FOUR DECADES OF PROGRESS IN PHOTOGRAPHIC INTERPRETATION SINCE THE FOUNDING OF COMMISSION VII

Robert N. Colwell
Professor Emeritus, College of Natural Resources,
University of California, Berkeley, California.

ABSTRACT: As a co-founder of Commission VII (Photographic Interpretation) of the International Society for Photogrammetry (ISP) and as its first President (1952-1956) the author describes from those perspectives the tenuous status of photo interpretation in the early 1950s. He then evaluates certain developments of the past forty years that have led to the present greatly increased usefulness of photo interpretation for both civil and military purposes. The items discussed, all in relation to the "Multi" concept as applied to photo interpretation progress, include those pertaining to the development of new sensors and sensor systems; new sensor-carrying platforms; new photo interpretation techniques and equipment; and new capabilities for displaying photo interpretation-derived results and incorporating them into various kinds of geographic information systems. Among the briefly-discussed examples of progress in photo interpretation that have been made possible by such developments are those pertaining to monitoring various components of the environment, and to managing the world's renewable and non-renewable natural resources. Also discussed are important photo interpretation-related roles that have been played by the United Nations (largely through FAO), the Vatican, various national and international space agencies and, especially, by ISPRS (primarily through its Commission VII). The paper concludes with a brief look to the future of photographic interpretation, with emphasis on the degree of "technology acceptance" that is likely to result in this fast-growing field.

Key Words: Image interpretation, Image Analysis, Multispectral, Remote Sensing, History.

INTRODUCTION

Most readers of this paper are sufficiently familiar with modern day photo interpretation techniques and uses that they will find few disclosures here that, individually, are newsworthy to them. They may find, however, that the paper gives them important insights as to what these developments provide collectively -- especially to those of us who were photo interpreters when Commission VII was founded some forty years ago. Such readers may also feel a justifiable sense of pride in having done their part in bringing photo interpretation to the highly respected status and high degree of usefulnes that it now enjoys.

One measure of the newness and growth rate of a particular science or discipline such as photo interpretation is to be found in the continuing degree of preoccupation among its participants with the terminology applied to it, and to closely related fields. Thus, within the present context it seems desirable to define various photo interpretation-related terms that are currently in use -- terms that will be employed throughout this paper. Although several such definitions have not as yet been agreed upon there appears to be agreement, in the broad sense at least, as to the meanings of the most relevant and commonly used terms, including those appearing in Table 1. Therefore, throughout this paper I will be using such terms in conformity with the working definitions contained there.

Nominally the present account regarding the development of photographic interpretation begins forty years ago. Even prior to 1952, however, many developments had occurred without which the rapid growth of photo interpretation during the last four decades would not have been possible. They included: (1) taking of the first photographs in about 1827; (2) taking of the earliest practical photography in about 1839; (3) obtaining the first true aerial photography from captive balloons in 1858 and from heavier-than-air craft in 1909; and (e) repeatedly demonstrating the military value of aerial photo interpretation, thereby prompting further increases in certain of its civil-oriented uses also. This was largely because officers of many nations were Reservists who had done military photo interpretation in wartime and had, upon returning to civilian life, found many ways in which to beneficially employ their photo interpretation expertise for civil purposes.

1. IMPORTANT PHOTO INTERPRETATION-RELATED DEVELOPMENTS OF THE PAST FOUR DECADES

1.1 Founding by ISP of the Commission on Photo Interpretation (Commission VII)

Prior to the founding of Commission VII in 1952 the following assertion was frequently made by photogrammetrists: "Photo interpretation is not of sufficient stature to merit its own commission within ISP." Rarely has such an assertion been made since then, however.

Until Commission VII was founded there was no organization which might logically serve as the international "clearing house" on the availability of aerial photography, area-by-area, nor on photo interpretation research, techniques and related matters. Prior to that time, there had been a great deal of needless duplication of effort both in the conduct of research and in the reporting of results relative to the field of photo interpretation. In some instances, the problem was one of omission rather than duplication.

1.2 Increased Amount, Kind and Availibility of Aerial Photography

Many newcomers to the field of photo interpretation find it hard to believe that, in the early 1950s, photo interpreters in the United States and, indeed, throughout the globe, were continuing to work (as in previous decades) almost entirely with a single type of imagery. It was usually black-and-white vertical aerial photography that had been taken at some time during the preceding 10-year period, probably during cloud-free, midsummer, high sun-angle conditions, using panchromatic film and a "minus blue" filter, and employing a camera having approximately 8 1/4" as its focal length and 9"x9" as its negative size, operated from an altitude of about 13,750 feet above the terrain to give a photographic scale of 1:20,000, or thereabouts. While the great potential benefits of acquiring and interpreting multiband, multidate, and multistage photography were beginning to be

TABLE 1. COMPARISON OF OLD VERSUS NEW PHOTO INTERPRETATION-RELATED TERMS

OLD TERM	CORRESPONDING NEW, MORE COMPREHENSIVE TERM
(1) <u>Aerial photo reconnaissance</u>: the acquisition of photos from an aircraft, whether for military purposes (hence the term "reconnaissance") or for civilian purposes.	(1) <u>Remote Sensing</u>: the acquisition of photos and/or related basic data from an aircraft and/or spacecraft, together with the analysis of such data.
(2) <u>Aerial Photography</u>: the product obtained through use of a camera mounted in an aircraft.	(2) <u>Remote sensing imagery</u>: the product obtained through use of cameras, optical-mechanical scanners or other image-forming sensors mounted in either an aircraft or spacecraft.
(3) <u>Photographic interpretation</u>: the process by which humans examine photographic images for the purpose of identifying objects and judging their significance.	(3) <u>Image analysis</u>: the process by which humans and/or machines examine photographic images and/or digital data for the purpose of identifying objects and judging their significance.
(4) <u>Photo interpreter</u>: the human who engages in conventional forms of photographic interpretation.	(4) <u>Image analyst</u>: the human who engages either in conventional forms of photographic interpretation or in programming and interacting with machines during the computer-aided analysis of remote sensing data.

recognized, at that time it was totally unrealistic in most instances to consider that such kinds of photography could be made routinely available to the photo interpreter at any foreseeable future date. Yet today multiple kinds of photography are, indeed, available for most areas of interest to photo interpreters, thereby increasing the accuracy of their interpretations.

1.3 <u>A Photo Interpretation Chapter in the *Manual of Photogrammetry*</u>

The second edition of the *Manual of Photogrammetry*, as published by the American Society of Photogrammetry (ASP, 1952) gave a form of recognition to photo interpretation that was notably absent in the first edition. Nearly 70 pages in the second edition consisted of a reasonably comprehensive and well illustrated chapter entitled "Photographic Interpretation for Civil Purposes." That chapter correctly portrayed the status of photo interpretation to be as follows: It is routinely being used to good advantage in many fields, but skeptics abound who are reluctant to abandon slower, costlier "on-the-ground" ways of obtaining essentially the same information.

As a further indication of ASP's interest in photo interpretation it requested that a companion chapter on "Photographic Interpretation for Military Purposes" be written. Upon its completion that chapter was reviewed by ten senior U.S. military officials. Nine of them said, in essence, "Excellent; no military security problems; by all means publish it." The tenth official said, "Oh, my God, what a breach of military security this is!" Ridiculous though his specific objections were, the chapter was rewritten in response to them. But, fearful of possible consequences to him personally, he still refused to approve it. Consequently the chapter was never published.

1.4 <u>The *MANUAL OF PHOTOGRAPHIC INTERPRETATION*</u>

In the mid-1950s it was proposed that the ASP produce a *Manual of Photographic Interpretation* that would constitute a companion volume to the Society's prestigious *Manual of Photogrammetry*. ASP authorized this undertaking despite disapproval by those who argued that there was not enough known about photo interpretation to justify writing a manual about it. Others argued that giving such prominence to the fast growing field of photo interpretation would subvert the stated photogrammetric aims of the Society. Even after the manual had been prepared, certain of the Society's board members strongly opposed authorizing funds for its printing. As a result publication was delayed by many months. When the Manual finally was published, as its Editor-in-Chief, and mindful of the dissention that still existed, I began my Introduction to the *Manual* with the following statement that many have applauded since:

> Rarely is a book published without the authors proclaiming it to be "very timely." The reader may find it refreshing to learn that many highly-respected photo interpreters have from the outset opposed the preparation of this *Manual of Photo Interpretation* on the grounds that it was <u>not</u> timely. They have argued that photo interpretation, as both a science and art, is still too young to permit the definitive, comprehensive treatment implied by the term "Manual of Photo Interpretation."
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> But, surely, through the years, similar arguments have been advanced with equal logic to deter the writing of books on everything from *Astronomy* to *Origin of Species*. Therefore, with full appreciation that we still have much to learn in photo interpretation, as in most other fields,

more than one hundred of the world's renowned photo interpreters have felt that *now* is the time to compile and publish the first truly comprehensive discourse on photo interpretation. They have gone about this joint undertaking with commendable humility, each willing to confine his contribution to a specified field; each willing to forego individual credit so that his material might better be integrated with that of others.

Among its other features, the Manual helped document (1) the great progress, internationally, that already was taking place (much of it through Commission VII) in photo interpretation, and (2) the rapidly increasing number of books, scientific articles and university-level courses, internationally, dealing with it.

The initial printing (10,000 copies) of that prize-winning first edition of the *Manual of Photographic Interpretation* sold out very promptly with the result that 5,000 additional copies were printed. Soon all of those copies were sold also. That Manual has since been out of print for more than 30 years, but is still often referred to. And it is still credited with having done much to bring about the great progress in photo interpretation that has taken place since then.

1.5 Improvements in Sensor Platforms and Sensor Systems

During the 1950s there were some startling improvements in the platforms used for acquiring aerial photography and related imagery. These ranged from the hovering helicopter to the U-2 aircraft. Furthermore, in both the United States and Russia great progress was made in the inventing of spacecraft (beginning with the Russian launch of "Sputnik I" in October, 1957). Some versions of those artificial satellites would soon prove to be useful as the platforms on which to mount cameras for the acquisition of photographs from space for use by photo interpreters.

There also were some noteworthy developments during this pioneering period in such sensors as panoramic cameras, continuous strip cameras, optical mechanical scanners, thermal infrared sensors and side-looking airborne radar systems.

1.6 The Heyday for Photo Interpretation "Keys"

Evidence of the interest commanded in the 1950s by photo interpretation keys (specially-constructed reference materials for use by photo interpreters in identifying various kinds of objects and conditions) is to be found merely from a survey of the literature for that period. For example, this matter was of such interest that in 1952, in the Report of the President of Commission VII of the ISP (Colwell, 1952), almost half of the entire lengthy report was devoted to discussing and illustrating such keys and to a parallel discussion of terminology problems and solutions associated with their use. Despite that seemingly disproportionate allocation of space to one topic, photo interpretation keys were again the primary topic at the 1955 annual meeting of ASP in the course of which a panel presentation consisting of nine papers was devoted to this subject. Although it is probable that the heyday for photo interpretation keys has passed, their usefulness for training and as reference materials continues to be recognized, even at the present time.

1.7 Improvements in Capabilities for the Analysis of Remotely Sensed Data

The techniques and equipment used by humans as they make direct visual analyses of aerial photographs were, for the first time, comprehensively described and illustrated in the aforementioned *Manual of Photographic Interpretation* (American Society of Photogrammetry, 1960).
During the late 1950s the first significant advances were made in the analysis of remotely sensed data by machines. As a result, there soon was to emerge a valuable and extensive field of photo interpretation or, more broadly stated, of "computer-assisted analysis of remotely sensed data". For example, almost no mention of this "computer assisted" capability appears in the first edition of the *Manual of Photographic Interpretation*, whereas it constitutes a very major part of the material contained in a companion volume published roughly a quarter century later entitled *Manual of Remote Sensing* (American Society of Photogrammetry, 1983).

1.8 Development and Use of the U-2 Aircraft

In the mid-1950s U.S. President Eisenhower became concerned that the Russians, having exploded their first atomic bomb in 1949 and having worked vigorously and clandestinely since then on improving it, might be able to subject the United States to a "thermonuclear Pearl Harbor." In an effort to obviate such a surprise attack Eisenhower therefore proposed an "open skies" policy under which each of the two super-power nations would be allowed to fly military reconnaissance missions over the other. This proposal was promptly termed by Soviet Prime Minister Nikita Kruschev as "nothing more than a bad espionage plot" and he rejected it.

The U.S. response to this rejection was that of developing the U-2 aircraft (aptly termed a "powered glider") and equipping it with a large camera having (1) a powerful lens of long focal length and (2) a high resolution photographic film that was so thin-based that, reportedly, thousands of frames of photography could be taken on a single roll of it. Presumably the U-2 would be capable of flying well above the range of Russian interceptor aircraft and of Russia's ground-based antiaircraft weapons and surface-to-air missiles. On July 4, 1956, the first U-2 photography was taken during a highly successful overflight of both Moscow and Leningrad.

Arthur C. Lundahl was the U.S. expert in charge of studying all U-2 photography obtained over Russia. He later said that it had been "like seeing the dawn after a long dark night of ignorance." Specifically the alleged "missile gap," "bomber gap," and "megatonnage gap" fears that were being expressed by many U.S. military experts were demonstrated from interpretation of the U-2 photographs to be largely unfounded.

On May 1, 1960, after nearly four years of successful U-2 reconnaissance had been performed, a U-2 was shot down near Sverdlovsk, Russia. Kruschev charged the U.S. with deliberate aggression and threatened to attack any Allied bases from which U-2 jets operated when photographing Russia.

Shortly thereafter the charges and counter-charges resulting from this photo reconnaissance episode led to the collapse of a previously scheduled summit meeting of the superpower nations in Paris.

Consequently the first hope for international arms control, a primary item for discussion at that meeting, had to be abandoned.

Meanwhile the Space Age had dawned in October 1957 and the episodes recounted above gave additional impetus to efforts of both superpowers to develop a capability for acquiring photo intelligence from earth orbiting spacecraft.

1.9 Establishment of a National Photographic Interpretation Center (NPIC)

To the extent that security regulations have permitted, the rationale for establishing such a center in the United States, and a documentation of NPIC's tremendous accomplishments in the three decades since then, have been provided in the open literature. The previously-mentioned Arthur Lundahl played a major role in the founding of that prestigious Center and served for many years (1962-1973) as its first Director.

1.10 Photo Interpretation in the Cuban Missile Crisis of 1962

Many accounts have been written regarding the role of photo intelligence in the Cuban Missile Crisis -- one of the most dramatic events of the last four decades. The U.S. took almost unprecedented action as a direct result of NPIC's photo-derived information during that crisis --action that very probably would have led to World War III had that information been wrong. Specifically, as reported in an official document of the U.S. Naval Institute (1976):

> On 23 October 1962, the White House announced a naval quarantine of Cuba to prevent entry of Soviet ballistic missiles and long-range bombers into Cuba. Previous photographic reconnaissance had revealed that missile bases were being built on the island, and that missiles were present. The Navy immediately moved eight aircraft carriers and 175 other ships into the area; the surface vessels, stationed in a 500-mile arc from the eastern tip of Cuba, were given orders to stop and search all suspected vessels. On the day after the quarantine was ordered, at least 25 Soviet ships nearing the line began to turn back, prompting Secretary of State Dean Rusk to say: "We're eyeball to eyeball, and I think the other fellow just blinked."

1.11 Advent of the Space Age

Slightly overlapping the period of progress that has just been described was the advent of the space age. Although the first artificial satellites began orbiting the earth in the late 1950s, photo interpreters did not receive the first useful space photography until somewhat later. Soon thereafter, photo interpreters became well aware that outer space was becoming the domain of earth-orbiting camera-carrying vehicles that offered a valuable additional vantage point from which to obtain photographs that they could use in studying the surface of the earth. That awareness was of such consequence as to dictate, in large measure, the content of all remaining portions of this article.

1.12 Early Space Age Improvements in Sensor Systems

Before photographs taken of the earth's surface from space became available, most remote sensing specialists underestimated the potential advantage that would be given by the overall "synoptic view" as recorded from an altitude of one hundred miles or more and covering a ground area per photograph that was at least a thousandfold greater than that to which they were accustomed. There also was a failure, prior to the dawning of the space age, to perceive the remarkable improvements that would be made in cameras and other sensor systems. For instance, the aerial photography of 30 years ago rarely permitted spatial resolutions of more than 25 line-pairs per millimeter to be discerned. Since then, improvements in both the photographic emulsions and sensor optics have made commonplace a four- to ten-fold improvement in such resolution. Furthermore, serious discussions regarding the potential for obtaining fortyfold improvements frequently are heard.

There also have been some continuing improvements in recent years in various kinds of sensor systems, including the previously mentioned panoramic cameras, continuous strip cameras, optical mechanical scanners, thermal sensors, and radar imagers. . Each of these systems, when used individually aboard a spacecraft, is able to provide certain kinds of information that cannot be obtained from any of the others. More importantly, when the remote sensing data that have been acquired by several of these sensor systems are placed in the hands of a competent image analyst, the "convergence of evidence" principle can be exploited in respects that heretofore were not feasible, thereby adding greatly to the amount and accuracy of information derivable from space-acquired remote sensing data.

1.13 NASA and its Earth Resources Survey Program

Within the United States the National Aeronautics and Space Administration (NASA) did much to bring about the early development and use of space photography, including the interpretation of it for civil purposes.

The NASA program of land remote sensing from space arose with the Mercury and Gemini programs, which obtained pictures of the earth having geological and agricultural significance. That program was given great impetus by Project Apollo, the U.S. effort to land men on the moon. A crucial element of Project Apollo involved the selection of landing sites on the moon, and for this purpose NASA undertook a precursor project called "Lunar Orbiter" in which five satellites orbited the moon (in 1966-67) and sent back thousands of pictures of the lunar surface. The instruments used in the Lunar Orbiter were first tested over terrestrial sites that simulated the lunar landscape, and the images thus obtained of these analagous areas here on Earth were compared with observations made on the ground (ground truth).

It soon became apparent that space-aquired images could be useful in studying geology and in mineral exploration on earth. The interest spread to other disciplines that could benefit from the making of such remote observations of the earth -- e.g., agriculture, forestry, hydrology, cartography, coast and geodetic surveying, and urban planning. In the United States this interest led to establishment of the Earth Resources Survey Program, sponsored by NASA and assisted by experimenters who were working in universities and elsewhere in many countries. It also led eventually to the publication of three NASA Summary Volumes in the years 1971, 1973, and 1976 -- each dealing with NASA-acquired space photographs and the interpretation of them.

Most of the early space photographs acquired by the United States were taken from manned spacecraft of the Mercury, Gemini and Apollo series through the use of 70mm Hasselblad cameras. The exposed film, upon being returned to earth by astronauts through a daring "reentry-and-splashdown" procedure, were processed, printed and interpreted in the usual manner. One well-illustrated example constitutes the subject matter of a 170-page book (NASA, 1971) which reports on the S065 experiment -- the first multiband photographic experiment from space. It was performed during the earth-orbiting flight of Apollo IX through simultaneous use of four boresighted Hasselblad cameras, each employing a different photographic film-filter combination.

1.14 The Development and Use of Digitizing Sensors
In the 1960s unmanned satellites, equipped with special digitizing sensors began telemetering back to earth, in digital form, and in many spectral bands, scene-brightness information, picture element-by-picture element. These images, while still in digital form, lend themselves to computer assisted analysis, as described quite fully in the *Manual of Remote Sensing* (American Society of Photogrammetry, 1983). But the digits also can readily be synthesized into photo-like images that lend themselves to direct visual analysis. Among such digitizing sensors that have now been developed are those capable of providing remotely sensed data in various non-visual parts of the electromagnetic spectrum such as the microwave, thermal infrared, and ultraviolet regions.

There are three major types of digitizing sensors, developed primarily for use in remote sensing from space, that are of great interest to image analysts. These are (1) the optical mechanical scanner or "line scanner" (whose principles are now employed in the Landsat MSS and TM sensor systems), (2) the linear array or "pushbroom imager," now used in the SPOT system, and (3) the frame sensor, such as the Return Beam Vidicon system, a pioneering use for which was found as early as 1972 on the first Earth Resources Technology Satellite, ERTS-1, which was later renamed "Landsat-1." From the photo interpreter's standpoint the significance of these sensor systems resides in the fact that all three of them directly provide digital data to the photo interpreter for each picture element ("pixel") within the scene that he wishes to analyze. Were this not the case, it is probable that little progress would have been made by photo interpreters in the last few decades in developing and using computer-assisted analysis to augment their direct visual analysis of photos and photo-like images.

Some recently developed digitizing sensors have wide fields of view and a high frequency of coverage. Among these are the NOAA AVHRR (Advanced Very High Resolution Radiometer) and the Nimbus 7 CZCS (Coastal Zone Color Scanner). J. Colwell and Hicks (1985) discussed uses for such digitally-acquired data for three types of applications: stratification, change detection, and area estimation. They concluded that such data have considerable promise as an aid in all three of these application areas and, indeed, in a wide variety of large area inventory/monitoring tasks. They assert that such satellite data have the following advantages compared to Landsat, especially for macro inventory (an inventory that covers a very large geographic area but usually with less accuracy and less detail than will be found in the resource inventories of smaller areas): (1) large area coverage per individual scene, (2) essentially simultaneous (unitemporal) coverage over large areas, (3) greater frequency of coverage, and (4) economy (lower cost per unit of area). The data may be used alone for some applications, such as broad stratification, but ordinarilly are useful for other applications (e.g., more detailed classification; area estimation) only when used in conjunction with other data sources, such as Landsat.

1.15 The Large Format Camera
One camera that was conceived in the early 1960s for obtaining photography of high spatial resolution from a manned earth-orbiting satellite is known as the Large Format Camera. Among the attributes of that camera are the following: focal length, 30.5 cm; resolution, 80 line pairs per mm; automatic exposure control, 1/250 to 1/30 second; format 23 x 46 cm (long direction in direction of flight); adjustable forward overlap (10, 60, or 80 percent); adjustable forward motion compensation; and a film capacity of 2400 frames.

On 5 October 1984, some 20 years after it was conceived, the large Format Camera was finally carried into space on Shuttle Mission STS-41G. Requests for coverage had been received for 368 sites located on all continents except Antarctica. The orbit inclination was 57° and the Shuttle operated at nominal altitudes of 352, 272, and 225 km. A total of 2160 frames were exposed -- some on panchromatic, some on natural color, and some on color infrared films. Optically, mechanically, and electrically, the camera operated without flaw, and many exceptional scenes were acquired on that historic mission, the photos from which have since been studied by photo interpreters throughout the world.

1.16 Equipment for the Image Analyst
Most of the data acquired by means of remote sensing is either in image form or in a form which can readily be reconstituted into a photo-like image (such as the data acquired by optical mechanical scanners or side-looking airborne radar devices). Consequently, most of the equipment needed for extracting information from remote sensing data is of a type that will facilitate image analysis in one way or another. Image analysts need equipment for three general purposes: viewing, measuring, and plotting. More than twenty devices for use in accomplishing these tasks are fully described and illustrated in the *Manual of Photographic Interpretation* (American Society of Photogrammetry, 1960), and these devices still represent "state-of-the-art" equipment, for most photo interpretations. When a photo interpreter must seek the maximum derivable information, however, and when computer-assisted analysis is to be performed, vastly improved equipment is, of course, available.

When multiband photography is obtained, the photo interpreter usually needs to color code each band and then combine the bands, thereby producing various image enhancements to facilitate the data-extraction process. Methods of doing this, and of displaying the results as in a GIS, are described and illustrated in the *Manual of Remote Sensing* (ASP, 1983) and elsewhere.

1.17 The International Symposia on Remote Sensing
In 1962 the first of a continuing series of symposia entitled "Remote Sensing of Enviroment" was held in Ann Arbor, Michigan, U.S.A. under sponsorship of the University of Michigan Willow

Run Laboratories. Those laboratories were the predecessor of ERIM (the Enviromental Research Institute of Michigan). ERIM has sponsored the symposia since the late 1960s.

As stated by the President of ERIM recently:

> The first symposium established a milestone in terms of defining and unifying the many diverse facets of this global technology. Ten subsequent meetings, also held in Ann Arbor through 1977, were aimed primarily toward stimulating the continued development and application of this technology worldwide, and toward encouraging an effective exchange of information through discussions and presentations on work planned, in progress, or completed.
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> The rapid spread of interest and activity in this broad multi-disciplinary field, and the response of the global scientific community to the Symposia, lead to a renaming of the series in 1969 when the Sixth Symposium became "The Sixth International Symposium on Remote Sensing of Environment." The internationalization of the meetings continued when the 12th International Symposium was held in Manila, Philippines in 1978. Since 1978 the Symposia have alternated between Ann Arbor, Michigan and other appropriate sites throughout the world.

Among groups throughout the world that are actively engaged in photo interpretation-related work and which frequently sponsor similar highly beneficial international symposia are the European Space Agency, the Canadian Center for Remote Sensing and its counterparts in Japan, India, Argentina, Brazil, China, Australia (through its CSIRO), Holland (through its ITC), the Vatican (through its Pontifical Academy of Science), the United Nations (through the FAO and COPUOS -- the Committee on Peaceful Uses of Outer Space), and the United States (through NASA, NOAA, the Agency for International Development, the Organization of American States, and the EROS Data Center). But perhaps the foremost among such sponsoring groups that are truly <u>international</u> is the ISPRS, as described below.

1.18 <u>Commission VII-Sponsored Symposia on the Interpretation of Remote Sensing Data</u>

Since 1952, when Commission VII was founded, there have been highly significant "world congresses" held under its auspices every four years. Three changes have occurred in recent years relative to those congresses:

(1) With the emergence, (steadily followed by the increasing importance) of remote sensing, the name of Commission VII has been changed from "Photo Interpretation" to "Interpretation of Remote Sensing Data", consistent with the name change of its parent society from ISP to ISPRS;

(2) Commission VII has been repeatedly reorganized into working groups on special topics that concern themselves with the analysis of various kinds of remotely sensed data as new kinds have been developed; and

(3) The frequency with which Commission VII symposia are held has been doubled from once every four years (as part of the quadrennial ISPRS meetings) to once every two years to provide for "Inter-Congress Symposia."

1.19 <u>The Vatican-Sponsored Study Week on Remote Sensing for Developing Countries</u>

This Study Week was held in June, 1986 at the Vatican at the request of the Pope. It involved participation by 35 experts from 16 countries. The title and theme of that Study Week was "Remote Sensing and Its Impact on Developing Countries" (Pontifical Academy of Sciences, 1986). The conclusions and recommendations resulting from that meeting (appropriately pertaining more to "food security" than "military security") were approved shortly thereafter at levels from which <u>action</u>, rather than mere pious pronouncements, might emanate. Specifically: Not only were the 11 principal findings and the 23 specific recommendations that resulted from that particular Study Week carefully reviewed and endorsed by the Pope, who is frequently asked for help and advice as he tours the developing countries; a short time later they also were reviewed, endorsed, and adopted (via COPUOS) by the entire General Assembly of the United Nations. They were then converted into a document that has since been widely circulated by that group with the intent that action be taken to implement all 23 of the adopted recommendations (United Nations General Assembly, 1987).

1.20 <u>Increased Emphasis on Using a Basic Science Approach to Photo Interpretation</u>

Much of the photo interpretation-related progress that has been described thus far in this paper has been achieved through what scientists term the "empirical approach." As such it has entailed the making of a series of trial-and-error experiments in order to eventually arrive at an acceptable solution to any particular problem. While some of the principles of basic science may have been employed in any such instance, the emphasis often was merely on arriving at an expeditious, empirical determination of "what works." In the mid-1960s a realization of this fact is what prompted a panel of ASP's scientists (Photo Interpretation Committee, 1963) to elucidate the "basic science" approach, as best they could, in an article entitled "Basic Matter and Energy Relationships Involved in Remote Reconnaissance." A major emphasis in that article is simply this: In the future, great strides will be made in the development of photo interpretation and remote sensing <u>only</u> if we start using far more effectively what scientists already know about certain basic matter and energy relationships.

To quote, from that article's preface:

> In the field of remote reconnaissance we have gone about as far as we can with empiricism. The time has come when real progress in the acquisition of information by remote reconnaissance must be sought through fundamental research, solidly founded on the basic sciences. It no longer suffices merely to identify the more obvious objects and conditions by examining an array of images, recorded by a variety of remote sensing devices. In obtaining more refined information about the physical universe, we need to think in terms of the basic physical parameters which characterize every piece of information presented by these images. *The primary objective of this report is to provide the photo interpreter or "image analyst" with an appreciation of the basic interactions between matter and energy that are at play when remote reconnaissance is being performed:* if this objective is

realized he will be better able to extract useful information from both conventional and unconventional kinds of imagery. The presentation will have realized its major objective, however, if it succeeds in motivating the reader to think more deeply in terms of these basic physical parameters.

Over the years it has been gratifying to see the ever-increasing extent to which photo interpreters have been progressing toward realization of that objective, partly as a result of that article. Reportedly, the article also has helped increase our professional stature through the inclusion of photo interpreters in various "basic science" symposia thereby overcoming the stigma of years past that had resulted from the loud and oft-repeated pronouncement of various "wags" to the effect that photo interpreters are appropriately called "P.I.s" because they actually are nothing more than "peering idiots."

2. INTEGRATING THESE ITEMS OF PROGRESS UNDER THE "MULTI" CONCEPT

2.1 Is the Whole Greater than the Sum of the Parts?

A synergistic effect has caused photo interpretation as a whole to progress much farther in the past four decades than might be suggested from the mere description that has just been given regarding certain individual items of progress. That this synergistic effect is real becomes more plausible when these items are grouped under the "Multi" concept, as in Table 2. For further evidence of this fact the reader is again reminded that Chapter I of the *Manual of Remote Sensing -- First Edition* (ASP, 1975) illustrates most of these contributing factors by applying each of them to one specific geographic area. As photo interpreters work on any particular project, however, they need to avoid the danger of becoming too "multi"-happy in trying to perform it.

2.2 One Important Area Lacking Progress

Four decades ago much photo interpretation-related research pertained to "human factors." Under this banner we were learning much about the importance of the photo interpreter's vernier acuity, stereoscopic acuity and freedom from color blindness (although "red-green confusers" sometimes were best). Effects of fatigue and measures for minimizing fatigue (even through the use of harmless stimulants) also were being studied, as was the importance of the photo interpreter's background, training, experience and, especially, his basic attitude about doing photo interpretation work. In fact, some 17 pages of the *Manual of Photographic Interpretation* (ASP, 1960) were devoted to these important topics.

Although it does not fit the pattern of statements comprising Table 2, the following is important: A greater amount of useful information usually is derived if the photo interpreter has "Multifactor aptitude" for his work than if he has aptitude in only a few "human factors" areas. Despite the foregoing, when compared to progress made during the past four decades in each of the 20 previously listed items, progress in the human factors area has been minimal, indeed. This is partly because of our minimal funding of "direct visual analysis" research during that period because of our all-out enthusiasm for funding research in the area of computer-assisted analysis. Such gross imbalance should be rectified, and the sooner the better.

3. A LOOK TO THE FUTURE

3.1 Potentially Greater Contributions to Geographic Information Systems

Of special significance in relation to the topic assigned to me for this paper is a well illustrated book, appropriately titled *Space Science and Applications -- Progress and Potential*, edited by McElroy (1986) and written by 25 authors. Three major parts of that book are devoted to the ever-increasing role and bright future of photo interpretation/remote sensing with respect to the global inventory, monitoring and management of the earth's land, ocean and atmospheric resource, respectively. These are, of course, the three primary components dealt with in geographic information systems such as those that are fast becoming of primary interest to ISPRS through its Commission VII. Judging from that highly authoritative book, our future in this regard appears to be very bright, indeed.

3.2 What Degree of Technology Acceptance Will Photo Interpretation/Remote Sensing Enjoy?

The answer to this question probably will provide the best measure of meaningful photo interpretation progress in the future, just as in the past when many potential users have failed to use this new technology.

Perhaps the best description of technology acceptance (sometimes called "technology transfer") is that provided by two sociologists (Hoos and Sharp, 1978). Paraphrased, it is as follows: "The transfer of a technology (such as photo interpretation/remote sensing) can be considered as having been completed only when that technology, being readily available in the marketplace, becomes generally accepted practice by the user agency and when the chief officer of that agency, upon routinely assessing all available technologies that are potentially useful, decrees that the one in question is the one that shall be used in every instance where objective analysis indicates its potential superiority....There is commonly a five-stage adoptive process by which this new technology is perceived, internalized and used: awareness, interest, evaluation, trial and adoption. If the technology is to be adopted in any given instance, the decision maker needs to be convinced of the technology's simplicity, direct applicability, continuing availability, cost-effectiveness and the timeliness with which it can provide the desired information."

3.3 What, Then, Are the Deterrents to a Potential User's Accepting a New Technology Based on Photo Interpretation/Remote Sensing?

In addressing this question, those international authorities who attended the previously mentioned Study Week (Pontifical Academy of Science, 1986) concluded that there commonly are ten such deterrents: overselling, overkilling, undertraining, underinvolvement, spurious evaluation, misapplication, timidity, inadequate infrastructure, inadequate understanding, and inordinate distrust. Though largely self-explanatory, each deterrent is defined and elaborated upon in their report.

3.4 Summary Statement

We have reason to believe that, in the future, great progress will continue to be made in virtually all of the fields of activity that are discussed in this paper -- and much of that progress will continue to be under the direct leadership of Commission VII. But in my opinion,

TABLE 2. ELEMENTS ENCOMPASSED BY THE "MULTI" CONCEPT AS IT IS APPLIED TO THE REMOTE SENSING OF NATURAL RESOURCES

1. More information usually is obtainable from *multistation* (stereographic) photography than from that obtained from only one station.

2. More information usually is obtainable from *multiband* photography than from that taken in only one wavelength band.

3. More information usually is obtainable from *multidate* photography than from that taken on only one date.

4. More information usually is obtainable from *multipolarization* photography than from that taken with only one polarization.

5. More information usually is obtainable from *multistage* photography than that from only one stage or flight altitude.

6. More information usually is obtainable from the *multienhancement* of this photography than from only one enhancement.

7. More information usually is obtainable from the *multidisciplinary analysis* of this photography than if it is analyzed by experts from only one discipline.

8. The wealth of information usually derivable through intelligent use of these various means usually is better conveyed to the potential user of it through *multithematic maps*, i.e. through a series of maps, each dedicated to the portraying of one particular theme, rather than through only one map.

one major thrust in the immediate future should be directed toward achieving a higher degree of acceptance of the truly marvelous technology that already has been developed -- much of it under the leadership of Commission VII since its founding some four decades ago.

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