

New RapidEye Image Products

Horst Weichelt, Scott Douglas, Massimiliano Vitale,
Frederik Jung-Rothenhäusler | RapidEye AG, Germany

Presented at JACIE 2011, Boulder CO

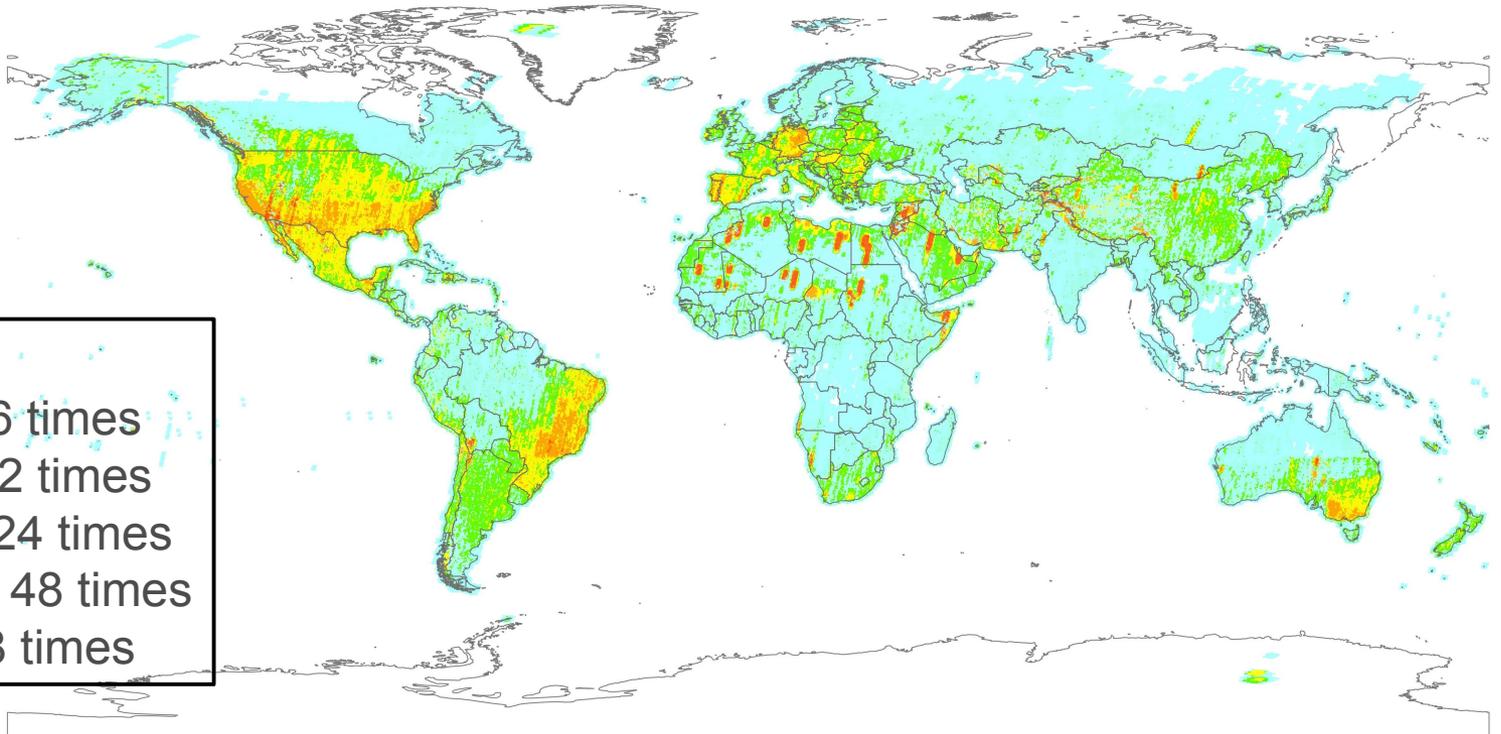
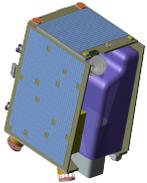
Content of the Presentation

1. New RapidEye image products and improvements to existing products

- Improved cloud masking
- Improvements of the positional accuracy
- RapidEye image mosaics

1. RapidEye's next satellite generation

RapidEye Acquisition Update



Legend:

Blue	1 – 6 times
Green	6 – 12 times
Yellow	12 – 24 times
Orange	24 – 48 times
Red	> 48 times

Since becoming operational in Feb. 2009, RapidEye acquired and archived imagery of more than **1.7 billion km²** of the Earth's surface, among them 1.3 billion km² with cloud cover below 20% (about 10 times the solid globe area)

Improved Cloud Detection

Current situation:

Existing algorithm “Cloud Cover Assessment” (CCA) underestimates cloud cover in temperate zones, and overestimates cloud cover in desert regions

Goal for cloud detection improvement:

- Improve cloud detection for small scattered clouds
- Improve cloud detection for bright uniform areas (e.g. deserts)
- Include the functionality of potential detection of cloud shadows and haze into the process

Currently there is no intention to add haze and cloud shadows separately into the cloud mask, but only to add the haze area to the clouds

Improved Cloud Detection

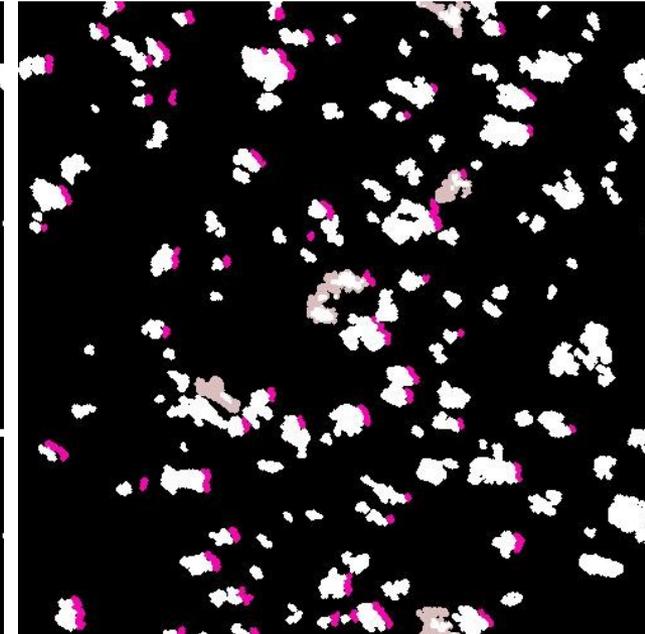
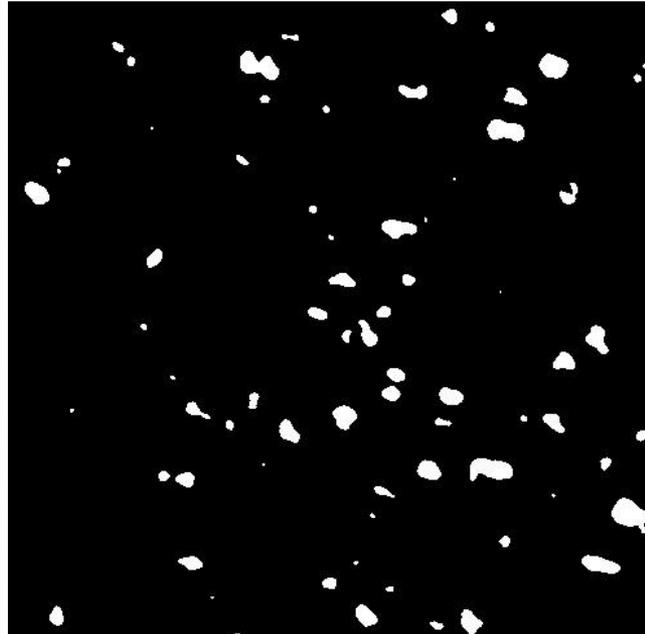
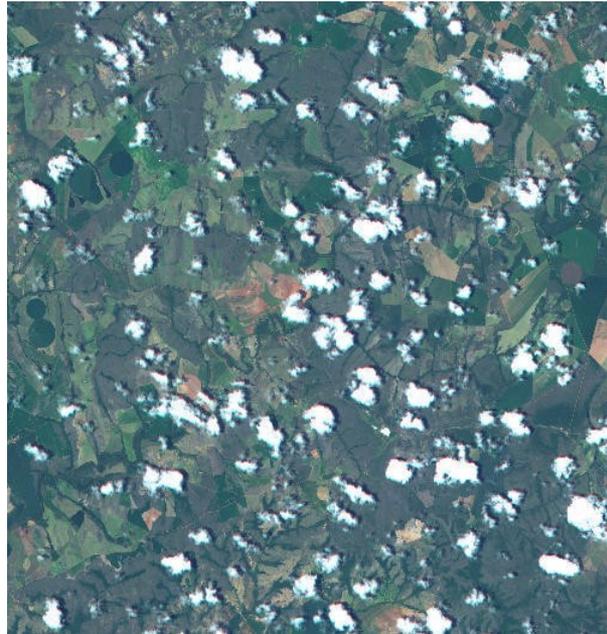
Improvement of the cloud detection process:

New solution “Enhanced Cloud Detection System” (ECDS) is more reliable for scattered cloud situations in heterogeneous landscapes

Image ID: 2575115

CCA: 4%

ECDS: 13% + 1% shadow



(white = cloud, red = shadow)

Improved Cloud Detection

Improvement of the cloud detection process:

New solution “Enhanced Cloud Detection System” (ECDS) is more reliable for situations with haze

Image ID: 2574465

CCA: 1.5%

ECDS: 3% + 1% shadow
+ 7% haze



(white = cloud, red = shadow, rose = haze)

Improved Cloud Detection

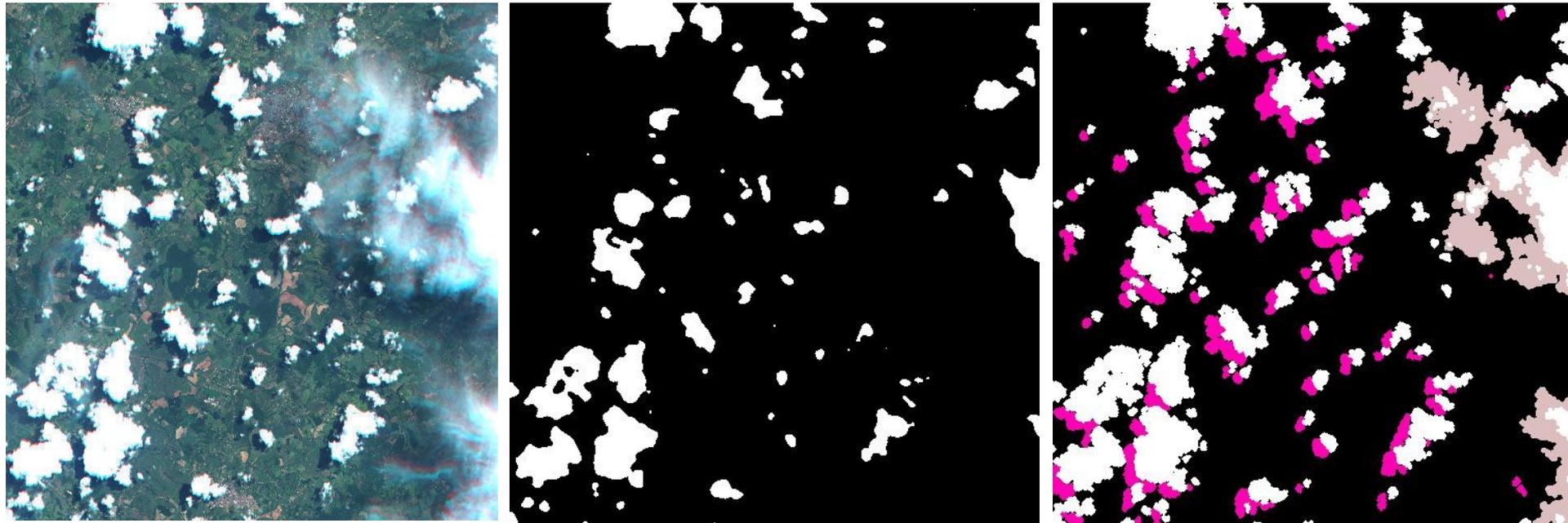
Improvement of the cloud detection process:

New solution “Enhanced Cloud Detection System” (ECDS) is more reliable for situations with haze and clouds

Image ID: 2616081

CCA: 11 %

ECDS: 18% + 6%
shadow + 6% haze



(white = cloud, red = shadow, rose = haze)

Improved Cloud Detection

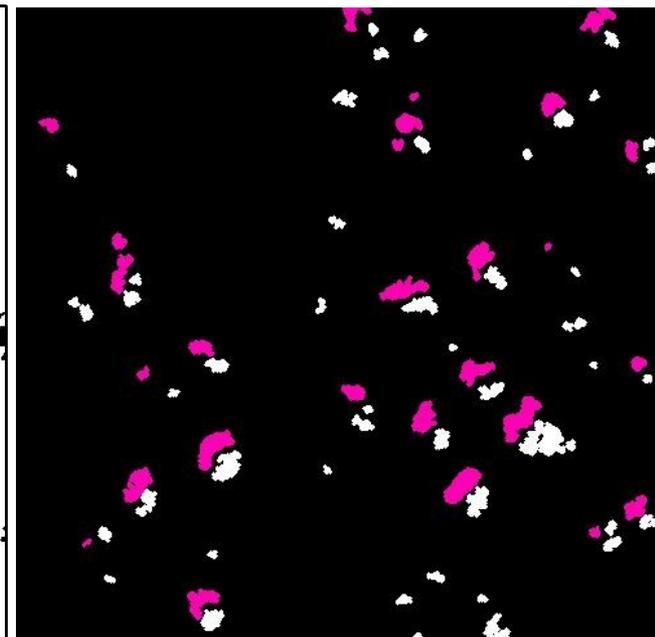
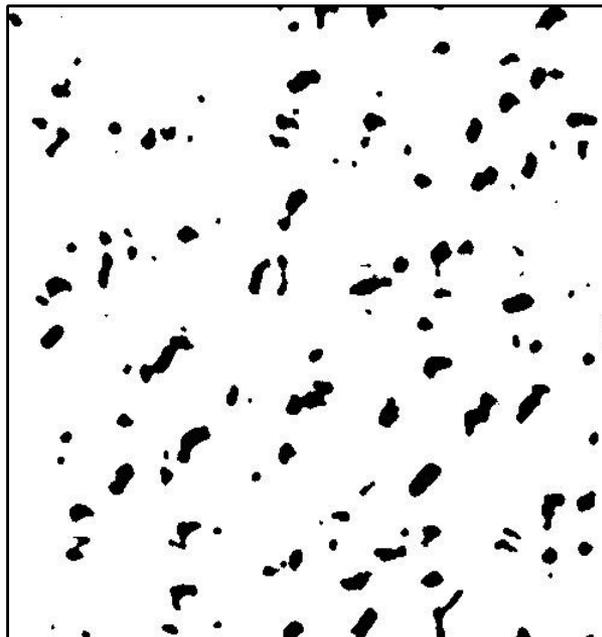
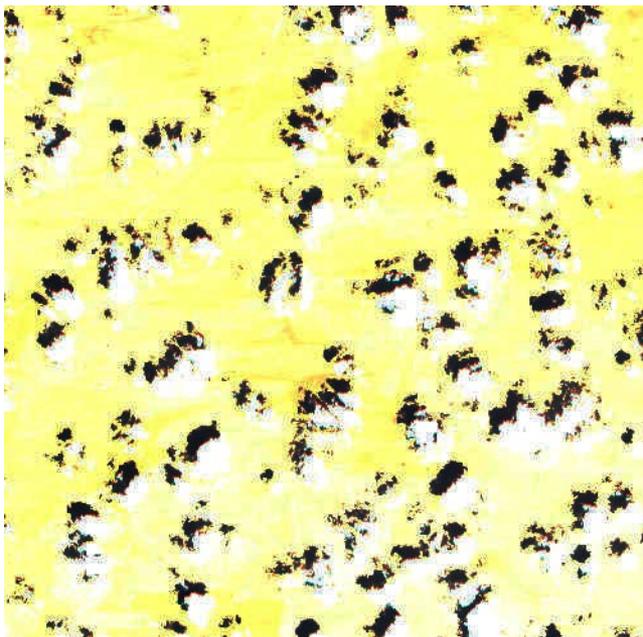
Improvement of the cloud detection process:

New solution “Enhanced Cloud Detection System” (ECDS) is more reliable for detecting clouds over deserts

Image ID: 2764900

CCA: 95.5%

ECDS: 2% + 2% shadow



(white = cloud, red = shadow)

Improvement of the positional accuracy

Background:

- Initial positioning and ortho–rectification of RE standard image products is based on a proprietary large **global GCP database**
- Positional accuracy strongly depends on **GCP accuracy**
- GCPs come from different sources, for most parts of the world the Landsat based GeoCover 2000 mosaic was used
- In previous JACIE conferences was shown that for some regions the GeoCover 2000 GCPs are less accurate, that in turn causes problems with the positional accuracy of the RapidEye standard image products

RapidEye decided to replace GeoCover2000 based GCPs in the database step by step by GLS2000 GCPs or other local sources where available.

Improvement of the positional accuracy

Assessment of the positional accuracy improvement

- Assessment was done for **normal image takes** out of the production process. Area selected for the assessment was **Brazil**.
- **Relative positional accuracy** was determined by evaluating the RMSE of all GCPs within one modeling interval of an image take.
- **Absolute positional accuracy** was determined using external GCPs provided by a Brazilian technical partner of RapidEye (Santiago & Cintra) for this assessment.

Improvement of the positional accuracy

Relative Accuracy Assessment

GeoCover2000 GCPs (red)

Total number of Model Intervals evaluated: 1564

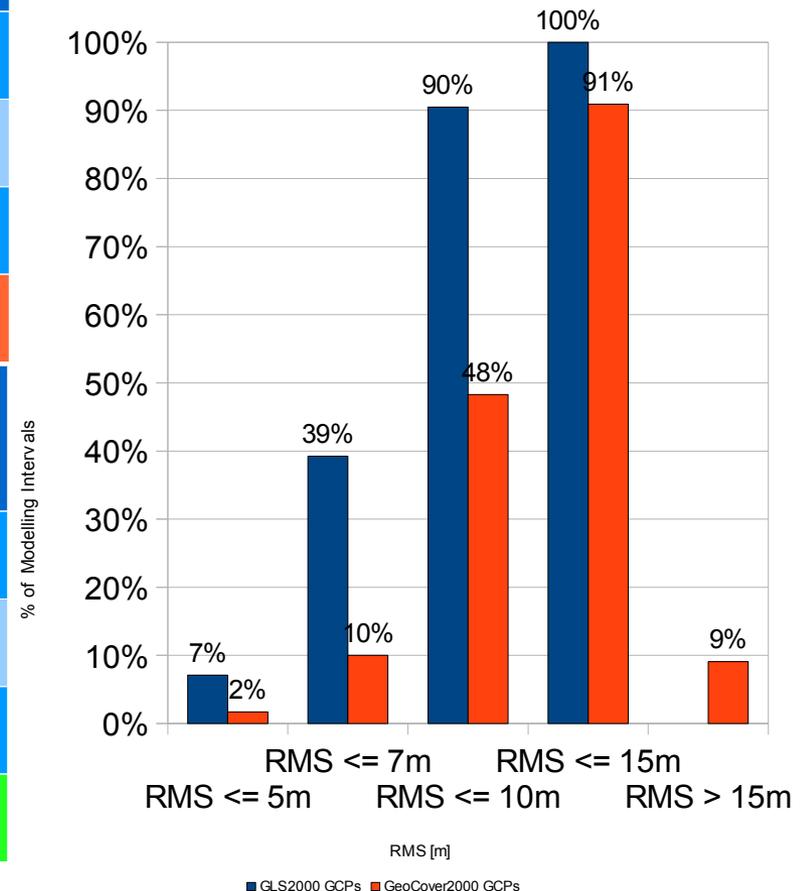
< 5m	5 to 7m	7 to 10m	10 to 15m	> 15m
22	108	498	555	118
< 5m	< 7m	< 10m	< 15m	> 15m
2%	10%	48%	91%	9%

GLS2000 GCPs (blue)

Total number of Model Intervals evaluated: 1564

< 5m	5 to 7m	7 to 10m	10 to 15m	> 15m
111	503	801	149	0
< 5m	< 7m	< 10m	< 15m	> 15m
7%	39%	90%	100%	0%

RMS errors with different types of GCPs



Tables show the number or percentage of model intervals

Improvement of the positional accuracy

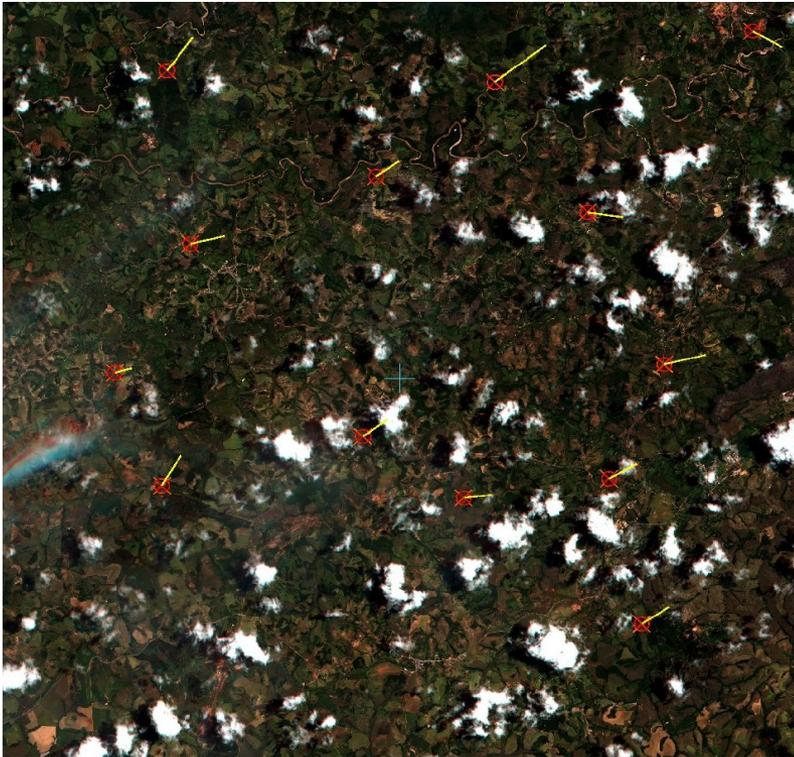
Results of the Relative Accuracy Assessment

- Measure for fit of different, e.g. adjacent, image products relatively to each other, does not reflect an overall absolute shift in location.
- GeoCover 2000 GCPs (“old”): **< 50%** of all image products **< 10 m** rel. accuracy (2 pixels), 10% above 15 m (3 pixels)
- New GLS2000 based GCPs: **90%** of the image products **within the < 10 m** range, nearly 40% even better 7 m (less 1.5 pixels).

Improvement of the positional accuracy

Absolute Accuracy Assessment

- Assessment done for 11 image products at 4 selected locations (tiles) with 8 to 15 reference GCPs for each tile
- Error bars shown in examples below magnified by factor 100



Improvement of the positional accuracy

Assessment of the Absolute Accuracy – Single Product

RefEasting	RefNorthing	OrthoEasting	OrthoNorthing	DeltaEasting	DeltaNorthing	δ_x^2	δ_y^2	$\text{SQRT}((\delta_x)^2+(\delta_y)^2)$
552760.06	7670101.49	552752.03	7670090.56	8.03	10.93	64.50	119.46	13.56
571018.49	7671395.10	571009.18	7671400.54	9.32	-5.44	86.79	29.59	10.79
567567.75	7651965.36	567559.25	7651959.72	8.50	5.64	72.24	31.81	10.20
551130.15	7660198.34	551124.82	7660196.84	5.33	1.50	28.36	2.25	5.53
568271.51	7660476.71	568258.49	7660473.58	13.02	3.13	169.50	9.80	13.39
562985.32	7669735.61	562969.35	7669723.50	15.97	12.11	255.06	146.65	20.04
553498.44	7664436.44	553487.77	7664433.86	10.67	2.58	113.93	6.66	10.98
565877.41	7665467.60	565866.49	7665469.20	10.92	-1.60	119.24	2.56	11.04
558874.08	7658105.20	558866.56	7658099.62	7.51	5.58	56.47	31.14	9.36
552600.23	7656502.43	552594.18	7656492.51	6.05	9.92	36.65	98.41	11.62
566541.06	7656717.17	566532.42	7656712.40	8.63	4.77	74.55	22.75	9.86
559276.05	7666641.67	559268.76	7666636.66	7.29	5.01	53.14	25.10	8.85
562018.11	7656088.36	562009.22	7656087.34	8.88	1.02	78.94	1.04	8.94
MEANx	MEANy	MEANcom	RMSEx	RMSEy	RMScom	StdDevx	StdDevy	StdDevCom
9.24	4.24	10.17	9.65	6.37	11.56	2.76	4.75	5.50

Improvement of the positional accuracy

All tested 3A products processed with the new GCPs meet the positional accuracy 1:50.000 with more than 10% margin, 8 of the 11 products with more than 20% margin.

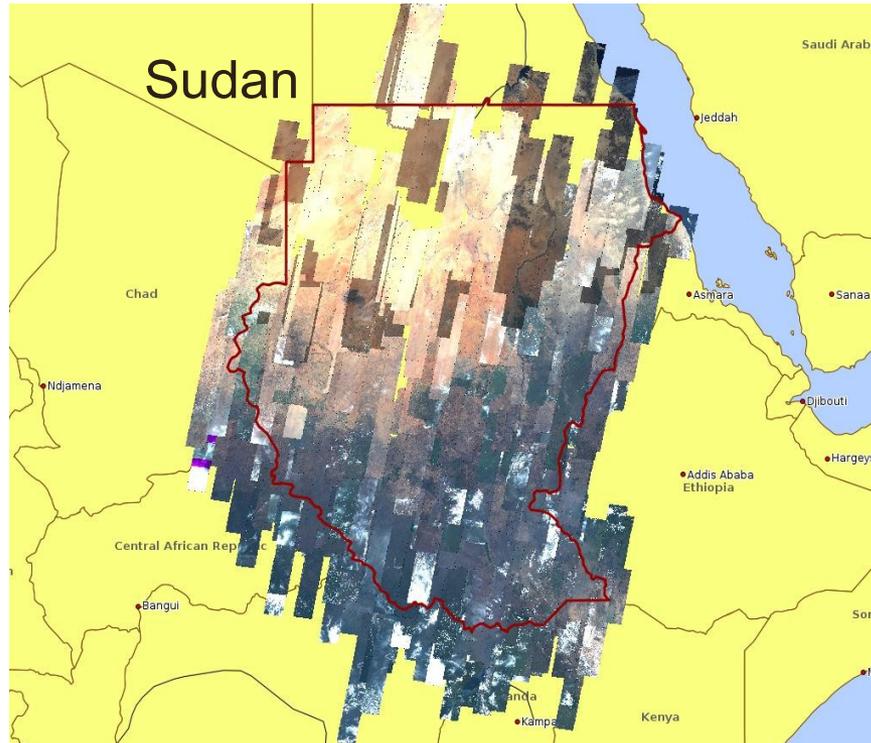
Product	NMAS MAP SACLE	NAMS CE90 (m)	RMSCom (m)	Mean Combined
	1:50,000	25,40	16,74	
IMG_0000-000-250-335	1:34528	17.54	11.56	10.17
IMG_0000-000-250-332	1:34737	17.64	11.63	8.17
IMG_0000-000-250-337	1:19295	9.8	6.46	5.82
IMG_0000-000-250-330	1:16607	8.43	5.56	3.04
IMG_0000-000-250-328	1:14576	7.4	4.88	1.34
IMG_0000-000-250-336	1:44564	22.63	14.92	11.72
IMG_0000-000-250-334	1:43698	22.19	14.63	12.39
IMG_0000-000-250-327	1:41786	21.22	13.99	10.00
IMG_0000-000-250-333	1:35066	17.81	11.74	9.73
IMG_0000-000-250-329	1:38232	19.42	12.80	9.85
IMG_0000-000-250-331	1:31661	16.08	10.60	6.38

New RapidEye Image Product Line: Mosaics

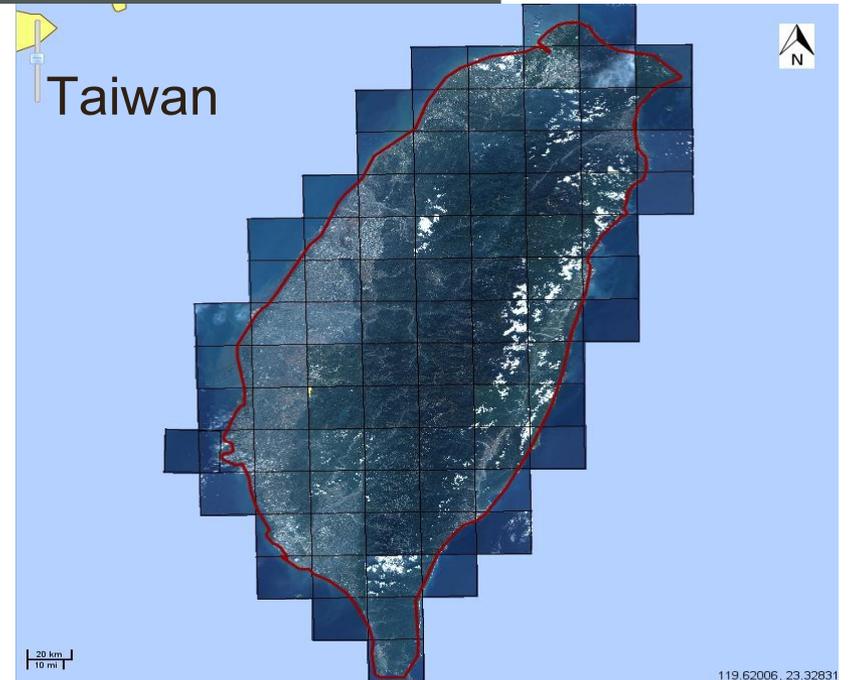
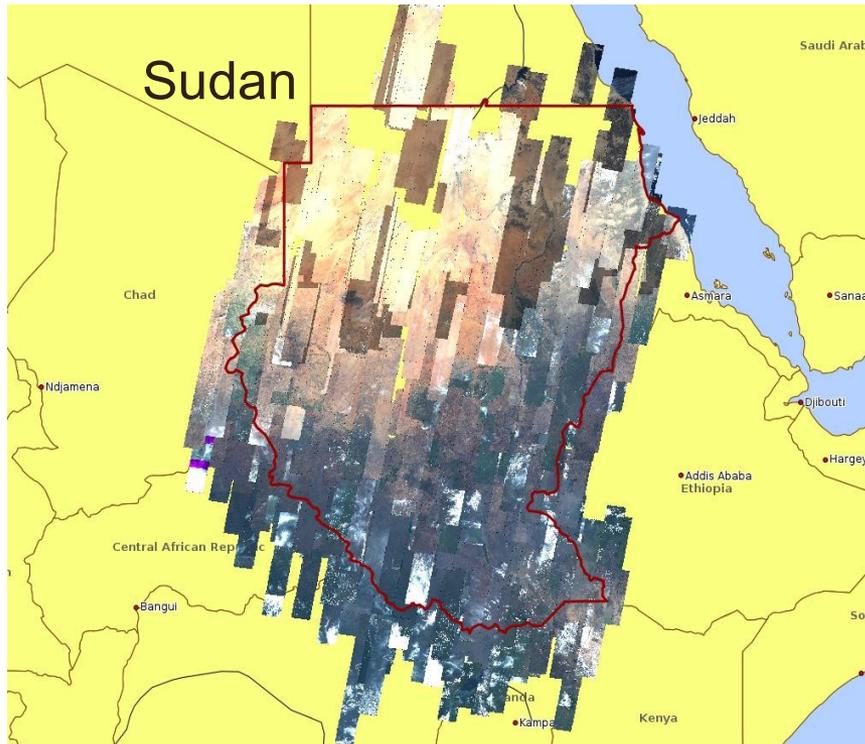
The mosaic products specification (not finalized) are:

- 3 band RGB 8-bit image, or 5 band with 16 bit image
- Five (5) meter pixel spacing
- Top quality color balancing with top quality feature adjustments, i.e. roads, rivers, etc are all connecting correctly
- Nearly cloud-free (less 5% except for tropical areas)
- Absolute Locational accuracy to within 2-3 pixels (depends on accuracy of the ground control points)
- Custom tiling and/or projection available
- Expected size of mosaics from “District Level” to “Several Countries Level”

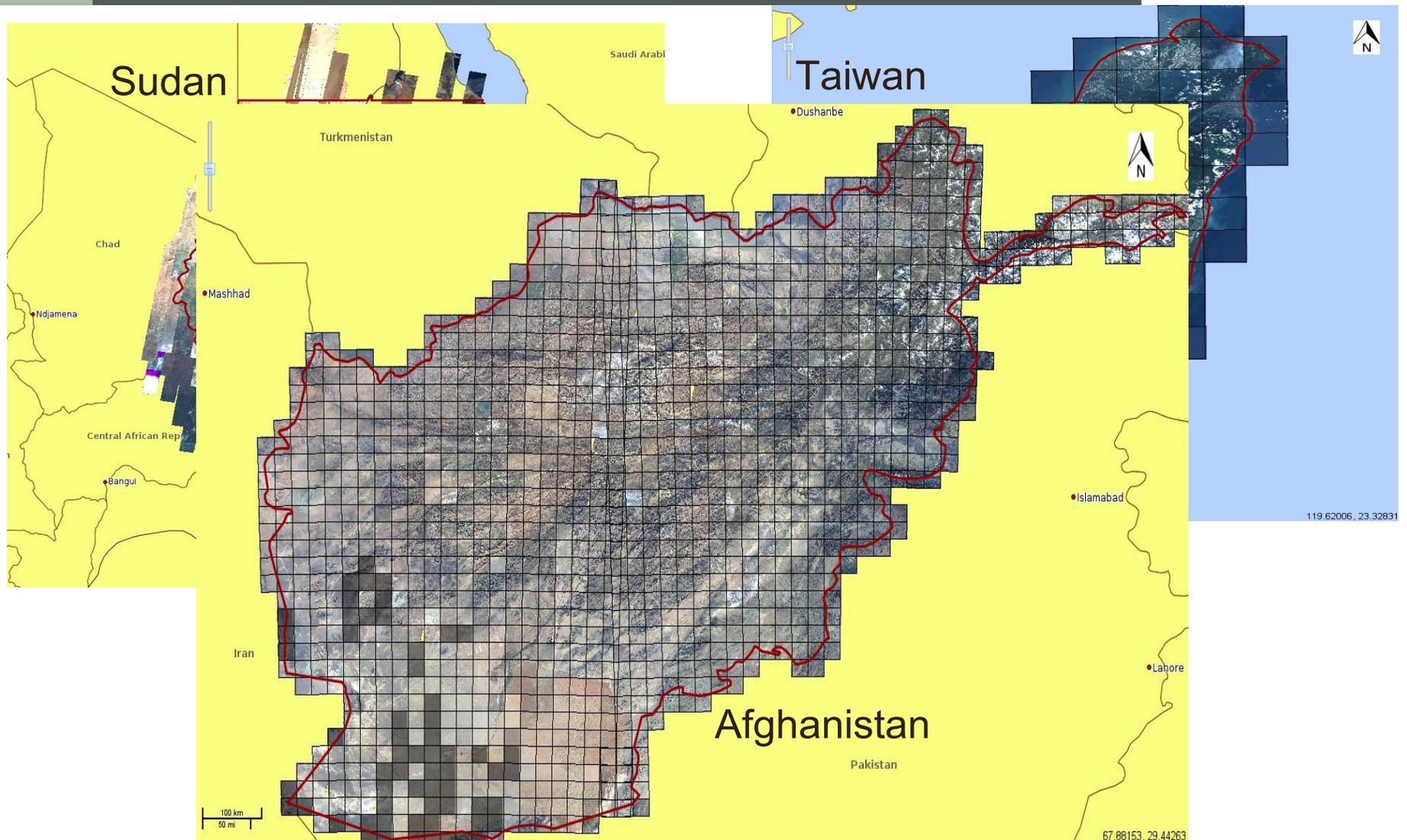
Mosaicking – Image Coverage



Mosaicking – Image Coverage



Mosaicking – Image Coverage



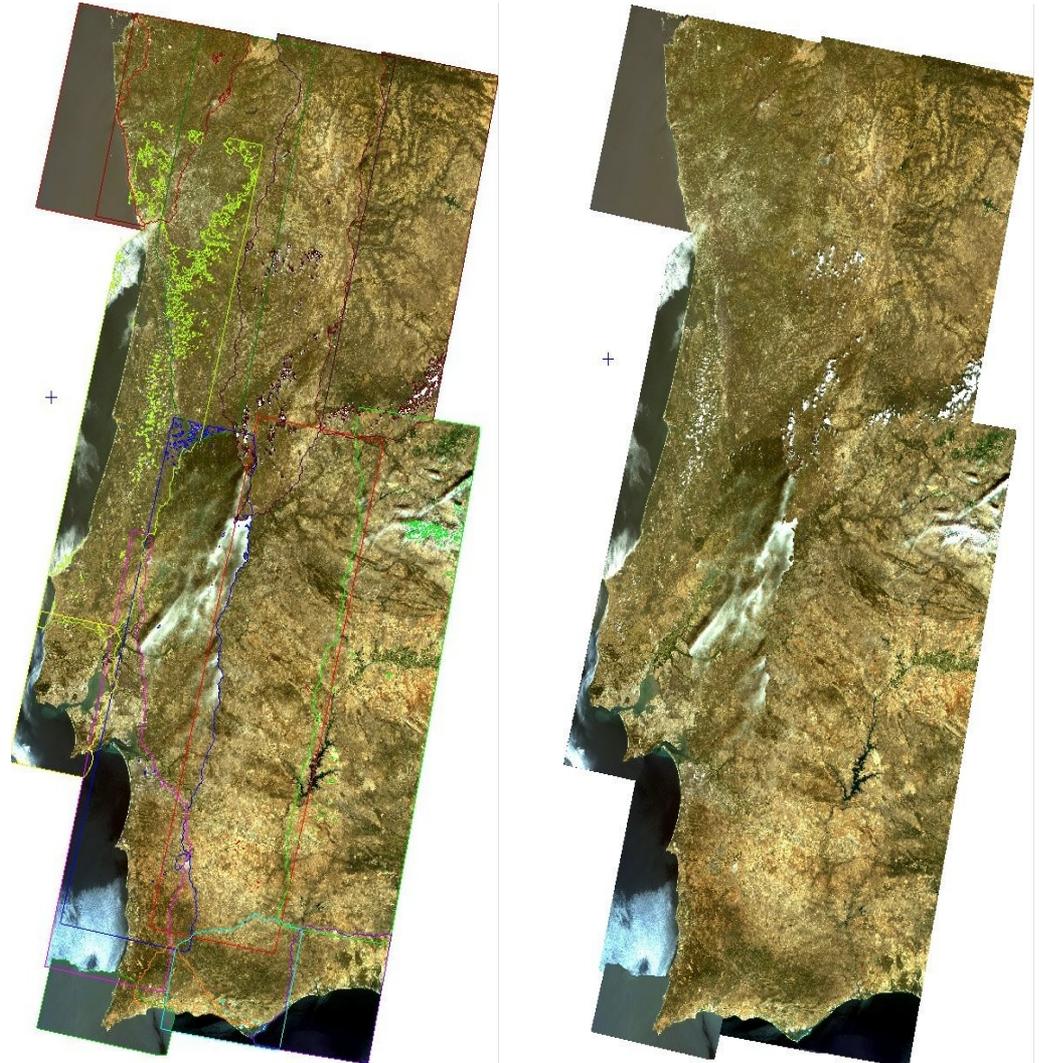
New RapidEye Image Product Line: Mosaics

Test example of mosaic generation

Test data for mosaic
taken over Portugal

Acquisition window was
a 10 week period in
Summer 2009

For 2010 another
coverage of Portugal
(not shown) available
from a 10 week
period in Spring 2010



New RapidEye Image Product Line: Mosaics

Subset of the Test example of mosaic generation

- Coastal area shown in the subset contains several image takes
- Tide effects cause different water levels visible in the bright sand at the shore line



New RapidEye Image Product Line: Mosaics

Subset of the Test example of mosaic generation

- Color balancing is done using automatically generated cutlines
- There are no visible differences in the mosaics on land surface



New RapidEye Image Product Line: Mosaics

Subset of the Test example of mosaic generation

- Color balancing is done using automatically generated cutlines
- There are no visible differences in the mosaics on land surface



New RapidEye Image Product Line: Mosaics

Mosaics – Current and Next RapidEye Activities

- Selection of software provider completed Done
- Start Implementation project Done
- On site installation Done
- Final acceptance End April
- Start of production May

RapidEye – 2nd Generation

RapidEye has started engineering work to prepare, develop and procure the satellites of the 2nd generation

Major objective is to find a balance between

- Stability and long-term comparability of the current imagery
- Innovation and consideration of updating current user requirements

Concept of the RapidEye business plan:

- Generate reliable, fast, and efficient information services
- Provide our customers with most up to date satellite imagery

Customer Needs Drive Technical System Design

- Guaranteed data availability, low risk of failure
- Large and repetitive area coverage
- Daily accessibility of any point on the globe
- High ground resolution (range between 5 to 8 m)
- Immediate processing of data to extract customer information
- High repetition rate for multi-temporal analyses
- High value for low cost

Preliminary Studies (started already in 2008/2009)

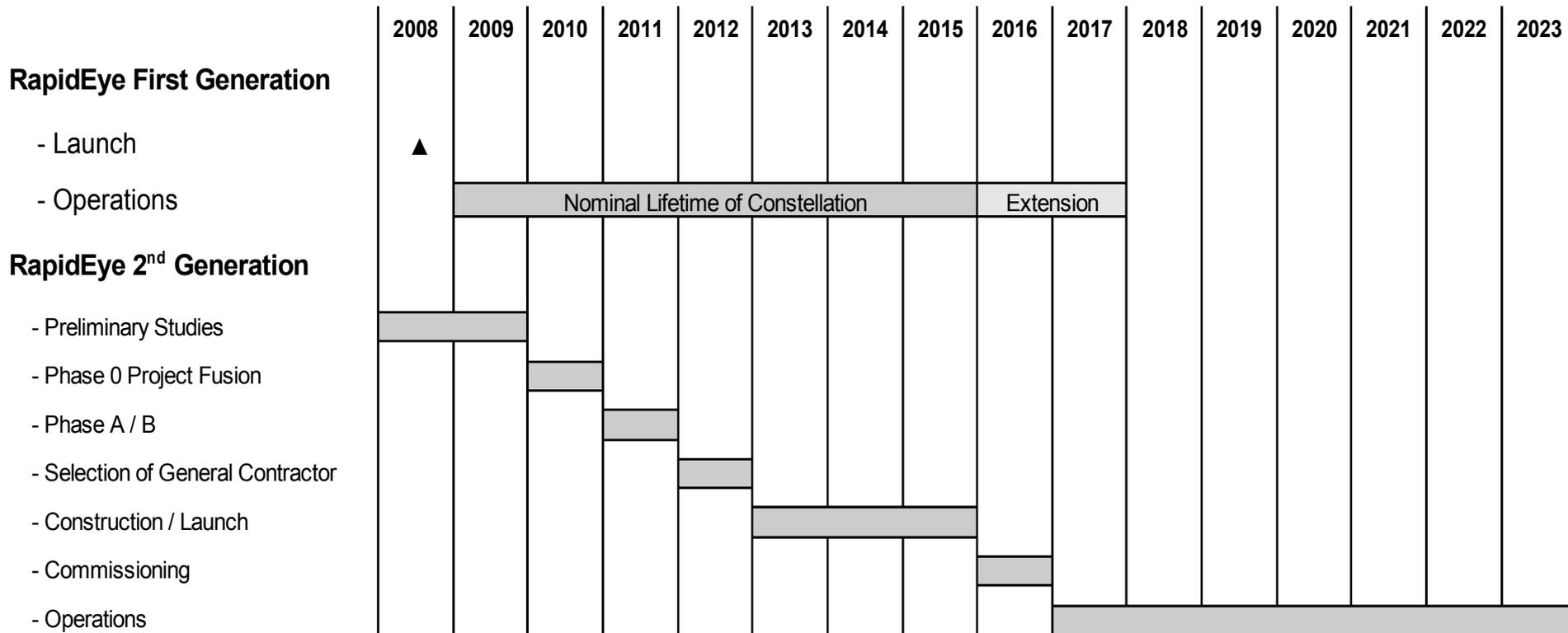
- Lessons learned evaluation by engineering-, operations- and project management team conducted in regular intervals during build, commissioning and operational phases.
- Customer feedback and market evaluation is standard business practice.
- Cooperation with scientists and technical partners provide new insights.

Phase 0 Study (2010)

- In close cooperation with an industrial team and funding support of the German Space Agency DLR
- First analysis of sensor as well as system requirements
- Further in depth analysis foreseen in Phase A

RapidEye – 2nd Generation

ROM Schedule



Summary RapidEye 2nd Generation

- System continuation is a requirement of the RapidEye business model.
- First potential system improvements have been identified. The technical design, e.g. spectral bands, capacity etc. are not fully defined yet.
- Transition period foreseen  operating both constellations in parallel
- Data policy and data access will be a continuation of the current business model.
- **RapidEye intends to ask all interested current and potential users of RapidEye data to participate within the requirements discussion.**

Thank You

contact: weichelt@rapideye.de