European Commission

JRC TECHNICAL REPORTS

New sensors benchmark report on Sentinel-2A

Geometric benchmarking over Maussane test site for CAP purposes

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2015

Report EUR 27674 EN

Joint Research Centre

New sensors benchmark report on Sentinel-2A

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JRC Science Hub
https://ec.europa.eu/jrc

JRC99517

EUR 27674 EN

ISBN 978-92-79-54237-4

ISSN 1831-9424

doi:10.2788/544302

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How to cite: Vajsová B, Aastrand P.; New sensors benchmark report on Sentinel-2A; EUR 27674 EN; doi:10.2788/544302

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Abstract

The main objective of the report is to assess whether the Sentinel-2 sensor can be qualified for Control with Remote Sensing programme, specifically in the Common Agriculture Policy (CAP) Controls image acquisition campaign. The benchmarking presented herein aims at evaluating the usability of Sentinel-2 for the CAP checks through an estimation of its geometric (positional) accuracy.
For that purpose, the External Quality Control of Sentinel-2 orthoimagery conforms to the standard method developed by JRC and follows a procedure already adopted in the validation of previous high and very-high resolution products.

1 Introduction

The Common Agriculture Policy (CAP) uses the "Controls with Remote Sensing" (CwRS) as one of control systems to check whether aids given to European farmers are correctly granted. The JRC service together with chosen Image Providers (IPs) assures both, a smooth acquisition of appropriate image data and their initial quality assessment.
Each newly launched satellite with an ambition to provide image data for the purpose of CAP checks has to pass a validation test to prove a fulfilment of CwRS requirements [ref. ii, iii].This geometric validation is based on the External Quality Control (EQC) of the orthoimagery and follows strict guidelines described by JRC in the so-called "Guidelines for Best Practice and Quality Checking of Ortho Imagery" [ref. i].
Within this context, the purpose of the current study is to perform an initial quality assessment with respect to the capabilities of the newly launched Sentinel-2A satellite, see chapter 2.
Namely, the sensor requirement implies that the planimetric accuracy of the orthoimagery, expressed as the Root-Mean-Square Error (RMSE) in Easting and Northing directions, should not exceed 15m to fulfill the geometric requirements and specifications of HR prime profile and HHR ortho profile defined in the HR profile based technical specifications for the CAP checks.

1.1 Objective

The aim of this report is to summarize the outcome of the geometric quality testing of the Sentinel-2 images acquired over the Joint Research Centre (JRC) Maussane test site.
The objective of this study is twofold:

- to evaluate the planimetric accuracy of the orthorectified Sentinel-2 imagery;
- to check if the orthorectified imagery of the Sentinel-2A meet the CAP CwRS Programme technical requirements (see Chapter 7) [ref. ii, iii].

2 Sentinel-2 mission

Sentinel-2 is an Earth observation mission developed by European Space Agency (ESA) as part of the Copernicus Programme to perform terrestrial observations in support of services such as forest monitoring, land cover changes detection, and natural disaster management, humanitarian relief operations, risk mapping and security concerns. It consists of two identical satellites, Sentinel-2A and Sentinel-2B providing continuity for the current SPOT and Landsat missions. The two satellites will work on opposite sides of the orbit. The launch of the first satellite, Sentinel-2A, occurred 23 June 2015 on a Vega launch vehicle. Sentinel-2B will be launched in mid-2016 [ref. iv].

The mission provides a global coverage of the Earth's land surface every 10 days with one satellite and 5 days with 2 satellites, making the data of great use in on-going studies.
The satellites are equipped with the state-of-the-art Multispectral Imager (MSI) instrument that offers high-resolution optical imagery. This MSI imager uses a push-broom concept and its design has been driven by the large 290 km swath requirements, together with the high geometrical and spectral performance required of the measurements [ref. v]

As a prime contractor to construct the Sentinel-2 satellite has been appointed Astrium Germany, leading also a consortium with core partners [ref. v]:

- Astrium France is providing the MSI payload
- Boostec is providing the three-mirror Silicon carbide telescope and the instrument baseplate
- Jena-Optronik is responsible for the 2 Video Compression Units (VCU)
- Sener is supplying the instrument Calibration and Shutter Mechanism (CSM).

2.1 Satellite sensor characteristics – design

Launch information	Date: June 23, 2015 Launch Vehicle: Vega rocket Launch Location: Europe's Spaceport near Kourou in French Guiana
Satellite weight/size/power	approx. 1200 kg; 3.4 m x 1.8 m x 2.35 m; 1.7kW
Orbit	Altitude: 786 km Type: sun-synchronous Period: min
Inclination/Equator Crossing Time	98.62 deg/ 10:30pm (ascending node)
Orbits per day	14.3 revolutions per day
Revisit rate	10 days with one satellite and 5 days with 2 satellites
Operational lifespan	7.25 years (with consumables for 12)
Coverage	all continental land surfaces (including inland waters) between latitudes 56° south and 83° north all coastal waters up to 20 km from the shore all islands greater than 100 km^2 all EU islands, the Mediterranean Sea all closed seas (e.g. Caspian Sea)

Table 1: Sentinel-2 mission - design

2.2 Satellite sensor characteristics – specifications

Spectral bands	13 (VIS–NIR–SWIR spectral domains) VIS: 443 nm (B1), 490 nm (B2), 560 nm (B3), 665 nm (B4) NIR: 705 nm (B5), 740 nm (B6), 783 nm (B7), 842 nm (B8), 865 nm (B8a), 945 nm (B9) SWIR: 1 375 nm (B10), 1 610 nm(B11), 2 190 nm (B12)
Spatial resolution (at nadir)	10 m 4 bands (B2, B3, B4, B8) 20 m 6 bands (B5, B6, B7, B8a, B11, B12) 60 m 3 bands (B1, B9, B10)
Radiometric resolution	12 bits/pixel
Swath widths	290 km at nadir

Table 2: Sentinel-2 mission specifications

The bands' spectral values idicate the central wavelength

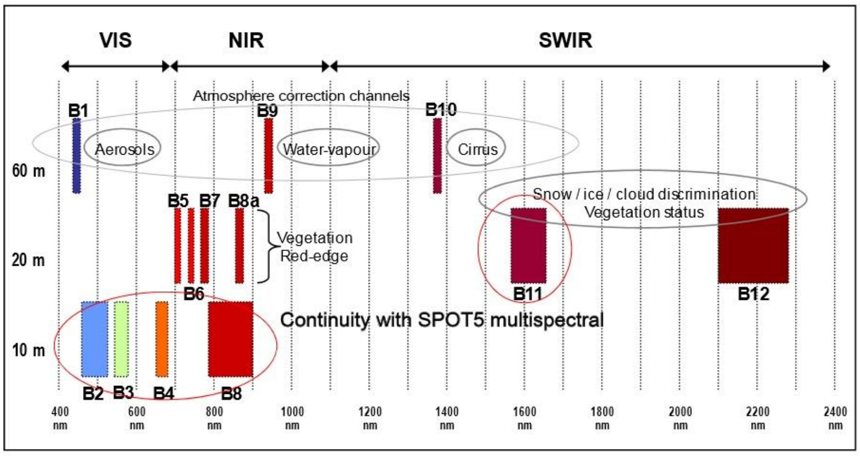

Figure 1: Spectral bands versus spatial resolution [ref. viii]

2.3 Sentinel-2 image products available to users

Level-1B (L1B)	Level-1B: Top of atmosphere radiances in sensor geometry. It is composed of granules, one granule represents the sub-image (25 x 23 km), Each The granule has a data volume of approximately 27 MB. Products require expert knowledge of orthorectification techniques. Pixel coordinates refer to the centre of each pixel.
Level-1C (L1C)	Top of atmosphere reflectance in fixed cartographic geometry (UTM, WGS 84). Level-1C images are a set of tiles of 100 km2, each of which is approximately 500 MB. These products contain applied radiometric and geometric corrections (including orthorectification and spatial registration). Pixel coordinates refer to the upper left corner of the pixel.
Level-2A (L2A)	Bottom of atmosphere reflectance in cartographic geometry. This product is currently processed on the user side by using a processor running on ESA's Sentinel-2 Toolbox. The possibility of making a standard core product systematically available from the Sentinels core ground segment is currently being assessed as part of the CSC evolution activities (image scene 100 km2)

Table 3: Sentinel-2 mission image products

2.4 Sentinel-2 Geometric Quality Requirements

- A priori absolute geolocation uncertainty:
  The a priori uncertainty of image location (i.e. before performing any processing) shall be better than 2km (3σ)

- Absolute geolocation uncertainty of Level-1B data :
  The geo-location uncertainty of Level-1B data with respect to a reference ellipsoid shall be better than 20 m at 2σ confidence level without the need of any GCP.

- Absolute geolocation uncertainty of Level-1C data :
  The geo-location uncertainty of Level-1C data with respect to a reference map shall be better than 12.5 m at 2σ confidence level with the need of GCPs.
  [ref. ix]

2.5 Sentinel-2 Data format

Sentinel-2 products will be made available to users in SENTINEL-SAFE format, including image data in JPEG2000 format, quality indicators (e.g. defective pixels mask), auxiliary data and metadata. In addition there will be the option to obtain the products in DIMAP format (where only higher level metadata is changing with respect to SENTINEL-SAFE format) [ref. vii].

3 Maussanne – test site

The geometric quality assessment of the Sentinel-2A image data has been performed over a standard test site of Maussane, located in French commune Maussane-les-Alpilles in the Provence-Alpes-Cote d'Azur region in southern France, see Figure 2.
The site contains a low mountain massif, mostly covered by forest, surrounded by low lying agricultural plains and a lot of olive groves. A number of low density small urban settlements and a few limited water bodies are present over the site [ref. xi].

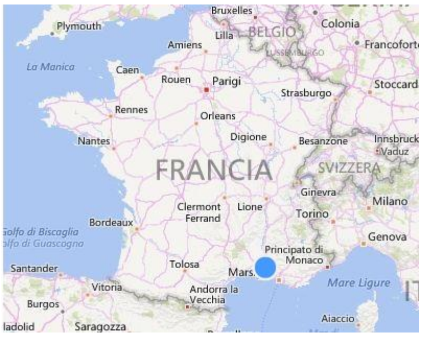

Figure 2 : Location of the Maussanne site

The site has been used by JRC for the geometric benchmarking of High Resolution (HR) and Very High Resolution (VHR) imagery since 1997 for the following reasons [ref. x]:

- it presents a variety of agricultural conditions typical for the EU, as well as urban settlements and water bodies,
- it contains a low mountain massif (650m above sea level) mainly covered by forest, surrounded by agricultural areas.
- during the years, a time series of reference data (i.e. DEMs, imagery, ground control points) has been collected. Altogether there are available 8 GCP datasets (292 points) of various positional accuracies, see Table 4 and Figure 3.

4 Input data

4.1 Independent check points (ICPs)

As mentioned above ICPs were retrieved from datasets of differential global positioning system (DGPS) measurements over Maussane test site that are updated and mantained by JRC.

Dataset	Point ID	RMSEx [m]	RMSEy [m]	Usage
GPS measurement for ADS40 project (2003)	11XXXX	0,05	0,10	used
GPS measurement for VEXEL project (2005)	44XXX	0,49	0,50	used
GPS measurement for multi-use (2009)	66XXX	0,30	0,30	used
GPS measurement for Cartosat-1 project (2006)	33XXX	0,55	0,37	used
GCP dataset for Formosat-2 project (2007)	7XXX	0,88	0,72	used
GCP dataset for Cartosat-2 project (2009)	55XXX	0,90	0,76	used
GPS measurement for SPOTproject (2002)	22XXX	n/a	n/a	not used
GNSS field campaign 2012	CxRx	<0,15	<0,15	used

Table 4: JRC points datasets – geometric specifications, more information see [ref. x].

As regards to the positional accuracy of ICPs, according to the Guidelines (Kapnias et al., 2008) [ref. i] the ICPs should be at least 3 times more precise than the target specification of the orthoproduct, i.e. in our case of a target 15 m RMS error the ICPs should have a specification of 5.0m (3m recommended). All ICPs that have been selected fulfil therefore the defined criteria (Table 4).

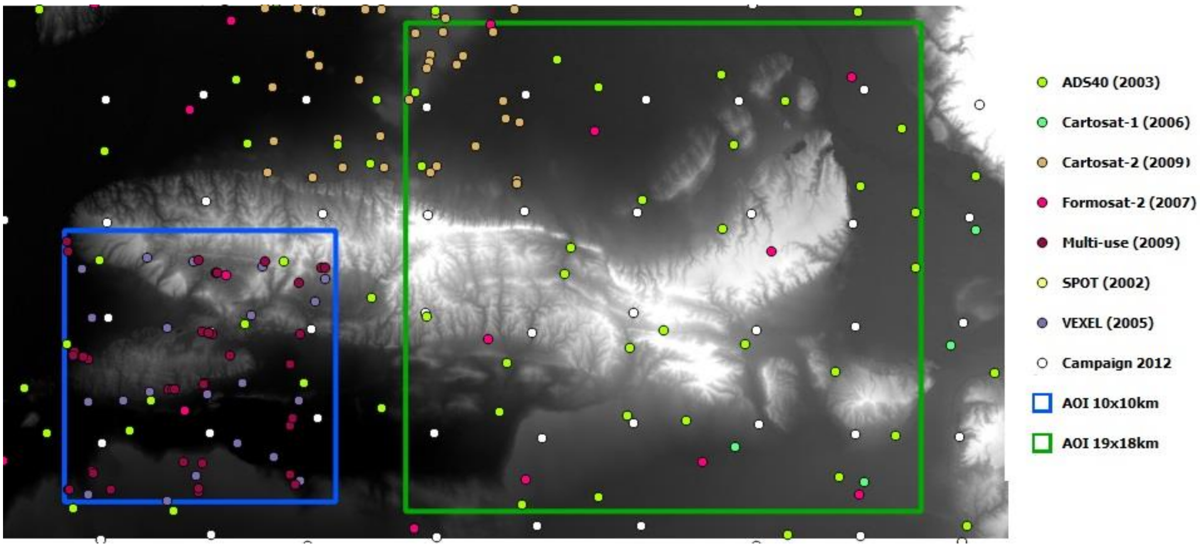

Figure 3: Maussane test site and related available JRC ancillary data: DEM and CPs.
The ADS40 DEM covering a large extent (35 x20 km²) over Maussane area is diplayed as a background grayscale layer (the brighter a pixel, the higher the elevation at that point). Over that same area, 8 datasets of CPs are retrieved from previous campaigns [ref. x] and represented as coloured dots on the figure. For geometric specifications of each dataset see the Table 4. The footprints of the two test areas are represented as coloured frames.

For the evaluation of the geometric accuracy of the Sentinel-2 ortho imagery, 15 to 21 independent ICPs were selected by a JRC operator. Considering the accuracy, distribution and recognisability on the given images, points from the seven datasets were decided to be used for the EQC, see Table 4.

5 Sentinel-2 testing dataset

Samples of the Sentinel 2A imagery used for testing were collected in August and September 2015, during the satellite's commissioning phase. Altogether 5 image scenes in the L1C product format have been downloaded and tested. Basic metadata of each image can be found in the Annex A at the end of the document.

5.1 1C level image product

For the testing purposes the L1C image product has been selected. This product results from using a Digital Elevation Model (DEM) to project the image in cartographic coordinates. Thus, geometric corrections including orthorectification and spatial registration on a global reference system is done already by an image provider within the processing level 1C. More about this image product in the Table 3, [ref. vi] or [ref. vii]. The assessed ortho products were displayed in the true colours mode with the Ground Sampling Distance (GSD) of 10m.

5.2 Global Reference Image

In order to meet the multi-temporal registration and the absolute geolocation requirements, a Global Reference Image (GRI) will be generated and used for the automatic extraction of GCPs for the systematic refinement of the geometric model at the end of the Level-1B processing.The database will be a composite of cloud-free (or with a limited presence of clouds), geometrically refined and mono-spectral (the current baseline is to use Band 4) Level-1B granules/datastrips covering a full repeat cycle (143 orbits, i.e. 10 days of acquisition).The GRI will be gradually completed (as the images become available all around the world) through an appropriate selection of Level-1B images followed by an accurate geometric refinement performed on the basis of spatio-triangulation [ref. ix]

The spatio-triangulation process is based on a bundle adjustment of set of images combined with orbit information and GCPs refinement.

GCPs can be found either by manual pointing, or by automatic correlation with an external database of images. For example, a number of exogenous images can be used (e.g. from Pléiades, SPOT, ALOS/PRISM) for correlation with Sentinel-2 images, so as to pick a number of GCP used in the refining process [ref. ix]

6 External quality control

The method for the external quality checks (EQCs) strictly follows the Guidelines for Best Practice and Quality Checking of Ortho Imagery (Kapnias et al., 2008) [ref. i].

Geometric characteristics of orthorectified images are described by Root-Mean-Square Error (RMSE) $RMSE_x$ (easting direction) and $RMSE_y$ (northing direction) calculated for a set of Independent Check Points.

$$\mathrm{RMSE}_{1\mathrm{D}}(East) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(X_{REG(i)} - X_{(i)}\right)^2} \qquad \mathrm{RMSE}_{1\mathrm{D}}(North) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(Y_{REG(i)} - Y_{(i)}\right)^2}$$

where $X,Y_{REG(i)}$ are ortho imagery derived coordinates, $X,Y_{(i)}$ are the ground true coordinates, n express the overall number of ICPs used for the validation.

This geometric accuracy representation is called the positional accuracy, also referred to as planimetric/horizontal accuracy and it is therefore based on measuring the residuals between coordinates detected on the orthoimage and the ones measured in the field or on a map of an appropriate accuracy [ref. xiii].

6.1 External quality control methodology

The whole Maussanne site that JRC has been using for the geometry benchmarking purposes (see chapter 3) is covered in total with 252 points which ground coordinates in planimetry are known. In order to effectively decide the exact EQC methodology a JRC operator went through all available datasets and checked the recognisability of the points on the Sentinel-2 images. As the Figure 4 illustrates, many ICPs were not in the Sentinel-2 images spotted. That was usually due to the changes of the landscape, growing vegetation, resolution of the Sentinel-2 or shadows.

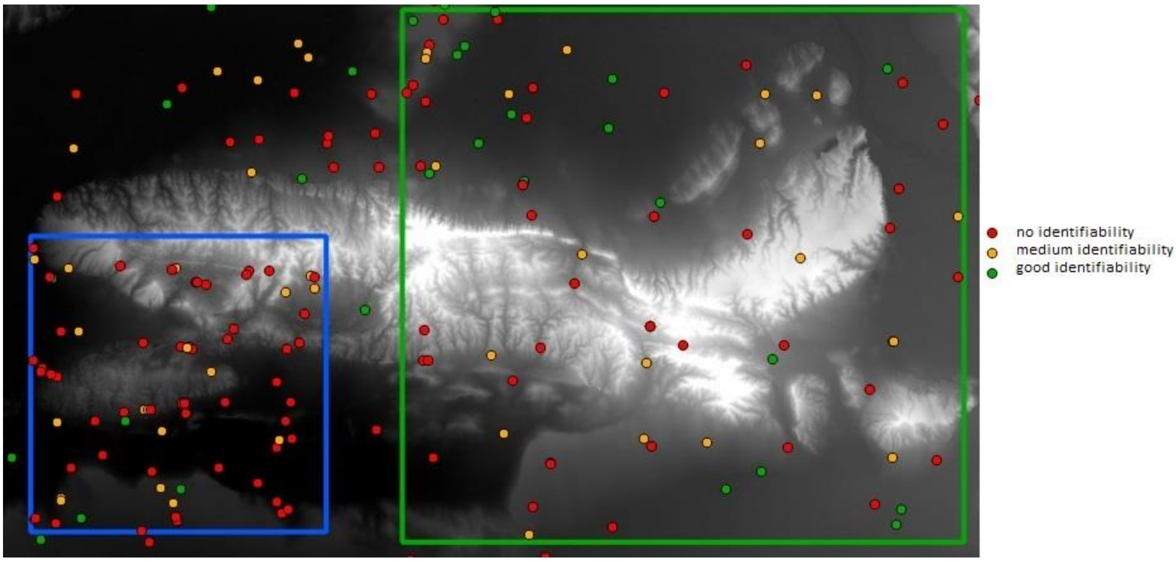

Figure 4: JRC ancillary data – visibility of ICPs on Sentinel-2 images

8 datasets of ICPs retrieved from previous campaigns [ref.x] and represented as coloured dots on the figure. Red colour represents a point not well identifiable, an orange coloure a medium identifiability and a green colour means that the point is on the image well visible and identifiable. For geometric specifications of each dataset see Table 4. The footprints of the two test areas are represented as coloured frames.

To provide accurate and reliable results two separate test AOIs were selected:

- "The small AOI", covering an extent of 10x10 km2, with UL corner at position (636225E, 4846850N) in EPSG 32631 (UTM zone 31N, ellipsoid WGS84) reference system, this AOI is usually used for VHR sensors benchmarking, therefore corresponding auxiliary image data are available (WV2, WV3. GE1, Pleiades..). See the blue box in the Figure 4.
- "The big AOI" covering an extent of 19x18 km2 (East x North) with UL corner at position (648800E, 4854500N) in EPSG 32631 (UTM zone 31N, ellipsoid WGS84) reference system, usually used for HR sensors benchmarking with corresponding auxiliary image data (SPOT5,6,7, RE, THEOS..). See the green box in the Figure 4.

To support the absolute geometric accuracy results calculated on the basis of ground true coordinates (measured in the field), also the relative geometric accuracy was considered.
The following ortho products were used as reference data:

- WV3 ortho image of max RMSE of 0.60m and pixel size of 0.40m, covering "the small AOI"
- SPOT 7 ortho image of max RMSE of 4.50m and pixel size of 0.1.5m, covering "the big AOI"

Sensor	Product	Collection date of the original image	Off nadir angle of the original image	Method used to orthorectify the original image
WV3	PSH	28/10/2014	14.1˚	RPC, 4GCPs
SPOT 7	PSH	03/10/2014	20.35˚	RPC, 4GCPs

Table 5: Basic metadata of reference image data used for relative geometric accuracy calculation

Concerning the relative geometric accuracy two different approaches for the ICPs selection were applied. The classic manual ICPs collection was complemented with an automatic correlation of ICPs.
For the automatic ICPs generation the Image AutoSync module of ERDAS IMAGINE was used, particularly the automatic point matching (APM) function.
The APM is a software tool that uses image-matching technology to automatically recognize and measure the corresponding image points between two raster images. In IMAGINE AutoSync, APM aims to deliver the coordinates of evenly distributed corresponding points between an input image (Sentinel-2A) and a reference image (SPOT 7, WV3) [ref. xvi]
The APM tool matches the control points by making use of a pyramid data structure to match level by level. When APM begins to run, firstly, it establishes respectively a 3×3 image pyramid data structure for the input image and the reference image, which is a group of image sequences generated from the low to high resolution. It begins to match from the lowest level of resolution. The APM finds the matching point and maps it to the search area of the last layer. Then it improves the resolution layer of both images and matches again in the search area. The cycle repeats until reaching the original image resolution. The matching points of the two images are obtained [xiv]. Further information about accuracy analysis of this module can be found in [ref. xv].

6.2 Outcome

6.2.1 Absolute geometric accuracy

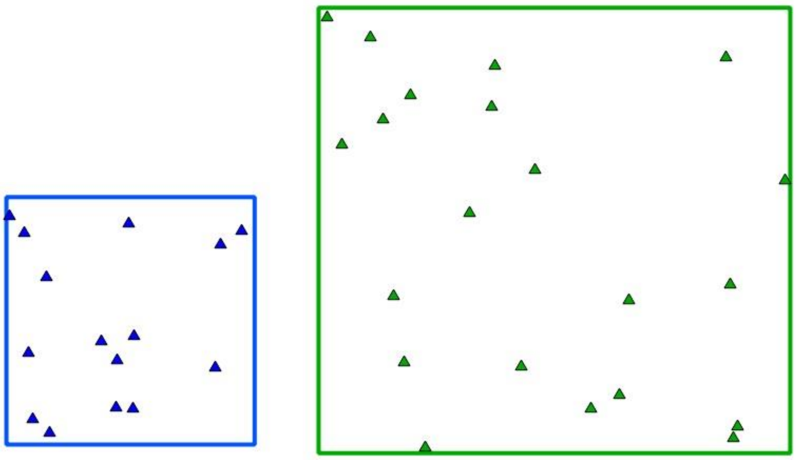

Figure 5: ICPs dataset used by JRC in the EQC of Sentinel-2A ortho imagery
The blue frame on the left represents AOI 10mx10m where 15 ICPs were selected. The green frame on the right represents AOI 19mx18km where 21 ICPs were used for testing.

	„Big AOI"		„Small AOI"	
Image S2A_*	RMSEx [m]	RMSEy [m]	RMSEx [m]	RMSEy [m]
820	5,18	5,03	4,67	6,29
863	4,65	4,69	3,10	3,52
963	4,96	5,11	5,74	4,08
1109	5,09	5,39	5,58	5,66
1249	5,42	6,29	8,76	7,54
Average	**5,06**	**5,30**	**5,57**	**5,42**

Table 6: Absolute accuracy - results of $RMSE_{1D}$ measurements in JRC ICPs dataset.
**See Annex A*

The total absolute accuracy calculated as an average of both AOIs over the Maussane test site:
RMSEx= 5,32m, RMSEy= 5.36m

6.2.2 Relative geometric accuracy

6.2.2.1 Manual selection of ICPs

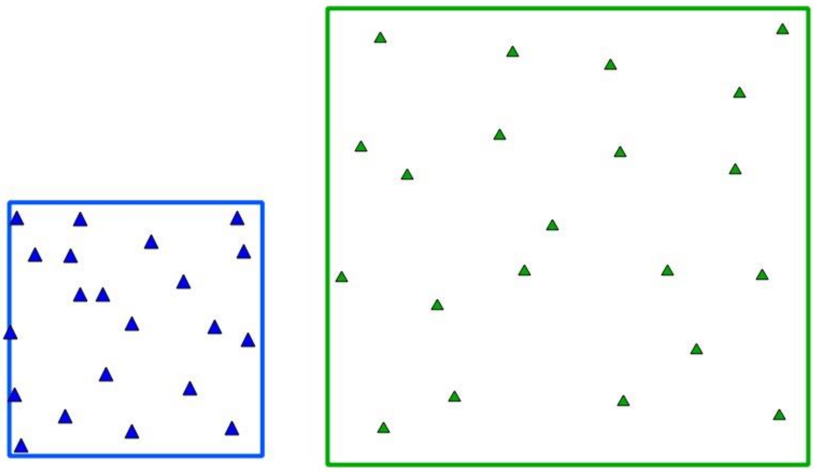

Figure 6: ICPs selected by JRC for the EQC (relative accuracy) of Sentinel-2A ortho imagery
In both areas 21 ICPs were selected.

	„Big AOI"		„Small AOI"	
Image S2A_*	RMSx [m]	RMSy [m]	RMSx [m]	RMSy [m]
820	4,11	7,25	3,13	5,59
863	3,54	5,43	2,87	4,14
963	5,96	6,49	4,18	4,79
1109	5,08	5,21	3,80	5,13
1249	3,51	6,68	2,92	6,63
Average	**4,44**	**6,21**	**3,38**	**5,26**

Table 7: Relative accuracy - results of $RMSE_{1D}$ measurements
**See Annex A*

The relative geometric accuracy compared to SPOT 7 ortho image:
RMSx= 4,44m
RMSy= 6.21m

The relative geometric accuracy compared to WV3 ortho image:
RMSx= 3,38m
RMSy= 5.26m

Since the absolute positions (e.g. DGPS measurement) of these check points are not known, the validation results can be interpreted as relative values to the reference ortho images, i.e. WV3 or SPOT 7 ortho image accuracy. The geometric characteristics of the WV3 image, and in particular its spatial resolution, are significantly better that the being studied Sentinel-2, therefore (only within this context) the ICPs coordinates measured on WV3 ortho image could be even treated as the absolute coordinates.

6.2.2.2 Automatic correlation of ICPs

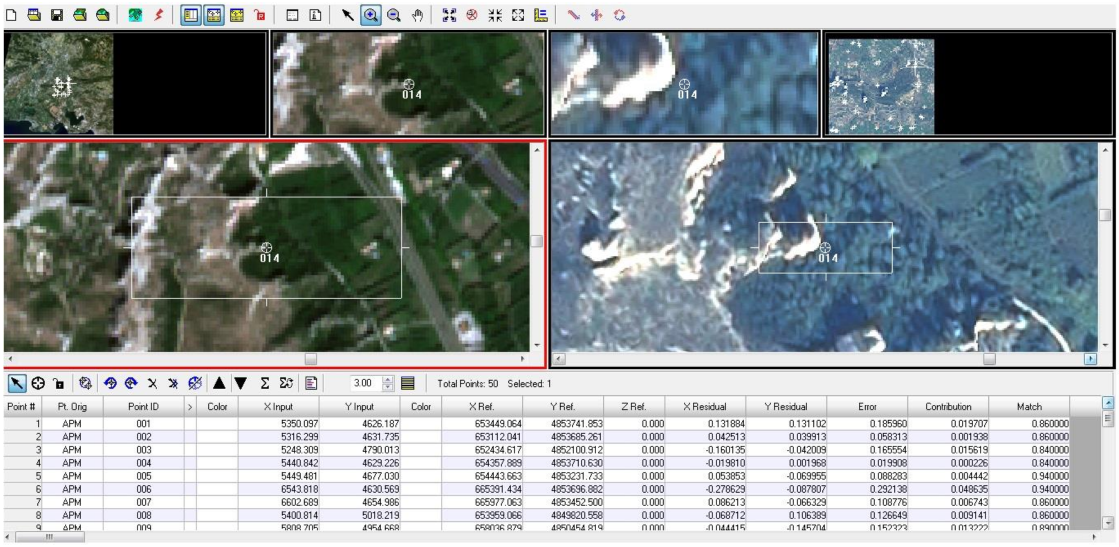

Figure 7: IMAGINE AutoSync – ICPs matching

„Big AOI“ SPOT 7			„Small AOI“ WV3	
Image S2A_*	RMSx [pix]	RMSy [pix]	RMSx [pix]	RMSy [pix]
820	0,099	0,142	0,201	0.259
863	0,162	0,158	0,968	0,974
963	0,165	0,171	0,168	0,210
1109	0,151	0,152	0,324	0,250
1249	0,127	0,113	1,039	1,112
average	0.141	0,147	0.540	0,561

Table 8: Relative accuracy - IMAGINE AutoSync module results
RMSEs which resulted from green band combination. *See Annex A

Band selected for matching: green
The more similar the radiometric characteristics of two images are, the better APM results can be achieved. Thus for the automatic matching it was always selected the same band combination. The best results (high number of good ICPs, low RMSEs) were achieved using green band combination (B3). See values in Table 8.

APM Strategy parameters used:
Default distribution
Search Size: 17
Correlation Size: 11
Least Squares Size: 21
Intended Number of Points: 40
Minimum point match quality: 80%

Matching the Sentinel 2A data with the WV3 reference image give less satisfactory results (higher values of RMSEs, much less ICP) due to the huge difference between the resolutions of the sensors.
The resolution creates a difference in the details of the two images. It is recommended to avoid mixing input and reference images with a resolution difference larger than a factor of six [ref xvi]. WV3 as a reference image apparently does not adhere to the suggestion (the resolution of the WV3 is 25x better than the Sentinel-2A one). There are substantial differences between the RMSEs of the images. To follow the recommendation we decided not to include the results into the summary.

6.3 Discussion

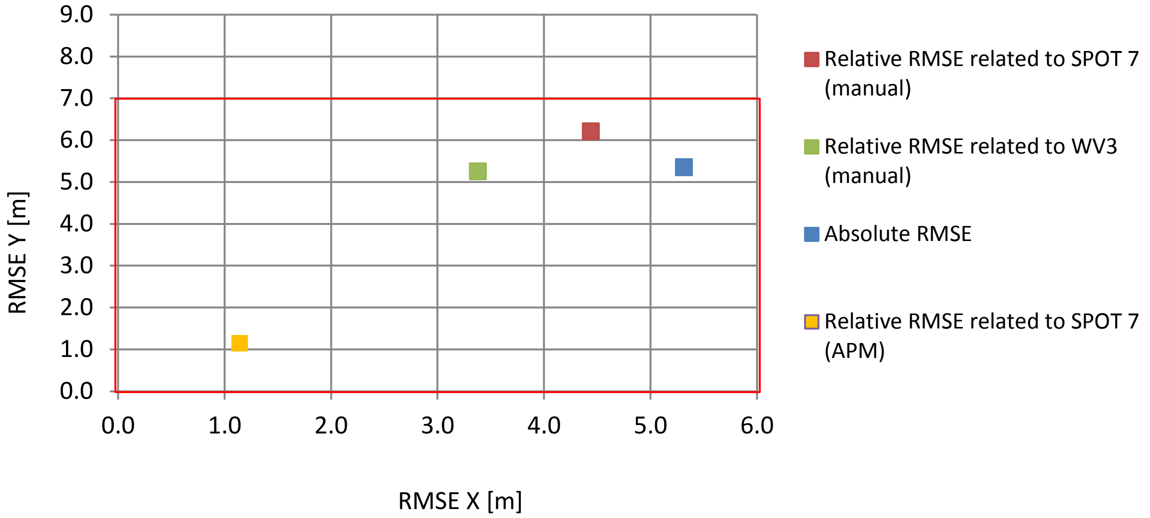

Figure 8: RMSEs summary

All calculated RMSEs resulted below one pixel. Regarding the absolute accuracy, the RMSEs of both tested AOIs were comparable and thus the final RMSE was calculated as an average.
The relative geometric accuracy values supported good absolute geometric accuracy results.

The automatic ICPs correlation is not limited to human visual interpretation and it is not so work intensive as manual point measurement. The output of the automatic point matching algorithm is better in accuracy in comparison to the current methodology, however the attention has to be paid to a suitability of a reference image (resolution, selected band, time of capture…) and APM strategy parameters.

7 Conclusions and prospects

The intrinsic geolocation performance of the L1C product is very good. The geolocation RMS error is below one pixel.
As far as the validation of the Sentinel-2A, L1C product is concerned, on the basis of the presented results, it is asserted that:

- The Sentinel-2A, L1C product geometric accuracy meets the requirement of 15 m 1D RMSE corresponding to the HR prime profile defined in the HR profile based technical specifications.

- The Sentinel-2A, L1C product geometric accuracy meets the requirement of 15 m 1D RMSE corresponding to the HHR ortho multispectral profile defined in the HR profile based technical specifications.

In the medium-term, geometric refinement using the Global Reference Image should further increase the geometric quality of the Sentinel-2A products.
The Sentinel-2A data are available to all users via the Scientific data Hub: https://scihub.esa.int/

ANNEX A

Image id (internal image id)	S2A_OPER_MTD_L1C_TL_MTI__20150819T203140_A000820_T31TFJ
Image short ID	S2A_820
Product level	Level 1C
Product Type	MSP
Collection date	19/8/2015
Ellipsoid Type/Projection	WGS-84/UTM, N31
Format	JPEG 2000
Bits Per Pixel	12

Image id (internal image id)	S2A_OPER_MTD_L1C_TL_MTI__20150822T204401_A000863_T31TFJ
Image short ID	S2A_863
Product level	Level 1C
Product Type	MSP
Collection date	22/8/2015
Ellipsoid Type/Projection	WGS-84/UTM, N31
Format	JPEG 2000
Bits Per Pixel	12

Image id (internal image id)	S2A_OPER_MTD_L1C_TL_MTI__20150829T203120_A000963_T31TFJ
Image short ID	S2A_963
Product level	Level 1C
Product Type	MSP
Collection date	29/8/2015
Ellipsoid Type/Projection	WGS-84/UTM, N31
Format	JPEG 2000
Bits Per Pixel	12

Image id (internal image id)	S2A_OPER_MTD_L1C_TL_MTI__20150908T203133_A001106_T31TFJ
Image short ID	S2A_1106
Product level	Level 1C
Product Type	MSP
Collection date	8/9/2015
Ellipsoid Type/Projection	WGS-84/UTM, N31
Format	JPEG 2000
Bits Per Pixel	12

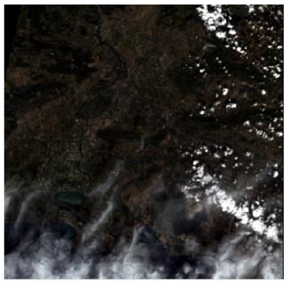

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Image short ID	S2A_1249
Product level	Level 1C
Product Type	MSP
Collection date	18/9/2015
Ellipsoid Type/Projection	WGS-84/UTM, N31
Format	JPEG 2000
Bits Per Pixel	12

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List of abbreviations and definitions

AD	Attitude Determination
ADS	Airborne Digital Sensor
AOI	Area of Interest
APM	Automatic Point Matching
CAP	The Common Agricultural Policy
CE90	Circular Error of 90%
COTS	Commercial off-the-shelf
CSM	Calibration and Shutter Mechanism
DEM	Digital Elevation Model
DSM	Digital Surface Model
EO	Earth Observation
EPSG	European Petroleum Survey Group
EQC	External Quality Control
ESA	European Space Agency
GCP	Ground Control Point
GRI	Global Reference Image
GPS	The Global Positioning System
GSD	Ground Sample Distance
HR	High resolution
IPC	Independent Check Point
IQC	Internal Quality Control
JRC	Joint Research Centre
LE90	Linear Error of 90%
LPIS	Land Parcel Information System
LVLH	Local Vertical/Local Horizontal
MS	Multispectral
MSI	Multispectral Imager
OD	Orbit Determination
ONA	Off Nadir Angle
PAN	Panchromatic
POD	Precision Orbit Determination
RMSE	Root Mean Square Error
RPC	Rational Polynomial Coefficient
SAR	Synthetic-Aperture Radar
TP	Tie Point
UTM	Universal Transverse Mercator
VCU	Video Compression Units
VHR	Very High Resolution
WGS 84	World Geodetic System 1984
1-D	One-dimensional

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Publications Office

doi:10.2788/544302

ISBN 978-92-79-54237-4