Types of Scanning

- Multispectral scanning
- Thermal scanning
- Hyperspectral scanning

Different radiation principles
Same operating principles
Same image geometry
Multispectral Scanners

• Advantages over multiband camera systems:
  – Photographic systems: 0.3 - 0.9 \( \mu \text{m} \) spectral range of sensing, wider bands
  – Multispectral scanners: 0.3 - 14 \( \mu \text{m} \), more (and narrower) bands

• MSS use the same optical system to collect data in all spectral bands simultaneously

• Airborne or space platforms
Types of MSS

- Across-Track Scanners (whiskbroom)
- Along-Track Scanners (pushbroom)
Across-Track Multispectral Scanning (Whiskbroom)

- Such systems scan the terrain along scan lines that are at right angles to the flight line.

- This allows the scanner to repeatedly measure the energy from one side of the aircraft to the other.

- Data are collected within an arc of $90^\circ$ - $120^\circ$. 
Across-Track Multispectral Scanning (Whiskbroom)

• Instantaneous field of view (IFOV): the cone angle (β) within which incident energy is focused on the detector

∀ β is determined by the optical system and size of detectors

• Pure and mixed pixels
Across-Track Multispectral Scanning (Whiskbroom)

D : diameter of circular ground area viewed (spatial resolution)

β: instantaneous field of view

H': flying height above terrain

\[ D = H' \beta \]
Across-Track Multispectral Scanning (Whiskbroom)

- Ground resolution cells are largest towards the edge of the image
- IFOV for airborne MSS typically ranges from 0.5-5 mrad
Across-Track Multispectral Scanning (Whiskbroom)

- Small IFOV means *high spatial detail* recorded, since an object can only be resolved independent of its background when the size of the object is equal to or greater than the size of the ground resolution element.
Across-Track Multispectral Scanning (Whiskbroom)

- Larger IFOV means:
  - Greater quantity of total energy on a detector
  - More sensitive scene radiance measurements due to higher signal levels
  - Improved radiometric resolution
Across-Track Multispectral Scanning (Whiskbroom)

• Larger IFOV also means:
  – Signal greater than background noise
  – Higher signal-to-noise ratio
  – Longer dwell time
Across-Track Multispectral Scanning (Whiskbroom)

- If the signal-to-noise ratio is increased by broadening the wavelength band over which a detector operates, spectral resolution is sacrificed.
Across-Track Multispectral Scanning (Whiskbroom)

- Ground pixel size (ground sampled distance) is determined by the sampling time interval during A-to-D signal conversion.
- GSD (ground sampled distance) vs GRD (ground resolution distance)
- Factors affecting spatial resolution: GSD, type of scene, distortions, image motion, illumination, atmosphere, and more…
Across-Track Multispectral Scanning (Whiskbroom)

- The incoming energy is separated into several spectral components that are independently sensed.
- Dichroic grating (to separate thermal and non-thermal energy forms)
Five Channel Scanner
Along-Track Multispectral Scanning (Pushbroom Scanners)

• The difference is the manner in which each scan line is recorded.

• A linear array consisting of numerous CCDs (detectors) is used to scan
Along-Track Multispectral Scanning (Pushbroom Scanners)
Along-Track Multispectral Scanning (Pushbroom Scanners)

- The size of detectors determines the size of each ground resolution cell (10,000 individual detectors)

- Each spectral band (or channel) requires its own array
Advantages of Pushbroom over Whiskbroom

• Longer dwell time  stronger signal, greater range of sensed signal  better spatial and radiometric resolution

• Better geometry (fixed relationship among detector elements)

• Lighter and smaller devices, require less energy
Disadvantages

• Need to calibrate more detectors

• Limited range of spectral sensitivity of commercially available CCDs
Cutting-Edge Technology

- MEIS: Multispectral Electrooptical Imaging Scanner
  - 8 linear arrays of 1728 elements each (0.39 - 1.1 µm)
  - IFOV: 0.70 mrad, total field of view 40 degrees
  - 256 signal levels

- Modular Optoelectronic Multispectral Scanner (MOMS)
  - Developed in Germany, the first pushbroom scanner to be tested from space (1983)
  - Monochromatic images at 20m resolution