4**: Preliminary results from the 2010 quality assessment of cadastre based LPIS in Spain and Poland - Résultats préliminaires de l'évaluation de la qualité du registre parcellaire basé sur le cadastre en Espagne et Pologne. (Robert POŚNIK, Rafal ZAWADZKI, ARMiR and Isabel ENCINAS, FEGA) | **P2-4**: RapidEye Background Mission Europe and applications for controlling stubble burning (Clemens STROMEYER, RapidEye) |
| 11.30-12.00 | **P1-5**: Parameters influencing the area accuracy measurement (Grega MILCINSKI, Sinergise) | **P2-5**: Update on the DMC Constellation and New Satellites for 2011 (Gary HOLMES, DMC International Imaging Ltd) |
| 12.00-12.30 | **P1-6**: LPIS update: a way to simplify and improve the control procedures. (Maurizio PIOMPONI, AGEA) | **P2-6**:<br>-Vineyard grubbing up by VHR Wordview2, test on 2 Italian zones<br>-Wordview2 geometrical performance and issues in orthocorrection: comparison between operational/commercial SW<br>(Alessandro FLAMINI, Sandrina PAOLINI, Livio ROSSI, AGEA-SIN) |

| | | |
|---|---|---|
| 12.30-14.00 | Buffet Lunch offered by SPOT IMAGE | |
| | Parallel session 3<br><br>SALA ALABASTRO<br><br>**GAEC: control methods and implementing measures**<br><br>Chair: Antonio FRATTARELLI, MoA Italy<br>Co-chair: Vincenzo ANGILERI, JRC | Parallel session 4<br><br>SALA OGGIONI (transl. EN/FR/DE/IT)<br><br>**New Sensors, new software, and their use within the CAP**<br><br>Chair: Robert STEIN, Eftas<br>Co-chair: Eugenio GERVASINI, JRC |
| 14.00-14.30 | **P3-1**: Main outcomes of the Rome 2010 GAEC workshop (Vincenzo ANGILERI, JRC) | **P4-1**: WorldView-2: Bringing a new satellite online for the CwRS 2010 (George ELLIS, European Space Imaging, EUSI) |
| 14.30-15.00 | **P3-2**: New GAEC Vegetation Buffer on water courses: possible methods of detection by RS products and existing data (Livio ROSSI, Paolo TOSI, Daniele BISCONTINI, Giulio MONALDI, Maurizio PIOMPONI, AGEA-SIN) | **P4-2**: Evaluating the WorldView-2, GeoEye-1, DMCII, THEOS and KOMPSAT-2 Imagery for use in the Common Agricultural Policy Control with Remote Sensing Programme (Joanna NOWAK DA COSTA, JRC) |
| 15.00-15.30 | P3-3: Semi-Automatic Mapping of Landscape Features within the framework of GAEC. A selected case study from the Czech Republic, (Roeland DE KOK, JRC) | **P4-3**: New spectral data available for the operational controls in agriculture (CwRS) and for detailed vegetation monitoring. A French experience on the potential benefits in using WorldView-2 new bands (Guido PERONI, SIRS) |
| 15.30-16.00 | Coffee break offered by SINERGISE | |
| 16.00-16.30 | **P3-4**: Expanding high resolution SAR products for risk mapping of new GAEC standards (Filippo BRITTI, Livio ROSSI, Roberto LIGI, Giulio MONALDI, AGEA-SIN) | **P4-4**: Results of test on the control of grubbed vineyard parcels over the CwRS zones ZICO and ZORA in France (Pascale DEMET, AgriMer) |
| 16.30-17.00 | **P3-5**: Control of GAEC standards regarding unwanted vegetation , abandoned lands and mapping of ineligible areas (Mihailescu OVIDIU, Bernadett CSONKA, S.C. GAUSS S.R.L) | **P4-5**: The evolution of CwRS in Cyprus (Simone PAPAKONSTANTINOU, Cyprus Agricultural Payments Organisation CAPO) |
| 17.00-17.30 | **P3-6:** Enhancing and using the LPIS as a Land Knowledge System: an example of using LPIS data for risk analysis and GAEC controls (Fabio SLAVIERO, Alberto IORI, Abaco Srl) | P4-6: Innovations at Paying Agency of Catalonia in on-the-spot checks using aerial photographs; UAV and dynamic publication of orthoimages (Albert DOMINGO **ROIGÉ**, Gencat, Valenti MARCO SANZ, CA Catalunya) |
| 17.30-18.00 | **P3-7**: An ICT backbone for the benefits of integrated ICT system for farmers, advisors and vertical and horizontal chain partners (Walter MAYER, PROGIS Software GmbH) | **P4-7**: Tools, tricks and examples for the LPIS Quality Assurance implementation" (Wim DEVOS, Pavel MILENOV, Piotr WOJDA, JRC) |

| | |
|---|---|
| 18.00-19.00 | Exhibition/Demo/Poster Sessions |
| | |
| 20.00-*** | Gala Dinner<br>RISTORANTE 'IL PIANONE'<br>Shuttles at 19.30 in front of Centro Congressi |

## Day 3 (26 November 2009)

| | |
|---|---|
| **Plenary 2: Campaigns 2010 and 2011**<br>**SALA OGGIONI (with translation EN/FR/DE/IT)**<br>Chair: Philippe LOUDJANI, JRC | |
| 09.00-10:30 | **PB-1**: GPS certification scheme (Martin GRZEBELLUS, NavCert)<br>**PB-2**: GPS validation (Krasimira GANISHEVA, JRC)<br>**PB-3**: , Conclusions GPS workshop (Cozmin LUCAU, JRC) |
| 10.30-11.00 | Coffee Break offered by EUROPEAN SPACE IMAGING, DIGITALGLOBE |
| **Plenary 2: Concluding session**<br>Chair: Simon KAY, JRC | |
| 11.00-12.00 | Reporting on parallel sessions (4 chairmen of parallel sessions) |
| 12.00-12.30 | Reporting of selection committee (Kadim TASDEMIR, JRC) |
| 12.30-12.45 | Concluding remarks (Simon KAY, JRC) |
| 12.45-14.00 | Buffet lunch offered by SIN Sistema Informativo Nazionale per lo sviluppo dell'agricoltura |

End of the conference

European Commission

**EUR 24800 EN – Joint Research Centre – Institute for Environment and Sustainability**

Title: Geomatics in support of the Common Agricultural Policy - Proceedings of the 16th GeoCAP Annual Conference, 2010

Editor(s): Kadim Taşdemir, Philippe Loudjani, Vincenzo Angileri, Beata Hejmanowska, Cozmin Lucau, Pavel Milenov, and Csaba Wirnhardt

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