Earth Resources Technology Satellite (ERTS) – 1973

Narrator: Thrusting outward into space, we gain new perspective on ourselves. How beautiful it is, our cloud-wreathed spaceship planet Earth. How beautiful and how small. The view from space shows us as never before the strict limits for accommodating man's growing numbers and his expanding technology. The Earth seen whole is a compelling reminder of the need to safeguard our earthly resources: soil and the land, food and fiber, the forests, the rivers, the lakes, the seas, the oceans, minerals, nonrenewable treasure. We are ever more aware that man's future on Earth depends on how well he conserves his earthly heritage. We need better ways to inventory and monitor our resources and to learn more about them.

Photography from an orbiting satellite can provide the information we need at a cost we can afford. The Gemini and Apollo programs provided the first Earth images useful in studying the planet's resources. These experiments have lead to the development of an unmanned satellite system for surveying Earth resources from space.

The Western Test Range in California, July 23, 1972. Perhaps no new development in space is more significant than this: ERTS, short for Earth Resources Technology Satellite. ERTS I, the first experimental ERTS satellite, circling the Earth pole to pole. Its job: to send back images of the Earth's surface about which we need more information, images obtained most readily, or in their most useful form, by remote sensing from outer space. Seen from far out, the forests and fields reveal the spread of disease and insect infestation. A spacecraft can provide geologists with clues to where to search for oil or metals. Space imagery can give us new knowledge of living marine resources. It offers an ideal means to monitor change, an ocean chewing away at the edge of a continent, a desert's advance, a volcano's fury, a glacier's creep, the dynamics of land use, and the growth and decay of cities. We can map the world from space and we can update the maps as the world changes. There is no end to the variety of ways space imagery may help us.

Pioneer work in interpreting images obtained by remote sensing was carried out at the University of California at Berkeley. A leader among the pioneers, Professor Robert Colwell:

Robert Colwell: For approximately 50 years, man has been taking inventory of various Earth resources such as timber, forage, soils, water, mineral, and agricultural crops through the use of conventional black and white aerial photographs that have been taken from an altitude of three to four miles above the surface of the Earth. One such photograph is shown in this view of our NASA San Pablo Reservoir Test Site, only a short distance from the Berkeley campus of the University of California, in which our work is headquartered. You will notice in this view that we can readily discern differences in muddiness of the water in these two reservoirs, we can see grassland differentiated from timberland and brush land, and, even among the tree species, to tell hardwoods from conifers and something of the volume of each.

Within the past few years, NASA has provided us with imagery taken from an altitude of 14 miles instead of 3 or 4. On this photography it is possible to see essentially the same resource features as on the larger scale photos, and we cover a tremendously increased area because of the higher altitude.

Narrator: Now NASA has made the great leap from 14 miles to outer space. ERTS is a flying observatory orbiting the Earth about 500 miles up. It carries two independent image sensors. One is a camera system, essentially three cameras in one; each camera is sensitive to a different color band in the electromagnetic energy spectrum. The three cameras simultaneously photograph the same area 100 nautical miles square. They take overlapping pictures as the spacecraft travels. The other sensor, sensitive to four spectral bands, is a line scanning device. Its optical system scans across the same 100-mile-wide path. If a ground station is in site, the spacecraft transmits the data from the sensors immediately; otherwise, stores it on tape for transmission later. The satellite's orbit, near-polar and circular, takes 103 minutes. Due to the Earth's rotation, each new orbit is displaced about 1500 miles to the west at the equator. The spacecraft makes three passes over North America daily, 14 around the globe. Each new day's path overlaps a part of the previous day's tract. Thus the Earth is progressively viewed at the same local time daily and is completely covered every 18 days, except for small areas near the two poles.

At Goddard Space Flight Center at Greenbelt, Maryland, the operations control center monitors the spacecraft's flight night and day, watching every element of its operation and issuing orders that control its performance. Each time the spacecraft comes over the Arctic horizon, it sends its stored data to the nearest of three ground stations which records it on tape. It continues to send data to the nearest ground station in sight. All tapes produced at the Alaska and California stations are shipped by fast mail to the station at Goddard for processing.

At the Goddard facility, the data is first annotated as to what each image is and when it was taken. The annotated data is converted to a film negative. The film is taken to the photo lab and developed. The spectral band images are printed in black and white. They may also be combined to form color pictures using contrasting colors to aid interpretation. The data is also transferred to tapes that can be processed by conventional computers. From the Goddard facility, a daily stream of images and tapes shipped to more than 300 principal investigators, over 100 of whom are in some 35 countries throughout the world. These investigators are using the data obtained from ERTS to study numerous problems involving the natural and social sciences.

Robert Colwell: This is a satellite photo taken by ERTS 1 from an altitude of more than 500 miles. The entire area shown on this high altitude aerial photo is encompassed in this small area of the satellite photograph. A view taken from our same vantage point, looking this seemingly short distance to Mount Diablo, shows that it is a tremendous distance away nevertheless. In this area we see the present boundary of the floodwaters from a recent flood, and by monitoring this every 18 days with photographs from ERTS, we are able to monitor the rate at which the floodwaters recede. In this way we can relate the mortality of fruit trees and other crops to the length of time they are inundated, which is of value in predicting damage to crops in future floods. Finally, if we look in this same view to the agricultural crops in the Sacramento–San Joaquin Valley we see one type of crop in this area, vineyards associated with sandy soils; an entirely different crop in this area, sugar beets and asparagus in peat and muck soils; still a third crop in the heavy clay soils, in this case rice, recognizable by its very dark tone; and other crops associated with soil types throughout the area.

Narrator: ERTS imagery, where a single small picture covers a vast area, puts a new premium on interpretive technique. The color additive viewer is all but indispensable for many investigators, among them NASA's senior geologist Dr. Nicholas Short.

Dr. Nicholas Short: The color additive is an instrument that uses color filters to enhance certain features of an image we're particularly interested in. For instance, here's a black and white picture of the Monterey Bay area in California produced by the infrared channel on the ERTS multispectral scanner. Now if we project this image through a green filter, the lighter grey tones which are vegetation, such as the farm areas in the Great Valley, will show up more green. By combining different spectral images and trying different filters we can get a wide variety of effects and choose the one that's best-suited to our needs. The investigator uses his ability to associate small color differences in the renditions we've just seen with ground features to get the desired information.

Narrator: Imagery may also be analyzed by isolating individual elements. This is called thematic mapping. In this ERTS image for example, the open water areas have been extracted and printed separately. Also the ice and snow areas. The U.S. Geological Survey has made thematic mapping a fine art. With the help of a computer and highly specialized equipment, information is produced that enables an operator to write precise instructions to the photo laboratory. When these instructions are followed, a single image may be subdivided into as many as 20 different foils, one showing only water, one for ice and snow, others showing forests, open fields, crops, bare soil, massed works of man, and so on.

Laramie, Wyoming. For scientists at the University of Wyoming, an ERTS size assignment: the state itself, Wyoming and its natural resources.

Robert Houston: The Wyoming project is multidisciplinary and includes such areas as botany, geology, zoology, plant science, and physics. Looks as though Wyoming will supply energy for a good part of the country and we hope we can do it without pollution. We hope through the use of ERTS…

Narrator: Professor Robert Houston, head of the geology department at the state university.

Robert Houston: …study of the natural resources of the state of Wyoming. We think in integrating all of these programs – the ERTS, the U-2, and the multi-level viewing with low-level aircraft – we will have a very suitable program for studying our natural resources.

Narrator: On the day of the ERTS flyover, ground conditions are tested. At the same time that the satellite swings toward Wyoming 500 miles up, a NASA C-130 prepares to make its imagery run over the same terrain at 20,000 feet. The aircraft carries more sensors than the satellite, and its images will be rich in detail. But it will not get the big picture; it will not return periodically, will not monitor. Plane and satellite complement each other.

Robert Houston: Wind 40 westerly.

Assistant: 40 westerly, got it.

Robert Houston: Humidity 40.

Assistant: Okay.

Robert Houston: Temperature 68.

Assistant: 68, check.

Robert Houston: Solar radiation is reading.

Assistant: Good.

Narrator: For the scientists who are evaluating ERTS, the multi-level approach using ground information, aircraft information, and space information is invaluable.

Robert Houston: Ron, let's see if we can identify some of these faults you found on the aircraft imaging on ERTS.

Ron: Alright Bob. On the aircraft image we've got about three miles of a fault here. If we look at this on the ERTS image we can extend it to about 60 miles. More exciting is one down here on the ERTS image, a very major structure, cuts across the whole mountain range. We've never known about it before until we had the ERTS image.

Robert Houston: What if we extended that into the basin. If we could it might be useful in petroleum exploration.

Ron: Possible, possible. So this makes a target out in the field to go look at on the ground.

Narrator: The rugged Wyoming terrain, yielding up secrets of her natural resources. But ERTS does not just help us to know nature's work better; man's work as well. At Dartmouth College, Professors Robert Simpson and David Lindgren are putting ERTS to work in regional planning.

Robert Simpson: We here at Dartmouth are concerned about a pressing social and economic problem: urban sprawl. And conversely with a disappearing resource: open land.

David Lindgren: Our general area of interest is that highly urbanized section of the Eastern Seaboard which extends from Boston southward to Washington and to which as been given the name megalopolis. Our specific area of interest is the New England section of it.

Robert Simpson: Increasingly the spreading problems of megalopolis require a broader-based treatment than that of individual metropolitan areas. This is an ERTS photograph of southeastern New England – Long Island Sound, the Atlantic Ocean, the base of Cape Cod, and Boston. By enlarging this area, which corresponds to the state of Rhode Island, we can make a land use map of that area.

Man: There it is along 44, the commercial ribbon development that we're gonna have to throw in with the industrial category.

David Lindgren: That's right. We find that on the ERTS imagery we can recognize at least eight different land use categories, each represented on the completed map by a different color. The red represents a combination industrial/commercial; the orange, multi-family housing; the yellow, single-family housing. You use green to represent woodland, blue for water, black for transportation, and brown for agriculture. Vacant areas are clouds on the photograph. The next step is to tabulate information from the map and input it to a computer.

Man: One commercial. One single residential. Now multi, multi. Two clouds.

David Lindgren: The immediate response available with the Dartmouth time-sharing system makes the database not only a display vehicle but an invaluable research tool as well. We've learned enough now to know that ERTS is a valid land use study tool for regional planning.

Robert Simpson: Yes, this gives us a new capability. We can monitor change and we can keep track of growth and we can tell whether that growth is in many cases a healthy form of growth or an unhealthy one.

Narrator: The flow of ERTS images is but the onset of a vast volume of space imagery to come, so vast that to study it we shall need all the aid from technology we can get. At Purdue University, at the Laboratory for Applications of Remote Sensing, they are pioneering in the use of the computer to analyze images. Professor David Landgrebe and his associates start with a computer-compatible tape that contains the imagery data, and the computer processes the image. In order to give the computer the information it needs to make its analysis, the investigators must know what's in the area covered by the image. They get this ground truth, as it is called, by making on the spot checks of what actually is there. Spectral readings taken close-up support the research. Training the computer, the investigator identifies specific shades of grey as, say, corn, soybeans, water, and so on. Once the computer knows these spectral signatures, it can identify what they represent anywhere in the image and it can print out its findings in whatever form the investigator requests.

At the Earth Satellite Corporation, a privately owned company, Dr. Robin Welch and his associates use low-flying aircraft to speed up ground truth studies. In a typical agricultural investigation, the farm fields are plotted from an ERTS image.

Robin Welch: We'll get it tomorrow if the weather clears, but we want to get these agricultural crops before they change much. And what we're gonna do is get the crop types plotted on this map as Steve and I fly it, and then we'll give those to you.

Narrator: Field by field, pilot and observer collaborate on the identity of each crop, doing in a few hours what would take days by car and on foot.

Robin Welch: Course we've got the coordinate locations so that your computer people will be able to just take that and enter right off the chart to train the computer as to what these agricultural types are. And I think they're accurate.

Narrator: But there are other parts of the world where ground truth is not yet accessible, where remote sensing plays a special role. One who knows this well is Mr. George Gryc, chief of the Branch of Alaskan Geology, U.S. Geological Survey.

George Gryc: I've been studying some of the latest ERTS imagery of Alaska. Alaska is ideally suited to remote sensing. Transportation is limited, terrain is rugged and includes some of the highest mountains and some of the greatest snowfields of North America. As this tectonic map indicates, the geology is complex, but we believe that with the use of the satellites we can map off the geology and help delimit some of the mineral resources. Our ERTS-A investigations in Alaska started with a remarkably cloud-free picture of the state that was taken by the weather satellite, the Nimbus weather satellite, in 1970.

Narrator: Studying this photo, geologist Ernest Lathram noted lines that seemed to be hitherto undiscovered faults.

Ernest Lathram: Now we are using ERTS imagery to determine the relationship between these previously unsuspected faults and the mineral resources of Alaska. If we compare the mineral deposits in Alaska to the linears shown on the Nimbus photograph, we can see a very definite relationship. For instance, at the intersection of these two linears, there has been a major copper discovery made recently. Now, on one of our first ERTS images, we see that in this area there is indeed a fault along that strike.

Narrator: In Alaska, ERTS imagery is also being used to improve and refine maps of the permafrost, perennially frozen ground that comprises 85 percent of the state's terrain in a variety of forms and that poses engineering problems for man-made undertakings. Another way ERTS imagery is being used is to monitor geologic hazards, such as volcanic eruptions, earthquakes, floods, glacial surges, and other potential dangers to man and his environment.

But it is not just in northern climates that ERTS imagery is being used to help deal with questions of ecology. As biologists have long known, wetlands are among our most valuable ecological assets, serving a series of life cycle and food production functions. The work of Professor Richard Anderson at American University may prove a useful aid in protecting the public interest. In coastal areas, wetlands below the mean high tide line legally belong to the people at large, but costly drawn-out court fights often arise as to just where the boundary line is in the hard to access terrain.

Richard Anderson: The upper wetland boundary is showing very clearly on this tree island, also the boundary between upland and wetland is very clear in this area. I think that means we're going to be able to say a lot about mean high water line in the wetlands, distinguishing between what is publicly owned and privately owned wetland and avoid litigation over wetland boundaries in the future.

Narrator: In addition to remote sensing from space, ERTS has another important capability: it collects and forwards data from censors on the Earth – data, for instance, about river flow and precipitation in New England, a region with a long history of flood disasters.

Saul Cooper: Twenty-one died during this flood. March 1936 was a springtime flood…

Narrator: Saul Cooper, in charge of the Flood Control Division, New England Region, Army Corps of Engineers.

Saul Cooper: Hurricane Diane in August 1955 caused this region its worst catastrophe. Ninety people lost their lives and damages of almost a half a billion dollars were experienced. To prevent such waste of human life and resources, the U.S. Army Corps of Engineers has built 35 flood control reservoirs strategically spotted from Connecticut to Maine, many local protective works, and several hurricane barriers. To maximize the effectiveness of this system, we created an automatic data collection network with radio reporting.

Narrator: The network funnels hydrologic data – river levels, tidal elevations, rainfall, and the like – to the Corps' regional control center at Waltham, Massachusetts. Now they are experimenting to improve the system by using ERTS. At some 25 stations, censors are producing hydrologic data as well as water quality information where rivers are being treated for pollution. Every three minutes, this ERTS platform transmits the data out to space. If the spacecraft is on a line of sight, it relays the data to a ground station. The data is forwarded via telephone lines to Waltham, where a computer processes it to obtain information that is useful in planning and invaluable in emergencies.

Saul Cooper: Of course, the big payoff will come during the next flood emergency. In this room, and around these tables, we gather to coordinate the flood control activities. Through data collection and space imagery, ERTS opens a door to new understanding of the world we live in. The door is open to all.

At the center of the continent at Sioux Falls, South Dakota, the U.S. Geological Survey operates a data center that receives, catalogs, and stores a daily flow of ERTS and high altitude aircraft imagery. Simultaneously, orders for pictures pour in by phone and mail. The computer queried as to what is available. Would you like to buy an image of 100-mile-square piece of the Earth where you live? The computer will search, tell what's available, process your order, and issue instructions to the laboratory. Daily, a mounting volume of imagery going to a long list of subscribers at universities and research agencies as well as individuals around the world, providing us with a more complete view of that world than we've ever had before.

With ERTS, man began the first comprehensive inventory of his earthly resources, and he launched a valuable new means of obtaining information needed to manage those resources for his future well-being. ERTS, a new chapter in space, is in fact a new chapter in man's effort to prove himself worthy of his earthly heritage.