The Introduction, replete with images and illustrations, is designed to cover the meaning embodied in the concept of "remote sensing", some of the underlying principles (mainly those associated with the physics of electromagnetic radiation [other related topics are deferred until Sections 8 and 9]), a survey of the chief satellite programs that have depended on remote sensors to gather information about the Earth, and some specialized topics . Emphasis is placed on the Landsat series of satellites that, starting in 1972, have provided a continuous record of the Earth�s land (and some ocean) surfaces using the multispectral approach. In this Introduction, and most of the Sections that complete the Tutorial, as well as several of the Appendices, each page will be individually summarized at the top and all illustrations will have captions accessible by clicking at the lower right of each display.

The page you are now on once again defines the term "remote sensing", develops a brief discussion of implications, and places limits on its meaning. It also draws distinctions between what are the usual areas of application (confined to measurements at selected wavelengths in the electromagnetic spectrum) and what can more conventionally be called geophysical applications which measure particles and fields.

INTRODUCTION:

The Concept of Remote Sensing

If you have heard the term "remote sensing" before you may have asked, "what does it mean?" It's a rather simple, familiar activity that we all do as a matter of daily life, but that gets complicated when we increase the scale at which we observe. As you view the screen of your computer monitor, you are actively engaged in remote sensing.

A physical quantity (light) emanates from that screen, whose imaging electronics provides a source of radiation. The radiated light passes over a distance, and thus is "remote" to some extent, until it encounters and is captured by a sensor (your eyes). Each eye sends a signal to a processor (your brain) which records the data and interprets this into information. Several of the human senses gather their awareness of the external world almost entirely by perceiving a variety of signals, either emitted or reflected, actively or passively, from objects that transmit this information in waves or pulses. Thus, one hears disturbances in the atmosphere carried as sound waves, experiences sensations such as heat (either through direct contact or as radiant energy), reacts to chemical signals from food through taste and smell, is cognizant of certain material properties such as roughness through touch (not remote), and recognizes shapes, colors, and relative positions of exterior objects and classes of materials by means of seeing visible light issuing from them. In the previous sentence, all sensations that are not received through direct contact are remotely sensed.

I-1 In the illustration above, the man is using his personal visual remote sensing device to view the scene before him. Do you know how the human eye acts to form images? If not, check the answer. ANSWER

However, in practice we do not usually think of our bodily senses as engaged in remote sensing in the way most people employ that term technically. A formal and comprehensive definition of applied remote sensing * is:

Remote Sensing in the most generally accepted meaning refers to instrument-based techniques employed in the acquisition and measurement of spatially organized (most commonly, geographically distributed) data/information on some property(ies) (spectral; spatial; physical) of an array of target points (pixels) within the sensed scene that correspond to features, objects, and materials, doing this by applying one or more recording devices not in physical, intimate contact with the item(s) under surveillance (thus at a finite distance from the observed target, in which the spatial arrangement is preserved); techniques involve amassing knowledge pertinent to the sensed scene (target) by utilizing electromagnetic

radiation, force fields, or acoustic energy sensed by recording cameras, radiometers and scanners, lasers, radio frequency receivers, radar systems, sonar, thermal devices, sound detectors, seismographs, magnetometers, gravimeters, scintillometers, and other instruments.

I-2 To help remember the principal ideas within this definition, make a list of key words in it. ANSWER

This is a rather lengthy and all-inclusive definition. Perhaps two more simplified definitions are in order: The *first*, more general, includes in the term this idea: Remote Sensing involves gathering data and information about the physical "world" by detecting and measuring signals composed of radiation, particles, and fields emanating from objects located beyond the immediate vicinity of the sensor device(s). The *second* is more restricted but is pertinent to most of the subject matter of this Tutorial: In its common or normal usage (by tacit implication), Remote Sensing is a technology for sampling electromagnetic radiation to acquire and interpret non-contiguous *geospatial data* from which to extract information about features, objects, and classes on the Earth's land surface, oceans, and atmosphere (and, where applicable, on the exteriors of other bodies in the solar system, or, in the broadest framework, celestial bodies such as stars and galaxies).

I-3 What is the meaning of "geospatial"? Are there any differences in meaning of the terms "features", "objects", and "classes"? ANSWER

Or, try this variation: Applied Remote Sensing involves the detecting and measuring of electromagnetic energy (usually photons) emanating from distant objects made of various materials, so that the user can identify and categorize these objects - usually, as rendered into images - by class or type, substance, and spatial distribution. Generally, this more conventional description of remote sensing has a specific criterion by which its products point to this specific use of the term: **images** much like photos are a main output of the sensed surfaces of the objects of interest. However, the data often can also be shown as "**maps**" and "**graphs**", or to a lesser extent, as digital numbers that can be input to computer-based analysis, and in this regard are like the common data displays resulting from geophysical remote sensing. As applied to meteorological remote sensing, both images (e.g., clouds) and maps (e.g., temperature variations) can result; atmospheric studies (especially of the gases in the air, and their properties) can be claimed by both traditionalists and geophysicists.

All of these statements are valid and, taken together, should give you a reasonable insight into the meaning and use of the term "Remote Sensing" but its precise meaning depends on the context in which it is spoken of.

Thus, as the above comments suggest, some technical purists arbitrarily stretch the scope or sphere of remote sensing to include other measurements of physical properties from sources "at a distance" that are more properly included in the general term "Geophysics". (Geophysics has a scientific connotation: it is pertinent to the study of the physical properties of Earth and other planets. It likewise has an applied connotation: it is the technology often used to search for oil and gas and for mineral deposits.) This latter is especially conducted through such geophysical methods as seismic, magnetic, gravitational, acoustical, and nuclear decay radiation surveys. Magnetic and gravitational measurements respond to variations in force fields, so these can be carried out from satellites. Remote sensing, as defined in this context, would be a subset within the branch of science known as Geophysics.

However, practitioners of remote sensing, in its narrower meaning, tend to exclude these other areas of Geophysics from their understanding of the meaning implicit in the term.

Still, space systems - mostly on satellites - have made enormous contributions to regional and global geophysical surveys. This is because it is very difficult and costly to conduct ground and aerial surveys over large areas and then to coordinate the individual surveys by joining them together. To obtain coherent gravity and magnetic data sets on a world scale, operating from the global perspective afforded by orbiting satellites is the only reasonable alternate way to provide total coverage.

One could argue that Geophysics deserves a Section of its own but in the remainder of this Tutorial we choose to confine our attention almost entirely to those systems that produce data by measuring in the electromagnetic radiation (EMR) spectrum (principally in the Visible, Infrared, and Radio regions). We will reserve our treatment of Geophysics to three pages near the end of this Introduction. There you are given examples of the use of satellite instruments to obtain information on particles and fields as measured inside and around the Earth; in Sections 19 and 20 (Planets and Cosmology) there will also be some illustrations of several types of geophysical measurements.

One mode of remote sensing *not* treated in the Tutorial is acoustic monitoring of sound waves in atmospheric and marine environments. For example, volcanic eruptions or nuclear (testing) explosions can be detected by sensitive sound detectors. Sonar is used to track submarines and surface ships in the oceans. Sound through water are also involved in listening to marine animals such as whales and porpoises.

It may seem surprising to realize that going to the doctor can involve remote sensing. Most obvious, on a miniature scale, is listening to a heartbeat using the stethoscope. But in the field of modern medical technology, powerful, often large, instruments such as CATscans and Magnetic Resonance Imaging, are now almost routinely used for non-invasive subskin investigation of human tissue and organs. This is indeed another major application of remote sensing that will be surveyed on pages I-26c through I-26e.

The traditional way to start consideration of what remote sensing is and means is to set forth its underlying principles in a chapter devoted to the Physics on which remote sensing is founded. This will be done in the next 5 pages. The ideas developed may seem arcane. These pages contain the "technical jargon" that remote sensing specialists like to banty about. With this caveat in mind, work through the pages, try to understand the esoteric, and commit to memory what seems useful.

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* The term "remote sensing" is itself a relatively new addition to the technical lexicon. It was coined by Ms Evelyn Pruitt in the mid-1950's when she, a geographer/oceanographer, was with the U.S. Office of Naval Research (ONR) outside Washington, D.C.. It seems to have been devised by Ms Pruitt to take into account the new views from space obtained by the early meteorological satellites which were obviously more "remote" from their targets than the airplanes that up until then provided mainly aerial photos as the medium for recording images of the Earth's surface. No specific publication or professional meeting where the first use of the term occurred is cited in literature consulted by the writer (NMS). Those "in the know" claim that it was verbally used openly by the time of several ONR-sponsored symposia in the 1950s at the University of Michigan. The writer believes he first heard this term at a Short Course on Photogeology coordinated by Dr. Robert Reeves at the Annual Meeting of the Geological Society of America in 1958.

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