Remote sensing platforms to remote sensing systems

1. 0 Introduction A remote sensing platform is designed with a relatively narrow set of purposes in mind. Many important decisions must be made when designing a remote sensing technology. The type of sensor and its capabilities must be defined. The platform on which the sensors will be mounted must be determined. The means by which the remotely-sensed data is received, transmitted, and processed before delivery to its end user must be designed.

All of these decisions are made based on knowledge of the target and the information about the target that is in demand, balanced by other factors such as cost, availability of resources, and time constraints. The end result of this process is a tool that is specifically designed to perform a task or a set of related tasks that will assist researchers in better understanding the process that is under investigation. 1. 1 Sensor Resolution There are many applications of remote sensing, and each sensor is engineered for very specific purposes.

The design and placement of a sensor is determined by the unique characteristics of the target that will be studied and the information that is required from the target. Each remote sensing application has specific demands on the amount of area to be covered, the frequency with which measurements will be made, and the type of energy that will be detected. Thus, a sensor must provide the spatial, spectral, and temporal resolution necessary to meet the needs of the application. Spatial resolution refers to the amount of detail that can be detected by a sensor.

Detailed mapping of land use practices requires a much greater spatial resolution than observations of a large scale storm system. Thus, land use satellites such as Landsat generally have greater spatial resolution than global weather satellites. Spectral resolution refers to the width or range of each spectral band measured by a sensor. Detection of some phenomena, such as vegetative stress, requires a sensor with sensitivity in a narrow spectral band so that differences in the spectral signatures at a specific wavelength can be detected.

Temporal resolution refers to the time interval between measurements. For some applications, such as monitoring the development of a severe thunderstorm, measurements are required at a frequency of a few minutes. Some applications, such as measuring crop production or insect infestations, require seasonal measurements, while others, such as geological mapping, require a single measurement. 2. 0Ground-Based Platform Remote sensing platforms that position the sensor at the Earth's surface are called ground-based platforms.

These systems are fixed to the Earth and the sensors are often standard tools used to measure environmental conditions such as air temperature, wind characteristics, water salinity, earthquake intensity and such. Ground-based sensors can be placed on tall structures such as towers, scaffolding, or buildings to elevate the platform. Ground-based sensors are generally less expensive to operate and maintain than air-borne or space-borne sensors, but they do not provide the aerial extent of the air-borne or space-borne platform.

Ground-based sensors are often used to record detailed information about the surface, which is compared with information collected from air-borne or space-borne platform sensors. One example of ground-based remote sensing are sensors mounted on buoys that make real-time measurements of water temperature, salinity, wind speed, and wind direction. The buoys are anchored in a body of water (the target) and they transmit the results of each measurement to receiving stations to be processed.

These sensors can be used to supplement or " ground truth" measurements made from air-borne or space-borne sensors. Ground-based remote sensing platforms can transmit data using ground-based communication systems, such as radio and microwave transmissions or computer networks. Some systems can store data on the platform, allowing researchers to manually collect the data from the platform. 3. 0Air-Borne Platform Air-borne platform is most often sensors mounted on fixed-wing aircraft, though other airborne platforms, such as balloons, rockets, and helicopters can be used.

Aircraft are often used to collect very detailed images of the Earth's surface and facilitate the collection of data over virtually any portion of the Earth's surface at any time. Air-borne platform systems elevate the sensor above the Earth's surface in order to increase its aerial coverage. They also allow researchers to monitor very large areas of the surface which would be impractical with ground-based sensors or impossible or dangerous to visit. Airborne remote sensing dates back to the early 900's when airplanes were used during the World Wars to conduct surveillance of the enemy. More recently, cameras mounted on aircraft have been used to monitor land use practices, locate forest fires, and produce detailed and accurate maps of remote or inaccessible locations on our planet. Weather balloons and rockets are still used by research scientists as a means for obtaining direct measurements of the properties of the upper atmosphere. These provide a less expensive and reusable alternative to aircraft and satellite systems.

Data collected in an aircraft can be stored on board and retrieved once the aircraft lands. The following image depict Atlanta, Georgia as seen from an airborne sensor mounted on a specially equipped Lear Jet 4. 0Space-Borne Platform In the early 1960's researchers started mounting sensors on satellites placed into orbit over the Earth and ushered in a new era of environmental remote sensing that continues to grow at a rapid pace today. The vantage point of space allows researchers to observe and measure phenomena on a time and spatial scale that was previously impossible.

Today, satellites provide us with views of the Earth that allow us to monitor global change and understand our planet. This wealth of data comes with a price, however. To build a satellite and place it into orbit is a very difficult and expensive endeavour, often coming with a price tag that approaches billions of dollars. Satellites must be operated remotely from the ground and data from the satellite sensors must be transmitted to the surface. The communications technologies in remote sensing satellites can be very complex and expensive to engineer and maintain.

A number of satellites have failed to reach orbit, or failed to operate once in orbit around the earth, which is a testament to the incredible complexity involved in designing, building, and operating a satellite. Data collected from a satellite platform can be transmitted to Earth in a variety of ways. A satellite can transmit data directly to a ground receiving station that is within its line of sight. When the satellite is not in sight of a ground station, it can store its data on board and " dump" the data later, when it is back in sight of a ground station.

Finally, for immediate transmission, a satellite can relay data to the ground receiving station through a series of communications satellites in orbit around the Earth, transferring data from one satellite to the next until it is able to reach the ground receiving station desired. The data received at the ground station are in a raw digital format. They may then, if required, be processed to correct systematic, geometric and atmospheric distortions to the imagery, and be translated into a standardized format. The data are written to some form of storage medium such as tape, disk, or CD.

The data are typically archived at most receiving and processing stations, and full libraries of data are managed by government agencies as well as commercial companies responsible for each sensor's archives. Land use satellites such as those in the Landsat program have monitored land use change for decades, providing detailed insight into how development has affected tropical rain forests, how climatic changes have affected agricultural production, how deserts advance and withdraw, and how the polar ice caps have retreated 5. 0Photographic Systems

The term “ photographic” refers to systems that use films coated with photo-sensitive silver halide emulsions to record an image. Photographic camera/film systems have been used since the first decades of the 20th century to collect spatial data. Aerial photographs are the primary data input for production of topographic maps, although various types of “ ground truth” information are needed to verify interpretation of the airphoto imagery and to ensure accurate transformation of the image data into map or GIS database format. Photographic films are sensitive to reflected EMR in wavelengths ranging from the mid-ultraviolet to the near-IR.

The camera’s entire field of view is recorded instantaneously. The film detects and records the EMR reflected from surfaces within the field of view as a continuous tone image. 5. 1Digital Camera Digital cameras are a recent development. Like the traditional photographic camera, they use a lens to focus reflected EMR but use an array of EMR sensors rather than photographic film to record the image. Sensor arrays can have different spatial resolutions, ranging from 512 by 512 for a 35 mm equivalent image up to 2048 by 2048 for applications requiring finer spatial detail.

The sensors detect reflected EMR for each wavelength for which they are calibrated. The resulting image is comprised of picture elements or pixels, each of which records a brightness value for the spatial field of view it detects. A 2048 by 2048 pixel image contains 4. 2 million pixels! 5. 2Trimetregon Camera A trimetregon camera is acutally an array of three cameras that take simultaneous overlapping images of the terrain. This type of camera is used to take airphotos in areas of mountainous terrain. The central camera in the array takes a vertical airphoto while the left and right cameras record oblique images of adjacent terrain.

This type of camera is used to obtain images of steep valleys. By flying along the valleys and collecting overlapping images of the floor and sides of the valleys, trimetregon cameras can overcome the problems that are associated with normal parallel traverse airphoto coverage in areas with high local relief. 6. 0Optical-Electrical Scanners Electro-optical scanners used in both airborne and satellite remote sensing are somewhat similar to digital cameras in that they use an array of electronic sensors, in combination with mirror/lens optical devices to scan a scene and record an image.

Each sensor in the array produces an electrical signal for each wavelength detected. The electrical signals can be recorded on magnetic tape. In the case of satellite sensors, the continuous electrical signals are usually converted into digital numbers representing up to 256 gray levels before being transmitted to Earth-based receiving stations. Optical-electrical scanners offer the potential of real time data acquisition since there is no delay while film is being developed and prints produced for distribution. 7. Passive Microwave Sensing A microwave radiometer is a passive sensor that simply measures electromagnetic energy radiated towards it from some target or area. As a passive sensor, it is related more to the classical optical and IR sensors than to radar, its companion active microwave sensor. The energy detected by a radiometer at microwave frequencies is the thermal emission from the target itself as well as thermal emission from the sky that arrives at the radiometer after reflection from the target. The thermal emission depends on he product of the target's absolute temperature and its emissivity, but at microwave frequencies (in contrast to the thermal infrared) it is the change in emissivity rather than the change in temperature that produces most of the significant differences between the various targets. The intervening atmosphere between the target and the radiometer can have an adverse effect on the measurement by attenuating the desired target signal and contributing unwanted thermal radiated energy due to its own temperature and emissivity. The microwave portion of the electromagnetic spectrum includes wavelengths from 0. mm to more than 1 m. It is more common to refer to microwave radiation in terms of frequency, f, rather than wavelength, ?. Recall that c = ? f where c is the speed of light. In frequency then, the microwave range is from 300 GHz to 0. 3 GHz. Most radiometers operate in the range from 0. 4-35 GHz (0. 8-75 cm). Atmospheric attenuation of microwave radiation is primarily through absorption by H20 and O2 and absorption is strongest at the shortest wavelength. Attenuation is very low for ? > 3 cm (f < 10 GHz). In general ? wave radiation is not greatly influenced by cloud or fog, especially for ? gt; 3 cm. Microwave sensing can be done day or night, in essentially any weather, particularly when operated at frequencies less than 10 to 15 GHz. Note also that the atmosphere is essentially opaque for f > 300 GHz (? < 1 mm). 7. 1Active and Passive Remote Sensors Remote sensing devices can be classified according to whether they are active or passive devices. Passive remote sensing devices detect reflected EMR while active remote sensing devices emit a signal and detect the intensity of the signal reflected back off an object.

A photographic camera used with available light and Landsat MSS, Landsat Thematic Mapper, or SPOT satellite imagary are examples of passive remote sensing systems. A photographic camera used with a flash attachment, radar and sonar are examples of active remote sensing systems. 8. 0Radar System Sensors RADAR stands for " Radio Detection And Ranging “ by virtue of sending out pulses of microwave electromagnetic radiation this type of instrument can be classified as an " active sensor" - it measures the time between pulses and their reflected components to determine distance.

Different pulse intervals, different wavelengths, different geometry and polarizations can be combined to roughness characteristics of the earth surface. Radar wavelengths range between less than 1 millimetre to 1 meter. Radar uses relative long wavelengths which allow these systems to " see" through clouds, smoke, and some vegetation. Also, being an active system, it can be operated day or night. There are disadvantages, such as the non-unique spectral properties of the returned radar signal. Radar only shows the difference in the surface roughness and geometry and moisture content of the ground (the complex dielectric constant).

Radar data are collected looking off to the side. Because radar measures the time that it takes for the signals to go from the antenna to the ground and back, this angled perspective is a necessity because this causes there to be a delay between the parts of the returned pulse that are farthest from the antenna and the parts that are closest. This very small delay is measured with very high precision, these measurements are filtered using complex functions for removing noise and then these time measurements are converted to a distance for every location in the radar swath and viola we have a map of the surface topography.

Cameras capture reflected visible wavelengths. Radar captures emitted microwave wavelengths that are bounced back to the antenna. . Plan Position Indicator - the kind of radar used by air traffic controllers is not considered an " imaging radar" Radar was originally developed in the 1950s, the first airborne system was called SLAR (Side-Looking Airborne Radar) and was used for improving the resolution for military reconnaissance, early airborne radar systems were limited by the physical size of the antenna however.

Later, SAR (Synthetic Aperture Radar), was developed and are widely used in many countries for civilian applications. Radar resolution has two components; the " range" resolution and the " azimuth" resolution. These are determined by, among other factors, the width of the synthesized antenna (which is dictated by the pulse interval) and the wavelength. . . Radar images show surfaces that bounce back the radar pulse (called " radar backscatter"), the bright areas are strong reflectors (such as buildings in an urban area, or a bolder field in the desert), while dark arts of the image represent surfaces that reflect very little or no energy (such as a frozen lake or oil film on the ocean). The amount of backscatter varies as a function of incidence angle, surface roughness and soil moisture (depending on the wavelength). A smooth surface acts like a mirror when the angle is small, but with angles greater than 20 degrees the amount of backscatter sharply declines because the signal bounces off the surface away from the antenna. The opposite is true for a rough surface.

At steep angles (incidence angle less than 20 degrees), most of the emitted pulse is scattered in random directions so that the total backscatter measured by the antenna is lower than from a smooth surface at the same angle. By changing the incidence angle and comparing how the backscatter changes with different angles it is possible to map different types of surfaces (such as smooth vs. rough lava). Backscatter for different incidence angles.

References Beth King, John A. 2005) Dutton e-Education Institute, College of Earth and Mineral Sciences, The Pennsylvania State University Jun Nogami(2003)Field Observation Using Flying Platforms Of Remote Sensing Education, Asian Institute Of Technology, Thailand Karen, Shuckman (2009)Open Educational Resources Initiative, Geography, College of Earth and Mineral Sciences, The Pennsylvania State University Liew . S. C (2001)Principles of Remote Sensing, Centre For Remote Imaging, Sensing and Processing, National University Of Singapore. Nicholas M. Short (2004)Earth system science, School Of Advanced Technologies Thailand