USE OF VERY HIGH RESOLUTION IMAGERY IN THE CONTROL OF AREA BASED SUBSIDIES WITH REMOTE SENSING

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ABSTRACT

As a part of the reform of the European Union's common agricultural policy (CAP), a control of the applications for subsidy was introduced in 1992, concerning at least 5% of all the applications for area based subsidy. The European Union found that remote sensing was an efficient tool to perform part of the control. This control now acts as the primary control of the applications for subsidy in most of the member states, demonstrating a strong benefit from the remote sensing data. With the recent development of commercial Very High-Resolution (VHR) satellite imagery, the benefit has been increased.

The task in the remote sensing controls is to verify the areas and crops that the applying farmers are declaring. To benefit from remote sensing data, the applications that are subject for controls are selected in sites slightly smaller than Spot-scenes (radius 25 km). The controlled applications are classified "rejected" or "accepted". The rejected applications are subject to further controls on the spot. The new VHR imagery allows smaller sites. In 2003, EU opened up for tests of the feasibility of these new image sources.

This paper describes the method and results of a test carried out by Danish Institute of Agricultural Sciences on a regular 11 km · 11 km QuickBird scene acquired in July 2003 and on an EROS scene from late May 2003. The test showed that the use of recent EROS and Quickbird imagery might give an advantage, because it allows more precise digitising and better compliance with the EU rules than archive orthophotos, because of frequent changes in land use. Panchromatic Quickbird images from May seem to give the most precise digitisation. The test also showed that there would be a large benefit in the controls if the Quickbird images would be available for the controls, when used operationally. Due to the timing schedule, the test was performed after the 2003 controls had finished.

Keywords: VHR, ortophoto, farming, digitising

INTRODUCTION

The main objective of the test carried out for Denmark was to evaluate the feasibility of using VHR data to improve the digitisation of field boundaries. Danish Institute of Agricultural Sciences (DIAS) carries out the Control with Remote Sensing (CwRS) for the Danish Administration (1). The outlines of the Danish CwRS sites for 2003 were already established when the site for VHR image testing was selected. The island Læsø was selected because it had a compact size that (almost) fits inside the maximum footprint of a single VHR scene.

Other reasons for selecting Læsø were the remote location from the Danish mainland (1½ hour ferry trip) and the large share of small parcels. The potential of using VHR data could be to reduce errors in the area and the crop verification. If fewer fields were unjustly rejected, it would reduce the travel activity for the Plant Directorate that carries out the on-the-spot controls.

Description of the test site

The eastern part of the control site FRED-DK is the island Læsø (Laesoe), located in the northern part of the Kattegat strait between Denmark and Sweden. It is the largest island in Kattegat with an area of 11,400 ha. The length of the island is about 22 km and the width varies from 2 to 12 km.

Natural vegetation and plantation cover about 71% (8,400 ha) of the total area of the island. About 2,200 people live on the island. Most of the island is only a few meters above the sea level – the highest point on the island is 24 m.

The land use pattern of the island is very mixed: agricultural areas, mixed agriculture and natural areas, natural pasture, bogs, coniferous forest, deciduous forest, salt marshes etc. Due to the complex land use pattern, the agricultural parcels vary from small parcels surrounded by forest to large natural grassland areas. The average parcel size is 3.5 ha. Table 1 shows the number of farms on Læsø and their area statistics (Organic farming or CABS (ordinary area subsidy)).

Table 1. Number of farms regarding type

	No.	**Parcels**	**Average parcels**	**Area (ha)**	**Average parcel area**	**Average farm area**
Organic farming and normal CABS	12	231	19.3	827.36	3.57	68.95
Normal CABS	61	1085	17.8	3789.12	3.49	62.12
Total	73	1316	18.0	4.616.48	3.51	63.24

IMAGERY

An acquisition window for the VHR satellite data was defined to be open in May 2003 in order to enable DIAS to use the data operationally.

EROS

An EROS Pan image was acquired on 9 May but the data were not available before 23 June. On 24 June, the data were downloaded from the FTP site. Actually, there were two scenes available, but they were practically identical so the one without haze was selected for further processing. On 25 June, 95% of the fields on Læsø was already digitised, so the imagery came too late to be used in the CwRS campaign. The EROS image format was delivered as 16 bit GeoTIFF with a resolution of 1.93 m. Figure 1 shows the complete coverage of the EROS Image.

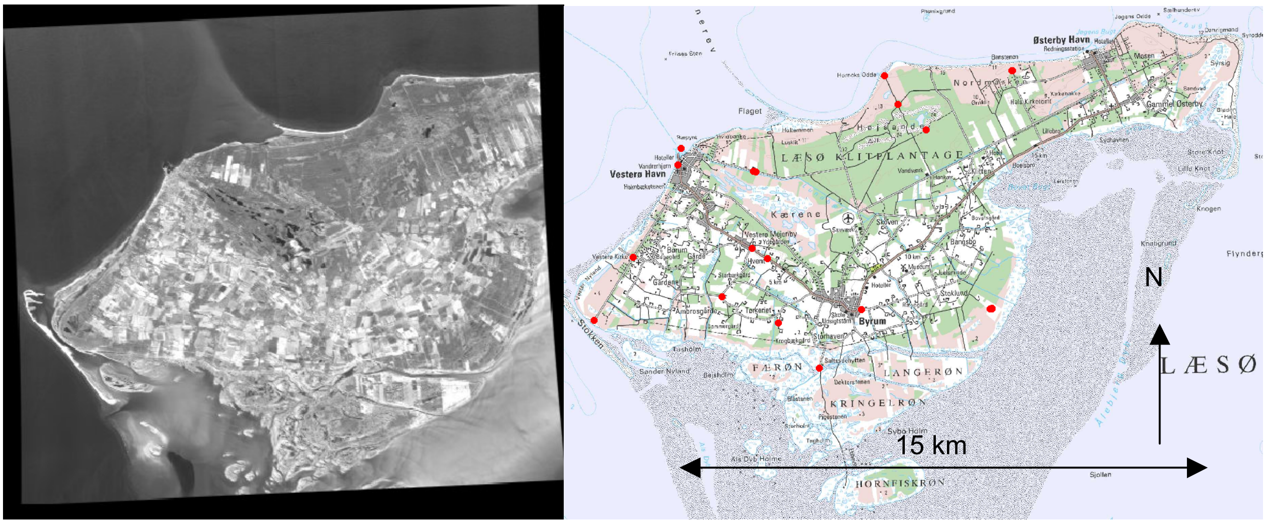

Figure 1. Coverage of the EROS image and the position of GCPs collected on the spot by GPS. EROS A "Distributed by ImageSat [2003]".

On 2 July, DIAS went to collect GCPs on the island while collecting credible ground data for the CwRS image classification. The whole day was spent on these two tasks. The points were collected using a survey grade GPS with beacon receiver. Before going to the island, a set of potential GCPs were identified on a print of the image. Most of these points were identifiable in the field. A few of the points were not as distinct or diffuse in reality compared with the image. In the open areas, a few extra GCPs were identified using colour orthophotos. The positions of the collected GPCs are shown as red dots in Figure 1.

Since the imagery could not be used operationally, the GCPs were not used until 21 August (after the end of the campaign). Together with the GCPs, image chips showing the GCP positions and a DEM were uploaded as well. The ortho-corrected image was downloaded from the supplier's FTP-site on 27 August.

QuickBird

The QuickBird imagery was acquired for the whole island on 24 and 29 July. Both panchromatic and multi spectral data sets were gathered. The images of 24 July covered the western part of the island with 95% of the agricultural parcels. The eastern images of 29 July covered the remaining part of the island. The western images had about 5% clouds concentrated in the southwest. The eastern images had more clouds - about 25% (incl. shadows) over agricultural parcels. Figure 2 shows the acquired multispectral images. Only data over the land were provided. Unfortunately, a couple of GCPs at the coast were outside the coastline polygon that was used for clipping. A gentler clipping would be preferable.

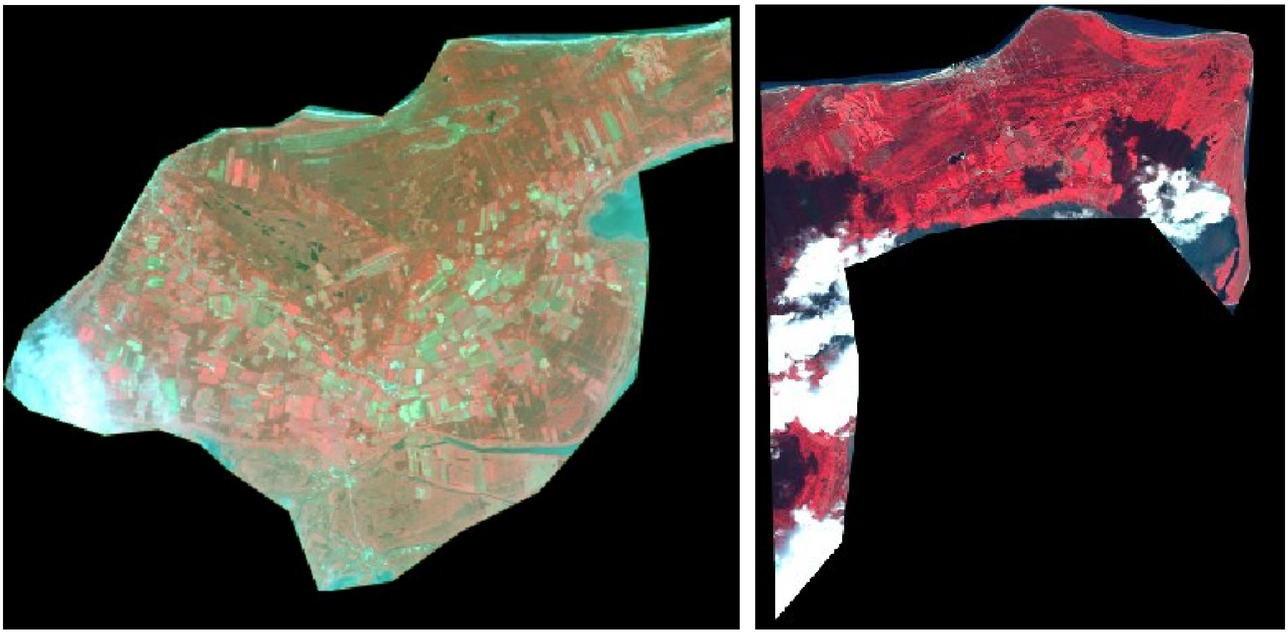

Figure 2. QuickBird multispectral images of 24 and 29 July 2003 at different scales. Quickbird "Distributed by EURIMAGE S.p.A. [2003]".

The agricultural area, covered by the EROS image, was completely within the western images, thus it was only the western panchromatic and multispectral QuickBird images of 24 July that were ortho-corrected by DIAS. The imagery was received as GeoTIFF in Standard OrthoReady 2A correction was made on a DVD on 6 August. The mean collected Ground Surface Distance (meanCollectedGSD) was 2.469 m for the multi spectral image and 0.618 m for the panchromatic image.

DESCRIPTION OF THE PERFORMED TEST/WORK

Ortho correction

The image provider carried out the ortho-correction of the EROS Pan images. No information on the quality of the correction was delivered with the rectified GeoTiff image. In order to be used in ArcView with the existing data, the EROS image was transformed from the WGS84 datum to ED50. Furthermore, the image was compressed from 110 MB to a 2.89 MB ECW file.

Both of the Quickbird images were corrected in Erdas Imagine 8.6 using the QuickBird sensor model. The model utilises the Rational Polynomial Coefficients (RPC's) that are provided as a part of the image delivery. When using the RPCs, the model used a first order polynomial, so besides the DEM, only a few GCPs were necessary in order to generate an ortho image. The DEM, with a 50-meter grid, was also used for correction of the SPOT and Landsat imagery in CwRS 2003. Besides the points collected by GPS, a number of points were identified in the colour orthophoto imagery from 2002 as seen on Figure 3.

The residuals from the ortho-correction of the QuickBird images are shown in Table 2. The GCP residuals are below 1 meter and the checkpoint residuals are also satisfactorily low. The maximum GCP errors were 0.902 and 0.854 meters for pan and multi, respectively. The maximum checkpoint errors were 0.764 m for pan and 1.911 m for multispectral.

Table 2. Ortho-correction residuals for QuickBird images – all residuals in meters

	Number of GCPs	GCP Residual X	GCP Residual Y	Total residual GCP	Number of Check-points	Check-point Residual X	Check-point Residual Y	Total residual Check-point
QB Pan	7	0,426	0,307	0,525	4	0,214	0,434	0,484
QB Multi	8	0,408	0,394	0,567	4	0,950	0,343	1,010

The QB panchromatic image was corrected to UTM with a ground pixel size of 0.60 m, while the QB multispectral image was corrected to a pixel size of 2.00 m. The spheroid was ‘International 1909/1924’ and the datum ‘European 1950 (West Europe)’.

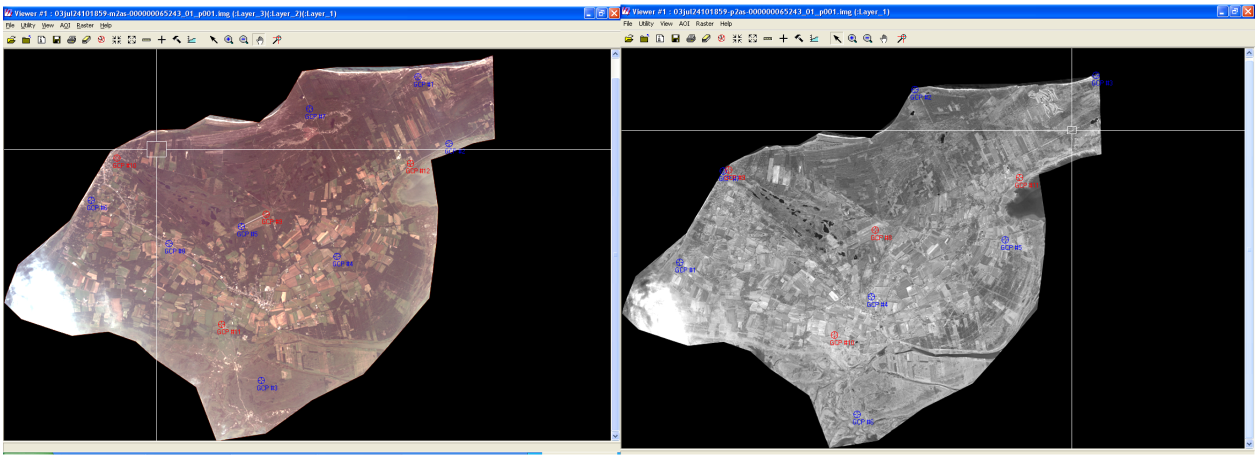

Figure 3. QuickBird - locations of GCPs shown in blue, checkpoints in red. Quickbird “Distributed by EURIMAGE S.p.A. [2003]”.

After ortho-correction, the data were converted to ECW format in order to be manageable in ArcView. The corrected QB pan image was 1.03 GB – this was reduced to 31.1 MB after compression. The corrected QB Multi scene was reduced from 385 MB to 8.52 MB; for both scenes, the visible loss was minimal.

The net time for the rectification process, for the two QuickBird images, was about 1 day per image. It was the first time, the operator rectified this kind of data, so that a faster processing time might possibly be expected in the future. On the other hand, Læsø is very flat, so it was easy to find proper GCPs.

Area Check

A total of 1087 fields were evaluated during the study. An application for comparing the different VHR images was setup in ArcView 3.2. Four image views were visible. 1) The colour archive orthofotos from 2002 that were used in the campaign. 2) The EROS panchromatic image. 3) The QuickBird panchromatic image and 4) the multispectral QuickBird image. On top of each image, the digitised field boundaries from the 2003 campaign were displayed. Furthermore, the LPIS boundaries were shown in yellow on top of the orthophoto. Figure 4 shows a screen-dump of this setup.

Field by field, the existing digitised boundaries were compared with the visible boundaries in the VHR satellite images. If a significant difference was visible in one or more of the images, the superfluous or missing area(s) were digitised and the size of this was recorded. Furthermore, it was noted which of the satellite images that were showing the difference and whether or not there were errors in the LPIS blocks. Finally, it was possible to fill out a comment text field in order to explain the possible cause of the discrepancy.

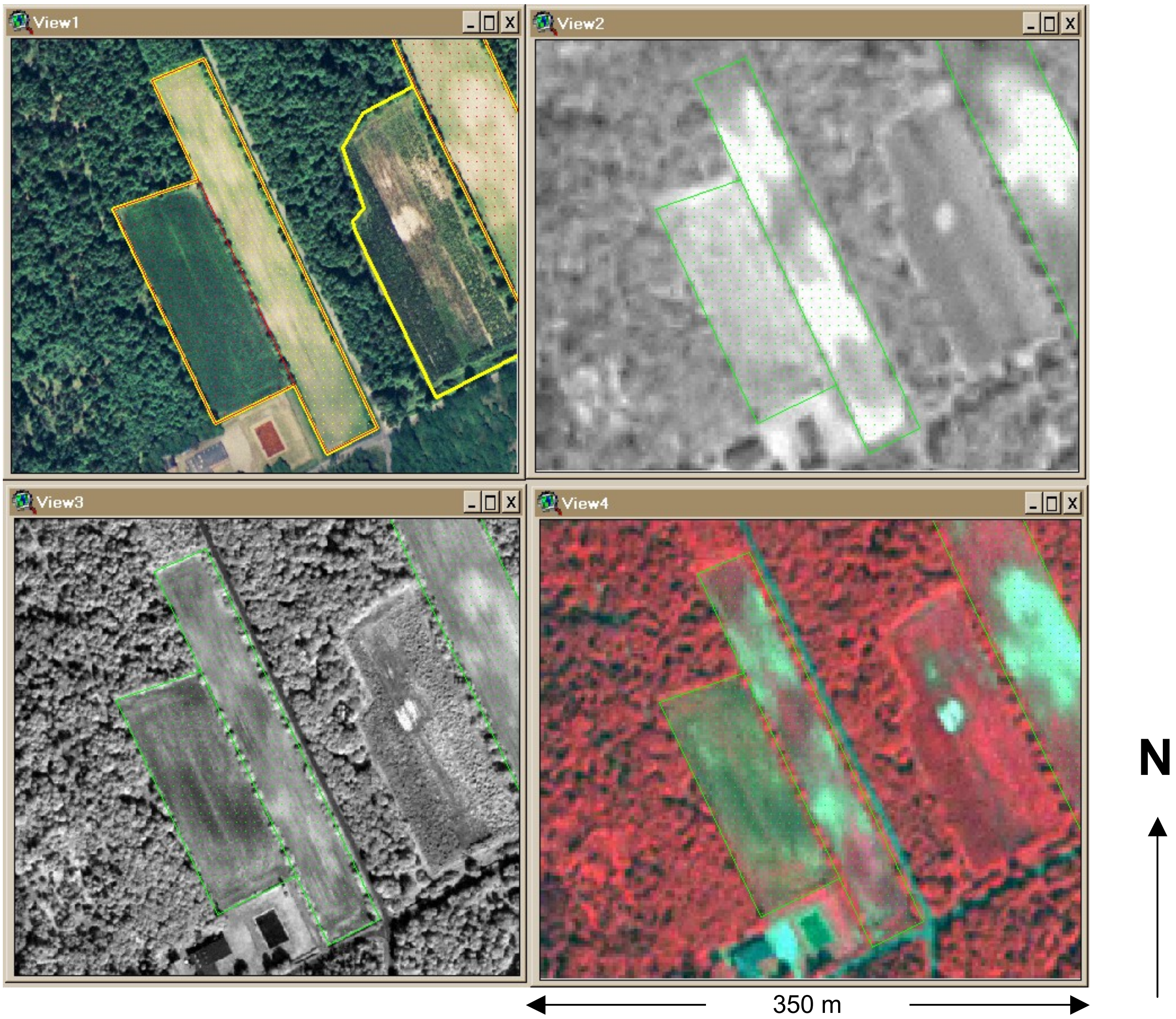

Figure 4. The VHR imagery shown in 4 windows. View 1) Colour orthophoto, View 2) EROS pan, View 3) QuickBird panchromatic and View 4) QuickBird multispectral. Quickbird "Distributed by EURIMAGE S.p.A [2003]" and EROS A "Distributed by ImageSat [2003]".

The maps, with the farmers' field sketches, were not used in this study, since they were returned to the administration after the end of the campaign. So, the evaluation was only based on what was visible in the images. The bias from the farmers' maps was therefore eliminated.

Figure 5 shows the digitised polygons of the agricultural parcels on top of the EROS pan image. The yellow fields had visible discrepancies. They are relatively evenly distributed with a dominant part towards east. Parcels outside the EROS image were excluded from this study.

RESULTS

Area check

Out of 1087 fields, 119 were found to have a different area than recorded. The total sum of the difference was 25.2 ha or 0.9% of the total declared area – in absolute terms 33.6 ha or 1.2 percent of the declared area. Out of the 119 fields, 25 had both extra and missing parts. For 6 of these, the net difference was zero. Visible errors in the LPIS block boundaries were found in 28 cases.

Figure 5. The digitised polygons of the agricultural parcels on top of the EROS pan image. Fields, marked with yellow, had visible discrepancies. EROS A "Distributed by ImageSat [2003]".

The EROS Pan imagery was able to show a discrepancy in 54 of the 119 fields. For QuickBird Pan, it was possible to see a difference in 115 of the fields, while the Quickbird multispectral showed a difference in 113 cases. So, the Quickbird imagery is apparently significantly better for digitisation. Unfortunately, the date of the imagery was quite different; early May for EROS and late July for the two QuickBird images, so, a direct comparison is not possible. However, based on our experiences, May images often have a larger contrast than images from July due to the different development of winter and spring crops. This indicated that a May QuickBird image may be even better for digitisation than this study indicates.

When the QuickBird pan imagery is compared with the orthophotos, we have from 2002, the QuickBird imagery is comparable in spatial quality – in some cases even better than the orthophotos.

Buffer tolerances

Based on the digitised missing or extra areas, new corrected digitised field areas were created (2,3). Out of the 119 fields with differences, 51 were still inside the buffer tolerance after correction. The remaining 68 fields were outside the buffer tolerance. The applied buffer tolerance was 1.5 m or 5% and a maximum of 1 ha per parcels. For each code, the changes are explained in the following:

'X' – inside tolerances: 51 fields out of the 119 had an X coding (inside tolerance) from the original digitisation. For 19 of these, the coding remained unchanged after applying the buffer tolerances on the corrected field areas. For 22 of the fields, the coding became C3- (over declaration). The remaining 10 fields went from X to C3+ (under declaration).

'C3-' - over declaration: 16 fields out of the 119 had a C3- coding (over declaration) from the original digitisation. For 13 of these, the coding remained unchanged after applying the buffer tolerances on the corrected field areas. For the remaining 3, the coding became X (inside tolerance).

'C3+' - under declaration: 48 fields out of the 119 had a C3+ coding (under declaration) from the original digitisation. For 16 of these, the coding remained unchanged after applying the buffer tolerances on the corrected field areas. For 27 of the fields, the coding became X (inside tolerance). The remaining 5 fields went from C3+ to C3-.

Table 4 gives an overview of the parcel area code changes that were described in the text above. Table 5 shows the number of changes for each code, generated from Table 3. The most important figure is that 35 more fields were rejected at parcel level after correction of the field boundaries.

Table 4. Overview of changes in parcel area codes

		Before			
		X	C3-	C3+	Sum
After	X	19	3	27	49
	C3-	22	13	16	51
	C3+	10	-	5	15
	Sum	51	16	48	115

Table 5. Number of changed parcel codes

	After-Before
X	-2
C3-	35
C3+	-33

Consequences of area discrepancies

An analysis of the consequences for each of the 27 declarations involved in this study found that the rejection of 35 extra fields would result in the rejection of 5 declarations that were originally accepted. The originally rejected declarations would remain unchanged.

CONCLUSION

The delivery of the EROS and the QuickBird imagery used in this study was too late to be used operationally in the CwRS campaign. This also meant that the collection of GCPs and the subsequent image rectification was given a lower priority than if they were to be used operationally. Therefore, the study became a post-campaign study with focus on the benefits of using VHR data for field parcel digitisation.

The results from the area checks were quite promising. A number of discrepancies were found and the most important results were:

- 28 errors in LPIS blocks, 119 fields with visible errors in parcel boundaries, 35 fields were rejected after applying tolerances leading to 5 more declarations would be rejected if the data were used in the CwRS campaign.
- More than twice the number of errors was detectable in QuickBird as compared with EROS imagery. QuickBird pan is comparable with 40-cm colour orthophotos in many cases.
- ECW or similar image compression is recommendable.

The test showed that the use of recent EROS and Quickbird imagery seems to give an advantage, because it allows digitising being more precisely and better complying with the EU rules. Panchromatic Quickbird images from the month of May seem to give the most precise digitisation. The test also showed that there will be a large benefit in the controls if the Quickbird images will be available for the controls also in the coming years, when used operational. Due to the timing schedule, the test was performed after the controls were finished.

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