


Summary of the VHR image acquisition Campaign 2014 and new sensors for 2015

Michaela Neumann, George Ellis, Samuel Bärish, Blanka Vajsova

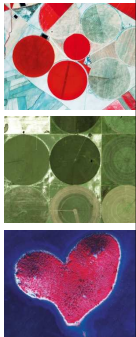
19 November 2014, Dresden – 20th MARS Conference




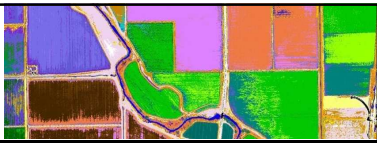
Presentation Outline

VHR Satellite Imagery for CAP Checks

- (1) Contractual & Overview
- (2) 2014 VHR Campaign Statistics
- (3) New Sensors: WorldView-3 and KOMPSAT-3 Benchmarking








Contractual & Overview

2014: First Year of Outsourcing



Michaela Neumann, European Space Imaging



Contractual & Overview

VHR Profile Provider

- Involved in CwRS since 2003
- European Space Imaging (EUSI) awarded multi-year (2014-17) contract for ***Supply of satellite remote sensing imagery and associated services in support to checks within the Common Agricultural Policy (VHR Profile)***
- In partnership with GAF AG and German Aerospace Center (DLR) and supported by DigitalGlobe, e-GEOS, SI Imaging Services, Imagesat International
- VHR satellites available in 2014: WorldView-1, WorldView-2, GeoEye-1, QuickBird + IKONOS, EROS B





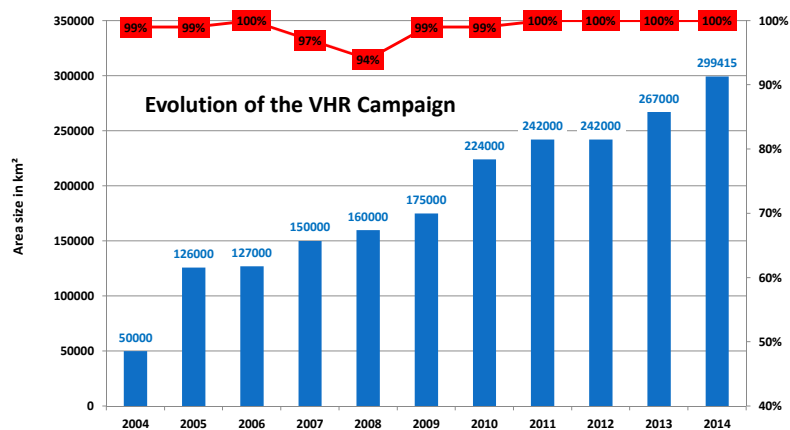
Contractual & Overview



Supply of VHR imagery & related services


- Communication with the MS and its contractors (feasibility iterations; image acquisition & delivery; ortho return)
- Ordering and Invoicing (EUSI-JRC)
- Source and Ortho data provision/return to JRC
- Improvements of VHR specifications
- NG-Lio development & maintenance (see presentation & demo)
- Benchmarking of new sensors (KOMPSAT-3 and WorldView-3)



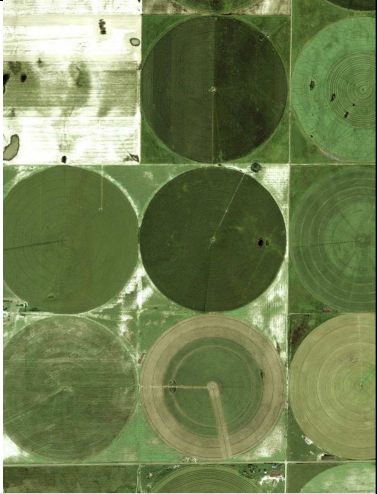
Campaign Overview



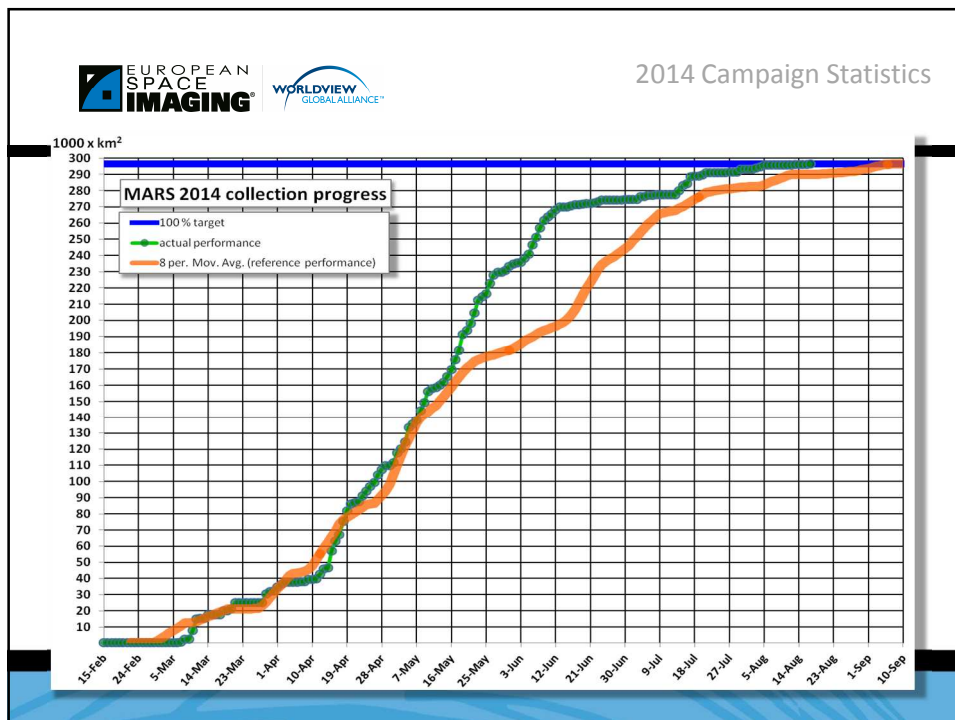



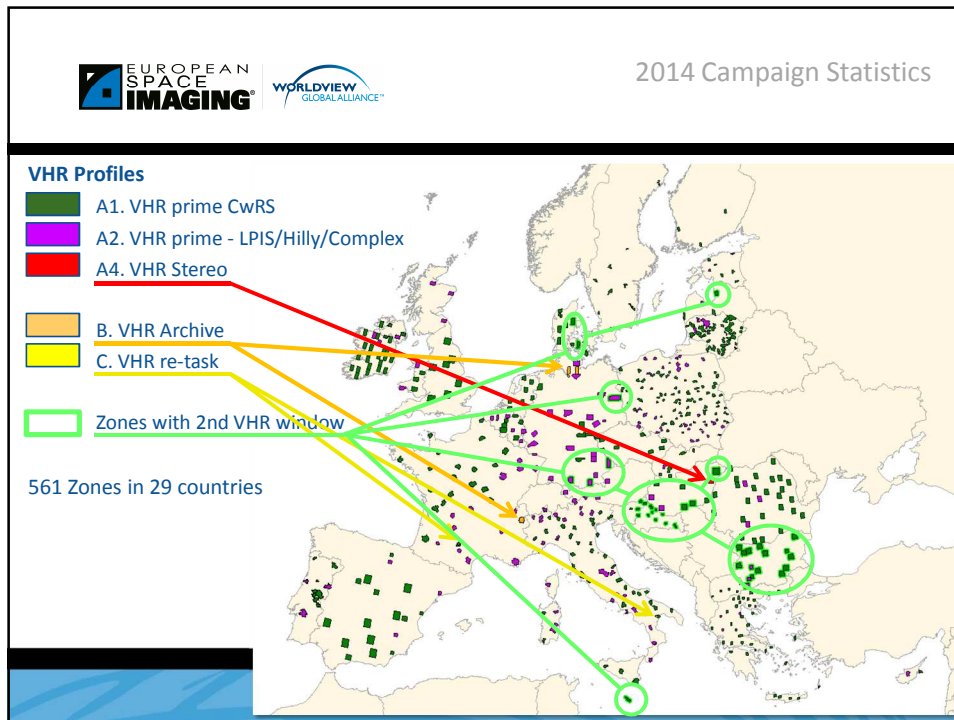


2014 VHR Campaign Statistics



George Ellis, European Space Imaging





2014 Campaign Statistics

VHR - Numbers

Planned/Purchased	No. of zones	Area [km ²]		
total	561	100%	299,415	100%
PROFILES				
A1. VHR prime – CwRS	405	72.2%	213,376	71.3%
A2. VHR prime - LPIS/Hilly/Complex	150	26.7%	82,272	27.5%
A4. VHR - Stereo	1	0.2%	899	0.3%
B. VHR archive	3	0.5%	2,641	0.9%
D. VHR re-task	2	0.4%	227	0.1%



2014 Campaign Statistics

VHR – more Numbers

	No. of zones	%	Area[km2]	%
total	561	100 %	299,415	100 %
VHR-1	516	92 %	272,605	91 %
VHR-2	42	7.5 %	24,169	8.1 %
Archive	3	0.5 %	241	0.9 %
VHR backup planned	53		43,239	
Failed	0		0	

Number of accepted uploads	780	100%
Validated	775	99.4%
Proposed	5	0.6%
Haze free	712	91.3%
Haze flagged	68	8.7%

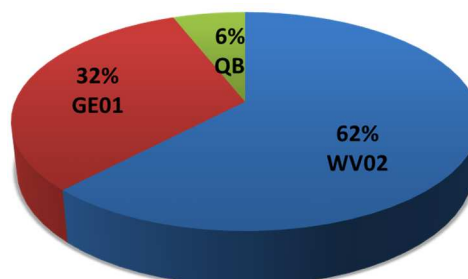
⇒ Back-up not used



2014 Campaign Statistics

VHR – Distribution of Area per Sensor

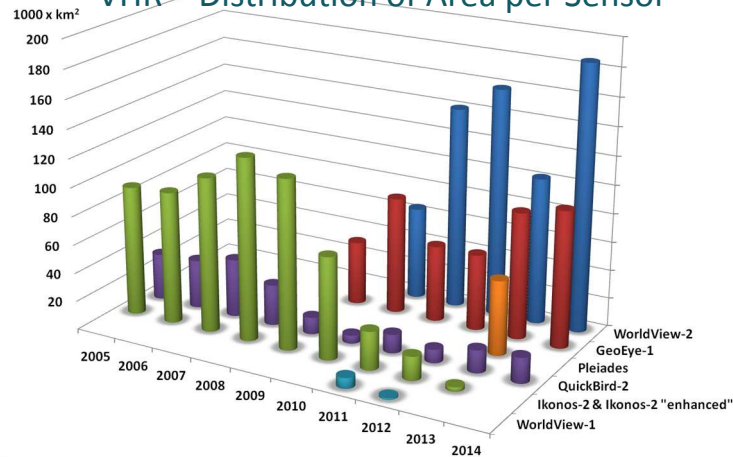
Sensor	Area [km ²]	%	No. of uploads
WV02	185,800	62 %	469
GE01	95,798	32 %	247
QB	17,817	6 %	64
Total area (CwRS+LPIS)	299,415	100%	780





2014 Campaign Statistics

VHR – Distribution of Area per Sensor



2014 Campaign Statistics

Year	2010*	2011*	2012*	2013**	2014
Average window length [days]	58	64	61	60	65
Average area [sqkm] /zone	640	555	516	510	534
Average acquisition time	31	14	17	18	17
Average time delay between first and last acquisition [days]	~18	~13	~11	~16	~4
Number of extended windows	46	13	0	20	7***
Number of re-tasked zones	8	10	0	4	2 (227sqkm)

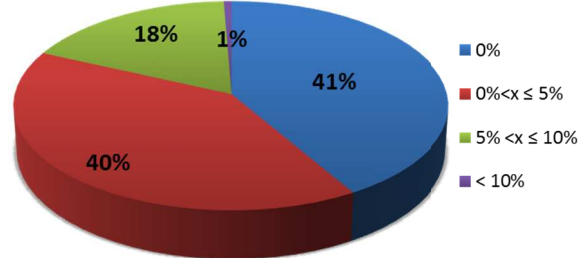
Success rate
[area]
100%
99%*
*in dedicated window without extensions

*Gervasini, E., Vajsova, B., Aspinall, C., San-Miguel, I., Breunig, J., Gentilini, S., Åstrand, P., Summary Report of 2012 CwRS Image Acquisition Campaign
**San-Miguel, I., Wirthardt, C., Breunig, J., Åstrand, P., Vajsova, B., 2013 Image acquisition campaign. 19th Annual MARS Conference
*** plus 1 zone extended but actually completed within window



2014 Campaign Statistics

VHR – Cloud Cover of Accepted Uploads



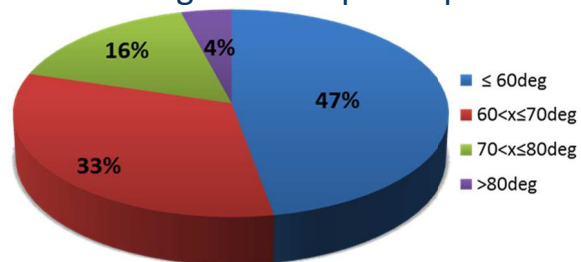
Year	validated			proposed	
	0%	0% < x ≤ 5%	5% < x ≤ 10%	>10 %	
2014	324	314	137	5	780 uploads
	41.5 %	40.3 %	17.6 %	0.6 %	100 %
2013	580		76	48	704 uploads
	82 %		11 %	7 %	100 %

Average cloud cover
per upload = 2.3%



2014 Campaign Statistics

VHR – Elevation Angle of Accepted Uploads



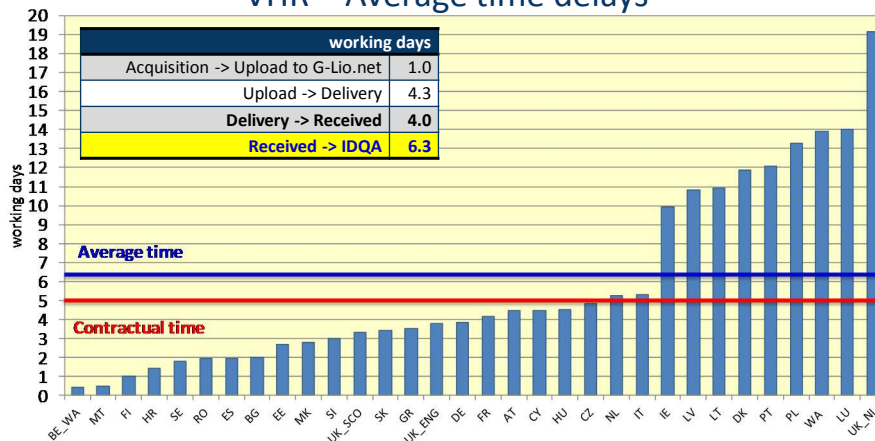
Year	≤ 60deg	60 < x ≤ 70deg	70 < x ≤ 80deg	> 80deg	
2014	368	254	126	32	780 uploads
	47.1 %	32.6 %	16.2 %	4.1 %	100 %
2013	355	256	155	57	823 acquisitions
	43 %	31 %	19 %	7 %	100 %

Average Elevation Angle
per upload 62.7deg



2014 Campaign Statistics

VHR – Average time delays



2014 Campaign Statistics

VHR – Image Return (status 11.11.2014)



Source Imagery

- Harvested automatically to CID portal via FTP



Orthoimagery

- 26/36 Contractors have returned imagery
- In process of delivery
 - 8 Contractors (HU, CZ, LT, AT, UK_Sco, IT, RO, BG)
- Waiting for response from GR, PT






New Sensors

WorldView-3
KOMPSAT-3 benchmarking



George Ellis, European Space Imaging, Samuel Bärtsch, GAF AG, Blanka Vajsova, EC-JRC




Satellite Constellation

WorldView3
8 band MS 31cm
8 band SWIR



NEW 2015

2014

Kompsat3
RGBN 70cm



NEW 2015

2012

WorldView2
8 band MS 46cm



2009

GeoEye1
RGBN 41cm



2008

WorldView1
PAN 50cm



2007

QuickBird
RGBN 48cm



END OF LIFE

2001

Ikonos
RGBN 82cm



1999

EROSB
PAN 70cm



2006

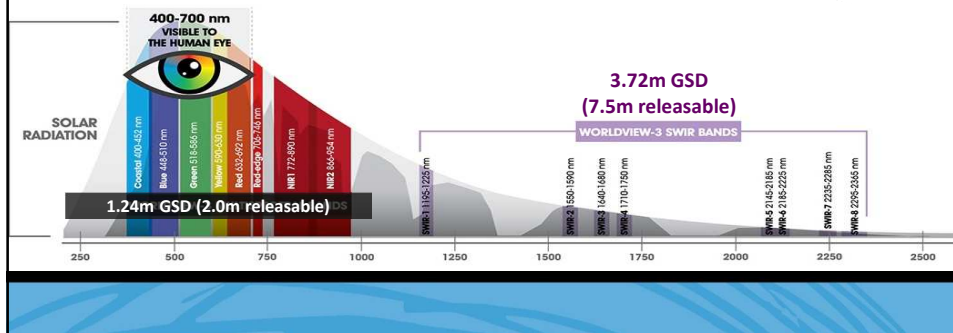
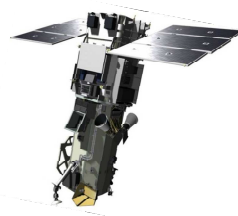
VHR Prime
VHR Backup



New Sensor: WorldView-3

WorldView-3 (launched 13 August 2014)



- First commercial high-resolution “super spectral” satellite
- 1 Pan, 4 standard + 4 additional VNIR
- 8 SWIR, 12 CAVIS (Clouds, Aerosols, Vapor, Ice and Snow)
- Highest Resolution: 0.31m GSD**
- Collection capabilities: 680,000 km² per day, stereo



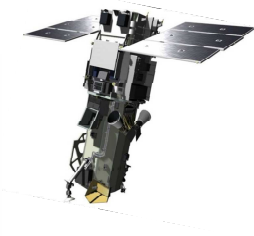

New Sensor: WorldView-3

Characteristics	WorldView-2	WorldView-3
Orbit	Sun-synchronous 770 km, 10:30 descending	Sun-synchronous 617 km, 10:30 descending
Spectral Bands	1 Pan 4 standard 4 added VNIR	1 Pan 4 standard 4 added VNIR 8 SWIR 12 CAVIS
Swath Width	16.4 km	13.1 km
Native Spatial Resolution (at nadir)	Pan 0.46 m Multispectral 1.84 m	Pan 0.31 m Multispectral 1.24 m SWIR 3.70 m CAVIS 30 m
Dynamic Range	Pan + MS: 11-bits per pixel	Pan + MS: 11-bits per pixel SWIR: 14-bits per pixel
Revisit Time	1.1 days at ≤ 1m GSD 3.7 days at ≤ 20° off-nadir (≤ 0.52m GSD)	< 1.0 day at ≤ 1m GSD 4.5 days at ≤ 20° off-nadir (≤ 0.35m GSD)
Agility	Bi-directional scanning and rapid retargeting using Control Moment Gyros (CMGs)	Bi-directional scanning and rapid retargeting using Control Moment Gyros (CMGs)







New Sensor: WorldView-3

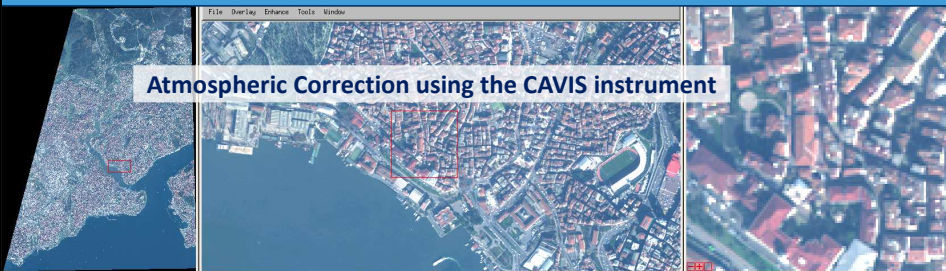


Madrid 40 cm, 21 Aug 2014




New Sensor: WorldView-3

TOA reflectance



Atmospheric Correction using the CAVIS instrument

Surface reflectance (after atmospheric compensation)





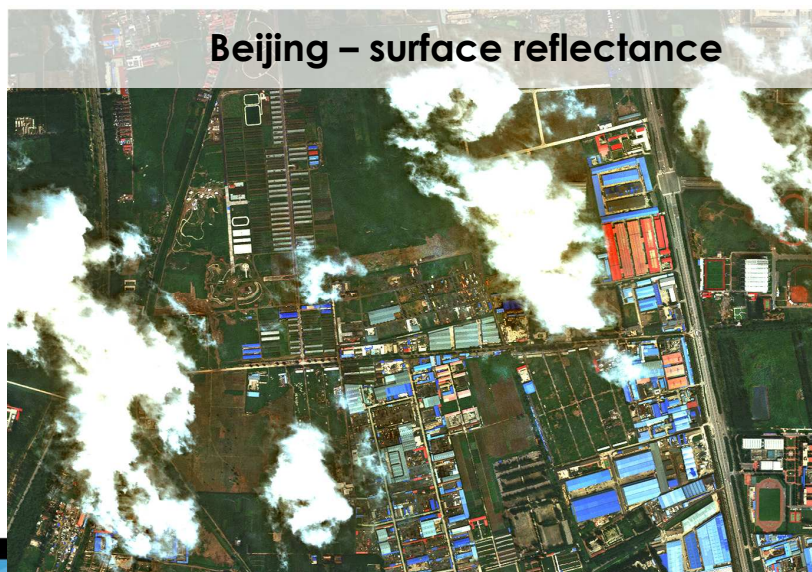
New Sensor: WorldView-3

Beijing - uncorrected



New Sensor: WorldView-3

Beijing – surface reflectance

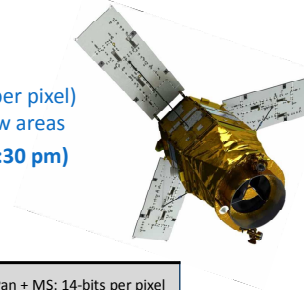




New Sensor: KOMPSAT-3

KOMPSAT-3 (launched 17 May 2012)

- **Highest bits per pixel** of commercial imagery (**14 bits per pixel**)
Better color balancing and data extraction from shadow areas
- Only VHR multispectral sensor with **afternoon orbit (1:30 pm)**
approx. 2 hours later than other VHR satellites
- Collection capabilities: **300,000 km²** per day, stereo



Orbit	Sun-synchronous 685 km, 13:30 ascending	Dynamic Range	Pan + MS: 14-bits per pixel
Spectral Bands	1 Pan 4 standard VNIR	Native Spatial Resolution (at nadir)	Pan 0.7 m Multispectral 2.8 m
Swath Width	16.0 km	Revisit Time	2.4 days at $\leq 1\text{m}$ GSD 3.8 days at $\leq 20^\circ$ off-nadir ($\leq 0.82\text{m}$ GSD)

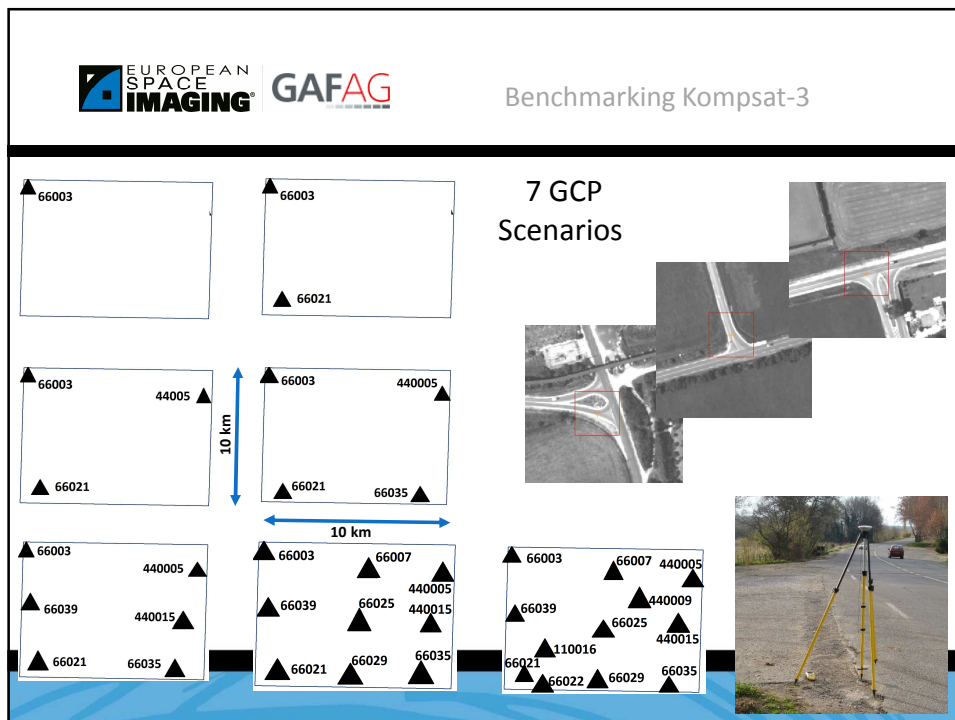
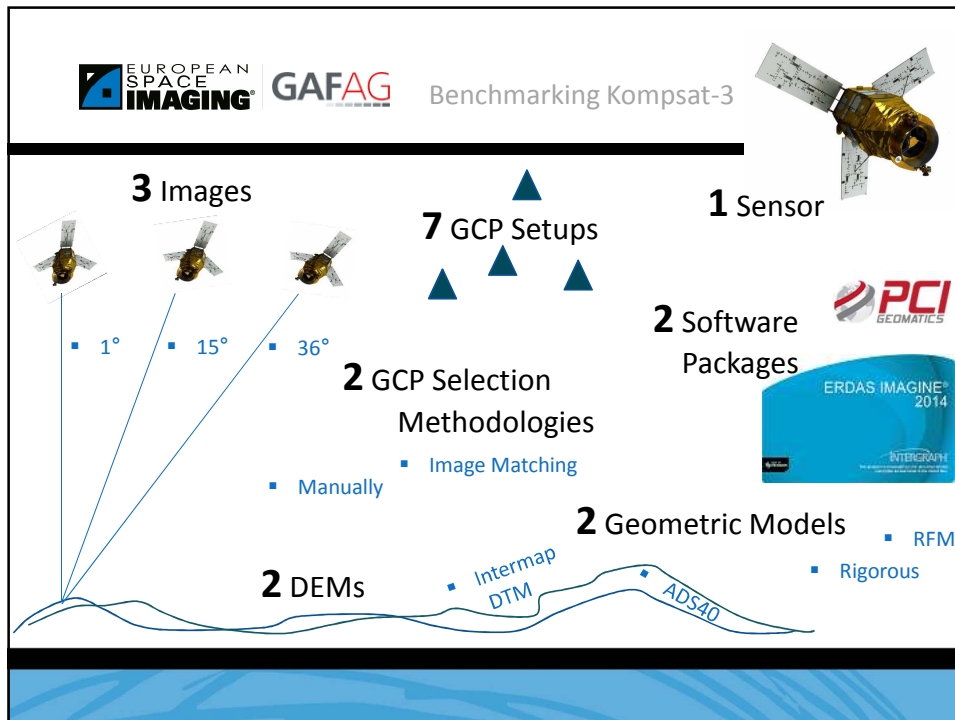


Benchmarking

Sensors and Methodology



Samuel Bärtsch, GAF AG



Adapting GCPs

„Classical“ Methodology –
 according to JRC „best practice“ Guidelines

 Adapting GPS Field Measurements
 manually to Images:

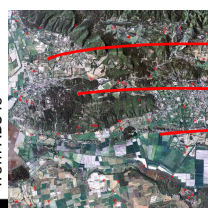
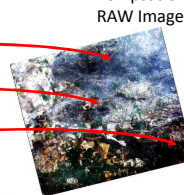
- Lengthy
- Sometimes hard to identify
- Limited repeatability (Operator specific)

„New“ Methodology –
 using PCI Geomatics' AutoGCP Tool

 Automatic Image-to-Image Matching
 to ADS40 Aerial Ortho Mosaic

- Fast
- More AOIs possible
- Repeatable (standardized)

new_ID	Easting_m	Northing_m	Ellips_He
110001	636327.864	4842638.669	52.144
110005	637518.944	4845752.916	97.808
110013	639418.256	4840602.349	68.608
110014	642889.226	4843376.953	119.93
110016	638647.342	4839449.608	51.561
110020	644315.711	4845689.97	252.446
110022	645030.755	4841227.483	60.343
140001	636881.715	4845450.019	56.21
140002	639252.597	4845847.942	152.81
140003	640999.134	4845715.569	153.48
140004	643544.233	4845535.279	197.24
140005	645815.166	4845076.105	176.54
140006	637241.307	4843631.124	56.87
140007	640019.09	4843239.849	94.91


 Reference Chip Database
 from ADS40

 Kompsat-3
 RAW Image


Scenario Configuration for the Benchmark

COTS	Sensor Model – Phase 1	Number of GCPs	DEM	ONA 1°	ONA 15°	ONA 36°
PCI Geomatica OrthoEngine 2013 Classic & New Methodology	Rational Function Model (0 order polynomial)	0	INTERMAP5mDTM/ DSM ADS40*	X	X	X
		1		X	-	-
		2		X	-	-
		3		X	X	X
		4		X	X	X
		6		X	-	X
	Toutin's Rigorous Model	9		-	-	X
		12		-	-	X
		6		X	X	X
		9		X	X	X
		12		X	X	X
		0		X	X	X
Intergraph Erdas Imagine 2013 Classic Methodology	Rational Function Model (0 order polynomial)	1	INTERMAP5mDTM/ DSM ADS40*	X	-	-
		2		X	-	-
		3		X	X	X
		4		X	X	X
		6		X	X	X
		9		-	-	X
		12		-	-	X
		0		-	-	X

*DSM ADS40 used only for 4GCPs, RPC0 in PCI Geomatics 2013 and Intergraph Erdas 2013

In Total 64 Orthoimages have been delivered to JRC for the EQC








Benchmarking

EXTERNAL QUALITY CONTROL OF
KOMPSAT-3 by JRC



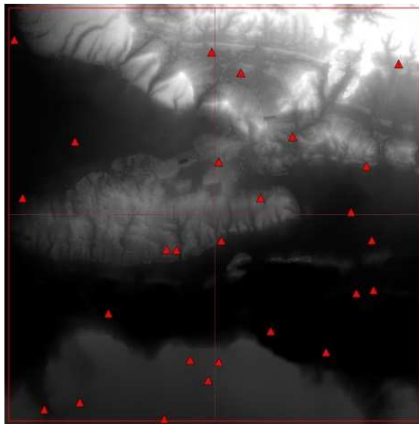
Blanka Vajssova, JRC



EXTERNAL QUALITY CONTROL OF KOMPSAT-3 by JRC

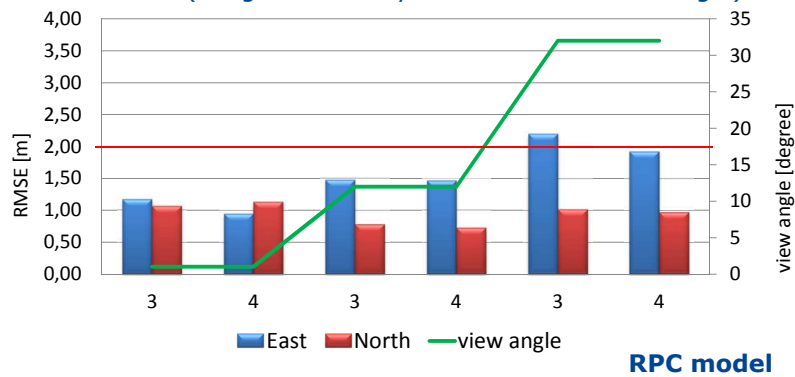
Ancillary data and method

- 64 orthoimages tested
- factors assed:
 - off nadir angle
 - software
 - 3D geometric correction
 - number of GCPs
 - DEM
 - GCPs detection method
- 20 to 26 ICPs were used with
(0.05m – 0.50m RMSE accuracy)



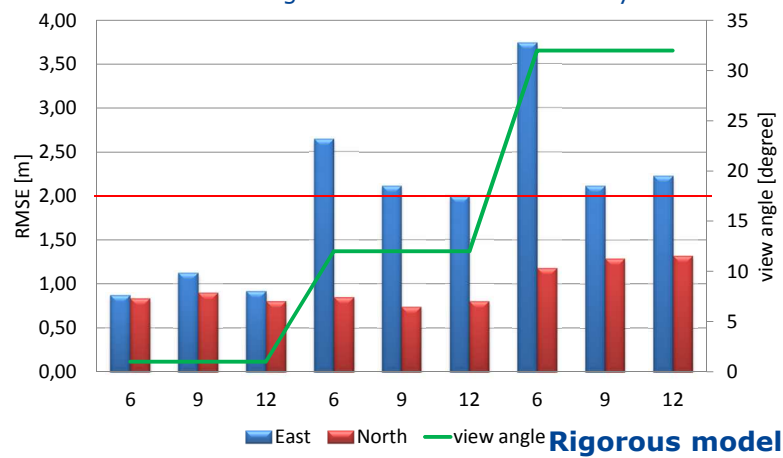
EXTERNAL QUALITY CONTROL OF KOMPSAT-3 Off nadir angle (1/2)

- sensitivity to increasing off nadir angle in the Easting direction
(a higher accuracy for a lower off nadir angle)



Off nadir angle (2/2)

- More GCPs in the rigorous model less sensitivity

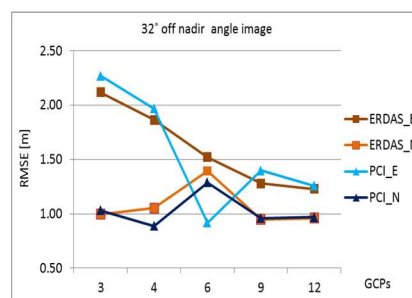
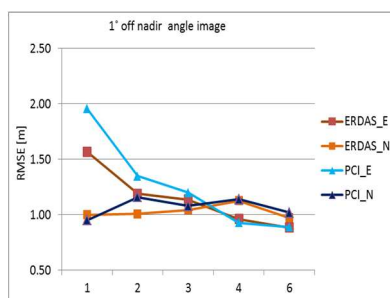




EXTERNAL QUALITY CONTROL OF KOMPSAT-3 Software, number of GCPs (1/2)

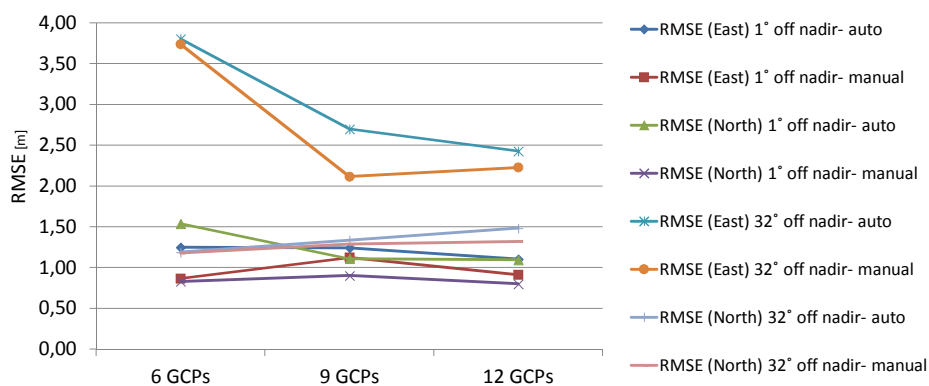
- Overall the accuracy is practically software independent
- RMSEs in the Easting direction are sensitive to the number of GCPs
- RMSEs in the Northing direction have a steady trend

RPC model



Software, number of GCPs (2/2)

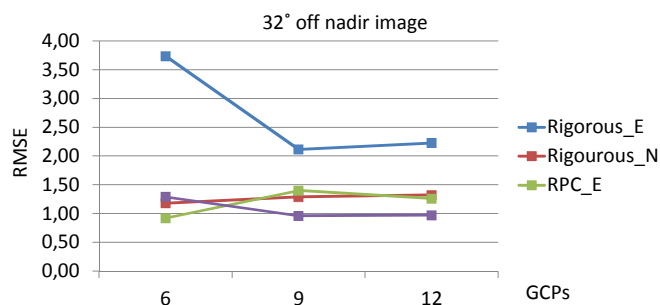
- Rigorous model – no clear correlation between RMSEs and number of GCPs
- Low off nadir angle – significant RMSE decrease from 6 to 9 GCPs





EXTERNAL QUALITY CONTROL OF KOMPSAT-3 3D geometric correction

- Very close ONA (1°) - both models give similar RMSE (around 1m)
- Higher ONA - rigorous model: significant increase of RMSE in the East component (up to 3.8m for 32° ONA)
- RPC model: RMSE around 2m when >3 GCPs used



EXTERNAL QUALITY CONTROL OF KOMPSAT-3 DEM, GCPs detection methodology

- Minimal difference found between DTM INTERMAP 5m and DSM ADS40 as for an influence on a horizontal accuracy
- Standard x Alternative methodology
 - RPC model:* close off nadir angle – RMSEs similar to each other (± 16 cm)
 - far off nadir angle - RMSE differences vary within 70 cm, results are inconclusive
 - Rigorous model:* standard manual method gives better result (max difference around 0.6m)



EXTERNAL QUALITY CONTROL OF KOMPSAT-3 Conclusions and recommendations

- geometric accuracy meets the requirement of 5 m 1D RMSE corresponding to the VHR backup profile
- geometric accuracy meets the requirement of 2 m 1D RMSE and $GSD \leq 0.75m$ corresponding to the VHR prime profile, on condition that:
 - off nadir acquisition angle max. 13° - 14°
 - RPC model with 3 GCPs (and more) are used
 - rigorous model with 12 (and more) GCPs are used



WorldView-3 – 30 cm resolution