Teaching Remote Sensing as Public Classroom Instruction

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ABSTRACT: Space and remote sensing education are potentially valuable contributions to today's secondary public school curriculum, and provide an opportunity to prepare young people for the technological world of tomorrow. Space education has proven a strong motivating factor in capturing and holding the attention of young students. Imagery from orbiting spacecraft gives students realistic perspectives on global geography and geology, relationships between nations, and Earth's dynamic forces such as weather. Space technology material is gaining acceptance in America as a secondary school subject, yet it is seldom taught as daily classroom instruction despite the fact secondary students indicate they need and want more technology education of all kinks. New techniques and systems for technology education are available for daily instruction, yet teachers often are not given the opportunity to learn or to use them. In addition, the educational system has a unique set of barriers that has slowed the implementation of space technology education in schools. Potentially, space-intensive companies and organizations can do much to encourage and assist teachers and administrators to adopt space technology as daily curriculum. Industry should actively seek a close working relationship with the educational community.

INTRODUCTION

PUBLIC SCHOOL INSTRUCTION in America, at the secondary level especially, is extremely weak in geography and the humanities which have all but disappeared from the curriculum. The reasons for this unfortunate situation are numerous, but they seem to fall into two broad categories: (1) the American clamor for more science instruction at all levels after the Soviet launch of Sputnik in 1957, and (2) the general disintegration of meaningful secondary curriculum resulting from a more "permissive" academic emphasis nationally, following the social disorganizations of the 1960s and 1970s.

The American public still does not understand that every penny spent on space technology has gone for salaries, the ongoing contributions of productive industry, the creations of our minds, and the untold benefits that we enjoy as a technological culture. That public attitude probably will not change for at lest the next half-century or more as we continue to work toward the space future. All the space hardware and experimentation we place in orbit must be supported by a competent ground-based space industry of technicians, scientists, clerks, managers, geographers, biologists, engineers, geologists, etc. Remote sensing is a vital part of that huge Earth-based infrastructure.

As the American culture in the 1980s begins to recognize the need for creative space technologies to be incorporated into the classrooms, there is a more hopeful outlook for the decade of the 1990s and beyond. One of the most important first subjects to be placed directly into the mainstream of public education should be more remote sensing because it touches so many academic fields and so many life-intensive activities at one time.

The value of remote sensing technology to the everyday classrooms of young America is one of the blessings of our age. From the savagely arid deserts of Africa to the amazing discoveries of jungle-hidden Mayan cities in South America, remote sensing has played a critical role in reshaping our comprehension of the world in which we live. Literally millions of lives have been saved, and billions of dollars in property, because of early weather warnings of our satellites not only in America but across the world as well.

From a Cajun fisherman's shrimp beds and the Louisiana bayous to the delicate tracking by scientists of the San Andreas Fault or the insect infestation in forests and wheat fields of the northeast, remote sensing has played a role as basic as human survival itself. If we are to use this most fundamental tool of all the space technologies adequately and responsibly, then we must encourage it as a classroom necessity and work directly with our public schools to teach it as one of the best and most competent of the available space technologies.

Remote sensing as a new and more meaningful approach to teaching geography, geology, international affairs, global culture, and related subjects is an excellent tool to focus daily instruction. Teachers find space education in general a strong motivating force in attracting and holding student interest because of its "real world" nature. Remote sensing satellite technology, however, is a highly productive instructional tool in geography and geology because it allows students not only to see the Earth as it truly is, but also provides opportunities for detailed study of topographic features and ecological relationships.

BACKGROUND

For the past ten years, it has been my experience to teach courses such as "Studying Earth From Space" and "Geography From Space" to junior and senior high school students, and for the training of both science and social studies teachers. Without exception, these opportunities offer immediate rewards as (1) heightened geographic perceptions, (2) close study of real-life situations such as the ozone gap and desertification in Africa, and (3) sharpening of skills in map reading, map comprehension, and place identification.

These three special skills are critical not only to our culture, but to our future as a nation involved in the space frontier. Innumerable recent studies have shown an alarming geographic illiteracy in our nation, especially the survey conducted by the National Geographic Society. These skills, therefore, need to be taught and re-taught at every educational level so that graduating high school seniors are prepared to apply these skills to the daily interpretations of news and business events, or studying at the college level. It is important for young people at the secondary level especially to be involved in a technology preparation system so they can function adequately in the technological world they are about to inherit.

The training of teachers should be a major priority of remote sensing industries because the education community cannot accomplish the task on its own and the skills of the information processing economy are not being taught to teachers. Remote sensing technology works hand-in-hand with the information

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processing economy in the creation of database systems, monitoring Earth systems, and the use of digital imagery as a disciplinary tool. Every teacher I have trained in the use of remote sensing skills which they can take back to their classrooms has been astonished at the simplicity of the technology and the broad range of application to everyday classroom subjects they are already personally teaching.

We need to concentrate attention on homeland Earth in order to view our planet as an integrated system of dynamic forces all acting upon each other to cause continuous change. A new global concept of Earth System Science (NASA,1986) is emerging, mainly through the efforts of the Advisory Council to the National Aeronautics and Space Administration. Orbital imagery and comparative planetology, made possible by remote sensing technology for planetary flybys and Earth observation studies, are critical technologies for understanding our own planet at a time when we are beginning to recognize and grapple with environmental crises. Remote sensing affords an excellent opportunity to merge weather, topography, tectonic movement, volcanic action, radiation physics, ocean dynamics, and other vital forces for a total global perspective.

Orbital imagery for the study of large areas of topography, where ground photos and normal aerial photography are inadequate, is an ideal instructional method in secondary schools. It often leads both students and teachers to a new perspective of our planet. During one particular lesson, for example, a 10th grade student literally jumped up from her seat while viewing a Meteosat image of Europe and exclaimed loudly, "Yes, now I see it! That's what Europe really looks like. . .and Italy *really is* a boot!"

Using spaceborne imagery and corresponding line-art maps (Figure 1), students can study major topographic or political features in a particular area. This is especially useful for processes such as poldering in the Netherlands. Polders stand out visibly in a Landsat image, and students can even follow the developmental process by labeling and coloring corresponding line-art maps. Students eight and nine years old have no difficulty learning Landsat or GOES satellite instrumentation, understanding the digital telemetry process, or memorizing the basic infrared color code and applying it to image interpretation.

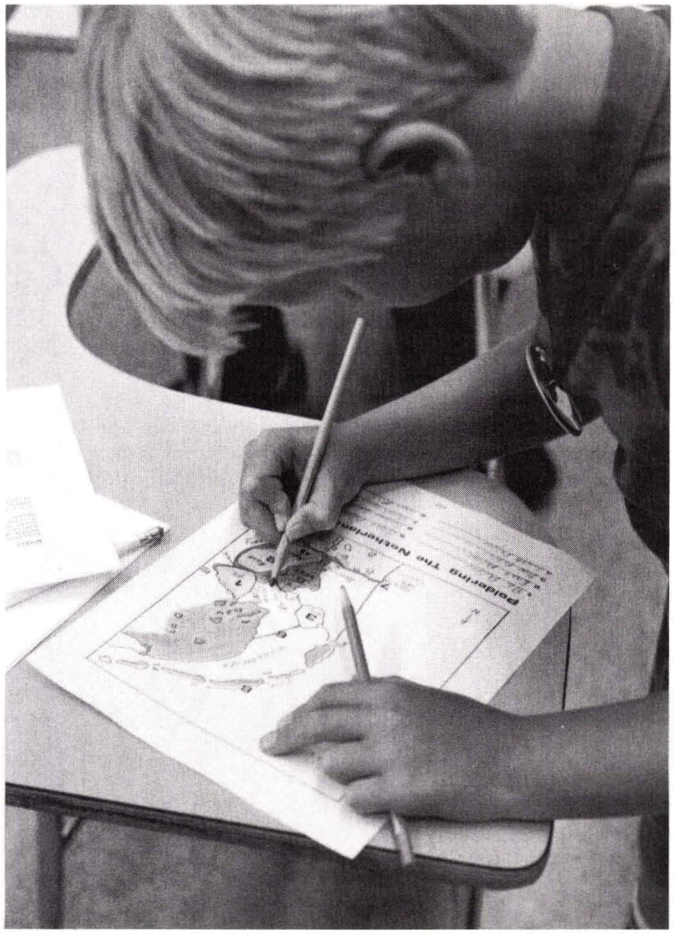


FIG. 1. Classic ERTS-1 (Landsat 1) Netherlands image serves as focal point for a class exercise about poldering technology. Students label and color a desk-size map using colors corresponding to infrared imagery, as this 12-year-old is doing.

For secondary school students, often the most exciting and meaningful activities are interpreting satellite imagery in infrared and false-color renditions, and tracking weather conditions. Students enjoy this kind of work because they have a chance to learn how to think individually and to arrive at a more stimulating real-life end-product. Also, young people know their futures are tied to space technology and they are eager to learn about newly available technologies.

Orbital imagery can have added impact for students when it is linked to ground truth photography. Two separate research trips to Europe in 1985 and 1986 allowed me to take an abundant amount of ground photography, and was coordinated with the European Space Agency's major data facility at the European Space Operations Centre in Darmstadt, West Germany. The ESOC facility furnished imagery from the Meteosat satellite for specific time periods, which were compared to ground truth photos taken at the same time. When the paired images are shown to students, the pairing provides proof of various concepts such as weather conditions and other details (Figure 2). These instances are simple but highly rewarding examples of ground truth verification.

Photos taken from the Shuttle Orbiter by hand-held camera can be used to introduce students to an additional range of subject matter. It is here that considerable excitement can be generated as students are able to see topographical features in panoramic splendor and in actual color.

Remote sensing for geography and geology led me to construct a visual system for teacher training to compare three different types of valuable imagery for the same region: (1) satellite digital data imagery, (2) normal aerial photo-reconnaissance imagery from low-flying aircraft, and (3) on-site ground truth photos. The result is an instructional method I have come to call "Three Dimensional Perspective In Reality," illustrated in Figure 3, which has immediate application for students from about 4th grade through upper graduate school levels, and with the adult public.

The system allows a viewer to see the same region from three different levels–satellite (800 kilometres), aircraft (3 to 16 kilometres), and ground level. For teacher training, where adults have had a much broader real-life geography experience, the system is proving to be a remarkable aid in remote sensing studies. While the system is still in the field-test stage, it already is bringing excellent results as a technology preparation system for later study of remote sensing techniques and imagery.

The value of space technology for daily classroom instruction has proven itself in a multitude of teaching situations (Becker, 1987), yet the education community has not begun to use the method because of a unique set of difficult barriers. Simplified, these barriers include

- Uneducated And Fearful School Administrators,
- Untrained Teachers,
- Absence Of Appropriate Instructional Materials,
- Lack Of Industry Contact With Daily Education,

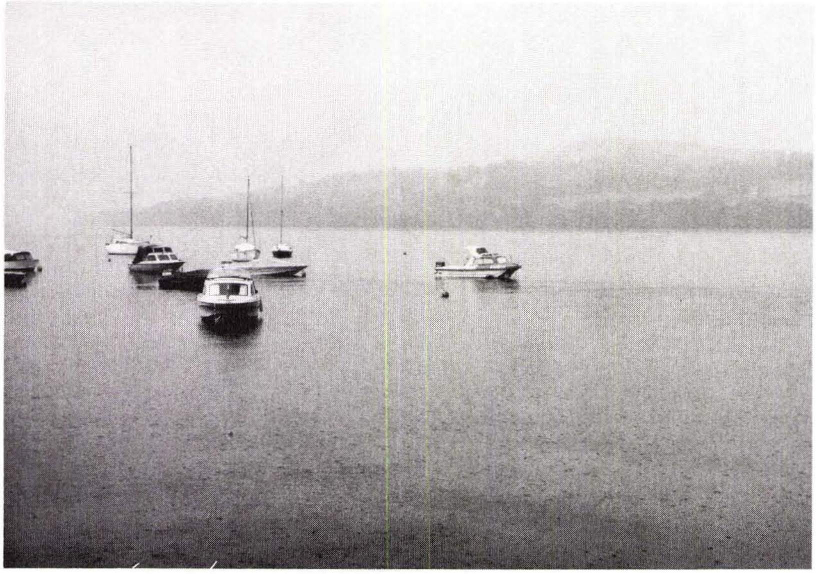


FIG. 2. On 13 August, 1986 the "bonnie shores of Loch Lommond" were not so beautiful as rain blanketed British Isles. ESA Meteosat image confirmed the heavy overcast. Simple, clear concepts have lasting meaning for young learners. Meteostat image courtesy European Space Agency, copyright 1986 by ESA.

- Education Is Not An American Priority, and
- Absence Of A Cohesive National Space Policy.

AN INDUSTRY-EDUCATION PARTNERSHIP

There must be cooperation between two giants of the American culture–between industry and education–to provide this important educational tool to teachers and students. Employees in an industry liaison office devoted to education, for example, can learn much by working hand-in-hand with educators instead of ignoring them, or by hiring competent professional teachers. Industry employees, once they understand the basic needs of an educational system and the daily classroom teacher, can assist in many different ways:

- training of public school administrators,
- teacher training in technologies and applications,
- simple re-formatting of products for better classroom application,
- general community support through television and print media,
- plant tours and update briefings for teachers,
- advice and assistance in the preparation of specific classroom materials, and
- internships during off-school hours.

Space-intensive companies can go one step farther–making kits of information available to teachers and school districts, sending news releases to schools requesting them, and furnishing visual material to teachers at cost plus mailing and packaging costs. National space agencies, American or foreign, can announce educational programs and materials through educational publications or in the general media.

A NATIONAL SPACE EDUCATION PROGRAM

The most rewarding technology to be introduced during Space Age I (1942 to 1980) is remote sensing if we measure a technology by its usefulness in solving human problems of everyday living. Remote sensing is a global necessity now, used daily in one way or another by most of the nations of the world. Two generations of global citizens have been born and grown up knowing only a world in which space technology has played a prominent, if not consistent, role. The pace of technology invention is rapid and we must find realistic ways to prepare young people to utilize these data and technologies for tomorrow's complex world.

This disturbing situation was brought home recently by a statistical study of 698 students in the 11th and 12th grades in two major cities–St. Louis, Missouri and Colorado Springs, Colorado (Becker, 1988)–privately published as "Student Attitudes About Technology Education: A Statistical Study." The survey to this point furnishes only preliminary data and additional statistical sampling needs to be done. However, the preliminary analysis of results is significant.

METHOD

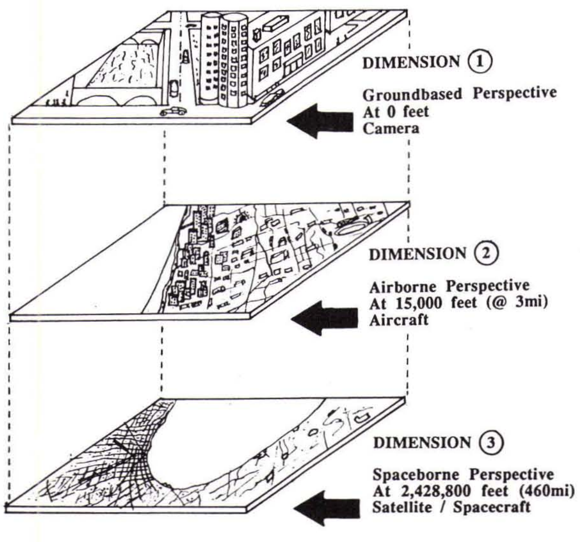
A random selection of students was directed to number from one to ten on a sheet of paper, was asked ten specific questions, and then was told to respond by writing the responses in column form on their paper. Individual differences, except age, were not taken into account because it is believed students across the national generally receive similar instruction. The questions asked were

(1) On a scale of 1 (low) to 10 (high), indicate how relevant you think your "whole school" course of study is.
(2) How much of your school time is spent exploring ideas about the technological world?
(3) Do you think studying concepts of modern technology would be helpful to you?
(4) Do you understand precisely how a weather satellite works?
(5) What is the purpose of America's space program?
(6) Define the term Poldering.
(7) How many nations are involved in the European Space Agency?
(8) How well does science serve the needs of society?
(9) Who was America's first astronaut?
(10) How important is the exploration and commercialization of space?

RESULTS

The compilation of raw score results are shown in Figure 4 as averages and as percentages of responses. Within the scope of the survey and its purposes, the results are believed to be significant even for the small size of the sample (698 students). It is expected that a broader sample would effect the results only marginally in either direction for each question, but for

ADVANCED EDUCATIONAL SYSTEMS
Satellite Perspective To Teach Geography And Geology
By Adding A Third Dimension
(Three Dimensional Perspective In Reality)



Life is a multi-dimensional experience. We need to learn in more than one perceived perspective no matter what the subject. We need a variety of viewpoints in order to "experience" a concept from various realities and approaches.

Intellectual	Physical	Sight	Flat
Emotional	Mental	Hearing	Dimensional
Spiritual	Psychological	Touch	Transparent

FIG. 3. Schematic of the "Three Dimensional Perspective In Reality" concept. The teaching method permits students to see the same region in three interrelated views, and provides needed emotional acquisition for real learning. The application works exceptionally well with the planets and the Moon, and is an ideal concept for remote sensing education.

Compilation Of Data By Question: Final Percents
Returns from 698 Participants, St. Louis and Colorado Springs
Thomas W. Becker, Researcher

Question 1 On a scale of 1 to 10, indicate how relevant you think your "whole school" course of study is. •Response - 6.76	Question 2 How much of your school time is spent exploring ideas about the technological world? •Response - 19.23%
Question 3 Do you think studying concepts of modern technology would be helpful to you? •Response Yes - 91% No - 09%	Question 4 Do you understand precisely how a weather satellite works? •Response Yes - 10% No - 90%
Question 5 What is the purpose of America's space program? •Response: 1. learn - 76% 2. don't know- 6% 3. keep ahead - 6% 4. protection - 5% 5. other - 7%	Question 6 Define the term Poldering. •Response Correct - (.2)% Incorrect - 99+%
Question 7 How many nations are involved in the European Space Agency? (Ans: 15) •Response: Correct - 01% Incorrect-99%	Question 8 How well does science serve the needs of society? •Response: poor - 03% average - 16% good - 52% excellent - 28% NR - 01%
Question 9 Who was America's first astronaut?" •Response: Correct - 11% Incorrect - 89%	Question 10 How important is the explorat-ion and commercialization of space? •Response: not at all -05% some -37% very -57% NR -01%

FIG. 4. Responses of 698 senior high school students in two cities to questions designed to elicit attitudes about technology education. The Survey was designed by the author (Becker, 1988).

the sake of accuracy the researcher plans to continue the polling process until the sample reaches at least 2000.

DISCUSSION AND CONCLUSIONS

The following conclusions can be drawn from the preliminary data:

(1) Technology education in America is not a public education priority, according to responses to questions in the survey (see especially questions 2, 3, 4, 6, and 9). As a result, the technology that drives daily business and shapes every aspect of our lives is encountered and learned totally by chance, and most certainly during out-of-school hours. The wide swing of scores in the responses to these questions shows a marked need for more technology curriculum reflecting the basic business of our culture and the world.

(2) Our nearly-graduating students probably did not receive the kind of education they expected, or feel will be useful to them in the world of work (see results of questions 1, 3, and 10). Student perceptions of present curriculum at the secondary school level indicate a disturbing displeasure with the content of their daily school experience. In addition, this lack of relevant subject matter does not offer a strong foundation for infusing a space or technology philosophy in young people. In a year or two, these 698 students will be standing in polling booths, purchasing technology-inspired retail products, and attempting somehow to make up for a lack of basic technology education. The overall pace of technological advances is thus slowed and, in some instances, interrupted altogether.

(3) Young people today have little or no knowledge of the technology of foreign countries. This critical factor colors their perceptions of and attitudes about other nations that show up later on in the business world (see questions 6 and 7). In a global community tightly knit together by lightning-quick communication (by satellite) and transportation (aerospace planes such as the Concorde jet), many students will not be able to participate successfully in international commercial ventures. Without a sound knowledge of foreign cultures, the coming world job market will be closed to them by companies unwilling to take a chance on their personal inability to establish and maintain foreign relationships, according to many conversations with European business people I have had while traveling in Europe. Student responses to question 7 ranged from one nation to as high as 76 nations for the membership of the European Space Agency!

(4) While students indicate a higher-than-expected view of their own knowledge of technology (see questions 2 and 4), they are partly confused by an erroneously perceived relationship between science on the one hand and technology on the other. Both science and technology are discussed and exhibited in the American culture, yet students do not know the difference between them nor have they been exposed to the fundamentals of either. This confusion also shows up in question 8 and 10 when the students are asked to make value commitments to scientific or technological issues.

Ironically, one of the basic beliefs built into the survey at the start was that "technology" is a pan-cultural term in America today. This eventually proved to be true–but unfortunately many people do not really understand what the term means, or that it is used so freely without comprehension.

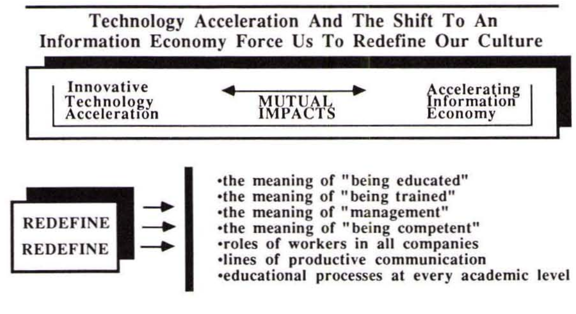


FIG. 5. The existence of new technology, as well as its pace, requires us continually to redefine our culture and its institutions.

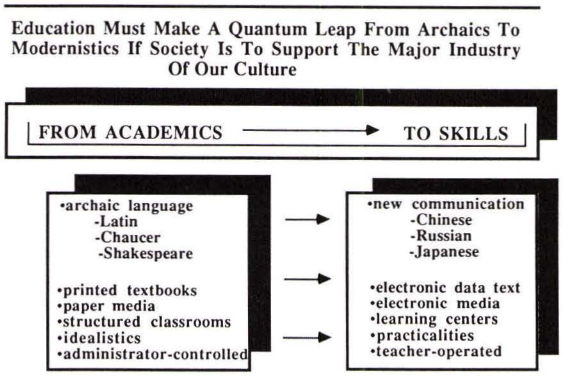


FIG. 6. To meet the challenges of the next civilization and the next century, we will have to teach more competent educational information that better fits the culture we are now designing.

(5) Are students interested in technology education? Yes, overwhelmingly so, according to the response to question 3 where 91 percent of the sample said that more technology education would be helpful. No more needs to be said, except that some kind of curriculum revision-toward-reality is drastically needed (also in the light of responses to question 1). Young people already know that their futures are tied to the space frontier, and they wonder why they are not being taught about it.

(6) If students in the sample were receiving a strong foundation in space technology, the response levels in questions 8, 9, and 10 would be different. Surely we cannot expect these students-turned-adults to support a technology-based culture intellectually or emotionally without any kind of technological foundation. Even 76 percent of the sample in question 5—"What is the purpose of America's space program?"—said the purpose is to learn, yet what we have already learned in the past 31 years or so is not available in schools.

(7) In answer to Question 9—"Who was America's first astronaut?"—many of the 89 percent who did not know wrote such names as Louie Armstrong, Chuck Yeager, Jesse Jackson, The Monkey, Darth Vader, Buck Rogers, Admiral Kirk, and George Washington. The two most frequent responses to this question (in order) were (1) Neil Armstrong and (2) John Glenn.

(8) The survey turned up one interesting factor that was not expected or provided for-a certain low level of student concern about current major issues. On a number of papers, students wrote such phrases as "does anyone care if I know?" or "who cares" or similar comments.

In summation of the Survey, it is interesting to note that there is definite depth of feeling in the overall responses. The students expressed themselves well and mostly honestly, and what they are saying is an indication of their true view of the present. The results should be taken seriously, and if educators need guidelines (Figures 5 and 6) for future educational programs, certainly this study offers something to think about.

Remote sensing is one of the keys to open the universe. If we are to use this most fundamental tool of all the space technologies adequately and responsibly, then we should encourage it as a classroom necessity and work directly with our public schools to teach it as one of the best and most competent of the available space technologies (Becker, 1986).

The next civilization in space now being designed by the world's leading spacefaring nations will depend on activities requiring considerable knowledge of orbital mechanics, space physics and biology, planetary geography/geology, and an expanded use of remote sensing. Space stations, instrumented orbital platforms, space transportation systems in and about the Solar System, and research and manufacturing facilities in space require educated workers schooled in space-based technologies. In order to meet all these technological challenges, we must begin now to initiate and wisely manage a national space technology education program or we will not be able to enjoy the riches of the next civilization along with other more farsighted nations.

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pc ARC/INFO Starter Course

6-8 November 1989

A pc ARC/INFO Starter Course will be offered by the Center for Remote Sensing and Mapping Science (CRMS) working in cooperation with the Environmental Systems Research Institute (ESRI), Redlands, California. This course is designed for participants who already own, or are planning to purchase pc ARC/INFO. The format of the course is a series of lectures and exercises intended to familiarize participants with data capture and editing, use of the new ARCSHELL menu interface, map coverage analysis, modeling, and map composition. Techniques for integrating remote sensing data with pc ARC/INFO will be introduced. Environmental monitoring, resource management, and urban planning applications are emphasized.