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History of Remote Sensing

In 1859 Gaspard Tournachon took an oblique photograph of a small village near Paris from a balloon. With this picture the era of earth observation and remote sensing had started. Other people all over the world soon followed his example. During the Civil War in the United States aerial photography from balloons played an important role to reveal the defense positions in Virginia (Colwell, 1983). Likewise other scientific and technical developments this Civil War time in the United States speeded up the development of photography, lenses and applied airborne use of this technology. Although the space era of remote sensing was still far away after the Civil war, already in 1891 patents were granted in Germany to successful designs of rockets with imaging systems under the title: 'new or improved apparatus for obtaining bird's eye photographic views of the earth'. Th e design comprised a rocket propelled camera system that was recovered by a parachute.

The next period of fast developments in earth observation took place in Europe and not in the United States. It was during World War I that airplanes were used on a large scale for photoreconnaissance. Aircrafts proved to be more reliable and more stable platforms for earth observations than balloons. In the period between World War I and World War II a start was made with the civilian use of aerial photos. Application fields of airborne photos included at that time geology, forestry, agriculture and cartography. These developments lead to improved cameras, fi lms and interpretation equipment. The most important developments of aerial photography and photo interpretation took place during World War II. During this time span the development of other imaging systems such as near-infrared photography, thermal sensing and radar took place. Near-infrared photography and thermal infrared proved very valuable to separate real vegetation from camouflage. The first successful airborne imaging radar was not used for civilian purposes but proved valuable for nighttime bombing. As such the system was called by the military: 'plan position indicator' and was developed in Great Britain in 1941. After the wars in the 1950 remote sensing systems continued to evolve from the systems developed for war efforts (Lillesand & Kiefer, 2000; Colwell, 1083; Harper, 1983). Colour infrared photography (CIR) was found to be of great use for the plant sciences. In 1956 Colwell conducted experiments on the use of CIR for the classification and recognition of vegetation types and the detection of diseased and damaged or stressed vegetation. It was also in the 1950 that significant progress in radar technology was achieved.

Two types of radar were developed at that time: SLAR: side-looking airborne radar and SAR: Synthetic Aperture Radar. Either development aimed at the acquisition of images at the highest possible resolution. Crucial to the SAR development was the ability to finely resolve the Doppler frequencies using a frequency analyses algorithm on the returning radar signal by the US Air Force research Centre. In the early 1960s the US started placing remote sensors in space for weather observation and later for land observations. TIROS (Television Infrared Observation Satellite) was the fi rst meteorological satellite. A long series of meteorological satellites followed this one. 1960 was also the beginning of a famous US military space imaging reconnaissance program called Corona (McDonald, 1995). Unfortunately, much of this programme remained classified until 1995. In 1970 the TIROS programme was renamed into NOAA (National Oceanic and Atmospheric Administration). Until today the NOAA Advanced Very High Resolution Radiometer (AVHRR) is orbiting the globe and collecting information on weather patterns in visible, near infrared and thermal wavelengths. NOAA-17 was launched on June 24, 2002. The 1950s and 1960s were also important for the organizational development of remote sensing. Various civil research organizations’ and universities became highly interested in these new technologies. This resulted in the start of various professional organizations’ and the publishing of remote sensing journals such as the IEEE Transactions on Geoscience and Remote Sensing, International Journal of Remote Sensing, Remote Sensing of Environment and Photogrammetric Engineering & Remote Sensing. Today remote sensing is not only taught at the university level but also at high schools. In the early 70s the first satellite specifically designed to collect data of the earth’s surface and its resources was developed and launched: ERTS-I Earth Resources Technology Satellite. Later, in 1975, this programmer was renamed into Landsat. This fi rst earth resources satellite was in fact a modified Nimbus weather satellite carrying two types of sensors: a four waveband multi-spectral scanner (MSS) and three return beam vidicon television cameras (RBV). The sensors aboard this satellite proved to be able to collect high quality images at a reasonable spatial resolution. These images gave remote sensing a worldwide recognition as a valuable technology. The main advantages recognized at that time were (Curran, 1985): ready availability of images for most of the world, lack of political, security and copyright restrictions, low cost, repetitive multi-spectral coverage and minimal image distortion. Landsat 2 and 3 were launched in 1975 and 1978, respectively, and carried the same payload as the fi rst satellite of this series. The payload was changed in 1983 with Landsat 4. The technically more advanced Thematic Mapper (TM) sensor replaced the RBV. An improved design of the TM, the ETM+ (Enhanced Thematic Mapper) was mounted aboard Landsat 7 and launched in 1999. The Landsat series is a very successful programme, various MSS and TM sensors exceeded by far its design life time and its imagery is probably the most widely used data in the Earth sciences. One black spot on its history record is the ‘failure upon launch’ of Landsat 6 in 1993.

Various other successful earth observation missions carried out by other countries followed the Landsat programme. In 1978 the French government decided to develop their own earth observation programme. This programme resulted in the launch of the first SPOT satellite in 1986. To the original SPOT design of three spectral bands a new sensor called Vegetation was added aboard SPOT-4 in 1998. Other earth observation missions are the Indian Remote Sensing Programme (IRS) started in 1988, the Russian Resurs series first launched in 1985 and the Japanese ADEOS (Advanced Earth Observing Satellite) put in orbit in 1996. The European Space Agency (ESA) launched its first remote sensing satellite, ERS-I, in the year 1991. ERS carries various types of sensors aboard among which the AMI, a C-band (5 cm radar) active microwave instrument. The main focus of the ERS programme is oceanographic applications although it is also widely used for monitoring tropical forests. In 1995 ERS-2 was successfully launched. In March 2002 ESA launched Envisat-1, an earth observation satellite with an impressive payload of I3 instruments such as synthetic aperture radar (ASAR) and a Medium Resolution Imaging Spectrometer (MERIS). An important recent development is the launch of high-resolution earth observation systems such as IKONOS and QuickBird. These systems have multi-spectral systems collecting information in 4 bands (blue, green, red and near-infrared) at a spatial resolution of 4 meters or better. IKONOS has also a panchromatic mode (0.45-0.90 Pm) with a spatial resolution of 1 m. With IKONOS, QuickBird and similar systems, space borne remote sensing approaches the quality of airborne photography.

Concepts of Remote Sensing

Remote sensing, also called earth observation, refers in a general sense to the instrumentation, techniques and methods used to observe, or sense, the surface of the earth, usually by the formation of an image in a position, stationary or mobile, at a certain distance remote from that surface (after Buiten & Clevers, 1993). In remote sensing electromagnetic radiation coming from an object, in case of earth observation this object is the earth's surface, is being measured and translated into information about the object or into processes related to the object. In the former measurement phase the following components are relevant:

- The source of the electromagnetic radiance
- The path through the atmosphere
- The interaction with the object
- The recording of the radiation by a sensor. These comprise the remote sensing system as illustrated in figure. The second phase can be considered to cover the following components:
- Transmission, reception and (pre)processing of the recorded radiance
- Interpretation and analysis of the remote sensing data
- Creation of the final product. The individual components will be briefly described in the next sections.