Principles of Satellite Remote Sensing

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Introduction

- Cartography
- Meteorology
- Environmental monitoring
- Agriculture
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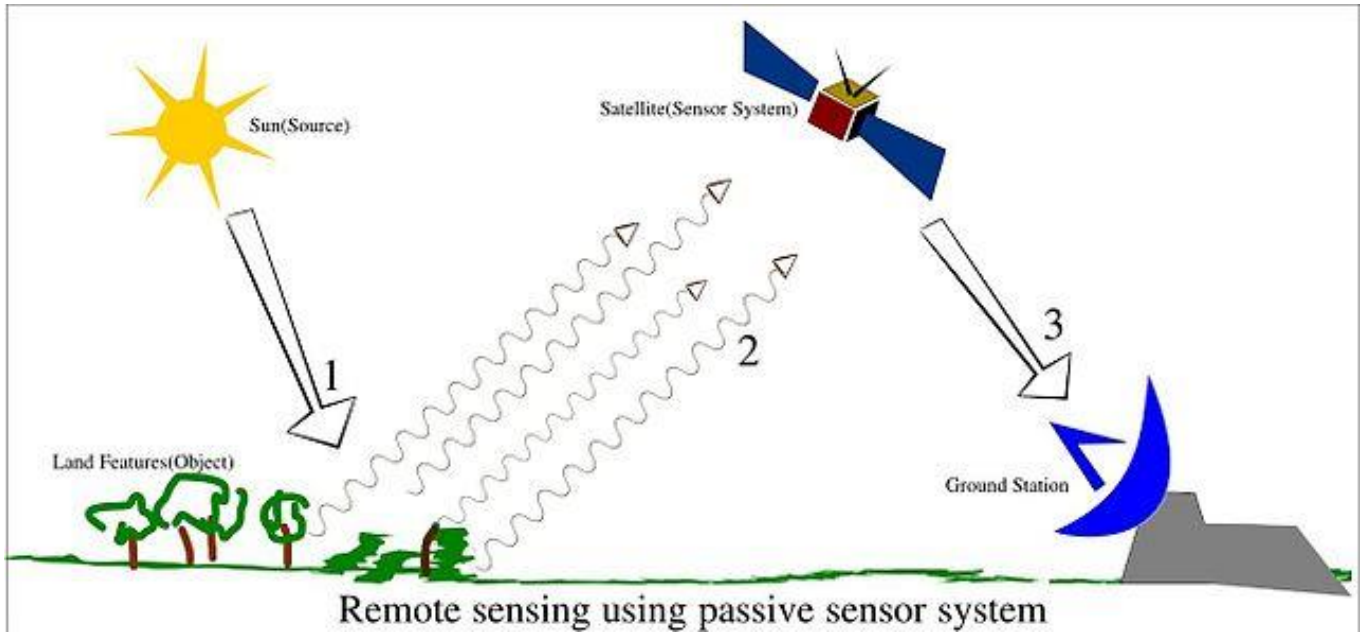
Introduction

Passive systems

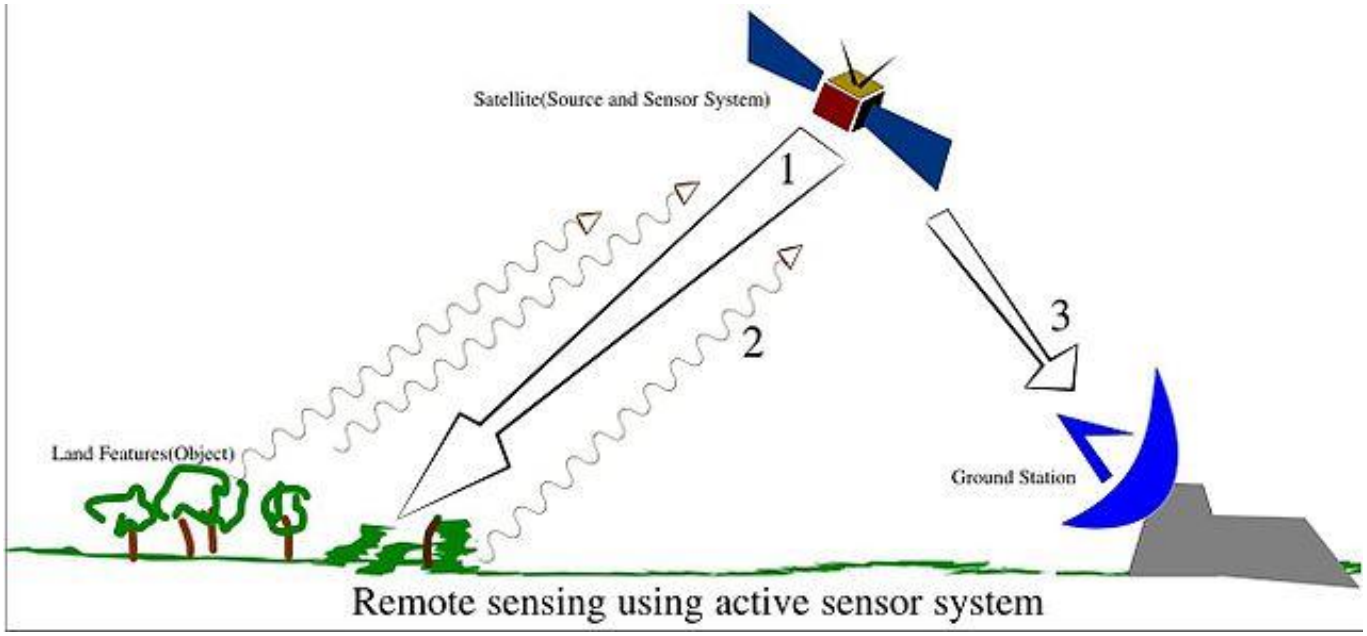
- Film photography
- CCD, CMOS



Introduction

Active systems

- Radar
- Lidar
- Sonar



History of RS

End of 1950s, almost 20 years before CCD. What can we do?

- Let's use the only suitable instrument we have: film camera
- Take images on film and send them on Earth in a special container

Some problems there:

- Unreliable
- Vulnerable to the radiation
- Limited amount of stored film
- Unable to send images of other planets

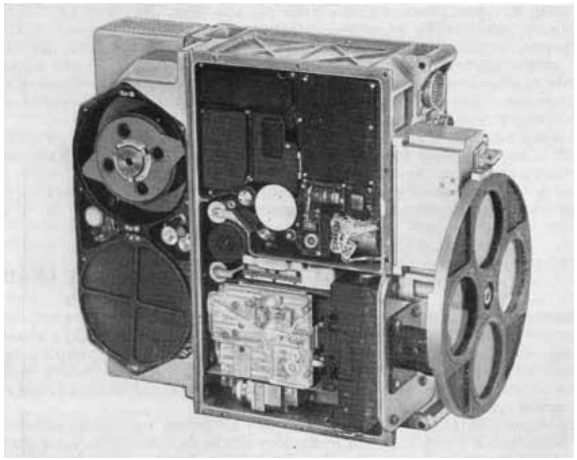
History of RS

In 1958 Slow-Scan Television was developed, so it became possible to send images on Earth via radio. But it's necessary to take the digital image. How?

Vidicon

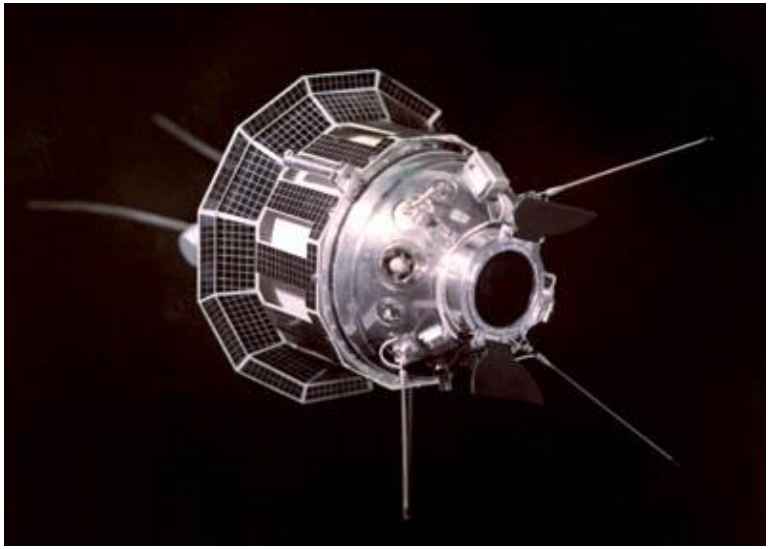
+ Quite simple
– Requires devices to store images

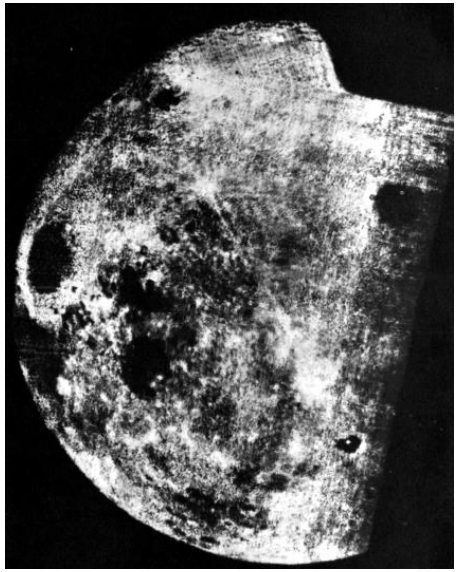
Phototelevision device

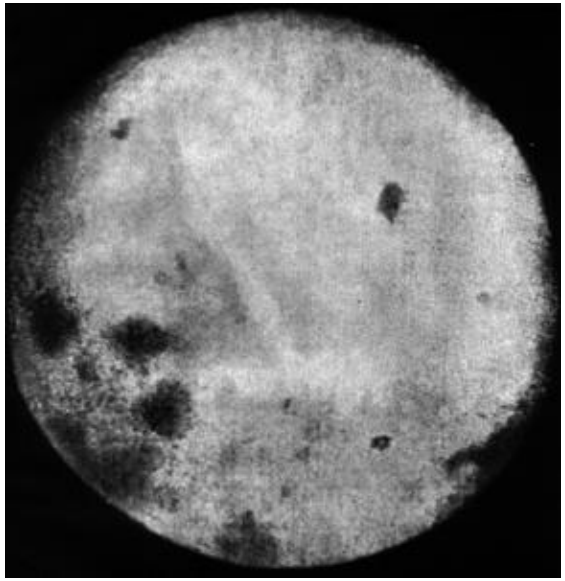


+ Much better resolution
– Very complicated

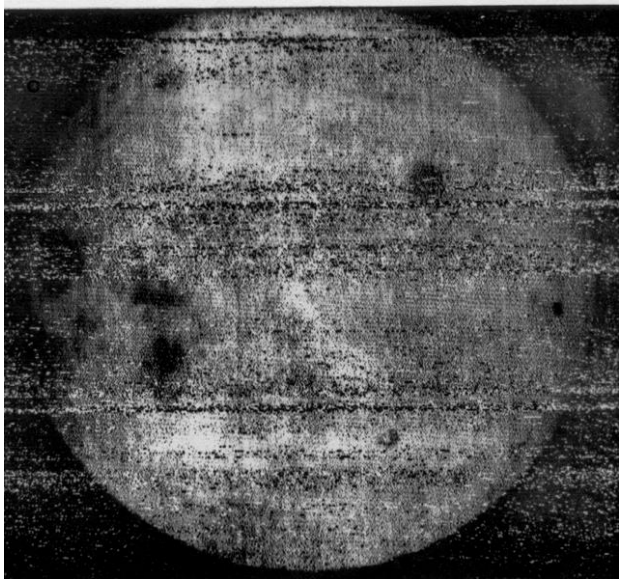
History of RS







Luna-3

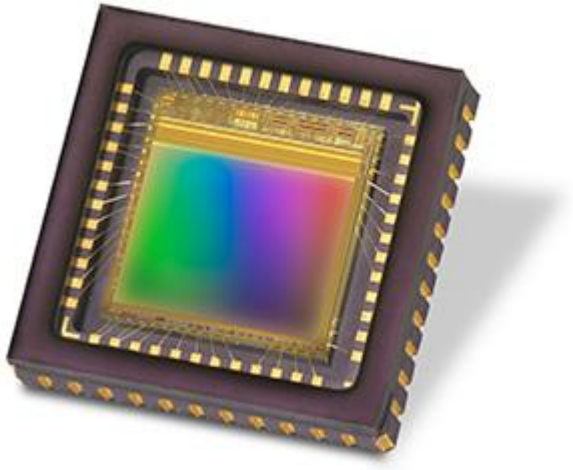


First images of the far side of the Moon

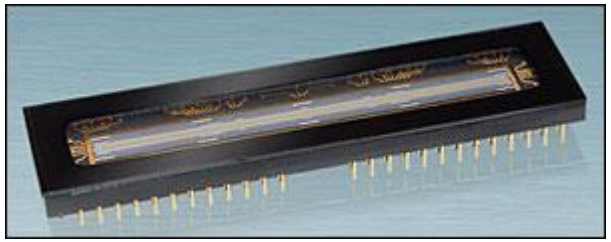
Modern Instruments

In the late 1960s new devices were developed: CCD* and CMOS†

Willard Boyle and George E. Smith, inventors of CCD



CMOS sensor



CCD line sensor

* - charge-coupled device
† - Complementary Metal–Oxide–Semiconductor

Modern Instruments

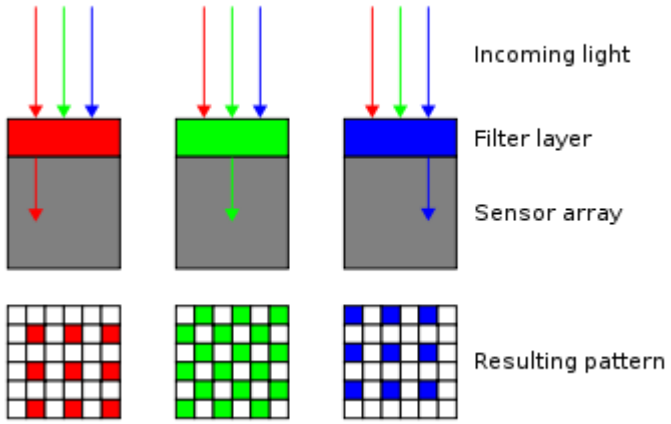
How do they work?

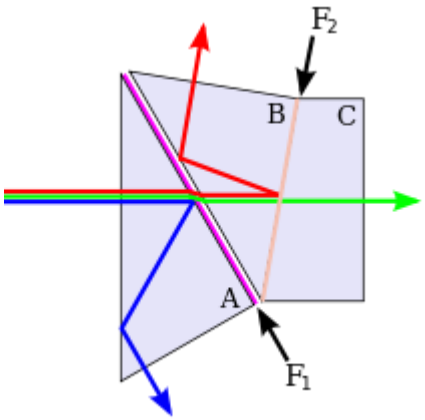
- During the exposure each pixel collects incoming photons
- More photons we collect – greater the charge (because of photo effect)
- Greater the charge – greater the voltage
- After “Reading” the voltage from all pixels, we get an image

Quiet simple for monochromatic images

Modern Instruments

How can we get color images?





Bayer filter

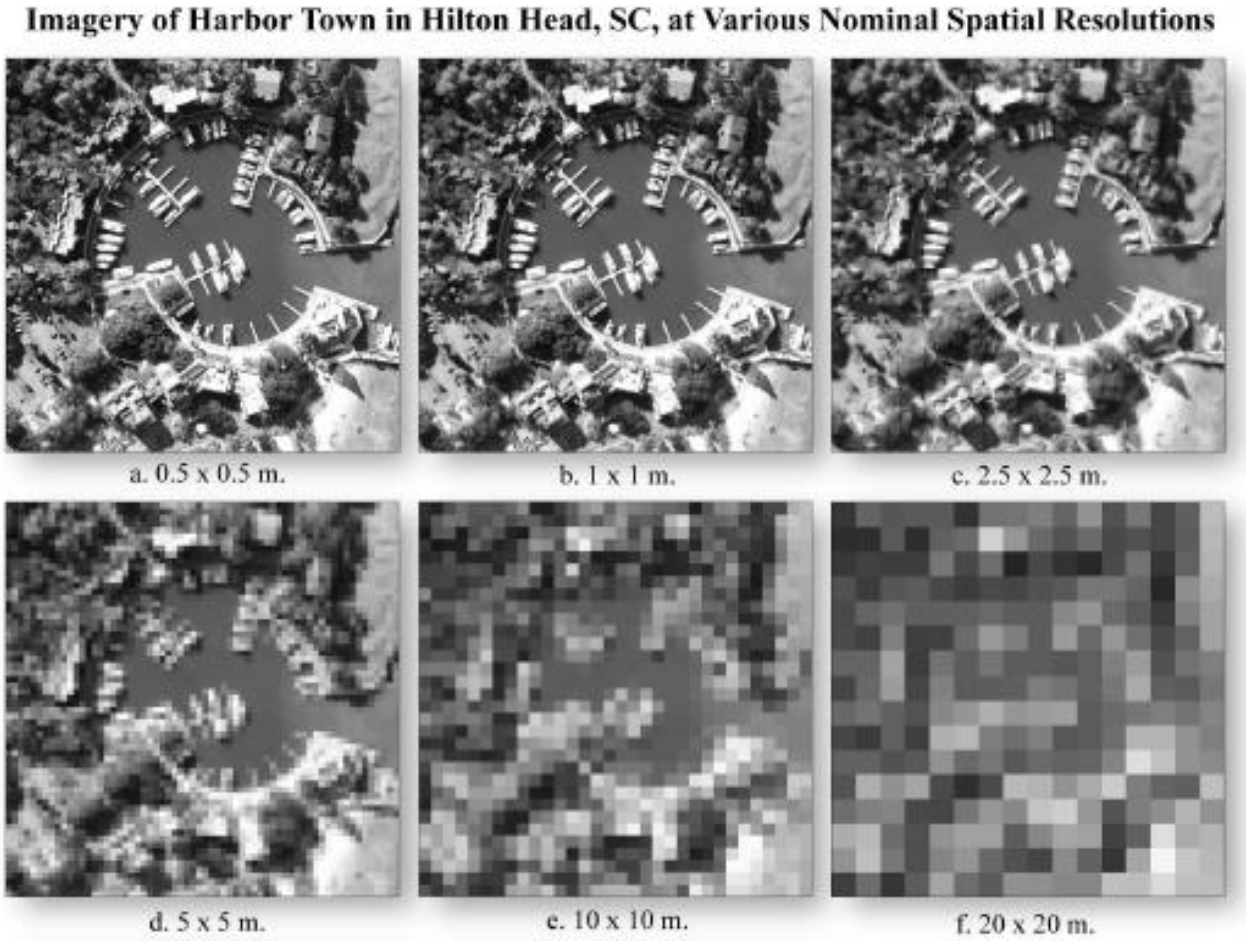
- Each pixel has it's own light filter which allows only the specific colour to walk through

Trichroic prism

- Split an image into 3 colours (red, green and blue usually)
- Each colour is registerd with it's own sensor

Sensor parameters

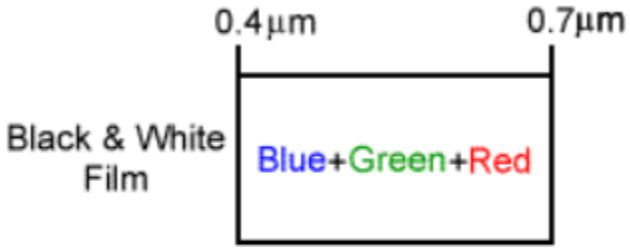
Spatial Resolution. Better resolution = smaller objects we can see



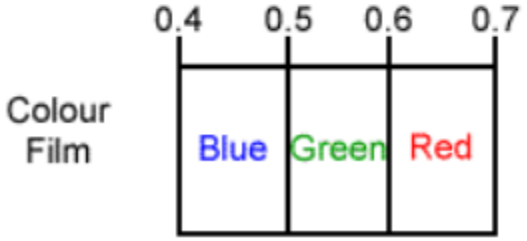
Sensor parameters

Spectral Resolution. Better resolution = more colours we can see (for visible spectrum)

- Low Resolution



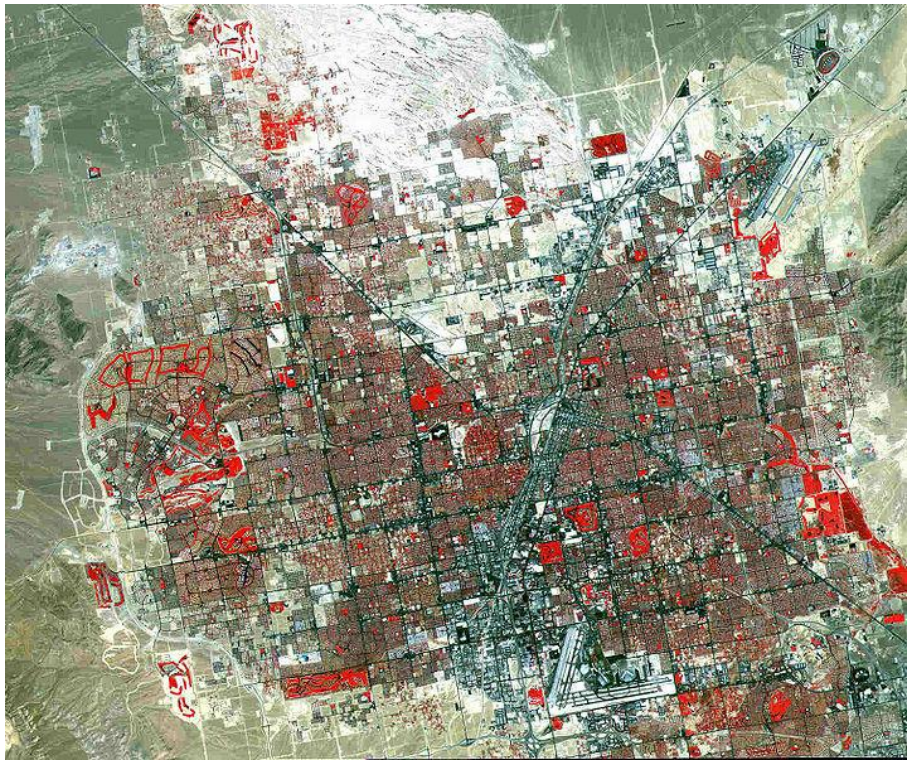
- Higher Resolution



Sensor parameters

How we can use multispectral images?

- We can get true colour images (images we see with our eyes) by combining Green, Red and Blue (RGB →RGB)
- We can combine them to get false colour images (may be suitable in different applications)



E.g. NRG→RGB (N for near infra-red band) mapping: grass-coverd areas are red

Sensor parameters

Radiometric Resolution. Better resolution = more grey value levels we can see

Modern means of RS

Resurs-P (TsSKB-Progress)

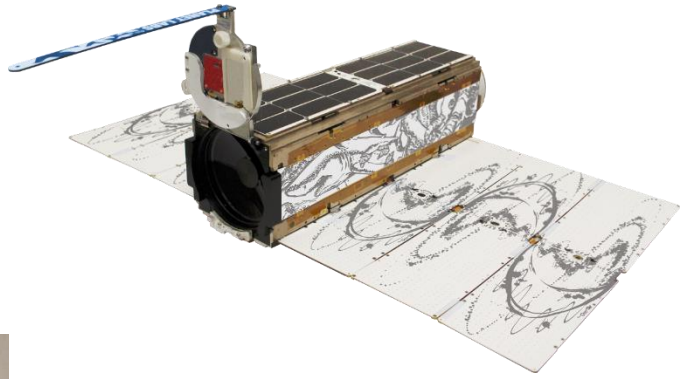
Panchromatic resolution, m	1.0
Multispectral Resolution, m	3.0-4.0
Swath, km	38

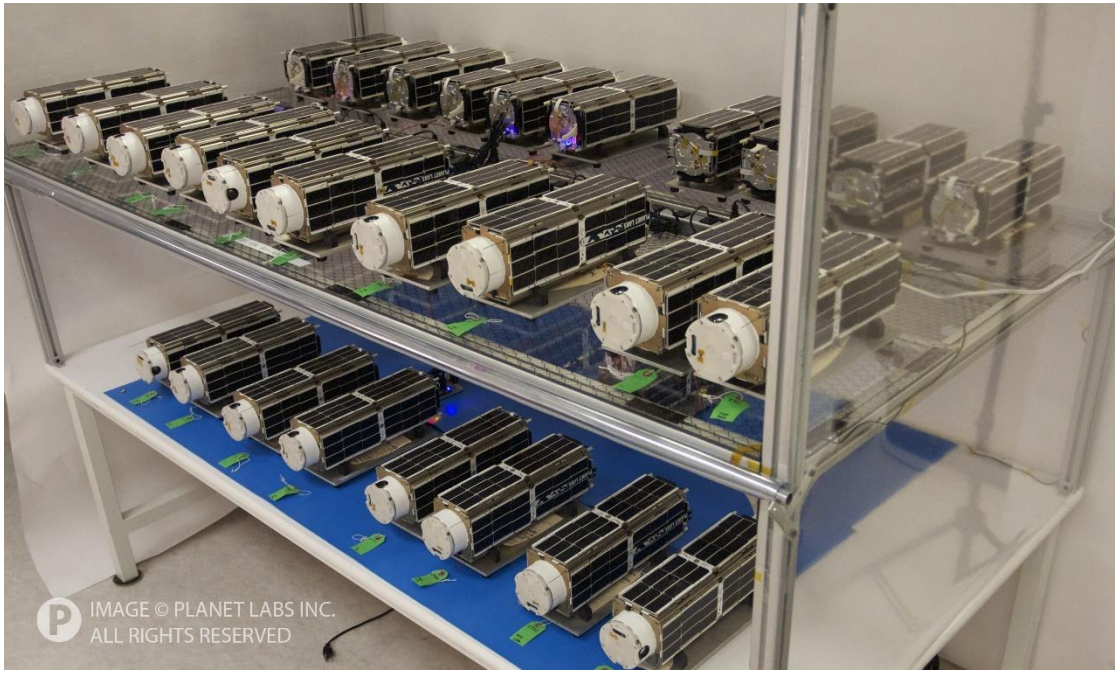
Panchromatic resolution, m	0.31
Multispectral Resolution, m	1.0-4.0
Swath, km	13.1

WorldView-3 (Digital Globe)

Modern means of RS

Constellations of small satellites (3U CubeSats) by Planet Labs. More than a 100 SCs

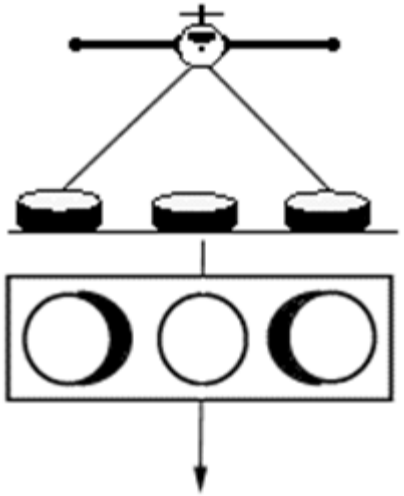




High temporal resolution, spatial resolution about 5 m

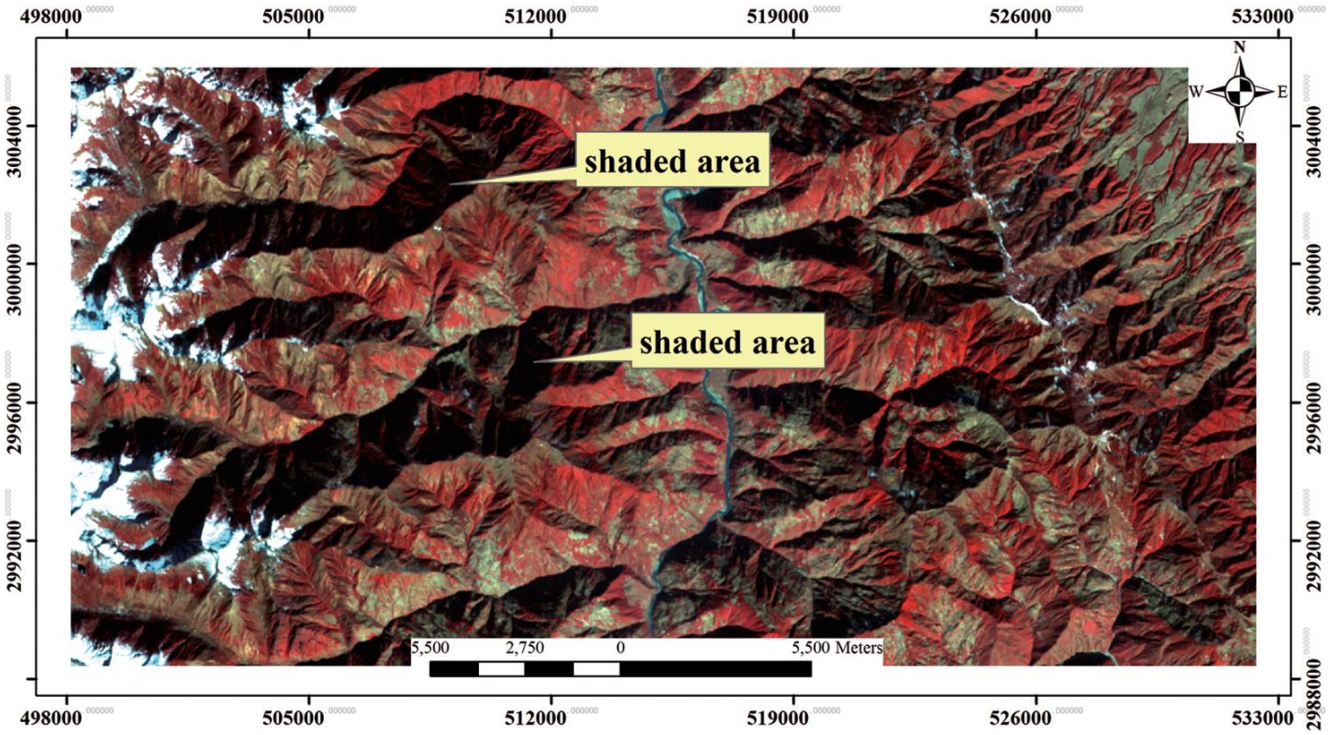
Problems

Geometric distortion (because of relief displacement)



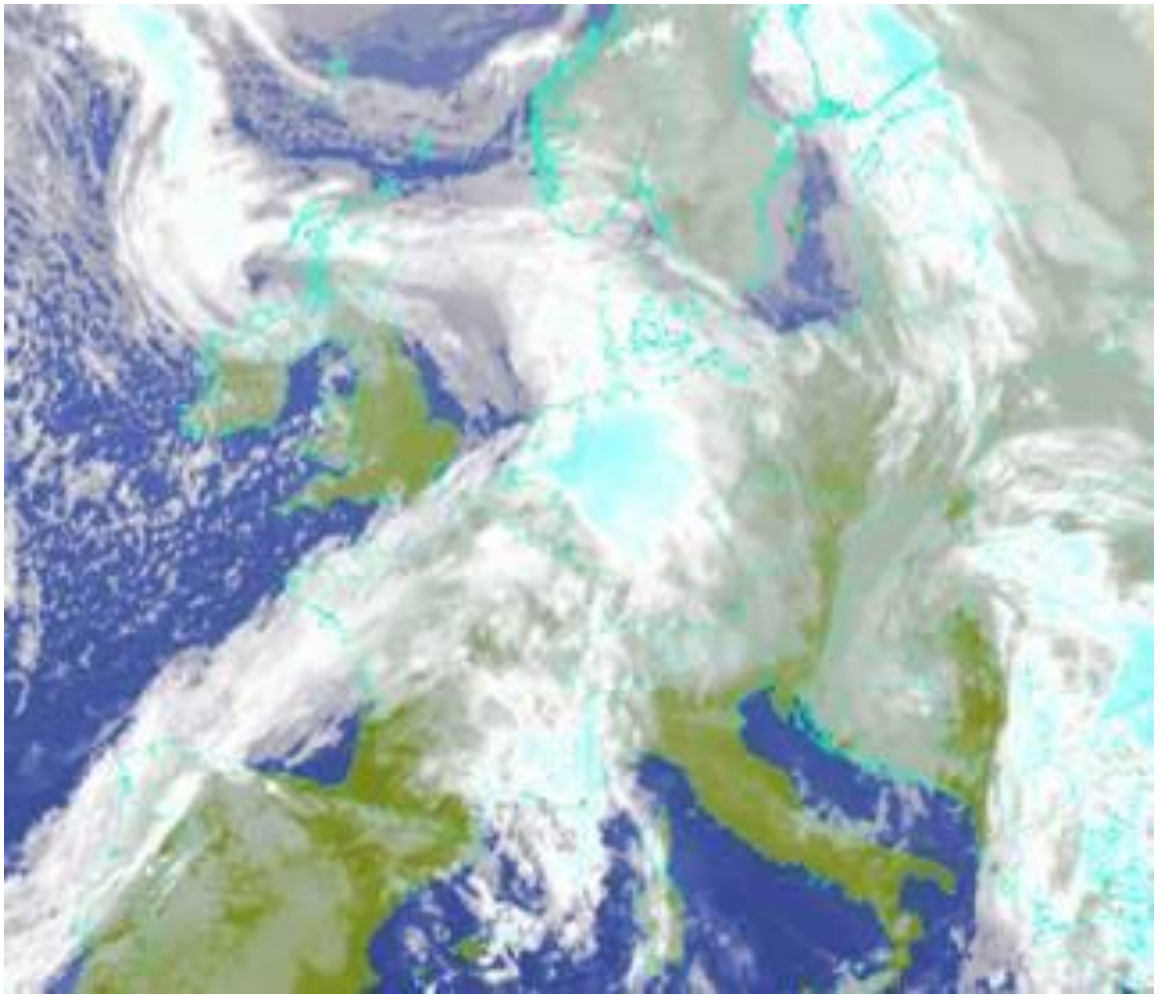
Problems

Topographic corrections

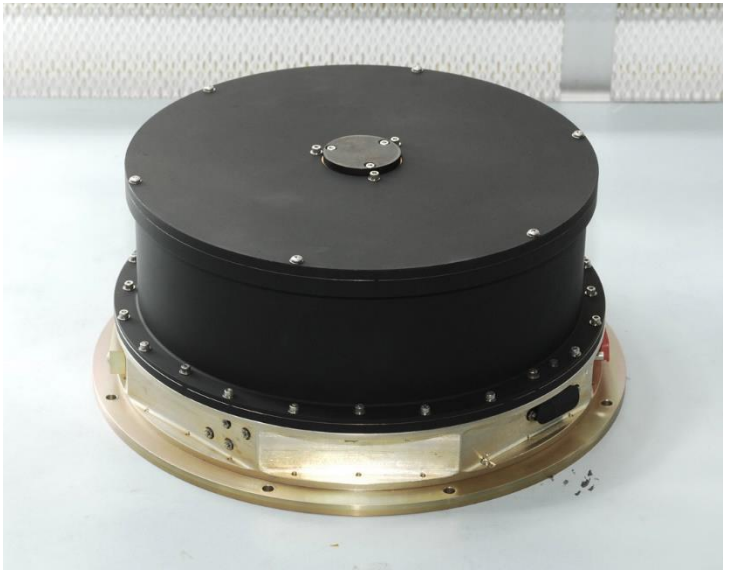


Problems

Clouds



Problems



Energy

- Camera require a lot of energy while active
- Attitude Determine and Control System (e.g. reaction wheels, CMGs, star trackers, magnetometers, etc) consume power

Where do we fly?

We can use natural feature of Earth:

- Our planet has a form of spheroid (almost)
- Because of that orbit of the satellite rotates
- We can use it for some purposes (e.g. always survey surface at the same illumination angle, never enter Earth shadow, etc.)