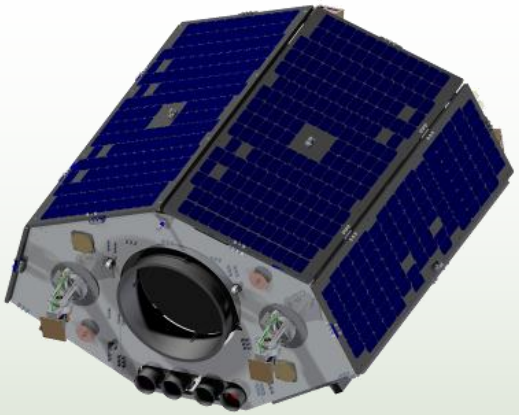
New sensors;

Update on developments in the DMC Constellation

JACIE, 17 April 2012

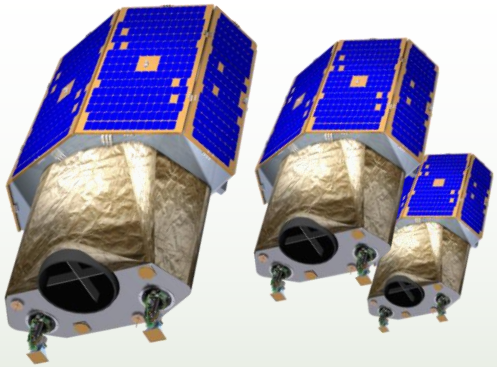
J. Paul Stephens
Director, Sales & Marketing
DMC International Imaging Ltd

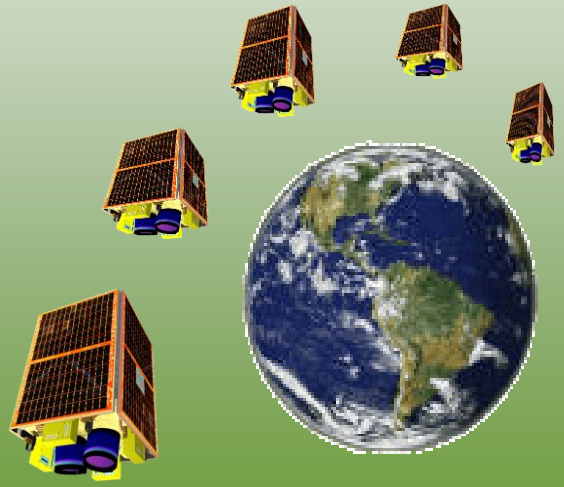
DMC Constellation Developments



High quality 2.5m service (2012)

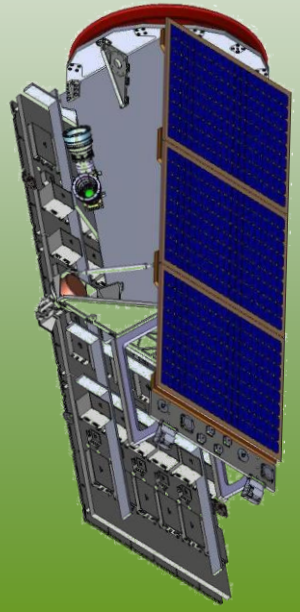
Daily 1m service (2014)





Daily 22m service (operational since 2002)

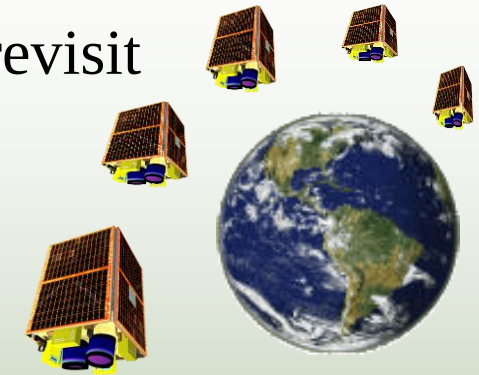
SAR 6-30m service (2014)



The DMC Constellation Concept

A Unique International Partnership Combining National Objectives, Commercial Applications and Humanitarian Aid

The first constellation designed to achieve daily revisit



The Consortium

The Coordinator

International Disaster response

↓

Commercial Imaging services

The Constellation

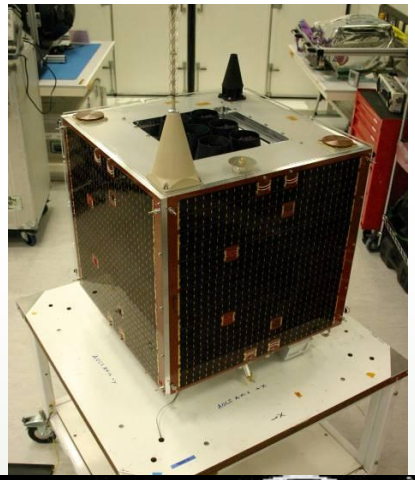
- ALSAT-1
- NigeriaSat-1
- UK-DMC
- BILSAT
- **Beijing-1**
- **Deimos-1**
- **UK-DMC2**
- **NigeriaSat-2 (2011)**
- **NigeriaSat-X (2011)**

DMCii and SSTL Company Organisation

- **Surrey Satellite Technology Ltd.**
  - Established in 1985, now 450+ staff
  - Acquired by EADS Astrium in 2009
  - 37 Satellites completed – c.200 satellite years on-orbit experience
  - 11 Further satellites (37-47) - currently being prepared for launch
  - 26 payloads in progress (5 optical, 22 navigation)
  - 6 satellites to be launched in 2012

- **DMC International Imaging Ltd.**
  - Wholly owned subsidiary of SSTL
  - Established 2003, now 25+ staff
  - DMC satellite operations, constellation coordination, calibration
  - Commercial data supply
  - Value-added analysis
  - International Disaster Charter activities

DMC Satellite Constellation



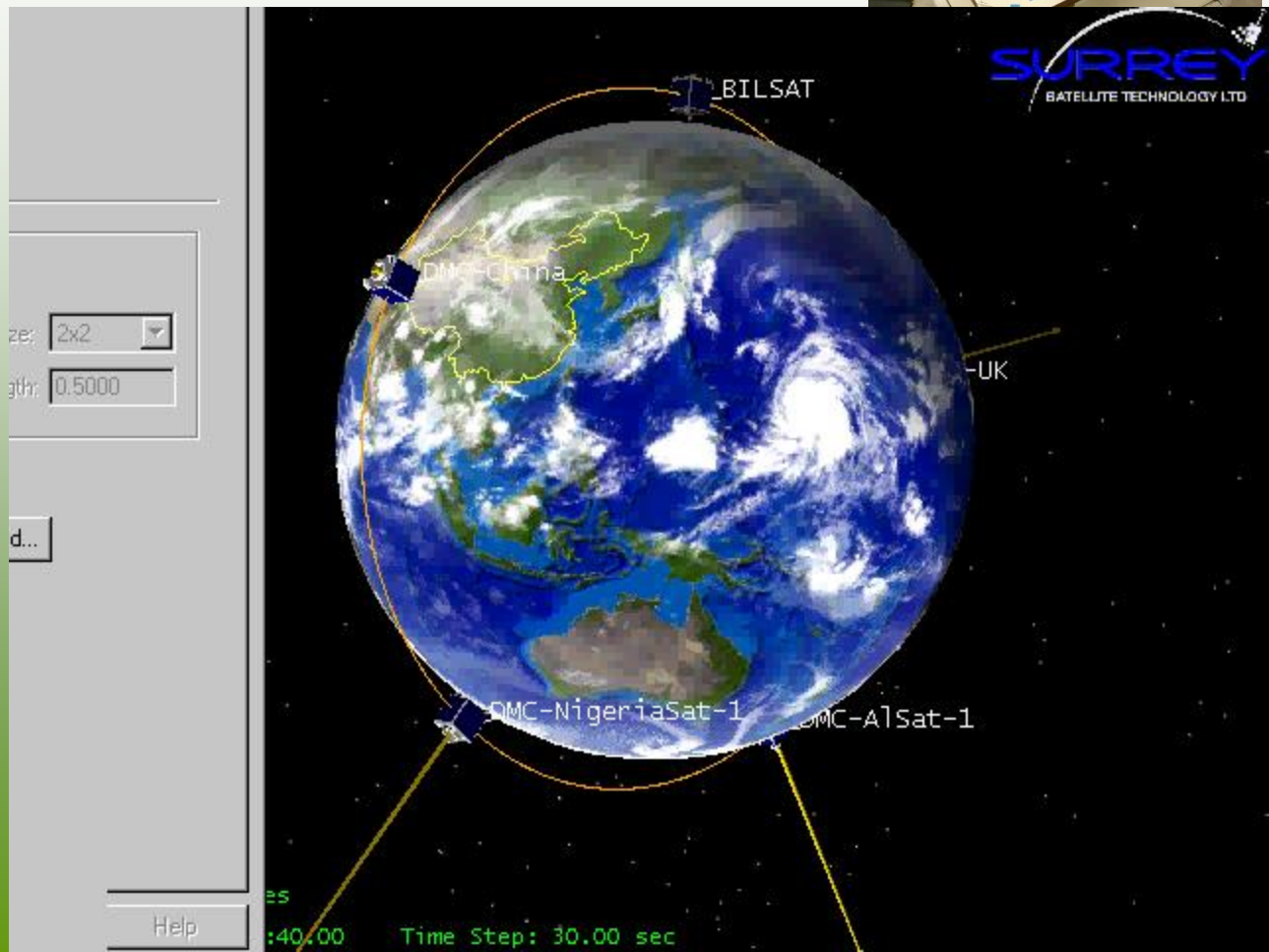
5+ satellites designed for Global Daily Imaging

Operational
- 2 sats @ 32 m gsd
- 3 sats @ 22 m gsd
- +2 in negotiation

Broad Swath 650+km

Landsat bands
- Red
- Green
- NIR

Landsat matched radiometric calibration



Radiometric Calibration

Excellent calibration is vital for quantitative applications

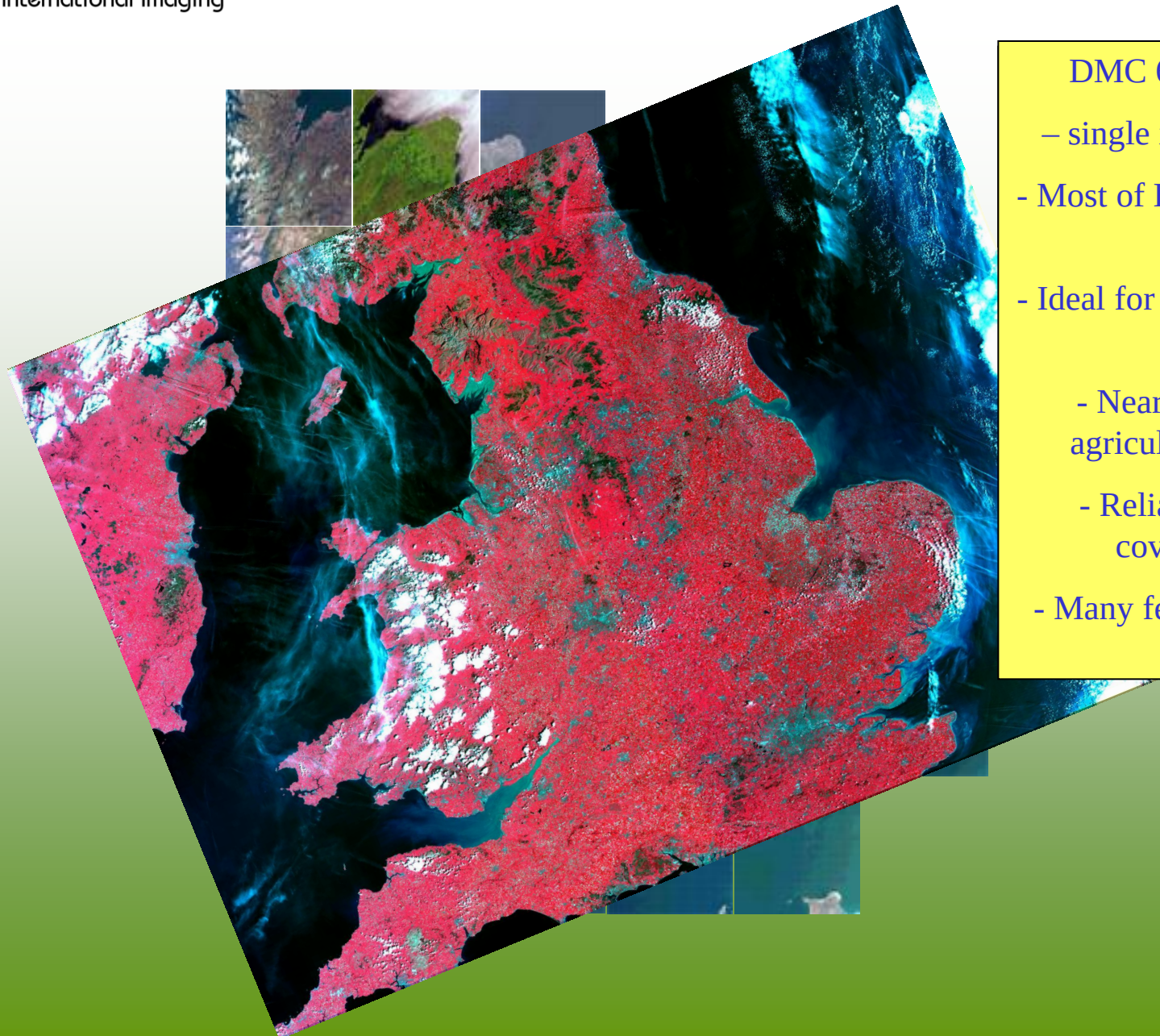
Three elements:

- **Absolute calibration**: a single ‘gold standard’ satellite using ground data (e.g. Railroad Valley, Tuz Golu)
- **Transfer calibration**: transfer from a few detectors to whole array (Dome C)
- **Cross-calibration**: transfer to all DMC satellites with overlapping images 30 minutes apart (Dome C)

Result:

- Relative calibration between satellites **<1%**
- Absolute calibration (all satellites) within **4-5%**
- Continuously tracking Landsat calibration within **1%**

Timeliness



DMC 600 x 560 km Image

– single image from UK-DMC

- Most of England captured within 1 minute

- Ideal for consistent classification approach

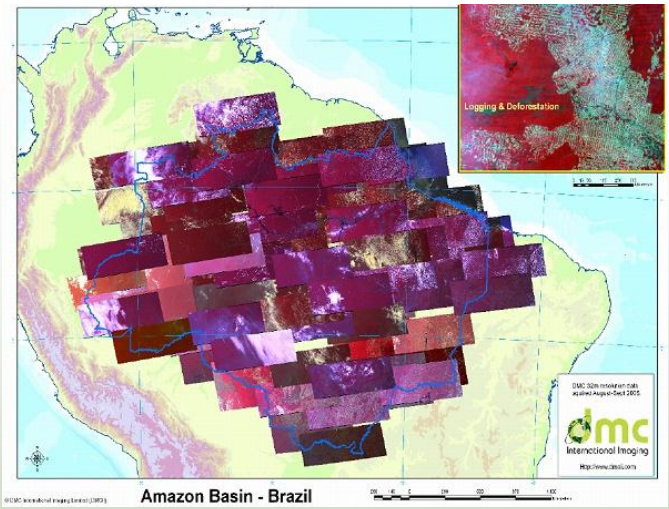
- Near real-time precision agriculture fully supported

- Reliable multi-temporal coverage per season

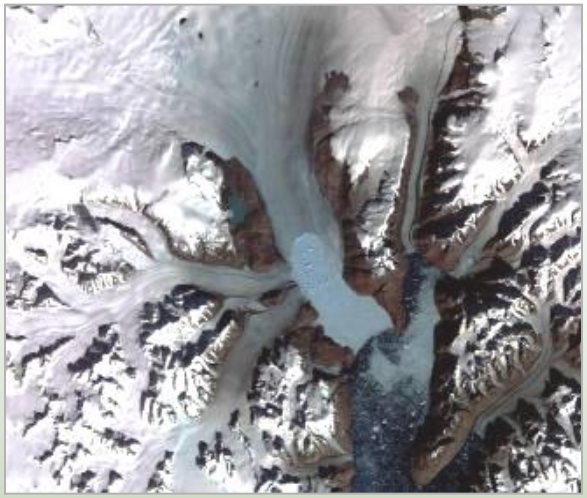
- Many fewer images to process than Landsat

Rapid mapping for disaster response

Multispectral imagery at 32m and 22m GSD



Deforestation & Land Cover



Global Science, Climate change

Flooding, disaster response

Fires: prediction, tracking

Rapid wide area coverage

Rapid Coverage of Large Areas

Forest monitoring

Brazilian Amazon

Annual DMC campaigns for INPE:

- **2005**
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012 ……

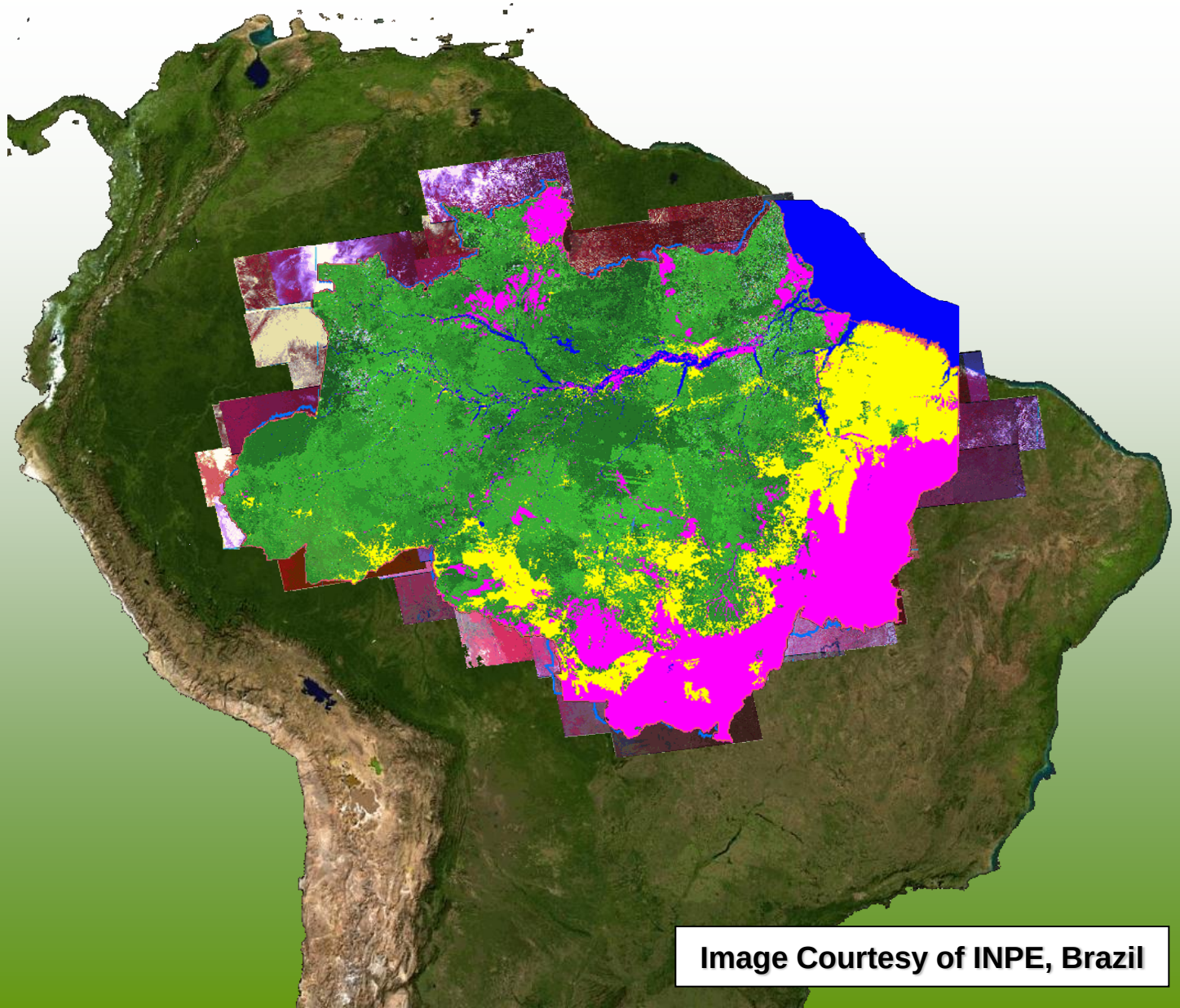


Image Courtesy of INPE, Brazil

Agriculture

DMC Constellation 2011 USDA Coverage

Two DMC satellites;

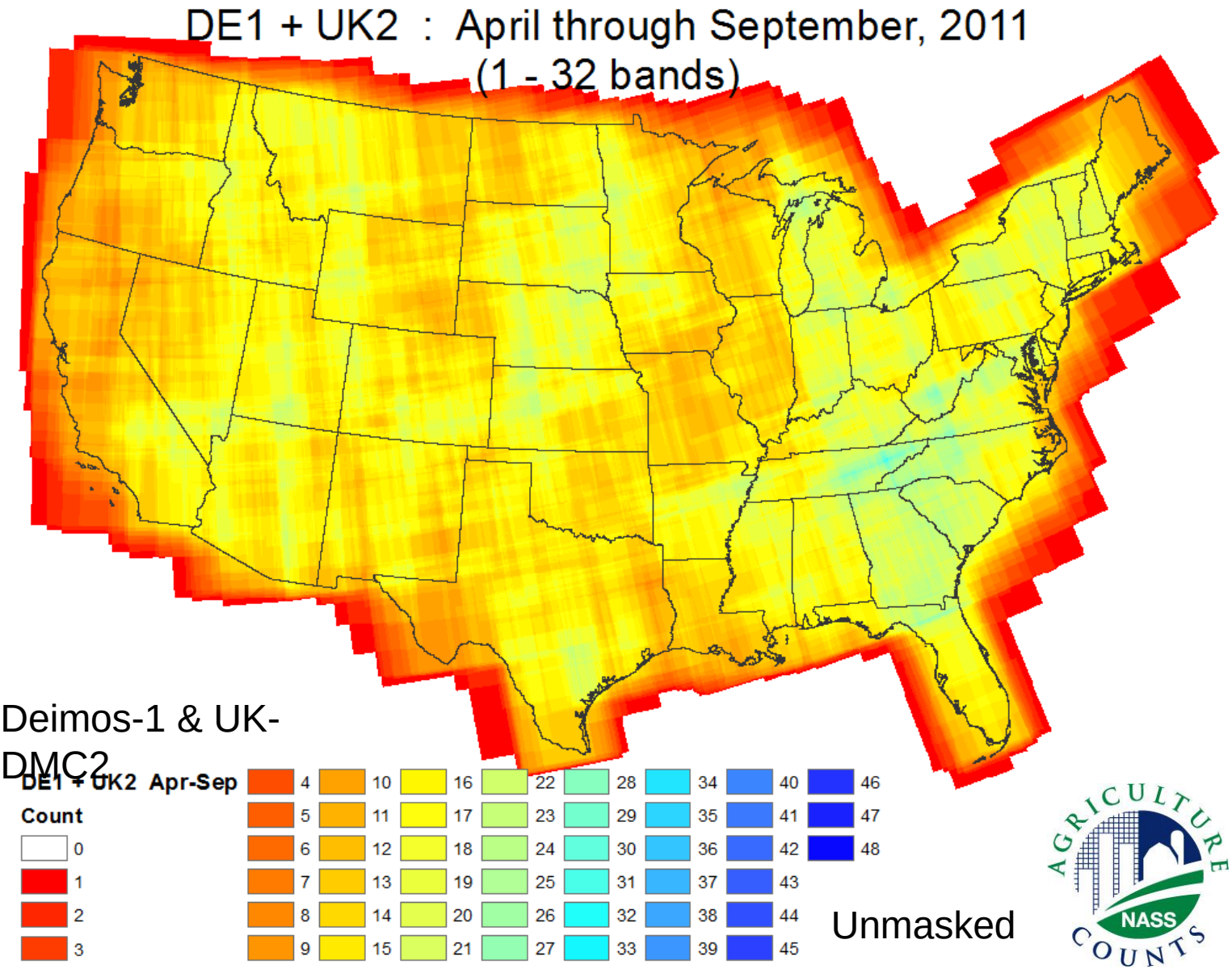
20 windows of 15 days <30% cloud

2 day revisit vs Landsat 16 day

22m vs 30m

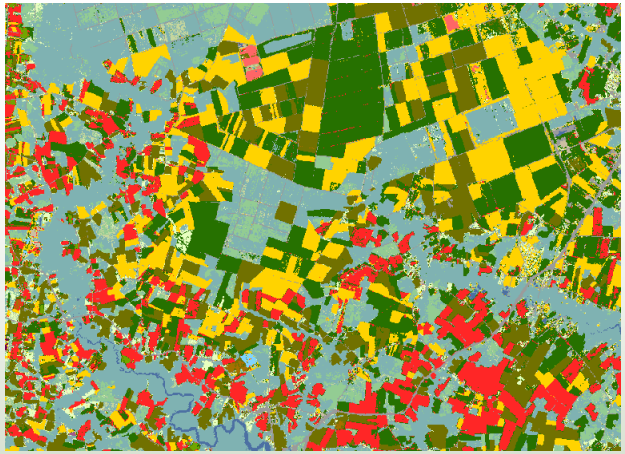
650km swath vs 185km

Improved crop monitoring



USDA NASS results - North Carolina

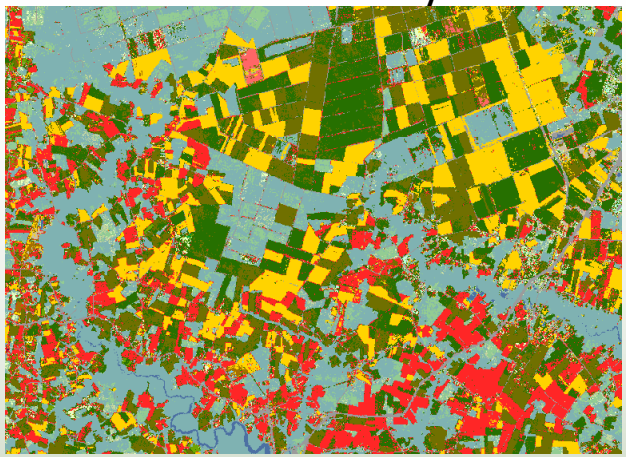
Landsat & DMC



	Producer	User
ALL CROPS	81.7%	
Corn	94.3%	92.1%
Cotton	96.3%	94.4%
Soybeans	84.7%	84.0%
WW/Soy	93.9%	87.9%
Pasture	66.5%	68.1%
Peanuts	87.1%	92.8%

118 bands

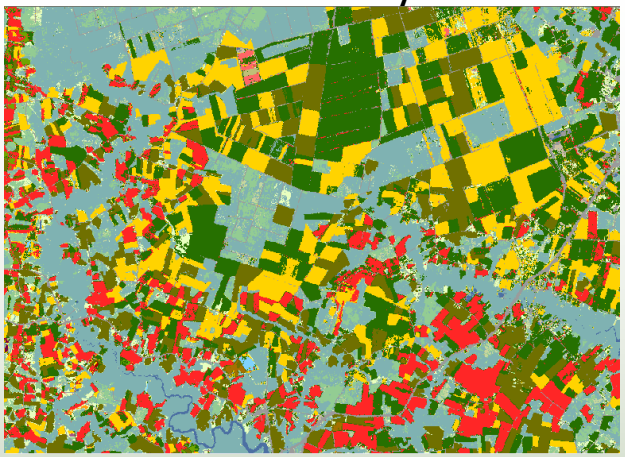
Landsat Only



	Producer	User
ALL CROPS	69.0%	
Corn	83.3%	81.9%
Cotton	91.0%	85.3%
Soybeans	62.9%	71.1%
WW/Soy	79.9%	82.0%
Pasture	58.5%	44.0%
Peanuts	71.4%	90.0%

73 bands

DMC Only



	Producer	User
ALL CROPS	81.6%	
Corn	94.6%	92.1%
Cotton	95.9%	94.4%
Soybeans	84.3%	83.3%
WW/Soy	93.8%	87.7%
Pasture	67.2%	68.9%
Peanuts	82.1%	91.0%

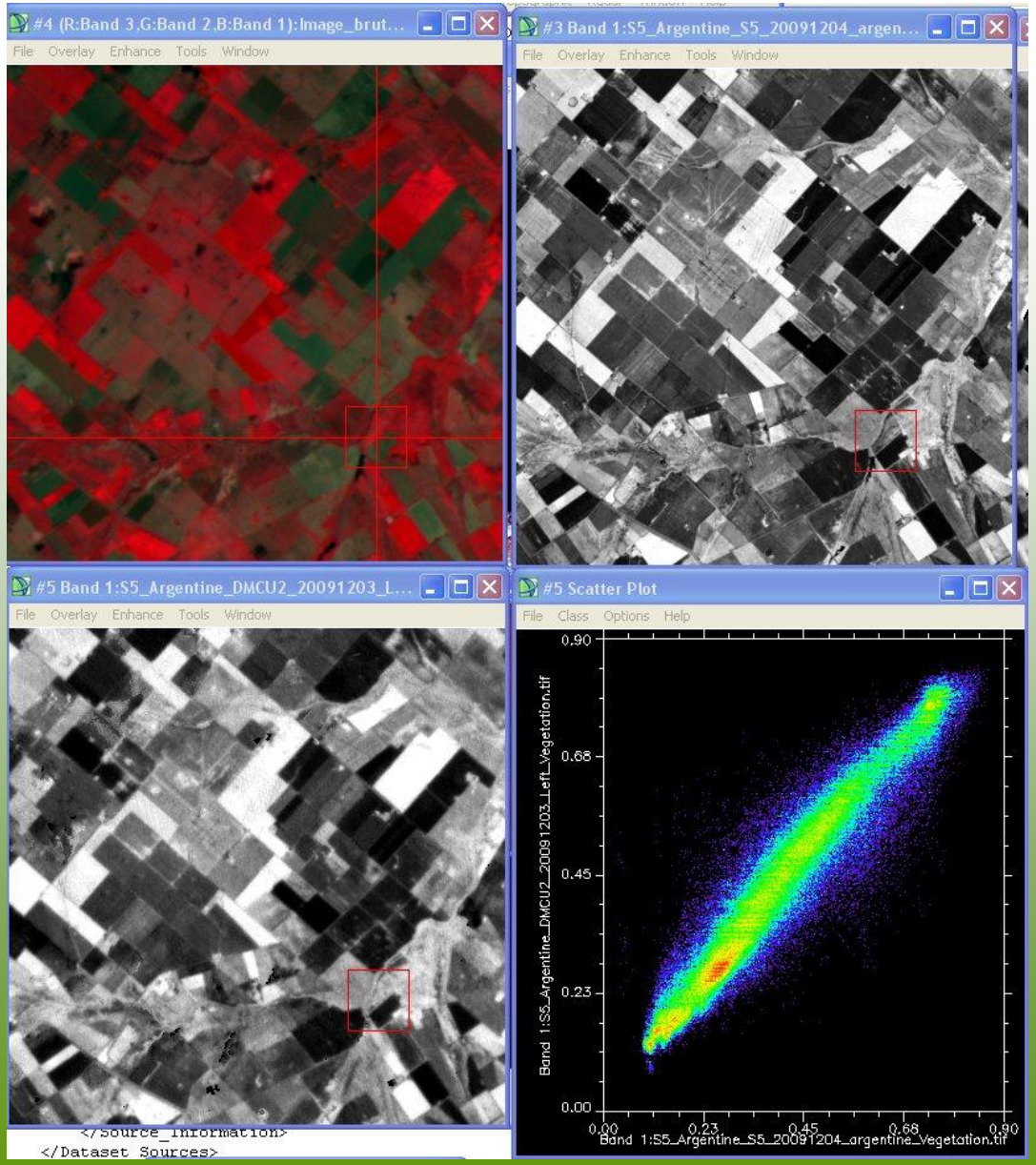
66 bands

Precision Agriculture

UK-DMC2 vs Spot5 data

- Plot of vegetation fractional cover derived from both UK-DMC2 and Spot 5 data.

- The result is a good 1:1 relationship across the full value range (bottom right image).



FarmStar: Final Map Product to Farmer

Bilan biomasse sortie hiver — Colza

. SCEA

Parcelle :

Sol : Limon argileux

C-080247-6 / 10002049B

Ilot : 8 **Surface :** 33.0 ha

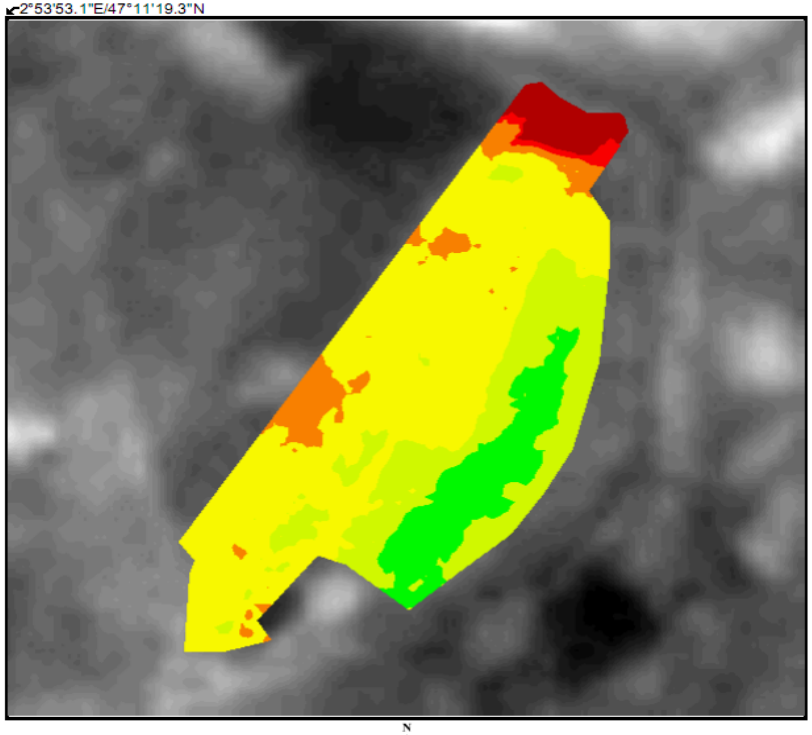
Précédent : ORGE D'HIVER

Variété : SAFRAN

Semis : 25/08/2009

Densité (grains/m²): 70

2°53'53.1"E/47°11'19.3"N



0 200m

N O E S

Projection : France Zone II étendu

Carte de biomasse

Biomasse de matière verte (kg/m²)	% Surface
0.0 - 0.2	0.0
0.2 - 0.4	4.0
0.4 - 0.6	1.0
0.6 - 1.0	6.4
1.0 - 1.5	54.4
1.5 - 2.0	21.9
2.0 - 2.5	12.5
> 2.5	0.0

Biomasse moyenne produite 1.4 kg/m²

Azote moyen absorbé 88 Unités / ha

Campagne 2009 - 2010

Vos parcelles vues du ciel

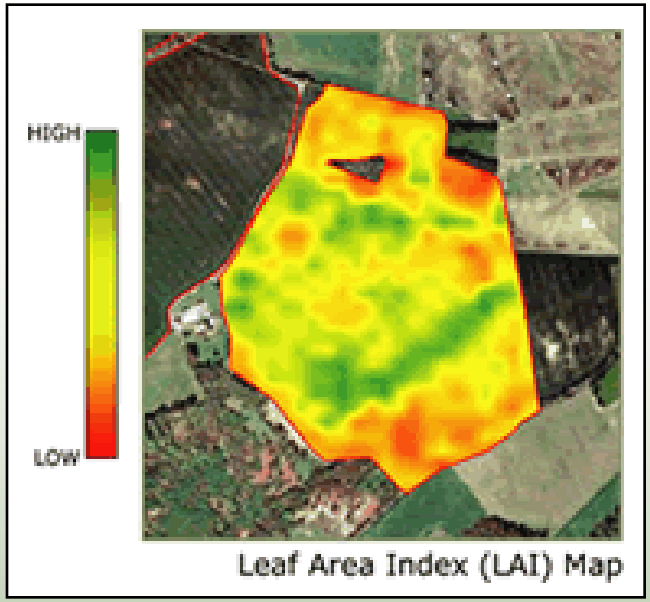
Produit soumis à licence d'utilisation : reproduction interdite sans autorisation - 01/03/2010.

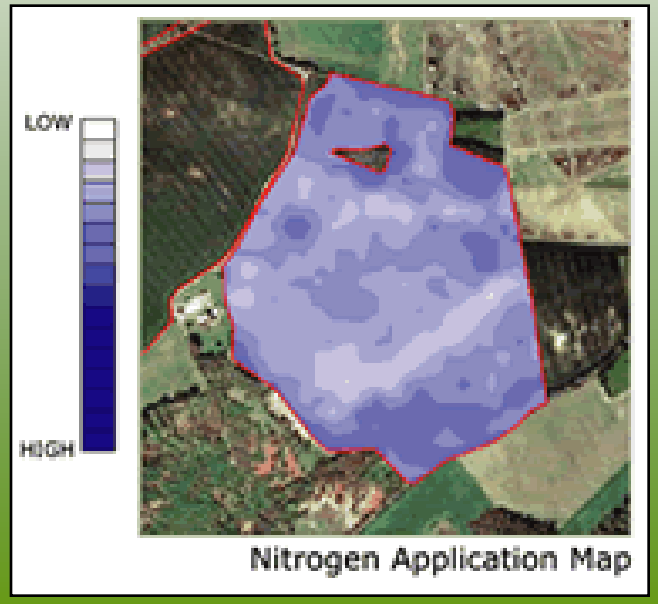
FARMSTAR infoterra CETIOM

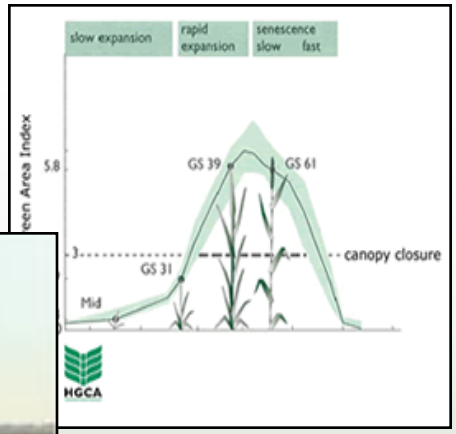
Biomass map end of winter (oilseed rape)

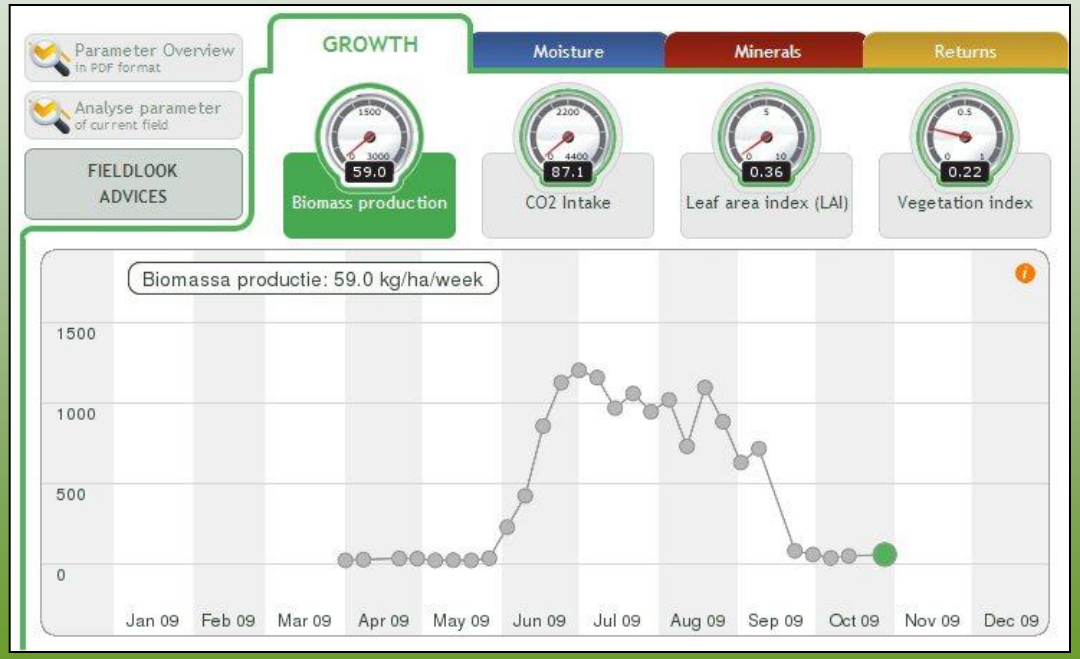
Images Courtesy of Spotimage, France

Daily Field Monitoring = better crop yields







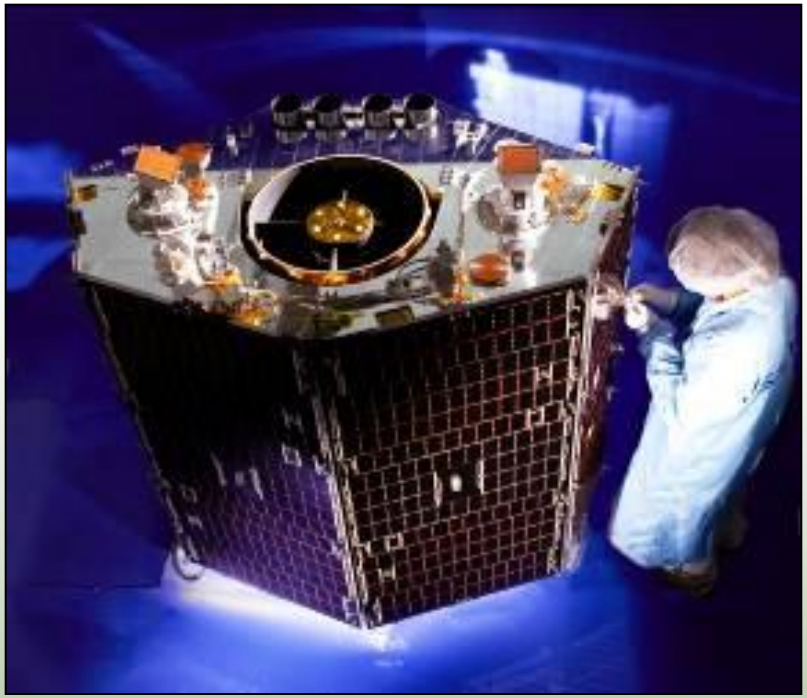


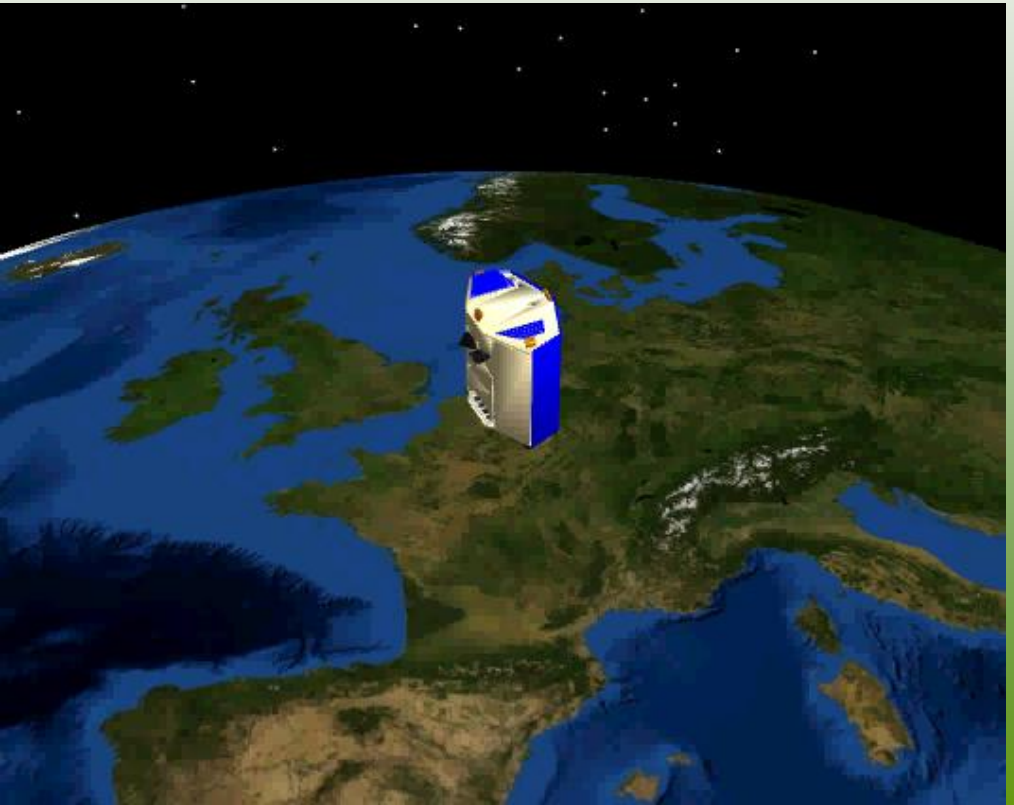
Images Courtesy of SOYL Ltd and WaterWatch SA

VHR 2.5m imaging

NigeriaSat-2

- 2.5m PAN (20-80km swath)
- 5m MS (20-80km swath)
- 32m MS (330km swath)
- High geolocation accuracy





Multiple imaging modes

- 2000 km along track
- 4x4 mode (80x80km)
- Along-track stereo

The NigeriaSat-2 Spacecraft

Based on the SSTL 300 platform, one of the most capable platforms in its class:

- 7.4 years lifetime

- 2.5m GSD panchromatic, 20km swath
- 5.0m GSD 4 band, 20km swath
- 32m GSD 4 band, 300km swath

- 100 to 400 scenes per day
- 70m absolute geo-location
- 45° roll/pitch fast slewing off-pointing ability
- 2 x 105Mbps downlink (can operate as 210Mbps)

- 98% availability

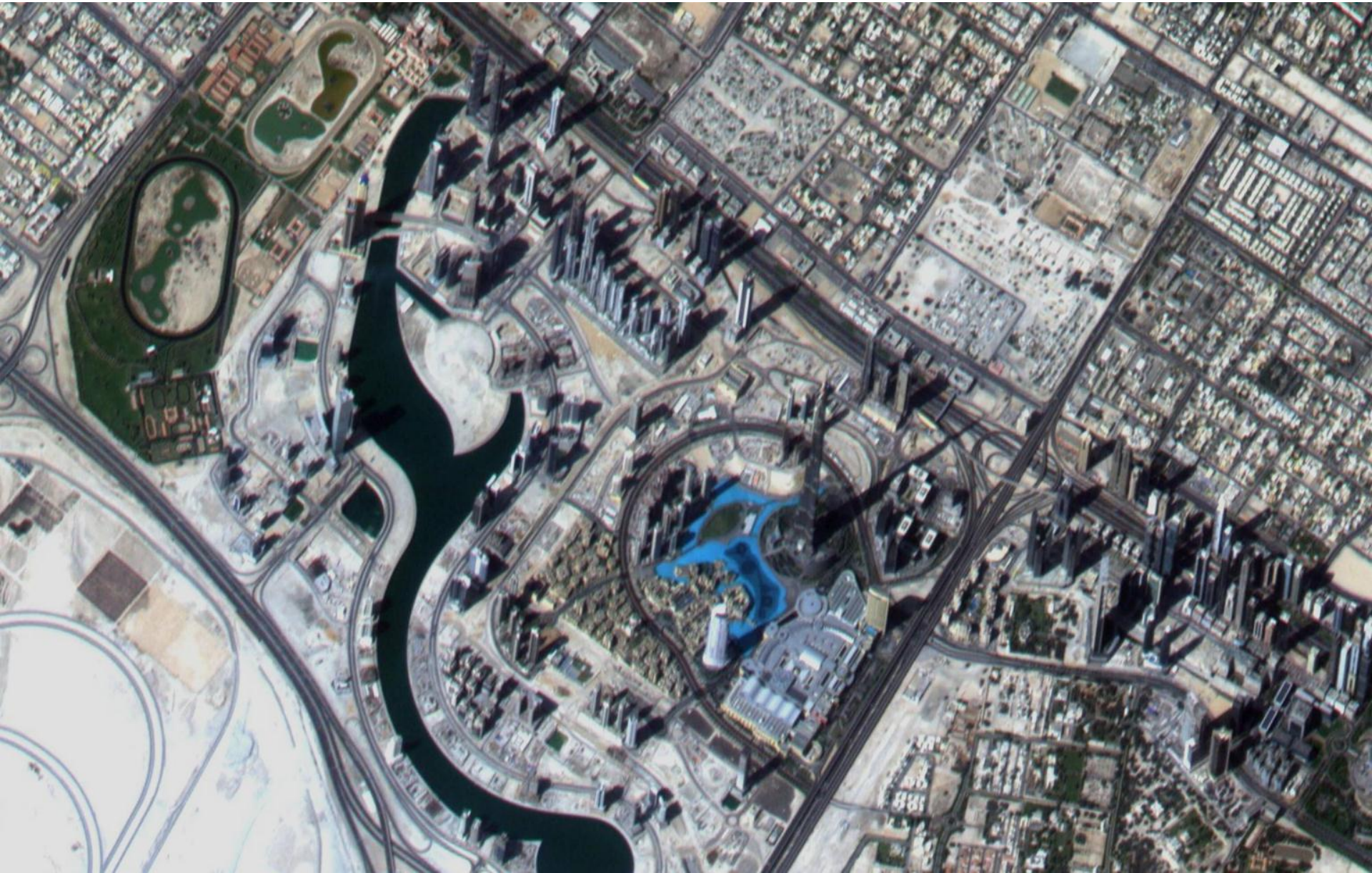
Operational Modes

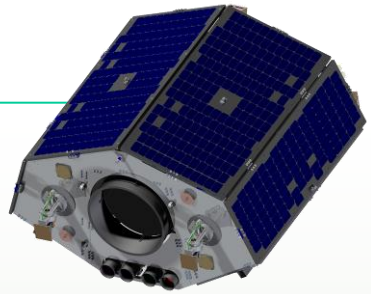
	#	Name	Description
Scene Modes	1	VHRI Scene Fast Response	Fast response VHRI mode. Permits short delay between images. Allows optional off nadir pointing up to 45-degrees and near real-time download.
	2	VHRI Scene Standard Response	High accuracy VHRI mode. Requires settling time between images. Allows optional off nadir pointing up to 45-degrees and near real-time download.
Compound Modes	3	Along-track Stereo 30 degree	Stereo image mode with 30 degree pitch angle. Off nadir roll permitted up to 35 degrees.
	4	Across-track Stereo	Stereo image mode with any roll angle permitted by the viewing geometry (up to 45 degrees). The two scenes are taken on different orbits
	5	Area 2x2	Area mode image comprised of 2x2 scenes. Pitch offset 30 degrees. Off nadir roll permitted up to 35 degrees. Final image ~40 x 45 km.

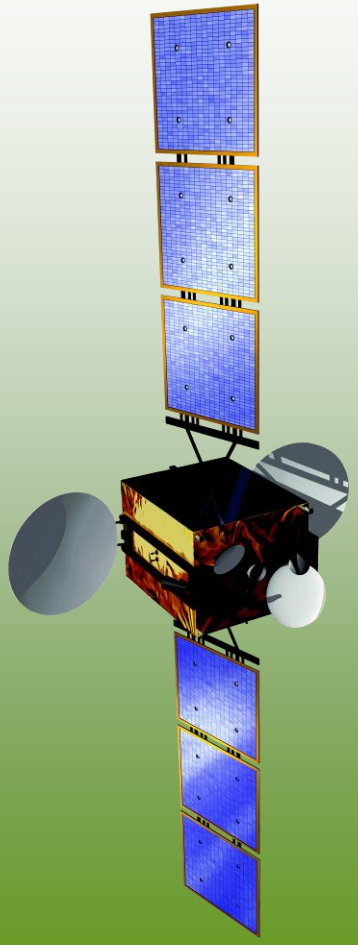
2.5m panchromatic and 5m multi-spectral

Salt Lake City Airport, USA; 2.5m pan-sharpened NigeriaSat-2 image,

Nigeriasat-2 offpointing 2.5m pan sharpened

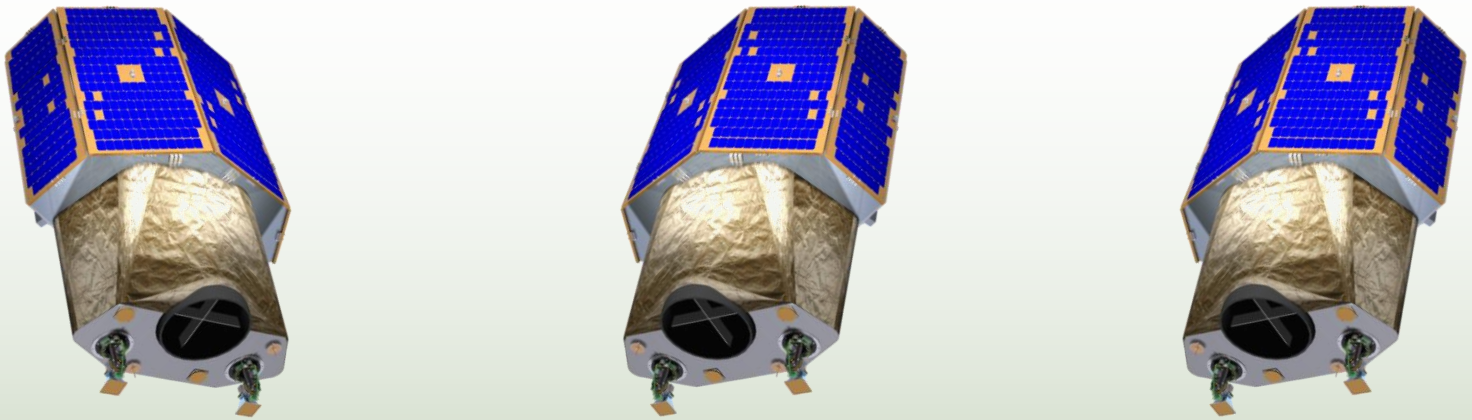






Next up

DMC3 VHR Constellation (2014)



- 3 satellites to launch together
- <u>Daily Revisit at 1 meter</u>
- Bands: B, G, R, NIR, Pan
- Resolution: 1m Pan; 4m MS
- Swath 23km
- Single pass 2x2 mode (40x45km)
- Owned and operated by DMCii

Mission Overview

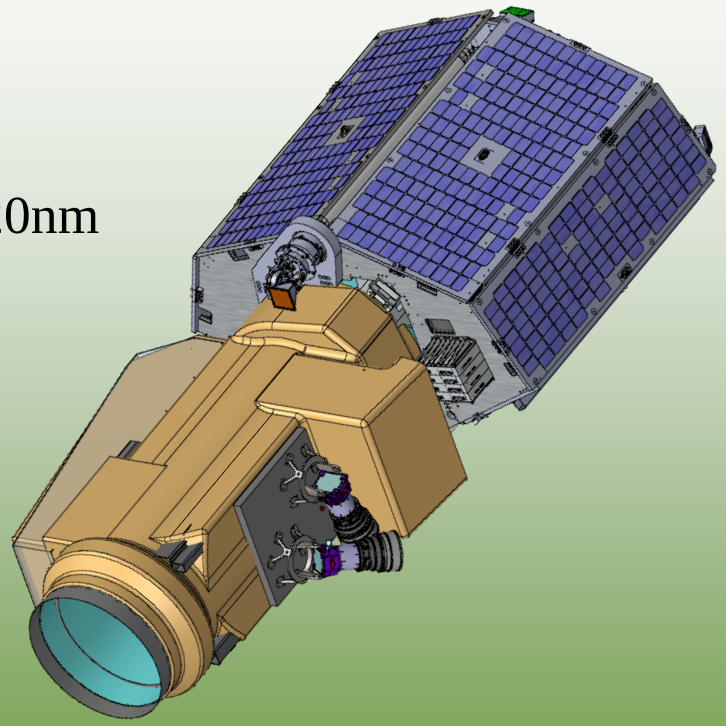
Three satellite Earth Observation Constellation.

- Global daily revisit.
- Commercial Imaging:
  - Disaster monitoring.
  - Environment and Resource monitoring.
  - Urban planning.
- High Resolution Imaging Payload
  - Panchromatic: 1m Ground Sampling Distance (GSD).
  - Multi-Spectral: 4m Ground Sampling Distance (GSD).
- Owned and operated by DMCii.
- Imaging capacity leased to commercial customers.

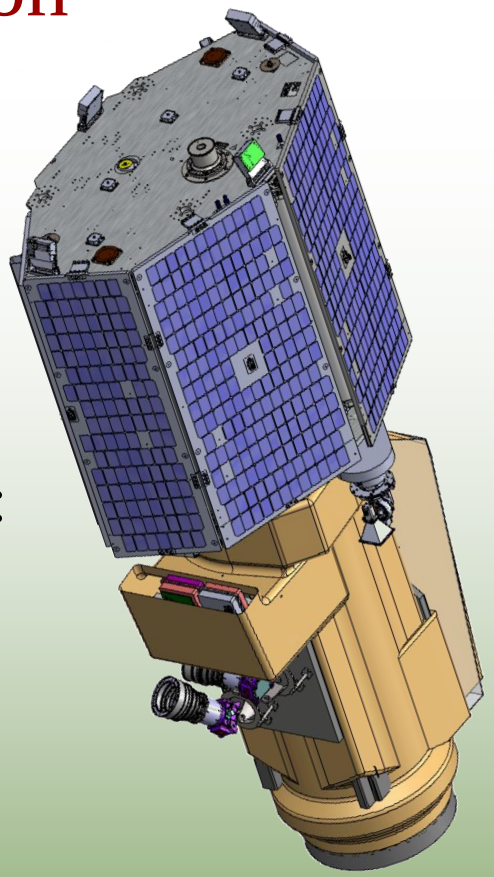
DMC3 Satellite Specification

Each satellite:

- Reference orbit: 630km, Sun Synchronous Orbit, 10:30 LTAN.
- 1m GSD Panchromatic
  - 450nm – 650nm; Band accuracy ±20nm
  - MTF: >10%
- 4m GSD Multi-Spectral
  - Red: 600nm – 370nm
  - Green: 510nm – 590nm
  - Blue: 440nm – 510nm
  - Near Infrared: 760nm – 910nm
  - Band accuracy ±20nm
  - MTF: >20%



Satellite Specification



Each satellite:

- Swath: 22.6km
- Swath length: 175 scenes
- Absolute radiometric calibration accuracy: <7%
- Pointing accuracy: <50m
- Off-pointing: ±45 degrees

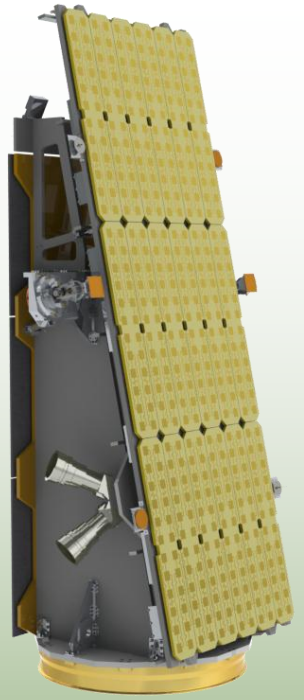
Constellation:

- 3 satellites
- Daily revisit - with offpointing
- 1 million km^2 imaging per day

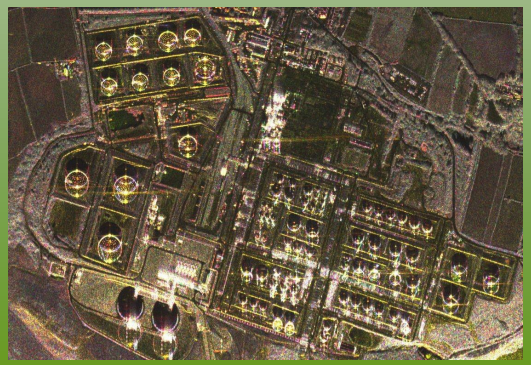
Nova SAR

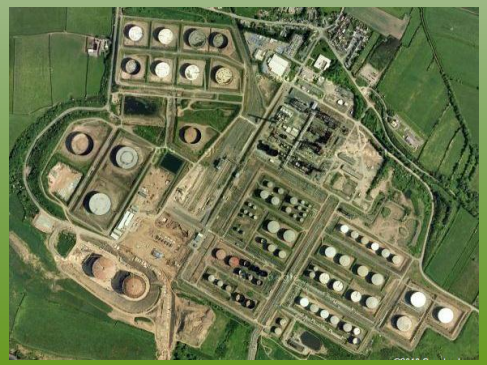
NovaSAR

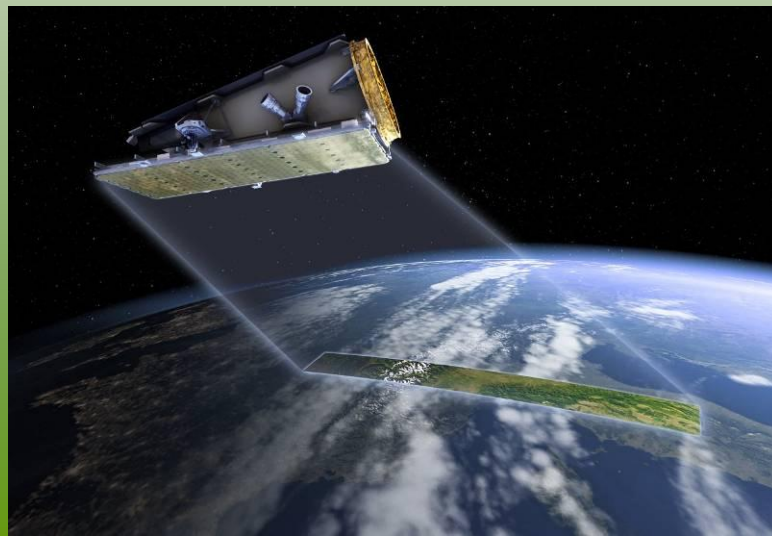
Funding of £21m ($32m) announced by UK Government



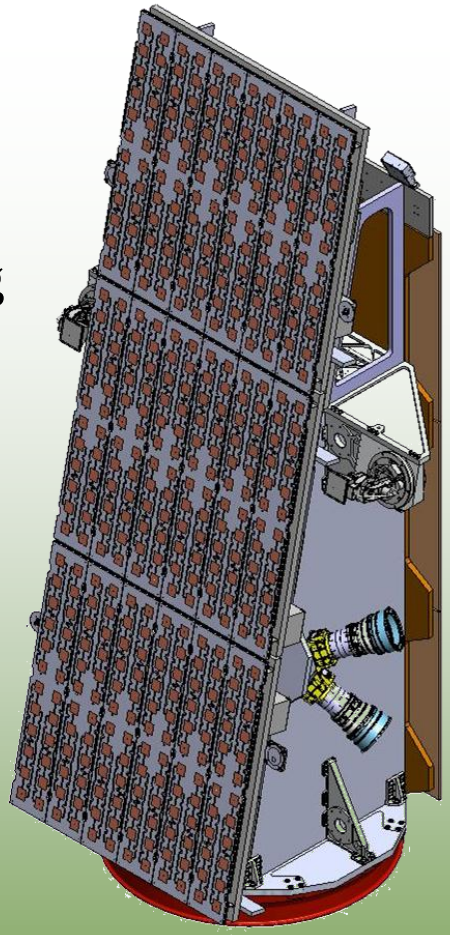
- Low-Cost SAR Satellite
- SSTL-Astrium Joint Programme
- Airborne Demonstrator Flown
- 4 Modes: 6-30m Resolution
- TechDemoSat Payload
- Launch 2014







Applications focused approach



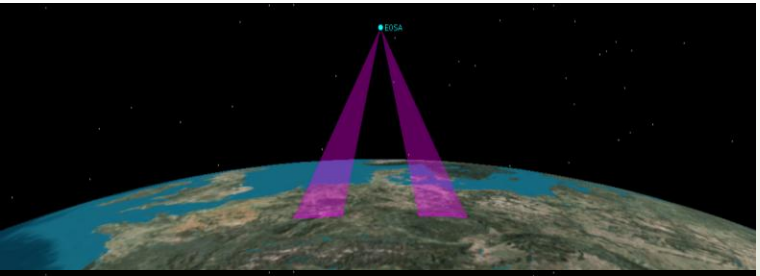
- Target applications:
  - Ship detection
    - Illegal shipping/fishing, oil bunkering
  - Oil spill monitoring
  - Forestry
    - Logging, forest fire damage
  - Flood management
    - Flood extent mapping
  - Land use mapping
    - Land registry
  - Agriculture
  - Disaster management
    - Earthquakes / landslides (mapping, infrastructure and building damage assessment)
    - Floods
- But, like any SAR, not limited to these.

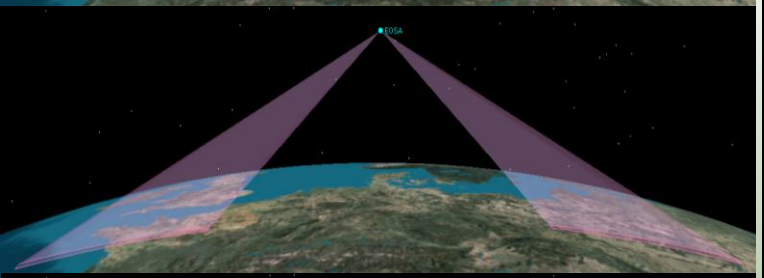
NovaSAR-S Specifications

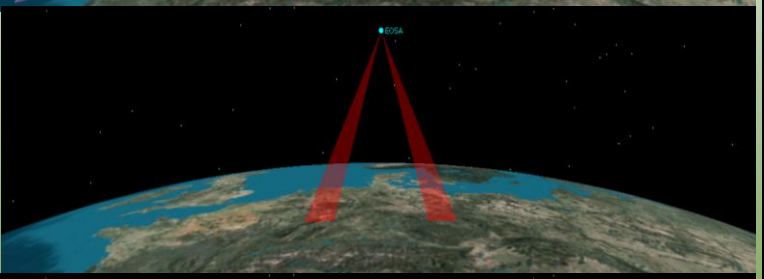
Imaging frequency band	3.1-3.3GHz
Antenna	Microstrip patch phased array (3m x 1m)
No. of phase centres	18
Peak pulsed RF power	1.8kW
Polarisations	HH, HV, VH, VV
Imaging polarisation	Single, dual, tri- or quad polar
Design life	7 years
Mass	<400kg
Lead time (OK to FRR)	24 months
Optimum orbit	580km
Propulsion system	Xenon
Payload duty cycle	At least 2min per orbit (image 800km)
Payload data memory	32GBytes
Downlink rate	105Mbps
TTC frequency band	S-band (2025-2110MHz, 2200-2290MHz)
Downlink frequency band	X-band (8.025-8.4GHz)

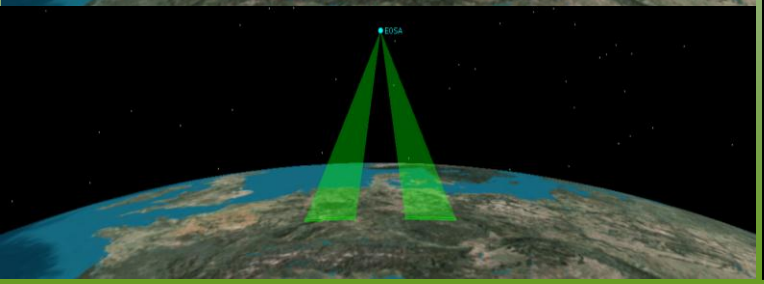
NovaSAR-S Baseline Imaging Modes

Baseline modes tuned in orbit by adjusting the pulse repetition frequency and beam steering





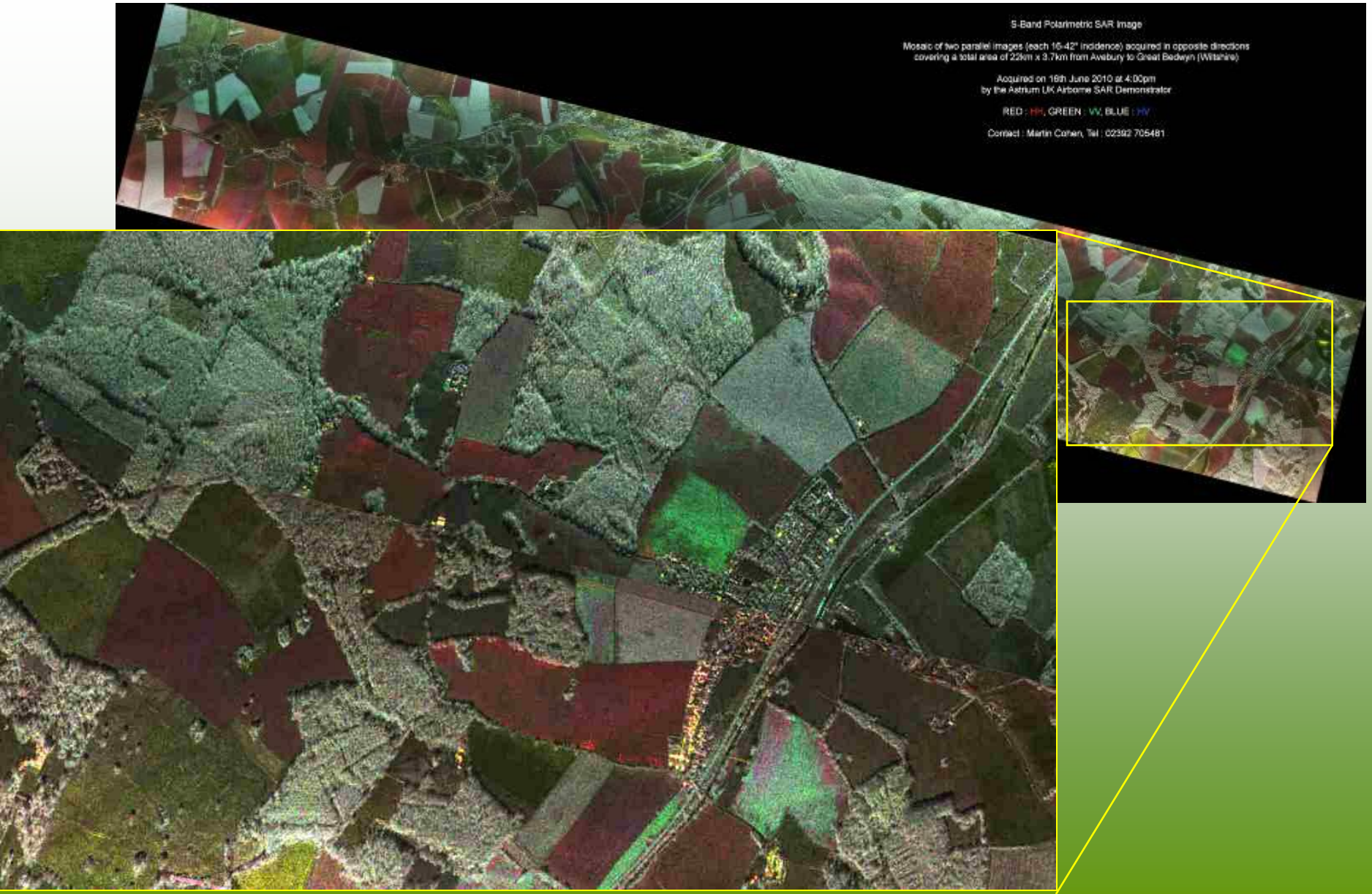




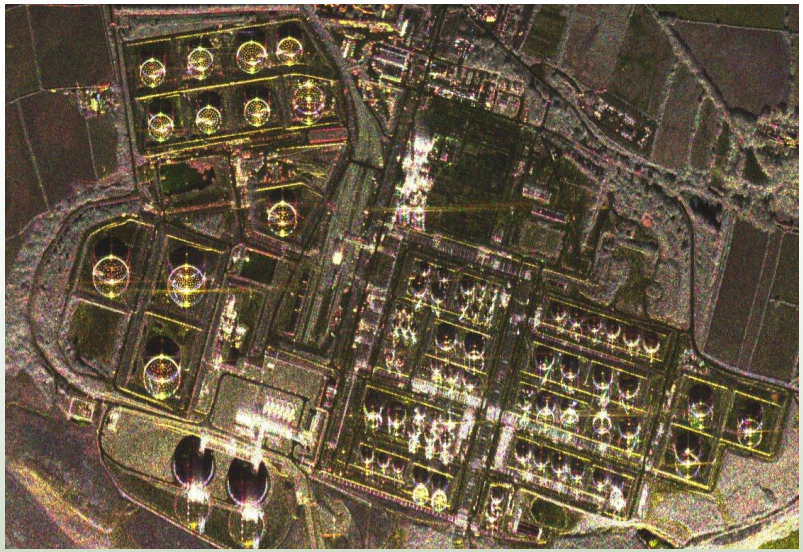
* range only

Mode	Inclination angle	Res. (m)	Swath (km)	Sensitivity (Neσ0)	Ambiguity ratio	No. of looks
1	16-29^0	20m	100km	<-19dB	<-16dB	4
2	53-75^0	30m	750km	<-12dB	<-18dB*	2
3	16-34^0	6m	22-35km	<-20dB	<-18dB	3.7
4	16-32^0	30m	150km	<-20dB	<-16dB	4

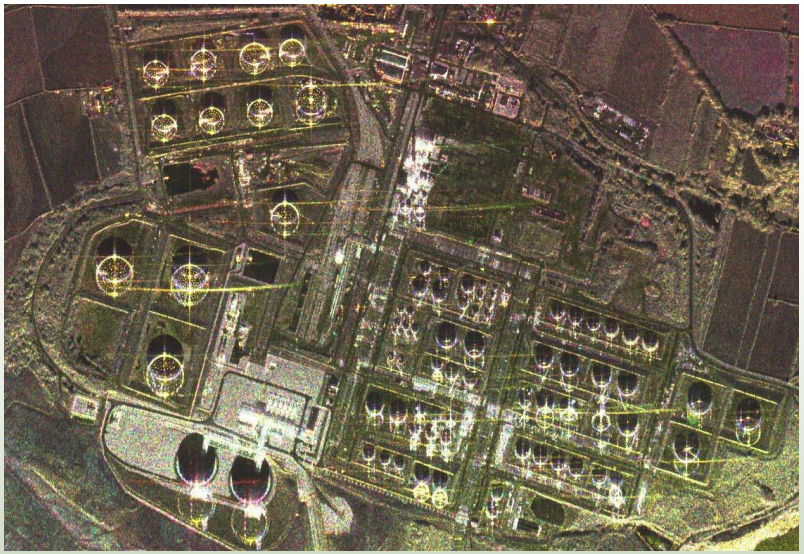
Airborne S-Band NovaSAR Images



NovaSAR - Airborne results



S-Band



X-band

Google Earth

Daily Planet

A new paradigm – Daily Planet

For better understanding and control of resources we need to monitor

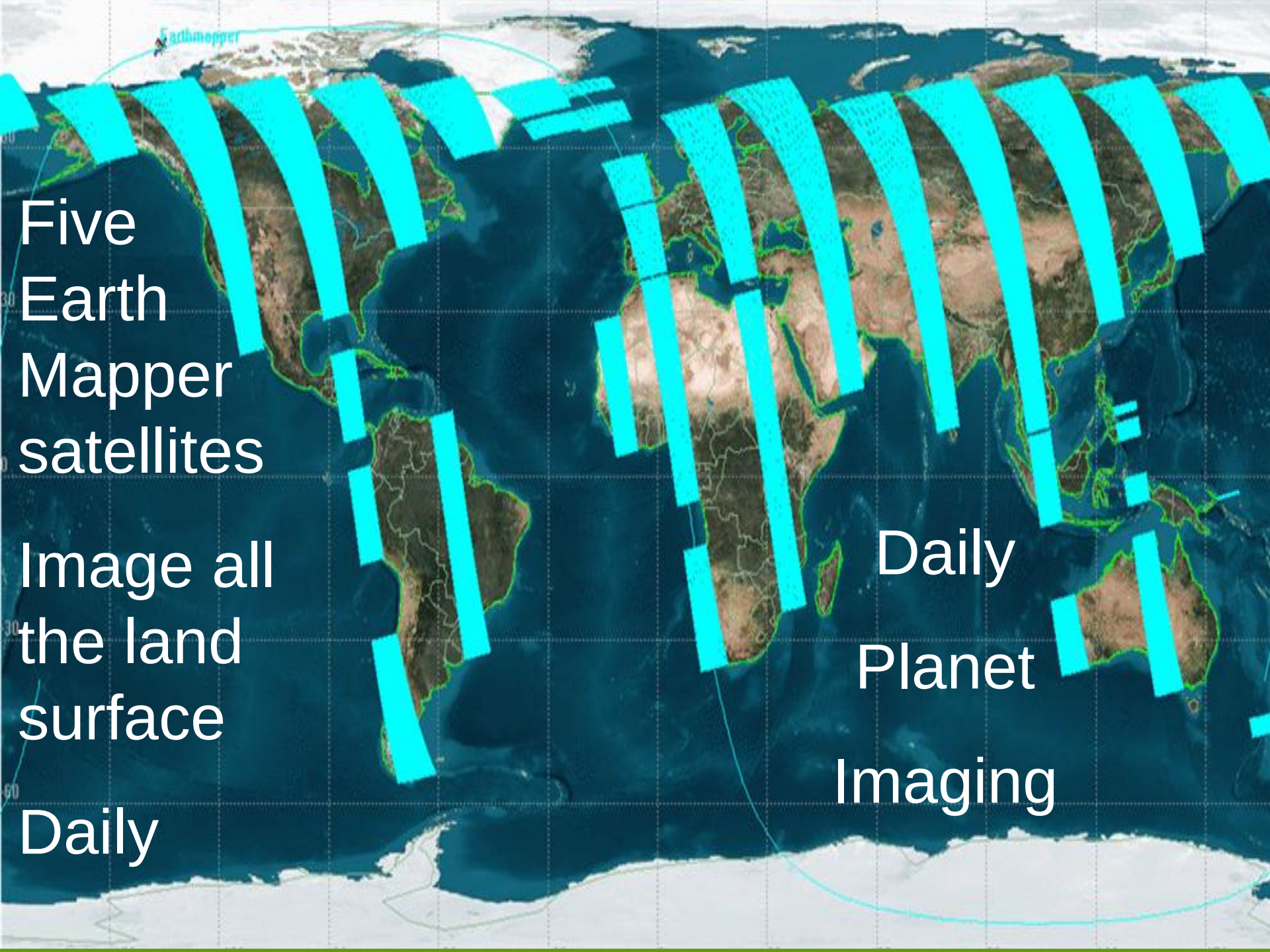
- Worldwide
- Daily
- Operationally

with

- adequate resolution
- core spectral bands
- high data quality

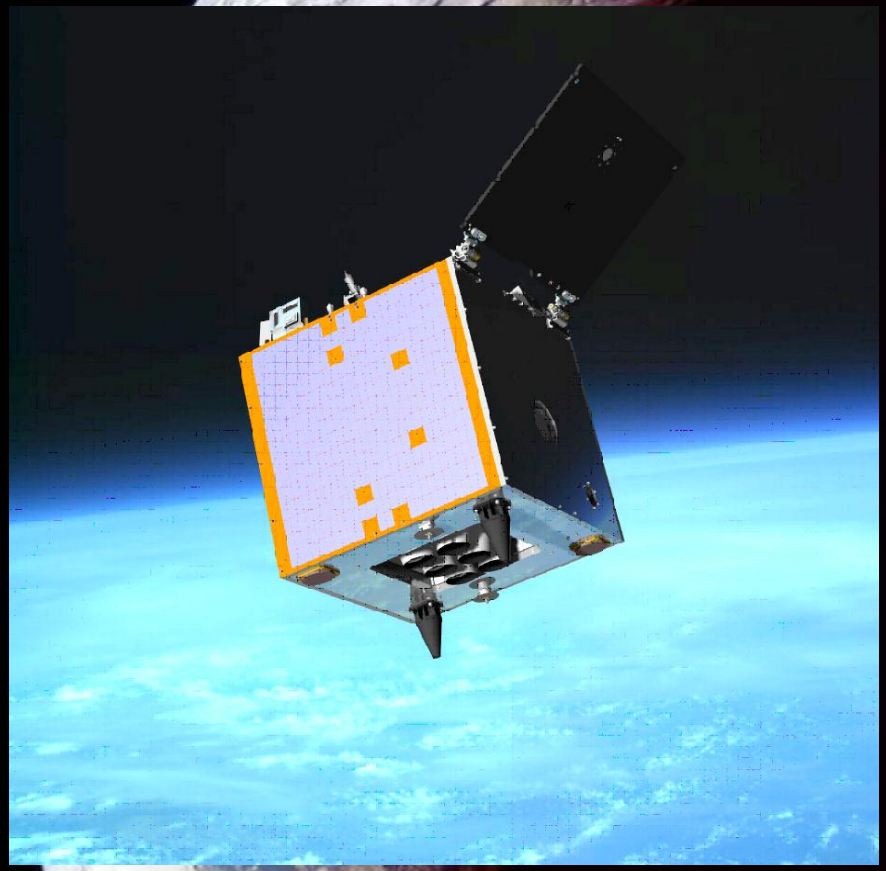
And it must be

- affordable
- sustainable


Earthmapper
Five Earth Mapper satellites
Image all the land surface
Daily
Daily
Planet
Imaging

How can we do it?

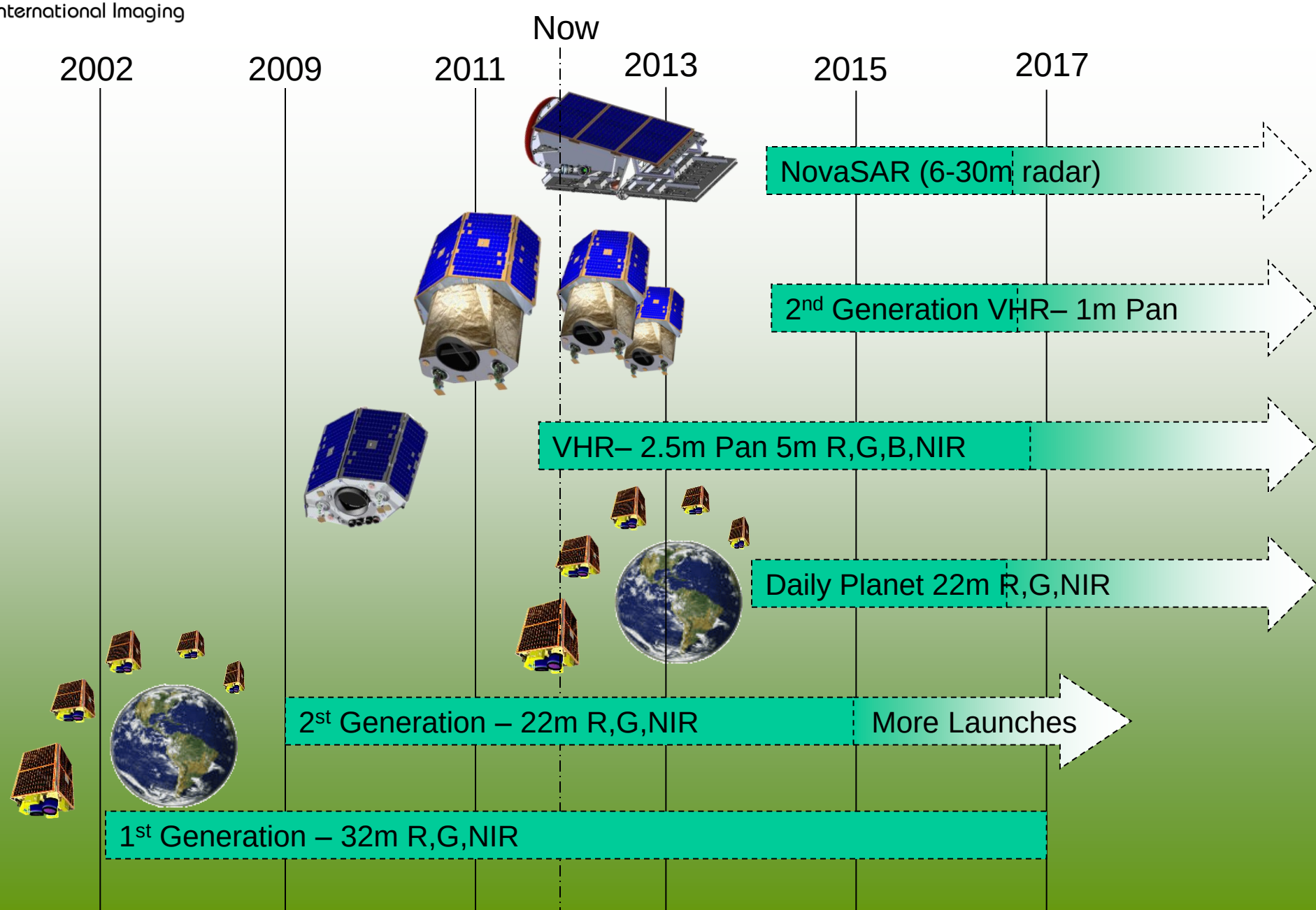
- EarthMapper satellite
  - SSTL 100 satellite
  - <100kg
  - 60cm x 60cm x 70cm
  - Large data storage and downlink capability
  - Image 650km wide
  - GSD 22metre resolution
  - 8bit data
  - 2.5:1 loss-less compression



Daily Planet

- Increases frequency of 22m data
- Stimulates new applications
- Core Landsat spectral bands
- Radiometry within <1% of Landsat
- extends 35 year Landsat archive

DMC Constellations – Sustainable Affordable EO



DMCii services 2012

- High quality rapid repeat continental or precision imaging @22/32m m/s
- VHR imaging on demand @2.5m pan, 5m m/s

Questions ?

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www.dmcii.com