ENVIRONMENTAL REMOTE SENSING:
OLD APPLICATIONS, MISSED OPPORTUNITIES,
AND NEW INFRASTRUCTURES

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Dr. Felsher has served as Senior Staff Geologist, U.S. Environmental Protection Agency Headquarters, Washington DC, (1971-1975) responsible for the coordination of all remote sensing activities for EPA's national enforcement effort. At National Aeronautics and Space Administration (1975-1980) he served as Chief, Geological and Energy Applications; first Program Manager of NASA's Regional Remote Sensing Applications Program; originator of NASA's National Space Grant College Program; Program Scientist for: OSTA-1 (first Space Shuttle Earth-viewing payload), Large Format Camera, and Heat Capacity Mapping Mission; and Senior Scientist for NASA's Non-Renewable Resources Program. He has served on the Board of Editors of the *Journal of College Science Teaching,* and *Remote Sensing of the Environment,* and is a Fellow of the Geological Society of America and a Senior Member of the American Astronautical Society. He is currently chairman of the ASPRS/ACSM Joint Committee on Remote Sensing and Mapping and a member of several other professional and technical societies.

The world of satellite remote sensing is now quite different than it was when Landsat-1 was launched in 1972. And I'm not referring only to the giant technological leaps made in sensors and image processing hardware and software. Of far greater importance to our security and understanding is the fact that satellite remote sensing, once the private domain of the esoteric researcher, has now moved onto the front pages of our daily newspapers, and into our living rooms via national television newscasts. The global public is now able to view the global Earth from space. We note the efficacy of a strip-mine re-vegetation program. We estimate the yield and production of forest, food, and fiber. We discover and assess the world's store of fossil fuels and minerals. We view Man's constructive re-shaping of his planet, and we follow the destruction wrought by war. We scan both the continents and the oceans. We can follow Earth's natural disasters and Man's follies. We monitor these phenomena over time and across national boundaries. And we finally begin to understand that our planet is indeed a single fragile system, each part of which interacts with, and is dependent upon, every other part. What better way to study the whole Earth than from the high ground of space? What better way to serve the whole Earth than as an advocate of the global application of satellite remote sensing.

Especially important are the applications of remote sensing that are specifically aimed at the mitigation and alleviation of actual environmental problems. And here, at the outset, I am differ-
entiating between the sophisticated *measurement* of environmental parameters, and the *employment of these measurements* in support of coordinated assessment, monitoring, and surveillance actions necessary to both mitigate natural disasters, and to prevent the further degradation of our planetary environment. The span of space-derived data being acquired by NASA and NOAA satellites speak well to the research activities being undertaken by those agencies. But I am more concerned with the *application* of these data. The following capsule descriptions are some examples:

(1) A large pulp and paper company moves its facility from the shores of Lake Champlain, and in doing so abandons responsibility for the sludge it has for many years deposited onto the lake bed. The mid-point of the lake in this area is the boundary between Vermont and New York. The state of Vermont then claims that the sludge has moved across the lake centerline, has degraded Vermont waters and wants the U.S. Environmental Protection Agency to have the paper company clean up the pollution. Vermont approaches EPA Region I officials in Boston, and that office backs up Vermont’s claim. The paper company, in New York, claims that there is no evidence that any pollutant has crossed the lake centerline, and approaches EPA Region II officials in New York. That office backs up the company claim. A Special Master is assigned by the Supreme Court, and a series of hearings are held which eventually recognize the fact that the water quality has degraded across the lake centerline into Vermont, and that the source of that pollution is the paper company sludge. The key piece of evidence is a Landsat multispectral scanner (MSS) image.

(2) Electrical generating plants use enormous amounts of cold water to pass over and cool the condensers. A Florida nuclear power plant discharges its thermal effluent into Biscayne Bay. Amazingly, the discharge pipe is constructed south of the intake pipe, even though the currents of the bay have a net northward flow. So the plant begins to draw in its own heated discharge water. Not-surprisingly, this diminishes the efficiency of the power plant operation, a situation noted by the plant operators who then attempt to solve the problem by moving the discharge pipe further south. This continues until the company blasts a six-mile-long, 18-foot deep, 200-foot wide canal into the Miami oolite, a hard rock formation, and is about to break into Card Sound, the next body of water to the south. Continued discharge of heated water at the expected rate of 4250 cubic feet per second into this area will quickly destroy this tropical environment, and eventually affect Biscayne Bay National Park. EPA enters the picture. A Consent Decree is arrived at whereby the company and the government decide on a plan to build a series of canals surrounding the plant. The water, moving south through the canal system, will cool through evaporation, and the cooled water will be pumped northward to the plant to be re-used. The re-
The thermal infrared channel aboard Landsat's Thematic Mapper clearly shows both the heated water cooling southward, and the cooled water in the northward-moving canals.

(3) A company moves taconite, a low-grade iron ore, from Minnesota's Mesabi Range to a beneficiation facility on the shores of Lake Superior. The beneficiation process, a non-chemical activity, simply crushes the taconite into a fine powder, removes the iron by magnetic separation, and compresses the resulting ore into iron-rich pellets, which are then shipped to steel mill furnaces. The plant is located at the lake shore because the ore-crushing procedure uses an enormous amount of water. Indeed, the discharge of tailings from the process starting in 1956, amounts to 63,000 tons per day. To bring that figure into context, note that fluvial sedimentologists have calculated that the amount of sediment naturally deposited by all rivers and streams entering Lake Superior amounts to 65,000 tons per year. The discharge has formed the largest man-made delta in the world. Studies at an EPA laboratory in Duluth point out that among the minerals "freed up" in the taconite beneficiation process are lath-like tremolite and actinolite. These are asbestiform minerals whose ingestion, it is claimed, may lead to gastro-intestinal cancers. In (still) the longest and most expensive federal trial of an environmental issue, the federal court ordered the company to halt its tailings discharge into Lake Superior, and directed the construction of a land disposal site. EPA aerial photos and Landsat imagery play a vital role in confirming Lake currents carrying the tailings toward Duluth drinking water intakes.

(4) The New York Bight has for scores of years been the garbage dump for everything from cellar dirt, to solid waste, to sewage, to industrial waste, to acid. An early Landsat image is used to indicate an acid dump, and, when published in a national science magazine, is the impetus to an early investigation of all kinds of nearshore dumping. The Coastal Zone Color Scanner (CZCS), which was operational aboard NOAA's Nimbus-7 satellite, was first preflight tested from a NASA U-2 aircraft over the New York Bight. The resulting image is able to differentiate "natural" sediment from two acid dumps, clearly indicating the potential for this sensor in environmental enforcement activities.

(5) The final example involves the discharge from a steel plant on the shores of Lake Michigan. The state of Illinois charges the plant with polluting the lake waters from which Chicago draws its drinking water supplies. EPA scientists secure a series of aerial infrared images, both black-and-white and color, and a SKYLAB satellite photograph of the area. From the Environmental Protection Agency's Inside EPA: "The pictures showed the heated water discharged from Indiana Harbor, where the company has a big steel mill, drifting north into Illinois waters with
little or no mixing. The heated water served to track the movement of the 'plume' of pollution, which other witnesses testified contains phenols, ammonia, suspended solids and other deleterious substances, requiring frequent shutoffs of Chicago's water supply intake."

Now, these are all what I call real applications of remote sensing to real environmental problems. What all five examples have in common is that they were undertaken in the early 1970's.

Even if pressed, I am unable to cite such examples during the past 15 years. The reason is simple. No research agency wants to jeopardize its status as an impartial, “facts-only” source of data. Least of all, a “Big-Science” agency such as NASA, dependent as it is upon the good graces of Congress, could not allow its Landsat satellites to be used for anything as programmatically dangerous as enforcement-related case-preparation surveillance and monitoring. Nor can NOAA, nor can any other research agency allow itself to get involved in real environmental issues. The result, insofar as operational aircraft- and space-derived remote sensing imagery was concerned, was an arms-length attitude between NASA and EPA that quickly enlarged into the lacuna, hiatus, and erosional vacuity we note today, (so-called cooperation between the agencies notwithstanding.)

Long-time followers of U.S. civilian satellite remote sensing are fully aware of the nineteen-year Random Walk that has passed for civilian space policy since launch of Landsat-1. My own view as to what is needed now, and what we have urged in briefings to both the National Space Council and Congress, is to pursue a wholly new approach --- a bold approach that steps back from the numbing institutional constructs and vested interests that to this day have prevented both a U.S. government and a U.S. commercial breakthrough in the real application of satellite remote sensing of Earth. We need a new way to look at space-derived data --- one that merges our current global environmental monitoring requirements with an institutional mechanism designed to actually apply the scientific measurements to real problems.

The road from satellite ozone depletion measurements to international regulations regarding uses of chlorofluorocarbons (CFCs) must first pass through an agency both willing and able to accept space-derived data, and understand that data, and enhance that data, and transform that data into cogent information, and optimally combine that information with other pertinent non-space-derived information, and press the resulting knowledge against existing laws and regulations, and then provide the appropriate regulatory and operational agencies with graphics, numbers, text, options, and recommendations. We need such an agency. No such agency exists today.
NASA, as an R&D agency, is recognized worldwide as the premiere space research institution that it is. The glory that is the National Aeronautics and Space Administration is perhaps best exemplified as it develops and flies instruments to construct a baseline archive of accurate and precise, scientific measurements. These measurements can be made looking outward to space, as from the Great Observatories that will be launched this decade, or inward to Earth as envisioned by the Earth Observing System (EOS) sensor suite to fly by the turn of the century. In any case, NASA is not an applications agency. We do not have an agency that translates scientific numbers into operational imperatives. I believe that the information that has already been, and that will be derived from space imagery, is the foundation for global environmental health and for global peace and security. I have urged the National Space Council and the Congress to establish a new, independent Space Remote Sensing Agency, and I now call upon you to support this concept. SRSA would accept R&D from NASA and NOAA, and from DoD and NIST, and from NIH and NSF. It would serve as the government’s institutional focus for all applications and problem-solving using space-derived data. A Space Remote Sensing Agency would be chartered to apply satellite remote sensing research to real Earth activities and problems, and to serve in support of a growing space remote sensing industry, neither of which are goals and objectives of any existing federal agency.

No longer will space remote sensing applications find itself in direct agency competition for resources with space basic research. No longer will the building of instruments and the taking of measurements be ends in themselves in satellite remote sensing. Federal remote sensing basic R&D will still be the offered seed. But this time the seed won’t drop onto bureaucratic concrete; it will germinate, and grow, and together with commercial spinoffs, will thrive.

The intention would be to bring together from existing civilian agencies, those federal civilian programs, organizations, personnel, and assets, that are currently engaged in the application of satellite remote sensing. As remote sensing applications do span the breadth of the federal government, a considerable existing base of such activities already exists in many agencies. The fact that these activities are each submerged within its own bureaucracy accounts for the reality that they are relatively unknown and their impact has been substantially attenuated over the years. Like the applications themselves, the “appliers” are spread widely, but thinly. Thus, it is not without some difficulty that I have been able to identify specific remote sensing applications units that are now in existence in the following departments and agencies. I have recommended that these programmatic entities be drawn together to form the core of a new Space Remote Sensing Agency:
From the Department of Agriculture: units within the Agricultural Research Service; Economic Research Service; Forest Service; Foreign Agricultural Service; and Soil Conservation Service.

From the Department of Commerce: units within the Bureau of the Census; National Institute of Standards and Technology; and National Oceanic and Atmospheric Administration.

From the Department of Energy: units within the Conservation and Renewable Energy Office; Environment, Safety, and Health Office; Fossil Energy Office; International Affairs and Energy Emergencies Office; and Energy Research Office.

From the Department of Health and Human Services: units within the Public Health Service.

From the Department of the Interior: units within the Bureau of Indian Affairs; Bureau of Land Management; Bureau of Mines; Bureau of Reclamation; Office of Surface Mining, Reclamation, and Enforcement; Minerals Management Service; National Park Service; U.S. Fish and Wildlife Service; and U.S. Geological Survey.

From the Department of State: units within the Bureau of Intelligence and Research.

As well, there are specific programs and units of the independent agencies as: Environmental Protection Agency; Federal Emergency Management Agency; National Aeronautics and Space Administration; National Science Foundation; Tennessee Valley Authority, and U.S. International Development Cooperation Agency.

Attempting to reorganize the government is never a trivial undertaking. Attempting to do so at this scale, and across so many departments and agencies is at once intimidating and challenging. But I believe that this action is vitally necessary if the U.S. is to: (1) have a viable civilian presence in the area of space remote sensing; (2) reclaim its international leadership role in space remote sensing; and (3) justify its enormous investment in its Mission to Planet Earth/Global Change programs, turning them from pure technological research to meaningful problem-solving applications.

I believe that the time has come for innovation and boldness. An independent Space Remote Sensing Agency will allow us to finally move past the acquisition of space-derived data for its own sake, to the application of space-derived information for the benefit of all Mankind.