In physical terms, instruments utilizing wavelengths larger than a tenth of a centimetre or so are primarily "electronic" and they intercept and emit signals using antennas; in the range below a tenth of a centimetre down to fifty nanometres or so, instruments are primarily "optical" utilizing both geometric and diffraction optics techniques; and as wavelengths become even shorter, instruments rely on particle physics, recording the interaction of discrete waves/particles with the sensor material. Only those waves not absorbed by the earth's atmosphere can be utilized to observe the earth's surface from a satellite. These regions of the spectrum are sometimes called "windows". Visible light, thermal infrared waves (with a wavelength centred around ten micrometres), most microwaves, and the longer ultraviolet waves pass through these "windows".[15]

Instruments can be categorized as:

- detectors or imagers
- active or passive

A *detector* indicates the presence of some intensity of electromagnetic radiation at some wavelength(s), but it doesn't explicitly give spatial information. The motion of the satellite or aircraft can however be used to create low resolution detector images, and for many surveillance applications this is adequate. Radiometers are examples of detectors. An *imager* can be thought of as a detector which also explicitly obtains information about the target's spatial features which can subsequently be processed into a picture. An example of an imager would be a camera.

Passive instruments intercept waves that originate independently from the target. Examples are cameras, telescopes, radiometers and spectrometers. An *active* instrument, on the other hand, first emits a wave toward the target and then consequently receives a returning wave which contains the desired information. Radars, lidars and electromagnetic sounders are examples of active sensors.

SPACEBORNE INSTRUMENTS AND CANADIAN CAPABILITIES

Visible region optical instruments

This category includes telescopes, cameras, spectrometers and interferometers. Picture resolution is defined as the smallest interval on the ground that can be distinguished by the instrument. It is usually limited by the imaging surface's ability to differentiate detail—no matter how precise the optical components may be. For electronic imagery, Charge Coupled Devices (CCDs) or similar solid state microchips are used. A CCD is retina-like and its imaging surface has on the order of 1000 by 1000 individual facets called "pixels", arranged in a rectangular matrix pattern. The resolution of these instruments is governed by the CCD's pixel size which is generally between five to thirty micrometres. Similarly, in a conventional camera it is the "graininess" of the film which limits the system's resolution.

The spatial resolution (r) of an optical instrument is determined by the distance between the target and the instrument's imaging surface (h), the pixel, or film grain, size (d), and the focal length (f), according to the following geometrical relationship:

$$\mathbf{r = \frac{h \times d}{f}}$$

As an example, if a verification satellite were at a 400 kilometre orbit altitude, and if a CCD with 10 micrometre-sized pixels were used in its instrument, then target resolution of one metre could be obtained if the instrument had a four metre focal length. This is large but feasible, and consistent with the sizes used for spy satellites. If a "folded optics" design were used the overall physical length could be less. Variations in the earth's atmosphere, spectral effects, reflection losses and other phenomena impose practical limits on the resolution which is geometrically possible.

Canada has industrial, academic and government research capabilities in optics. For example a number of private companies build precision optics components, and several universities, such as Laval (Quebec), are well known for optics research. The NRC's Dominion Observatory (Victoria) is one of several institutions that has developed complex land-based optical systems, including a laser system targeted at the moon, a portable astronomy system for Saudi Arabia and participation in the 3.6 metre Canada-France-USA telescope located on Hawaii's Mauna Kea. Under contract to NRC, an Ottawa firm has developed an advanced ultraviolet (UV) imaging CCD camera system for Sweden's Viking spacecraft which, launched in February 1986, is now yielding the most detailed ultraviolet pictures yet obtained of the Aurora Borealis. At present a Western Canadian firm is developing a Wide Angle Michaelson Doppler Imaging Interferometer (WAMDII) scheduled for a Shuttle science mission. Two Ontario firms, in collaboration with France, are teamed to develop a large Wind-Imaging Interferometer (WINDII) for flight on NASA's Upper Atmosphere Research Satellite (UARS), which is scheduled for a Shuttle, or Titan, launch in the late 1980's.[6] Numerous Canadian companies market ground and airborne optics instruments.

Synthetic Aperture Radar (SAR)

An imaging radar differs from a detection-only type radar in that the transmitted beam is relatively narrow, and the wave reflected from the target is