

#### Introduction to Remote Sensing, Earth Observation Optical & Radar Satellites

#### REGIONAL TRAINING ON THE USE OF DRONES, SATELLITE IMAGERY AND GIS

JUNE 07, 2018

ANDREW STEELE SALES ENGINEERING MANAGER, DIGITALGLOBE ASIA-PACIFIC

See a better world.



# The science of obtaining information about objects or areas from a distance



https://www.ebay.com/p/Minion-Goggles-Despicable-Me-Glasses-Goggle-Eyes-Nerd-Glasses-Fancy-Dress/1431506947





http://disney.wikia.com/wiki/Dusty\_Crophopper

# .... and Satellites!



#### **There are Many Types of Satellites Out There**

- Communication Satellites
  - To broadcast television, internet, and enable telephone applications
- Weather Satellites
  - To record and monitor the Earth's climate: temperature, pollution, cloud movement
- Navigational Satellites
  - To help aircraft and vessels navigate and determine geographic location
- Earth Observation Satellites
  - To observe the earth with various sensors, including optical and radar cameras. Typically used for environmental monitoring and various mapping applications.



DigitalGlobe



https://www.satimagingcorp.com/satellite-sensors/worldview-3/

#### **Sensor Specifications Characterized by Resolution**

Spatial Resolution

How big are the pixels? How far can you zoom into the image?

Temporal Resolution

> What is the revisit time until the sensor can collect data over the same location? How often is the pixel collected? What time of day does the sensor collect images?

Spectral Resolution

What range of the spectrum can the sensor interpret? How many bands does the sensor have?







## **Spatial Resolution: How Big are the Pixels?**

- Low Resolution Systems
- (> 1Km Pixel Size: NOAA-AVHRR, )
- Medium Resolution Systems
  (100m ~ 1Km Pixel Size Terra/Aqua-MODIS)
- High Resolution Systems
  (5-100m ; Landsat TM/ETM+, SPOT 5)
- Very High Resolution Systems

(<5m; GeoEye, IKONOS, Quickbird, WV)

#### Wide Area Collection



Collection



#### How much detail is required?



#### How much detail is required?



#### How much detail is required?







IMAGE © 2015 PLANET LABS



### **Coverage vs Spatial Resolution**



#### Temporal Resolution: How frequently are the pixels collected?

- Monitor natural and man-made changes through repeat collections
- Frequency dependent on sensor field of view, and the number of satellites in a constellation.

Satellite Sensor	Spatial Resolution	Imaging Capability	Number of Satellites
MODIS	250m	Roughly global, daily coverage	2
LANDSAT	15m	Consistent imaging and revisit every 8 days	1
PLANET	3-5m	Roughly global, daily coverage	+175
DIGITALGLOBE	30cm	Imaging selected areas only on a deman basis, with a combined revisit of 1 day	5

#### How frequently does it change?

JANUARY	FEBRUARY	MARCH	APRIL
1 2 3 4 5 6 7	1 2 3 4	1 2 3 4	1
8 9 10 11 12 13 14	5 6 7 8 9 10 11	5 6 7 8 9 10 11	2 3 4 5 6 7 8
15 16 17 18 19 20 21	12 13 14 15 16 17 18	12 13 14 15 16 17 18	9 10 11 12 13 14 15
22 23 24 25 26 27 28	19 20 21 22 23 24 25	19 20 21 22 23 24 25	16 17 18 19 20 21 22
29 30 31	26 27 28	26 27 28 29 30 31	23 24 25 26 27 28 29
MAY	JUNE	JULY	AUGUST
1 2 3 4 5 6	1 2 3	laca kolo tala hondu talan bolida talah kon uladar 1	1 2 3 4 5
7 8 9 10 11 12 13	4 5 6 7 8 9 10	2345678	6 7 8 9 10 11 12
14 15 16 17 18 19 20	11 12 13 14 15 16 17	9 10 11 12 13 14 15	13 14 15 16 17 18 19
21 22 23 24 25 26 27	18 19 20 21 22 23 24	16 17 18 19 20 21 22	20 21 22 23 24 25 26
28 29 30 31	25 26 27 28 29 30	23 24 25 26 27 28 29	27 28 29 30 31
SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
ылын жоюн талын чержелі төлері класні штасні 1 О	1 2 3 A 5 6 7	1 2 2 A	1 D DE RODER TATON MONEON THREE NON UNDER
3 4 5 6 7 8 9	8 0 10 11 12 13 1 <i>4</i>	5 6 7 8 9 10 11	3 4 5 6 7 8 9
10 11 12 13 14 15 16	15 16 17 18 19 20 21	12 13 14 15 16 17 19	10 11 12 13 14 15 16
17 18 19 20 21 22 23	22 23 24 25 26 27 28	19 20 21 22 23 24 25	17 18 19 20 21 22 23

26 27 28 29 30

24 25 26 27 28 29 30



6

24 25 26 27 28 29 30

29 30 31

## Where is it cloudy now?





#### Where are icebergs?





#### Where are new subdivisions?







#### How many vehicles?







#### **Car traffic throughout the day?**





#### **Spectral Resolution: More than the Eye can See**



- Satellites extract information from the energy reflecting off of the Earth's surface
- Satellites have the ability to interpret specific light reflectance in the form of a wave, that is associated with a specific wavelength and frequency.
- The range of specific wavelengths are also known as "bands" describing the channel of light



#### **Multispectral Imagery Applications**

- Measure vegetation health
- Monitor biomass
- Perform crop yield analysis
- Detect flooding
- Detect forest fires
- Perform bathymetry analysis
- Generate land cover classification maps
- Perform change detection







### The remote sensing industry is evolving: 2020



# **Operator of the world's highest-performance commercial imaging constellation**





#### Sensor bands

Panchromatic



Potential Area 150,000 sqkm/day





18.0 km













# **Future Constellation**

# Space Surveillance Missions Timely and consistent monitoring

of land, sea and space

#### **More Satellites!**

#### WorldView Legion

- Line collectors which sweep across the ground with fast rates and wide swaths
- 30cm spatial resolution, 8 band multispectral resolution



#### **Increased 8-band color capacity**



#### **Double 30 cm capacity**



### **Our combined constelltion provides intraday revisit**



### The combined constelltion provides intraday revisit



### The combined constelltion provides intraday revisit



### The combined constelltion provides intraday revisit





## **Radar Introduction**



#### **SAR Is Fundamentally Different From Optical**



There are significant differences in how the two types of satellites collect imagery

Optical, or passive sensors rely on the sun to generate the illumination they need to take.

SAR sensors are active sensors, and can image through clouds, rain or darkness

λ (m)



 Increas v (Hz) 7 rays X rays Long radio waves Increasing Wavelength  $(\lambda) \rightarrow$ Visible spectrum



SAR sensors are ideal for regions of the earth that are cloud covered on a regular basis

Use, duplication or disclosure of this document or any of the information or images contained herein is subject to the restrictions on the title page of this document ©Maxar Technologies 2018.



## **Radar Sees The World Differently**





MDA

Use, duplication or disclosure of this document or any of the information or images contained herein is subject to the restrictions on the tille page of this document. ©Maxar Technologies 2018.

#### **A Different View from Optical Data**





Use, duplication or disclosure of this document or any of the information or images contained herein is subject to the restrictions on the tille page of this document. ©Maxar Technologies 2018.



#### Tu-95MS BEAR Parking Apron SE

Ukrainka Airbase, Belogorsk, Russia DOI: 15 May 08 / 11 Sep 09 – 15 Oct 09 SEN: Worldview-1 / RADARSAT-2 GEO: 511012N/1282638E DOP: 31 Mar 10

#### 20100331001-4/10

MDA.





#### **Commonly Used Frequency Bands**

Frequency band	Frequency range		range	Application Example		
• VHF	300 KHz	•	300 MHz	Foliage/Ground penetration, biomass		
• P-Band	300 MHz	•	1 GHz	biomass, soil moisture, penetration		
• L-Band	1 GHz	-	2 GHz	agriculture, forestry, soil moisture		
C-Band	4 GHz		8 GHz	ocean, agriculture		
• X-Band	8 GHz	-	12 GHz	agriculture, ocean, high resolution radar		
• Ku-Band	14 GHz	•	18 GHz	glaciology (snow cover mapping)		
• Ka-Band	27 GHz		47 GHz	high resolution radars		



# Synthetic Aperture Radar (SAR) Satellites





## **RADARSAT-2**

DADAR	DOAT DO	and the second second	a second s	
KADAF	SAL-2 ST	vstem (	anah	lities
10.127.11			- pas	

Satellite Launch	December 2007
Imaging Modes	21
Spatial Resolution	1 to 100 metres (highest resolution commercial C-Band SAR)
Swath Width	18 to <mark>500</mark> km
Scene Size	144 km <sup>2</sup> (Spotlight) to 265,000 km <sup>2</sup> (OSVN)
Polarization	Single, Dual and Quad Polarization Modes
Look Direction	Routine left-and right-looking
On-board Recording	Solid-state recorder
Spacecraft Location	GPS on-board
Imaging Band	C-band
Large Capacity	28 minutes per orbit (current use >10'/orbit)
Frequent Tasking	4 times per day



## **RADARSAT-2 Beam Modes**





## **Selected Beam Mode Coverage**



ScanSAR Wide ~100 m resolution 500 x 500 km

ScanSAR Narrow ~60 m resolution 300 x 300 km

#### Maritime Surveillance

Wide Fine ~8 m resolution 150 x 170 km

Wide Multi-Look Fine ~8 m resolution 90 x 50 km

Wide Area Surveillance

Wide Ultra-Fine ~3 m resolution 50 x 50 km

Spotlight ~1 m resolution 18 x 8 km

Site Monitoring



# **Serving a Wide Spectrum of User Applications**

Maritime Surveillance		Ice Monitoring	A Solution	Oil spill and oil seep detection
Land Target Detection and Classification		Change Detection		Elevation change/ Subsidence Detection and Measurement
Disaster Management	RADARSAT-2	Mapping		Hydrology
Agriculture		Forestry		Geology

