



GAFAG

ESA TRAINING COURSE ON RADAR AND OPTICAL REMOTE SENSING

Vilnius/LITHUANIA, 3-7 July, 2017

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GAF AG



Agenda

- Introduction

Theoretical part

- Current developments in space sector
- Examples from Landcover/ Landuse and Forest mapping projects
- Sentinel-2 Facts and Figures (Specs, Coverage,...); how to access and download Sentinel-2 scenes
- Change Detection

Practical part

- SNAP/Sentinel-2 Toolbox introduction (data import, mosaicing, color manipulation, data export, Reprojection, Band Select, Resampling, Subset , become familiar with Sentinel-2 bands and color combinations)
- Indice calculation (NDVI, NWI, NBRI)-Calculation with SNAP (QGIS)
- Classification with SNAP/QGIS
 - Unsupervised Classification
 - Supervised Classification



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Trends and Developments in Commercial Satellite Imaging

More than 1000 Satellites in Earth Orbit!

Weather

Communication

Navigation

Research

Astronomy

Reconnaissance

Earth-Observation

Source: ESA

(nonexhaustive) Selection of Earth Observation

Optical Systems

Resolution > 1m

- SPOT-5
- Aster
- IRS P5
- Rapideye
- ResourceSat-2
- SPOT-6/7
- Landsat-8
- ZY-3
- CBERS-4B
- Sentinel-2A/B
- [ALOS-3 \(2016\)](#)
- [EnMAP \(2018\)](#)

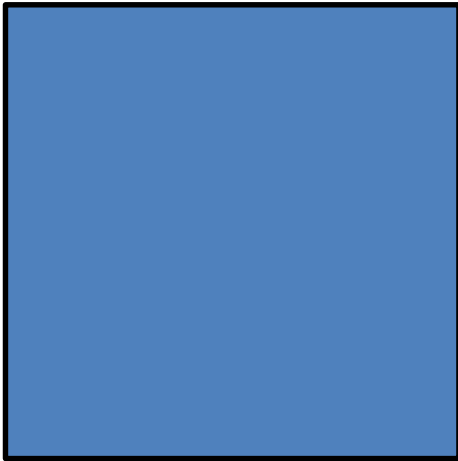
Resolution < = 1m

- Ikonos
- EROS-B
- Kompsat-2
- WorldView-1
- GeoEye-1
- WorldView-2
- Pléiades-1A/1B
- Kompsat-3 & 3A
- SkySat-1/2
- Deimos-2
- WorldView-3
- Asnaro-1
- WorldView-4

Radar Systems

- ERS / Envisat
- SRTM
- ALOS PALSAR
- Radarsat-2
- Cosmo-Skymed
- TerraSAR-X
- TanDEM-X
- Sentinel-1A
- Kompsat-5
- ALOS-2
- PAZ (2015)
- Sentinel-1B (2016)
- [RCM \(2018\)](#)

30 m

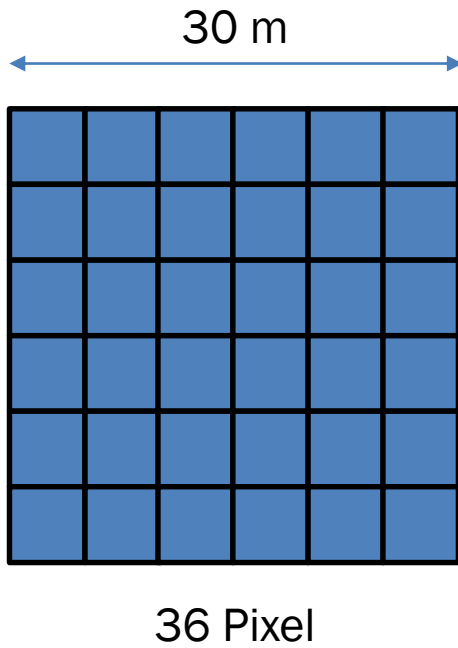


Example: Increasing Spatial Resolution (Munich)

Landsat TM: 30m, Natural Color



Scale:
1 : 100.000

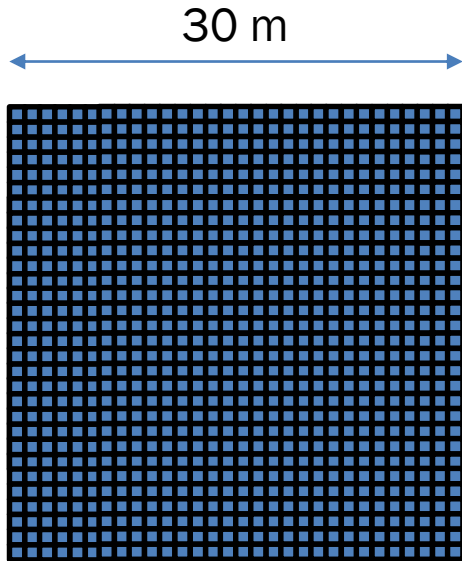


Example: Increasing Spatial Resolution (Munich)

IRS 1D: 5m, Natural Color Merge
© Euromap



Scale:
1 : 18.000



900 Pixel

Example: Increasing Spatial Resolution (Munich)

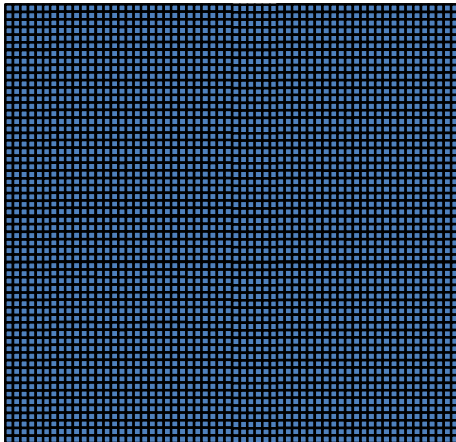
IKONOS: 1m, Natural Color Merge

© European Space Imaging



Scale:
1 : 5.000

30 m



3600 Pixel

Example: Increasing Spatial Resolution (Munich)

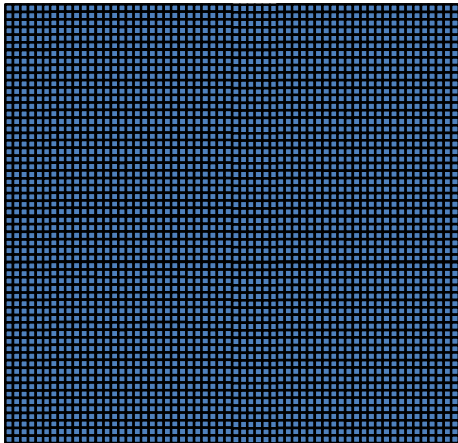
GeoEye-1: 0.5m, Natural Color Merge

© e-geos



Scale:
1 : 1.800

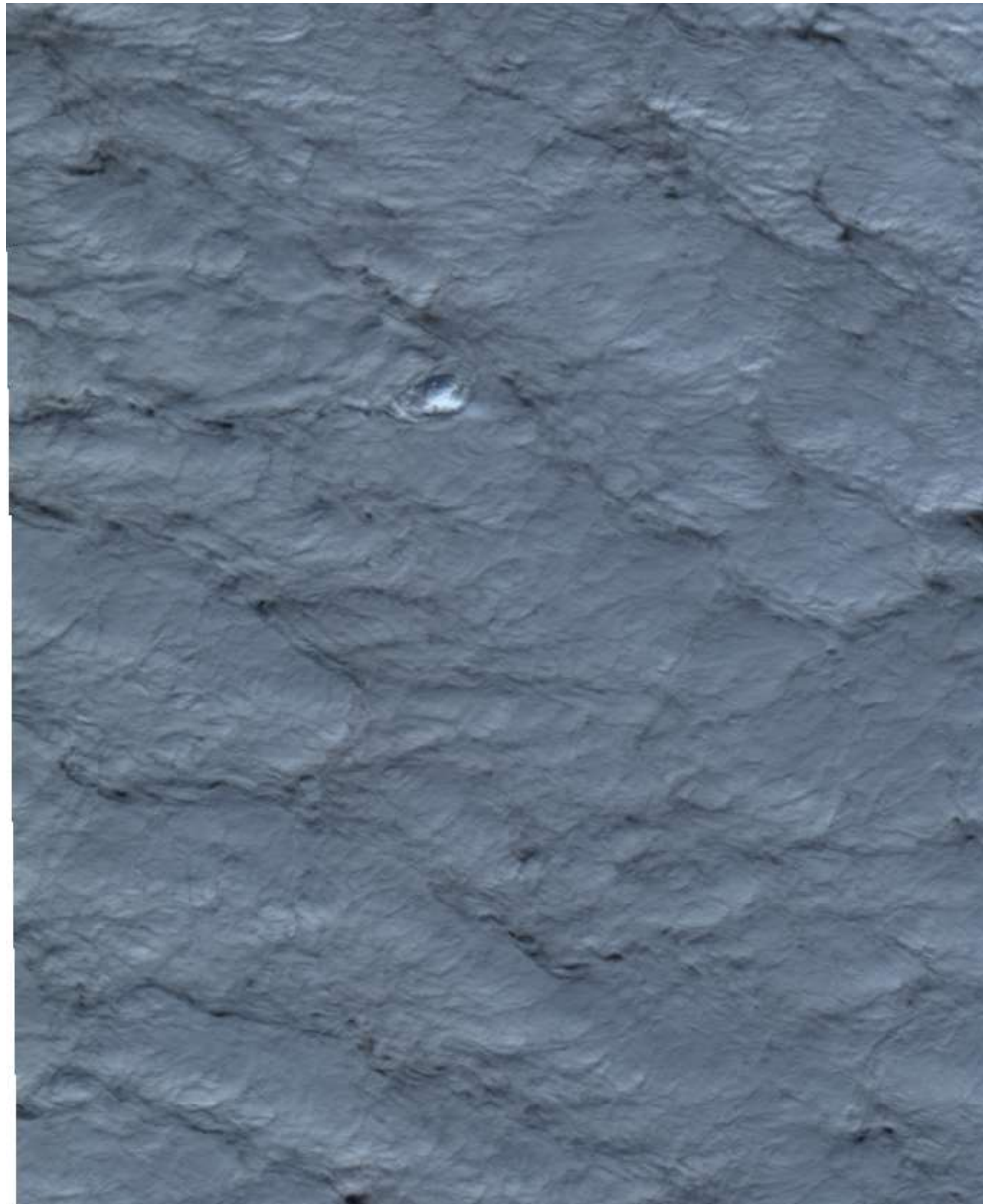
30 m



10000 Pixel

Example: Increasing Spatial Resolution (Munich)

WorldView-3: 0.3m



Scale:
1 : 1.000

WorldView-3 Image,
Airport Madrid,
Product Resolution 30cm
© DigitalGlobe 2014

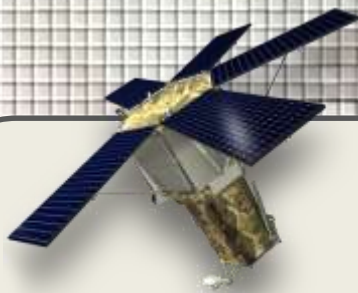

DigitalGlobe



WorldView-4 Image,
Sydney,
Product Resolution 25cm
© DigitalGlobe 2017



To be continued...



2016

DigitalGlobe
WorldView-4
30cm ?
25cm ?



2017

ImageSat
EROS-C
30cm ?



2018

IRS
CartoSat-3
25cm



Trend or Development: Better spatial Resolution

TerraSAR-X Staring Spotlight Mode

(Short Glance on Radar Sensors)



Trend: More Spectral Bands

Multi- and Superspectral Systems:

RapidEye: B, G, R, RedEdge, NIR

WorldView-2: Coastal, B, G, Yellow, R, RedEdge, NIR, NIR2

Landsat-8: Violet, B, G, R, NIR, Cirrus, SWIR1, SWIR2, TIR1, TIR2

WorldView-3: Coastal, B, G, Yellow, R, RedEdge, NIR, NIR2, 8 x SWIR, 12 x CAVIS

Sentinel-2: B, G, R, 4 x RedEdge, NIR, 2 x SWIR, 3 x ATM-Corr

Hyperspectral Systems:

EnMap: 228 Bands, 30m Resolution, Launch: 2018

Alos-3: HISUI 185 Bands, 30m Resolution, Launch: 2016

IRS HySIS: 272 Bands, 30m Resolution, Launch: 2016



Existing, or planned Constellations:

RapidEye: 5 Satellites

AirbusDS: Spot6/7 and Pléiades-1A/1B

Skybox: 24 SkySat Satellites

Airbus/hisdeSAT: TerraSAR-X, TanDEM-X and PAZ

Planet Labs: HR-Satellite Swarm 28+ Cubesats

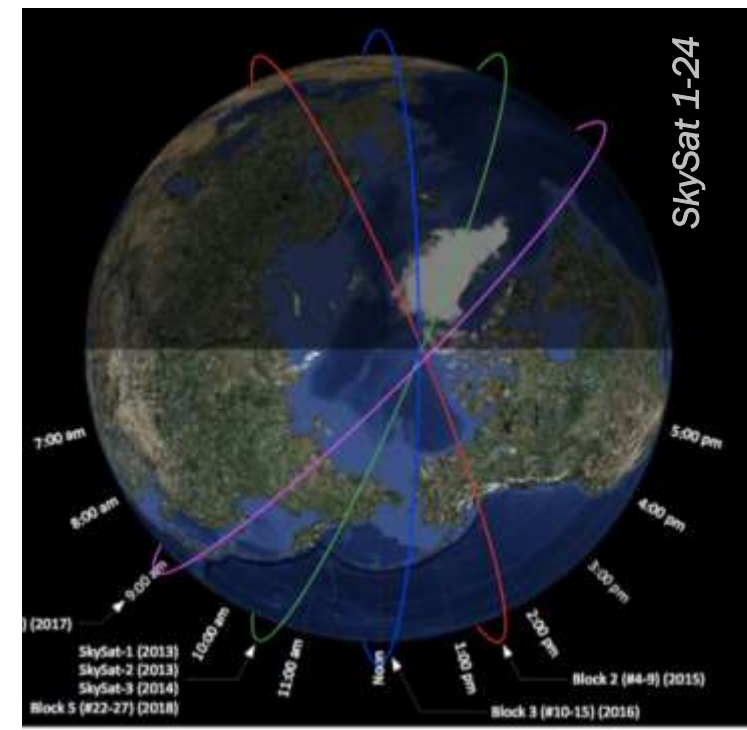
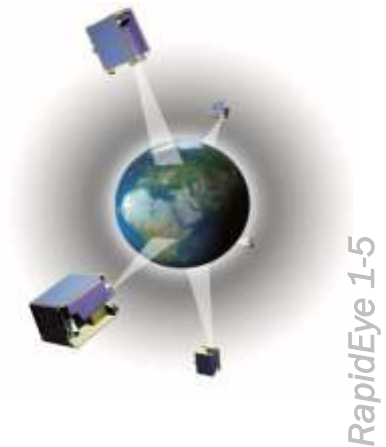
OmniEarth: 18 HR-Satellites from 2016

Dauria/Deimos: 8 HR-Satellites from 2016

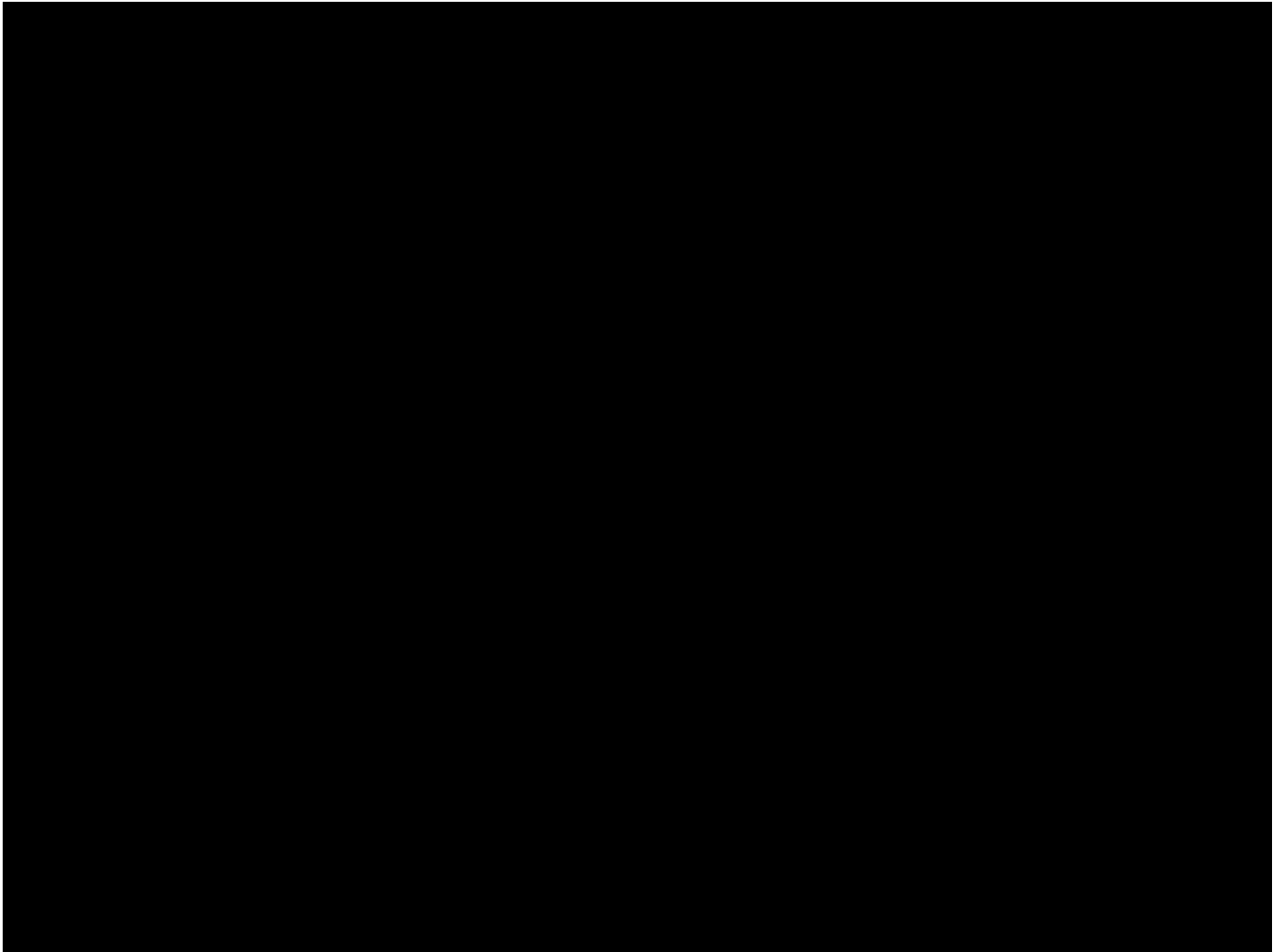
BlackSkyGlobal: ? Satellites from 2015

CanadianSpaceAgency: 3 x Radarsat from 2018

RapidEye+: 5 HR/VHR-Satellites from 2019



Skybox: 24 SkySat Satellites in 4 Orbits



Trend: Constellation of Satellites

Use Case: Country Mosaics in short Time Frame

RapidEye Mosaic of China in 6 Months



80% of the 7,8 Million km² have been captured from September 2009-Januar 2010 with less than 5% Cloud Cover

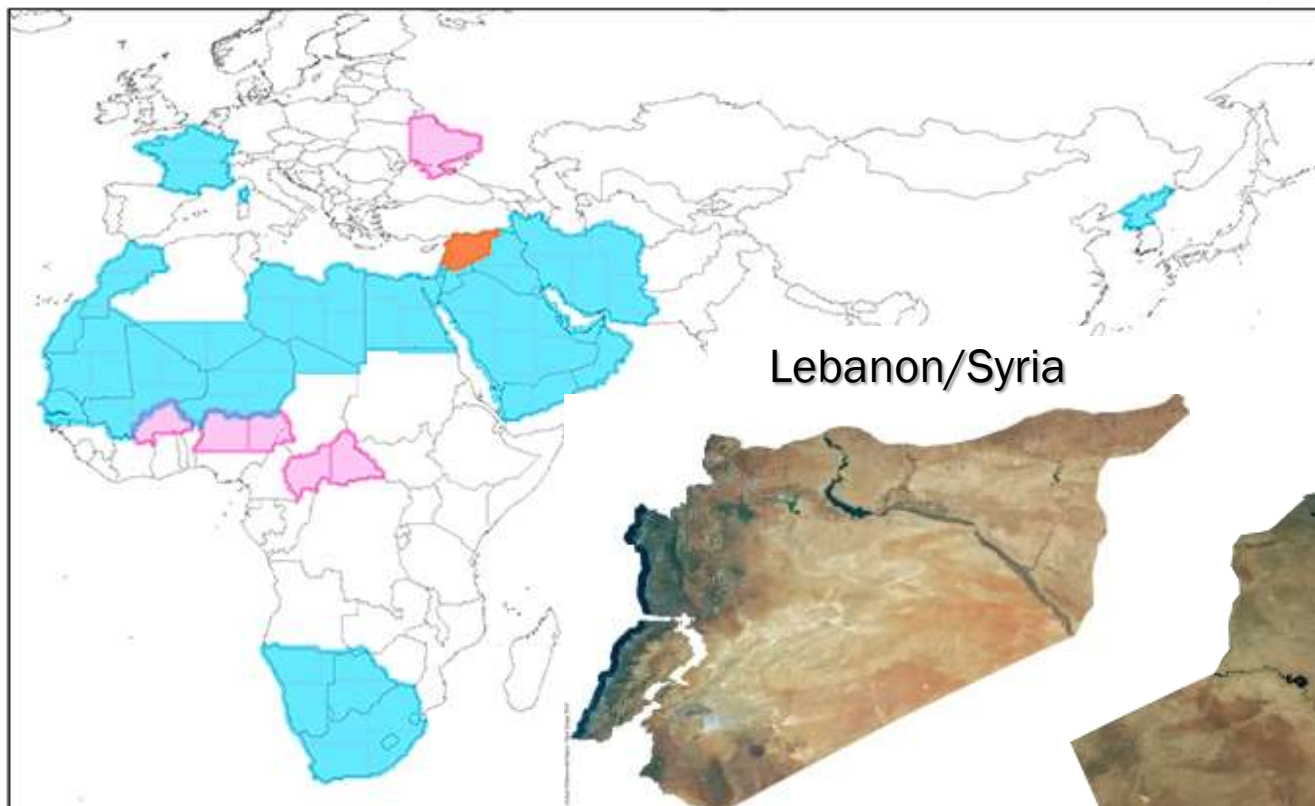


BlackBridge
Delivering the World

Trend: Constellation of Satellites

Use Case: Country Mosaics in short Time Frame

SPOTMaps 1.5 based upon SPOT6/7 Data



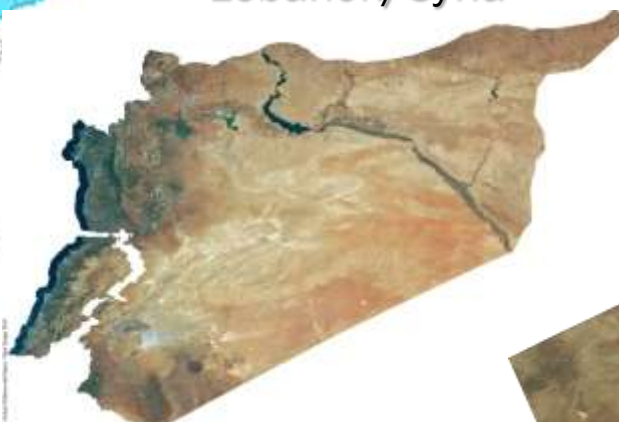
Legend

225.580 sq km	SPOTMaps1.5_v2-updated_Processing_Batches
21.697.501 sq km	SPOTMaps1.5_Available_Batches
2.435.689 sq km	SPOTMaps1.5_Processing_Batches

SPOTMaps 1.5 status dated 2015/03/25



North Korea



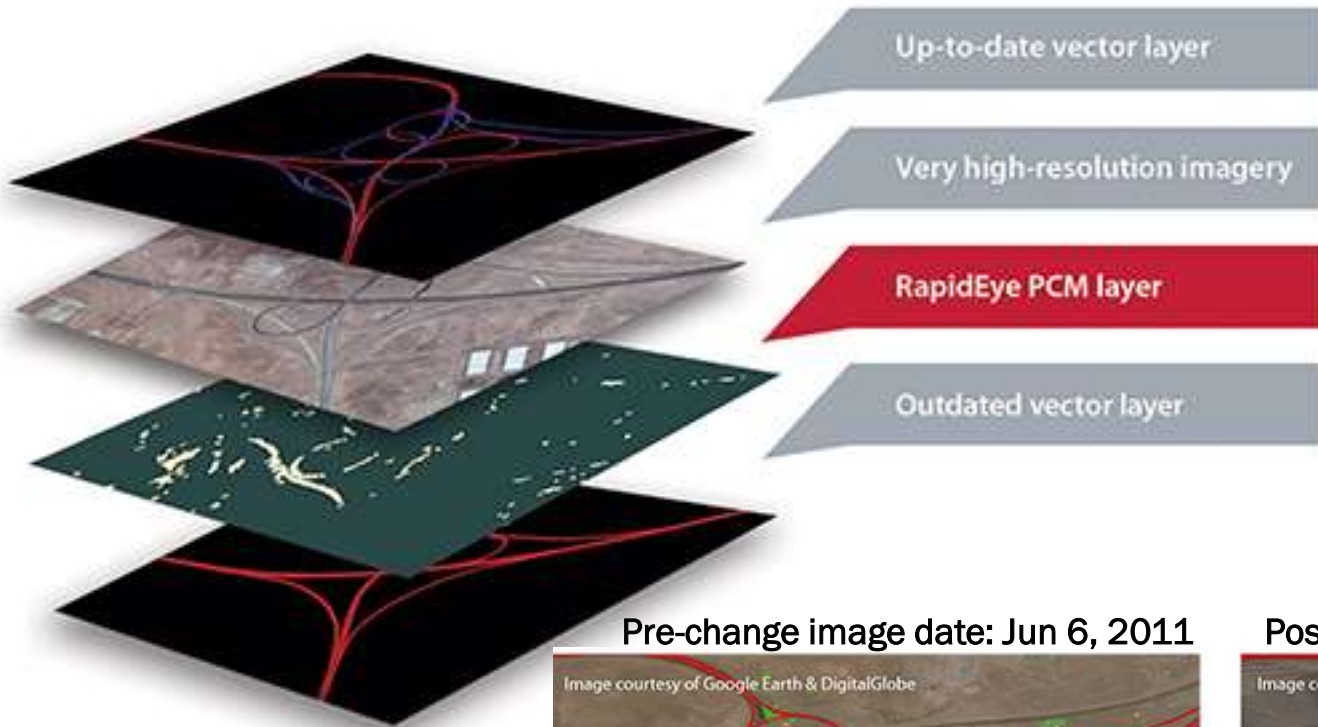
Iraq



Lebanon/Syria

Use Case: Detecting and Monitoring Change

RapidEye Persistent Change Monitoring (PCM™)



RapidEye PCM is an MDA-patented change detection method that compares a stack of images over time to quickly identify real change areas.

Pre-change image date: Jun 6, 2011



Post-change image date: Dec 11, 2012



Use Case: Monitoring with Very High Resolution Satellite Images

Documentation Construction of WC Stadium São Paulo, Brasil



Trend: Smaller and more Cost-Efficient Systems

Weight based Classification:

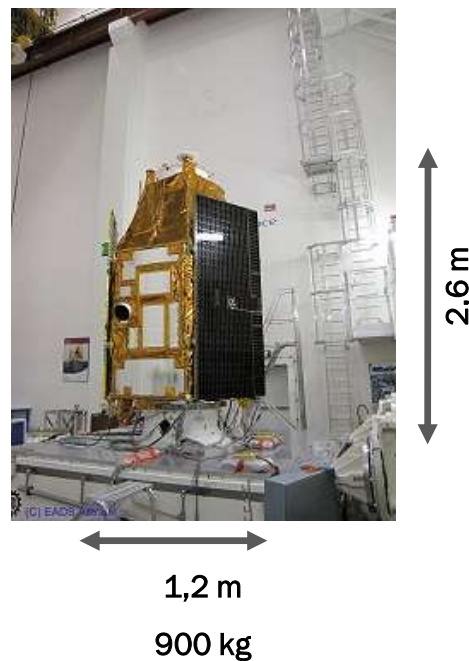
Source: Kramer & Cracknell, 2008

Large	> 1000 kg
Mini	100 - 1000 kg
Micro	10 - 100 kg
Nano	1 - 10 kg
Pico	0.1 - 1 kg

WorldView-2



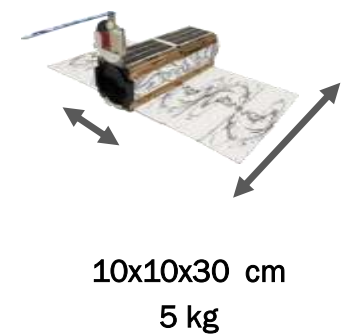
Pleiades-1a



SkySat-1



Flock-1



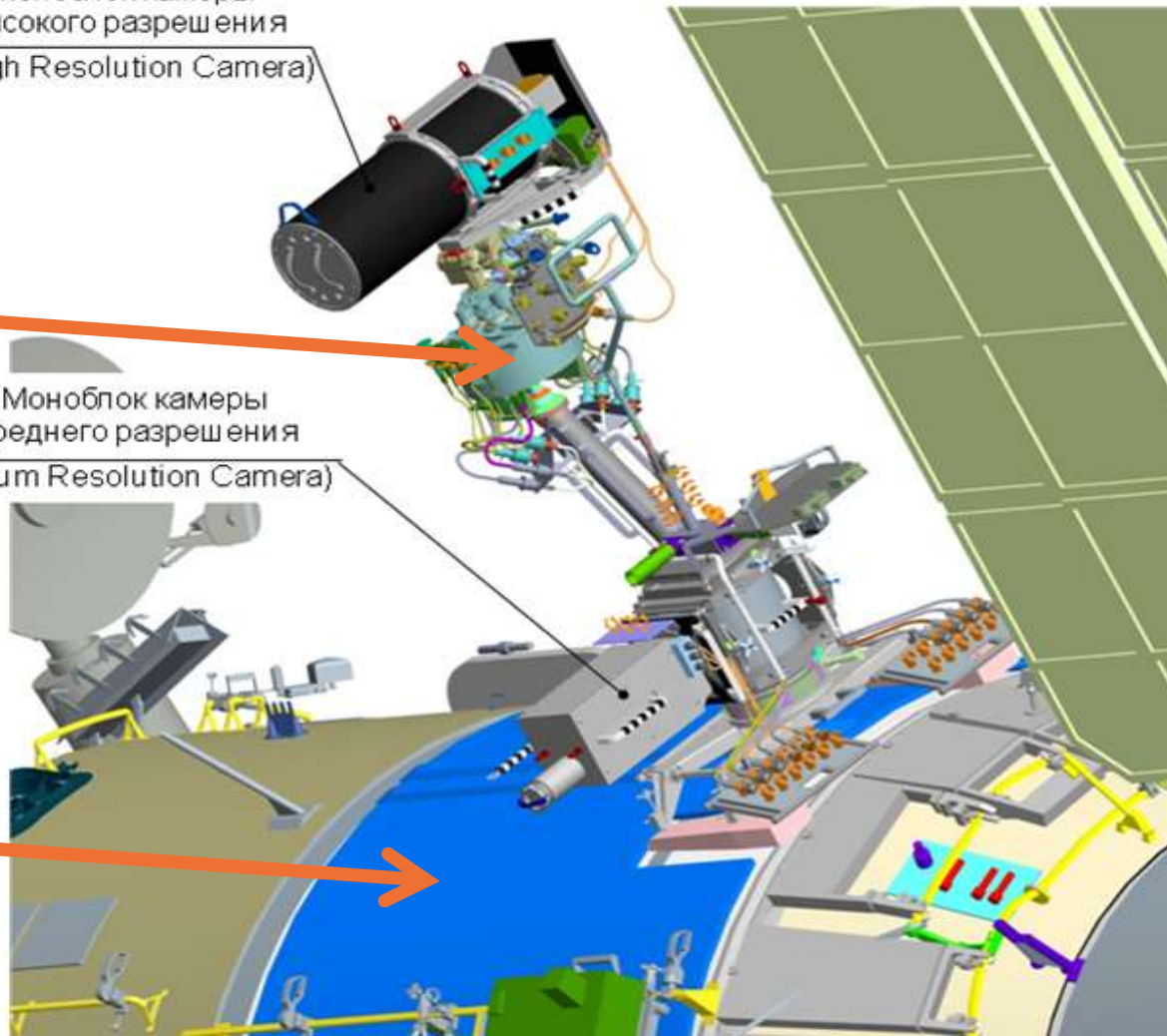
ISS Zvezda Service Module

Моноблок камеры
высокого разрешения
(High Resolution Camera)

Bi-axial
Pointing
Platform

Моноблок камеры
среднего разрешения
(Medium Resolution Camera)

Zvezda Service
Module



Specifications of the UrtheCast Camera System

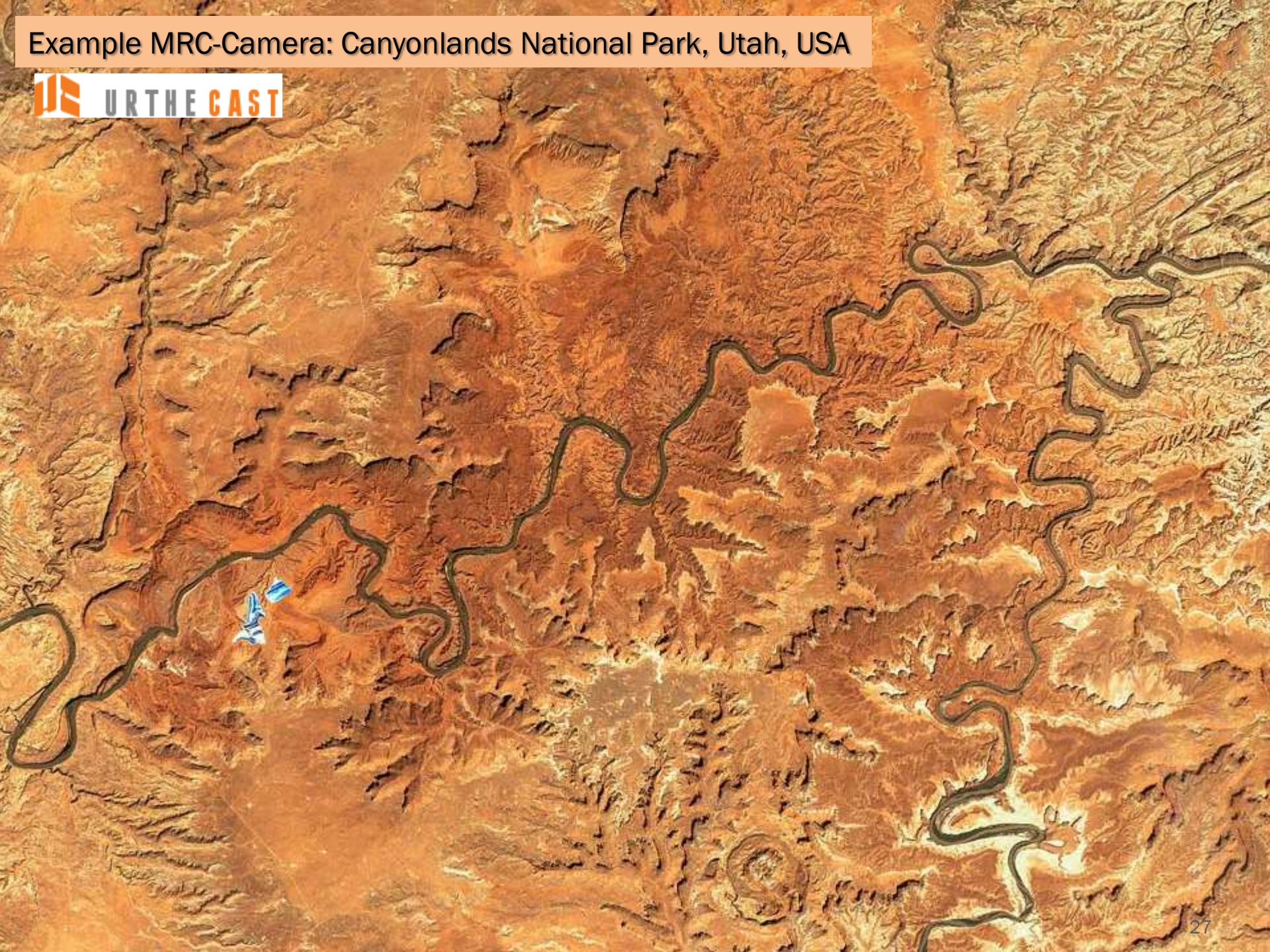


Provider	UrtheCast, Canada
Sensor Resolution (GSD = Ground Sample Distance)	2 Cameras outside ISS Multispectral (MRC): 5.0 Meter Video (HRC): 1.0 Meter
Spectral Bands	MS: & HD+ Colorvideo
Dynamic	MS: 12-bit
Capacity	MS: 24h/7d/365 Video: 60-90s Length/150 Videos per Day
Swath (Nadir)	MS: 45.0 Kilometer Video: 3.4 x 5.0 km
Agility	MS: only Nadir Video: up to 30° Off-Nadir
Repetition	Depends on Geographic Latitude of Target and Orbit of ISS



Example MRC-Image Dubai

Example MRC-Camera: Canyonlands National Park, Utah, USA





Skybox Imaging, SkySat-1 Video – Burj Kalifa

Specifications

Image Bands	Panchromatic	450 - 900 nm
	Blue	450 - 515 nm
	Green	515 - 595 nm
	Red	605 - 695 nm
	Near-infrared	740 - 900 nm
Panchromatic GSD	0.8 - 1.0 m @ nadir1	
Multispectral GSD	2.0 - 2.5 m @ nadir1	
Swath Width	7.8 - 8.5 km @ nadir1	
Bit Depth	8 or 16 bits	



Skybox + Google
Imaging

On 10th of June 2014 Google und Skybox Imaging announced that Google will take over Skybox for 500 Million US \$.

Specifications

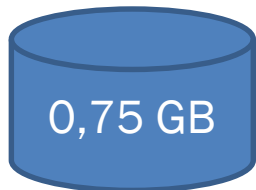
Color	Panchromatic (black & white)
Duration	Up to 90 seconds
Frame Rate	30 frames per second
GSD	1.1 - 1.2 m @ nadir1
FOV	No smaller than 2.0 X 1.1 km
Bit Depth	8 bits
File Format	MPEG-4 (H.264 encoding)







Example – Disk Space for 10km x 10km VHR:



IKONOS
1m
4 Bands
16bit



GeoEye-1
0,5m
4 Bands
16bit



GeoEye-1
0,4m
4 Bands
16bit



WorldView-3
0,3m
4 Bands
16bit

Upcoming Scenarios: more Bands (WorldView-3), increased Resolution (WorldView-4 0,25m?), Monitoring (using Constellations), Videos ...

Commercial satellite image market is in change

DigitalGlobe WV4



Airbus D&S

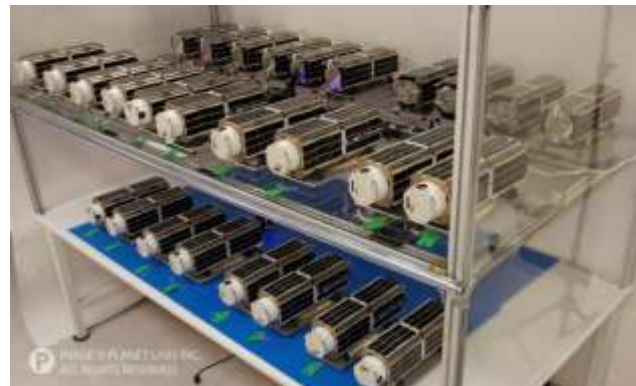
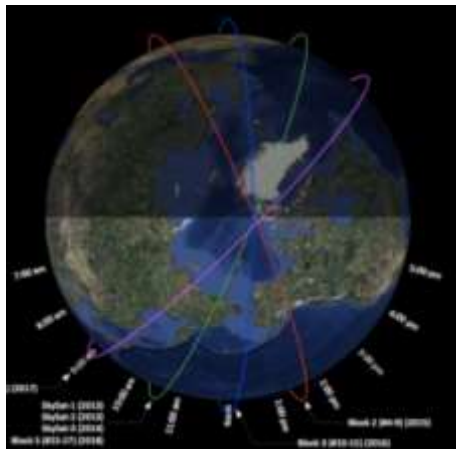
ONE TASKING



- New Systems
- New Providers
- Constellations
- New Products (e.g. Videos)
- More Information (Higher Resolution: geometrical, temporal, spectral)
- Instant Access (Acquisition, Archive, Production, Delivery)



Terra Bella



Planet Labs



UrtheCast

Conclusion: Commercial Satellite Image Market is in Change

„Silicon Valley goes Space“



Source: Planet Labs



Grand Canyon
as seen from
Planet Labs
Flock Satellite

