Historical Development of Remote Sensing

For a long time remote sensing ***was*** aerial photography and photogrammetry using analogue mechanical or optical equipment. That all changed with satellites and the space race. The space race refers to the 20th-century competition between the two Cold War rivals, the former Soviet Union (USSR) and the United States (USA), for dominance in spaceflight capability. It had its origins in the missile-based nuclear arms race between the two nations that occurred following World War II, aided by captured German missile technology and migrant German personnel. The technological superiority required for such dominance was seen as necessary for national security, and symbolic of ideological superiority. The space race began with the launch of Sputnik on 4 October 1957. Sputnik was about the size of a (large) football, weighed 84 kg and had no camera on board. This was the beginning of the space race leading up to sending a manned mission to put a man on the Moon in July 1969, and bring him back, with some samples of Moon rock to provide research material for geologists. Between 1957 and 1978 the space race left a legacy of just over 20 years of rapid development of (a) communications satellites (a highly profitable commercial enterprise of some secondary relevance to remote sensing) and (b) various Earth-observing remote sensing satellites. It also left a continuing human space presence on the International Space Station, as well as sparking increases in spending on education and research and development, which led to beneficial spin-off technologies.

In the early days the satellite-related activities were almost entirely confined to the USA and USSR during this period. India built its first satellite, Aryabhata, which was launched in 1975 by the USSR. China was also active during this period, launching its first communications satellite on 24 April 1970.

Weather satellites

The first real success of remote sensing satellites in serious scientific work was in meteorology. Previously some photographs of cloud systems were taken from the ground and from aircraft flying above the clouds. But satellites provided the opportunity of viewing cloud systems from above and over large areas and so numerous images of cloud systems were generated. Such images are very familiar these days. They are used to allow weather forecasters to see weather systems developing in a way that was not possible before. They are valuable to presenters of weather forecasts on television or on other media. They are valuable in training meteorologists and they are valuable to research workers in meteorology studying historical weather events.

The first weather satellite to be considered a success was TIROS-1, launched by NASA on 1 April 1960. TIROS-1 operated for 78 days and proved to be much more successful than Vanguard 2. TIROS-1 was the first of a long series of polar-orbiting spacecraft which operated under various names of TIROS, ESSA (Environmental Science Services Administration), ITOS (Improved TIROS Operational Satellite) and NOAA (US) (National Oceanic and Atmospheric Administration) up to NOAA-5 which was launched in 1976. For the first 10 years or so these spacecraft carried vidicon cameras, i.e. television cameras, but around 1970 vidicon cameras were being replaced by scanning radiometers of increasing complexity as time went on. There is a parallel US military programme, the DMSP (Defense Meteorological Satellite Program) with a set of similar spacecraft and instruments to the NOAA civilian programme.

The USSR/Russian weather satellite programme of satellites, the Meteor satellites, was developed in the 1960s, not surprisingly in parallel with the US programme, although information about the Meteor programme was difficult to obtain outside the USSR. Not surprisingly the data has not been used seriously outside the USSR (or Russia).

Landsat

On 23 July 1972 the Earth Resources Technology Satellite was launched by NASA ((US) National Aeronautics and Space Administration) This satellite was quickly re-labelled Landsat-1. Landsat-2 was launched in 1975 and over the years there was a succession of subsequent Landsats launched until the most recent satellite in the programme, Landsat 8, was launched on 11 February 2013. The Landsat programme is the longest-running enterprise for the acquisition of satellite imagery of the land surface of the Earth. To date the instruments on the Landsat satellites have acquired millions of images. For many years the cost of Landsat data was too high for some potential programmes. Between 1972 and 1978 Landsat data was mostly used in land-based applications. It was largely handled by visual interpretation of photographic products but was beginning to be handled digitally, although without the benefit of the digital image display devices that we nowadays take for granted.

New satellites and instruments

1978 was an interesting year in terms of satellite data sources for different applications. There was an established set of sources of data for meteoro1ogical applications from polar-orbiting and geosynchronous satellites. There was also an established source of data for land-based applications from the Landsat programme (Landsat 3 was launched in 1978) but there were at that time no other rival sources of land use/land cover data from remote sensing satellites. The first rival to appear on the scene was the French SPOT (Satellite Pour l'Observation de Ia Terre (Satellite for the observation of the Earth)). SPOT-1 was launched on 22 February 1986 and transmitted multispectral data at 20 m resolution and panchromatic data at 10 m resolution. The SPOT system continued with SPOT-2 (launched on 22 January 1990) and on to SPOT-7 (launched on 30 June 2014). Following SPOT-1 many other countries launched their land observation satellite systems at various improved spatial and spectral resolutions, with various levels of operationality and various levels of ease of access to the data by potential users.

The AVHRR was conceived in the mid 1970s as a scanning radiometer to be flown on the NOAA polar-orbiting satellites for meteorological purposes, including the study of sea surface temperatures; the first in the series was launched in 1978. But since then – for a whole variety of reasons – it came to be one of the most valuable sources of data for non-meteorological purposes in a whole variety of environmental scientific and management contexts.

The AVHRR was originally designed for meteorological purposes, i.e. to provide additional information to forecasters, supplementing the data from ground stations and radiosondes, in the public presentation of weather forecasts, for teaching students of meteorology, and in meteorological research. But in the end it proved to be applicable in very many other fields, see. One of the earlier and more spectacular successes, apart from sea surface temperatures, was in providing normalized difference vegetation index (NDVI) data for the whole global land surface.

Small satellites

Already in the earIy 1960s, the first spacecraft of a family of tiny communication satellites, referred to as OSCAR (Orbiting Satellite Carrying Amateur Radio), was designed and developed by a California-based group of amateur radio enthusiasts. OSCAR-1 was the first battery-powered amateur satellite. It had a mass of 4.5 kg and was launched on 12 December 1961.

In 1969 the Radio Amateur Satellite Corporation (AMSAT) was founded in Washington DC as an educational organization to give amateur radio satellites an international base. Some OSCAR family advancements were achieved but like many new developments, the small satellites of the early space age were simply overlooked by the established space industry and the space agencies.

Oceans – satellite oceanography

1978 was a key year for the extension of satellite oceanography beyond the early studies of sea surface temperatures from thermal infrared satellite data. and this was because of the launch of SEASAT and the flying of CZCS on NIMBUS-7.

SEASAT was the first Earth-orbiting satellite designed for remote sensing of the Earth's oceans using active microwave wavelength instruments. The mission was designed to demonstrate the feasibility of global satellite monitoring of oceanographic phenomena and to help determine the requirements for an operational ocean remote sensing satellite system. Specific objectives of SEASAT were to collect data on sea-surface winds, sea-surface temperatures, wave heights, internal waves, atmospheric water vapour, sea ice features and ocean topography. Many later remote sensing missions owe their existence to the successful proof of concept legacy of SEASAT.

Landsat had the advantage of spatial resolution (80m and later 30m) but suffered from poor temporal resolution (once in 18 days, later once in 16 days, but less in cloudy areas.) There had been occasional Landsat images acquired of marine algal blooms, which had caused great excitement among oceanographers. Landsat was very good for slowly varying situations, geology, deserts and forestry for example, but achieved only limited success with crop studies.

Some space systems designed for remote sensing use as land, ocean, and weather observers will be introduced and exemplified in the course. We will list here the principal ones flown by several nations (identified in parenthesis) along with the date the first (and sometimes only) of each was launched.

Group 1

Primarily Land Observers: Landsat (1-6) (1973); Seasat (1978); HCMM (1978); SPOT (France) (1-3) (1986); RESURS (Russia) (1985); IRS(1A-1D) (India) (1986); ERS (1-2) (1991); JERS (1-2) (Japan) (1992); Radarsat (Canada) (1995); ADEOS (Japan) (1996) (Note 1: SIR-A (1981), (Note: SIR-A (1981), SIR-B (1984), and SIR-C (1994) are radar systems flown on Space Shuttles), OrbView (USA/OrbImage) (1-3) (1995), IKONOS (USA/Space Imaging) (1999), CBERS (1-2) (China-Brazil) (1999), KOMPSAT (Korea) (1999), Terra (EOS AM-1) (USA/Japan) (1999), EROS-A (Israel/Imagesat) (2000), Quickbird (USA/DigitalEarth) (2001), ENVISAT–1 (ESA) (2002), DMC (AISAT-1, NigeraSat-1, BILSAT and BNSCsat) (Algeria, China, Nigeria, Turkey and UK) (2002-2003), ICESat (USA) (2003).

Group 2

Primarily Meteorological Observers: TIROS (1-9) (1960); Nimbus (1-7) (1964); ESSA (1-9) (1966); ATS(g) (1-3) (1966); DMSP series I (1966); the Russian Kosmos (1968) and Meteor series (1969); ITOS series (1970); SMS(g) (1975); GOES(g) series (1975); NOAA (1-5) (1976); DMSP series 2 (1976); GMS series (Japan) 9 (1977); Meteosat(g) series (1-7) (Europe) (1978); TIROS-N series (1978); Bhaskara (India) (1979); NOAA (6-1418) (1982); Insat serie I (India) (-1A, -1B, -1C, -1D) (1983); ERBS (1984); MOS (Japan) (1987); serie DMSP F (8-16) (1987), UARS (1991); Insat series II (India) (-2A, -2B, -2C, -2D, -2E) (1992), GOMS (g) (Russia) (1994), TRMM (U.S./Japan) (1997), Insat serie III (-3A) (India) (2003), MSG–1 (Meteosat Second generation) (Europe) (2004) (Note 1: g = geostationary).

Group 3

Major Use in Oceanography: Seasat (1978); Nimbus 7 (1978) included the CZCS, the Coastal Zone Color Scanner that measures chlorophyll concentration in seawater; Topex-Poseidon (1992); SeaWiFS (1997), JASON 1 (France-USA) (2001), Aqua (EOS PM-1) (USA) (2002), Resourcesat-1 (India) (2003).

UAVs, drones

The first important source of remote sensing data acquisition was the use of air photos, and the first revolution after that was the addition of data from Earth-orbiting satellites and geostationary satellites. It is probably no exaggeration to say that the next revolution in the acquisition of remote sensing data has been the arrival of the UAV (Unmanned Aerial Vehicle, drone, or whatever else we choose to call them) on the scene. Of the three needs of spatial, spectral and temporal resolution the UAV particularly addresses the questions of spatial and temporal acquisition. Once you have a UAV you can acquire data where and when you want it, and reasonably cheaply.