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FRIENDS OF THE EARTH[SM]

February 1, 1993

Memo to: Katie McGinty

From: Brent Blackwelder

Re: NASA

The attached report on what should happen to NASA's Mission to Planet Earth should provide helpful background and recommendations as the Administration proceeds to look at the future of NASA.

Friends of the Earth believes that Dr. John McElroy, Dean of Engineering at the University of Texas at Arlington, would be a superb candidate for the NASA Administrator.

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BUILDING ENVIRONMENTAL LITERACY
AND CONSENSUS FOR SUSTAINABLE DEVELOPMENT
THROUGH
NASA'S MISSION TO PLANET EARTH

CLINTON / GORE POLICY PROPOSALS

January 6, 1993

"If we could first know where we are, and whither we are tending, we could far better judge what to do and how to do it."
Abraham Lincoln, June 1858.

'I did not understand what the United States was saying until I saw pictures of my country from space. Madagascar is bleeding into the sea.'
Didier Ratsiraka, President of the Democratic Republic of Madagascar, 1992.

SUMMARY

Vice President Elect Al Gore wrote in **Earth in the Balance**,

> "Mission to Planet Earth should be a Mission by the people of Planet Earth...specifically, involving as many countries as possible that will use schoolteachers and their students to monitor the entire Earth daily..."

We agree. **Mission to Planet Earth must be an open, broadly useful program whose equal objectives are science, practical environmental resource management applications, and the widest possible public education, including improved environmental science literacy in all nations.**

NASA must be much more aggressive in **getting the information out to the people** about Earth science and environmental and global climate change, to help the Clinton / Gore Administration build wide consensus for responsible stewardship of the planet and sustainable development policies.

The enclosed proposals will help accomplish this objective because the world responds to pictures of the Earth and data collected from space.

We propose changes primarily to existing NASA programs. [1] They have been reviewed and agreed to by individual astronauts, state government and university researchers, and public interest groups, including Conservation International, Friends of the Earth, the Sierra Club, and representatives of the Nature Conservancy.

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[1] Coordination among federal government agencies must also be seriously examined, but is outside the scope of this report.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

I. POLICY RECOMMENDATIONS --

MISSION TO PLANET EARTH MUST BE DESIGNED TO SERVE HUMANITY

Mission to Planet Earth (MPE) program design has been limited by Bush Administration policies to serve theoretical science. To realize MPE's potential for environmental protection and human betterment, the Clinton / Gore Administration must make fundamental changes.

Policy Recommendations:

(1) **Choose NASA and White House Space Council leadership and staff that will make NASA Earth science programs the top NASA priority.**

The new NASA Administrator must recognize the reality of the global environmental crisis, and understand that the greatest contribution NASA can make to future of humankind is helping to preserve the Earth.

Select **Congressional Liaison Personnel** who are committed to Clinton / Gore policy on NASA Earth sciences. Designate a strong policy **oversight person at the National Space Council** to assure proper implementation of Administration priorities for MPE.

(2) **Use the space program as a strong environmental education tool**. Encourage NASA to aggressively distribute both existing and forthcoming environmental data (Shuttle and satellite) as a high agency priority. This should be done on an ongoing basis, through Earth Science and public education programs, and the press.

(3) **Spread MPE data widely and systematically to all legitimate users,** including resource managers in federal, state and foreign governments, public interest groups, universities, public libraries and primary and secondary schools. This will serve practical natural resource management objectives, and will improve environmental science literacy. It can be accomplished through modifications to existing programs.

(4) **Establish a formal environmental applications program to maximize practical use of satellite data for resource management, with special emphasis on the needs of state governments and resource managers.**

Sensors in the EOS array are specifically designed to answer important process questions about Earth as a working system. We recognize that without TOMS [2] on the Nimbus 7 satellite, there could hardly have been a Montreal Protocol. The need, however, extends beyond dedicated sensors and pre-planned research.

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[2] Total Ozone Mapping Spectrometer.

Research applications must focus particular attention on (1) defining ecosystems and their characteristics, (2) serious ecological problems, and (3) the regional impacts of anticipated global climate change. Many important applications are anticipated including: drought management, forest impacts, severely changing storm patterns, coastal erosion, and other natural phenomena that determine government economic planning. Regional environmental modelling is essential to informed decision-making by states and smaller countries as they plan their economic strategies. Current identification of such applications is informal and ad hoc.

(5) **Formulate global environmental policy on the basis of existing knowledge,** including existing space derived data and EOS precursor missions.

MPE must never be used to postpone necessary environmental protection measures. Existing data must be quickly gathered, synthesized and distributed to support actions that minimize risk in Earth science areas we do not fully understand.

(6) **Address critical science and environmental impact issues early in the MPE program.**

Maintain the funding and schedules for those parts of NASA's environmental satellite and information programs that precede the EOS launch. These precursor satellites are scheduled for launch in the early 1990s, and offer opportunities to acquire essential data as soon as possible. NASA should give the Earth Sciences programs adequate priority in its overall budget to allow both (1) smaller or earlier environmental satellites, with accompanying data acquisition and analysis, and (2) the EOS program.

If opportunities exist for early launch of smaller, relatively inexpensive satellites that will provide key environmental or global change information, these should be pursued as a priority.

(7) **Quietly systematize and accelerate the use of space data in environmental enforcement policies.**

Space-derived data has long been used in the enforcement of environmental laws and agreements. In the 1970s, Landsat data was used to prove fault in Great Lakes water pollution litigation, and to police illegal strip mining. Skylab imagery together with aerial photography has tracked polluted water plumes. NOAA satellite data has been shared with the Brazilian government to police unpermitted forest burning and educate rural farmers.

In the last decade, the use of satellite data for enforcement has atrophied due to commercialization policies and slack environmental law enforcement by the Reagan and Bush Administrations. While some institutional reticence is expected, all federal agencies with jurisdiction over environmental laws,

treaties and agreements should now be strongly encouraged to use space-derived data in the full exercise of their duties, including enforcement. [3]

Previous use of satellite data suggests that if a system were in place to identify ecological and natural resource problems, and transmit timely information to relevant regulators, at least some potentially disastrous policies and activities might be identified and altered in time to avoid severe ecological damage and enforce existing laws.

As increasingly sophisticated sensors are placed in orbit, and as military satellites are made available for additional civilian missions, the potential for using space-derived data for enforcing environmental laws and treaties will increase.

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[3] From the time of Landsat 1, space derived data has demonstrated a capacity to resolve disputes. One dramatic early example involves the African Sahel. In the early days of Landsat, scientists analyzing data from the Sahel, which had been reduced -- ostensibly by drought -- to a veritable moonscape, encountered an anomaly; an area of several hundred square miles, with sharply defined rectangular boundaries, that produced a strong near infrared signal characteristic of vegetation. A visit to the site revealed a large, fenced enclave maintained by a French ranching company that contained an isolated, intact ground cover of grass and shrubs. This proved precisely what local scientists and observers had been saying; the loss of ground cover across the Sahel was not caused by drought, although the overall dessification of the region is of climate origin), but by ill-conceived technological intervention.

In the years preceding the disaster, U.N. agencies and U.S. AID drilled up to 1800 stock watering wells across the Sahel belt, permitting seasonal nomads, who had previously been obliged to trail their herds south out of the zone, to remain in the Sahel year round. Instead of 20 million cattle for 6 months each year, the Sahel was soon supporting 80 million cattle annually. The natural checks against overgrazing were bypassed, the equilibrium between the nomads and the land was shattered, and an ecological calamity resulted, replete with human misery.

A second example from the early 1970s concerns a U.S. federal circuit court case, in which it was alleged that asbestos laced taconite tailings discharged into Lake Superior were entering the Duluth, Minnesota water system. The accused mills denied the allegation, but Landsat imagery defined plume tailings from the Mesabi iron range extending south to the area of Duluth's water intakes. Landsat provided the definitive evidence leading to a court victory for the plaintiffs, and an order limiting the discharge.

A third example is the use of the infrared sensor aboard NOAA 11 to identify unpermitted burning in remote areas. The U.S., in cooperation with the Brazilian government, has established a system that can locate illegal burning and transmit the information to local authorities in a matter of hours after its discovery from space.

Finally, an anticipated example is the ability of the Synthetic Aperture Radar (SAR) to track seagoing vessels. Even the single-band SARs currently aloft are able to "see" vessel wakes for several hours after a ship has passed, and determine approximate vessel speed and class. Potentially, different kinds of vessels will exhibit distinctive signatures. SAR is now being investigated as a means of enforcing fishing regulations in the Bering Sea. It may be the most effective system available to locate "pirate fishing" by use of drift nets; which have been banned under U.N. resolution. Evidence exists that Taiwan plans to ignore the ban on a massive scale.

While systematic global monitoring with SAR may not become feasible until 1995, when Canada's RADARSAT is launched , with a swath width of 500 miles, there is great hope that the technology can be useful, if not crucial, for fishing treaty and regulation enforcement. Enforcement by SAR could be especially powerful if used with high resolution DOD sensors. SAR imagery will, and Shuttle mission photography already provides the ability to track oil slicks from bilge-cleaning by vessels world wide.

II. PROGRAM RECOMMENDATIONS

INFORMATION FOR THE PEOPLE -- How to use space derived data for maximum public service, public education, environmental monitoring and conservation, and to establish international consensus for sustainable development.

1. Mobilize the unrealized potential of all existing space remote sensing resources to guide global environmental policies and benefit the public.

   A. **Establish a National Emergency Satellite Observation System**, through which pictures and imagery of hurricanes, floods, fires, etc (including a before and after time series) are systematically provided in as near real time as possible to emergency response teams.

   B. **Formalize and expand a Space Shuttle Global Environmental Monitoring Program.**

   Shuttle Earth observations are in full swing and can provide important information to decision-makers and the public now. The present informal Shuttle observation project should be made an ongoing JSC program, with aggressive distribution of photographs to the public, media and schools. Photographs should be highly publicized in the press by the Administration, giving the people of the world an **"Earth Status Report"** on environmental conditions and activities around the world after each Shuttle mission. Coordination between Shuttle observations and NASA Code S Earth Sciences should be strongly encouraged; Shuttle data should be incorporated in the global change baseline.

   C. **Establish a Landsat and EOS Precursor Satellite Environmental Applications Program.**

   Landsat should be used as the starting model for training federal, state and local government, universities, foreign governments, non-profit environmental research organizations and others how to use satellite data to formulate sustainable development policies, in preparation for EOS data. A grassroots user infrastructure should be established. This will help assure maximum practical use of MPE data, and help to avoid costly errors in the Global Change Data and Information System (GCDIS), National Research Education Network (NREN) and the Earth Observation Satellite Data and Information System (EOS/DIS).

   The national user infrastructure is currently so far behind information collection, that if the data stream from EOS and other advanced satellites were available today, widespread value would be slight. If we do not develop this infrastructure, the new armada of Earth viewing satellites will yield only a fraction of its potential for planetary stewardship.

D. **Declassify as much environmentally useful data as bonafide national security concerns will permit.**

E. **Establish a strong Environmental Education Mandate** in the Mission to Planet Earth Program Office and throughout NASA.

Use existing information, as it is gathered and synthesized, in a massive classroom environmental education program to teach Earth System Science and our impact on the planet as they are now understood, and involve school children in MPE research and applications.

2. **Mobilize future policy and resources for maximum environmental applications and public benefit.**

A. **Assure an Open Data Policy** -- Environmental space-derived data must be made low cost, user friendly and easily accessible for practical applications to government resource managers and the public service community.

Commercialization of raw or minimally processed data must be prohibited. Commercialization should be stimulated through competitive value-added services. "Open skies" policies must be strictly enforced.

The 1992 Landsat data policy process has established beyond rational dispute that **commercialization of unenhanced satellite data has no place in a publicly financed remote sensing program such as MPE.** Informal studies found that the lower the cost of the unenhanced data, the greater the overall demand, and the greater the public benefit.

The Administration should anticipate and firmly reject commercialization proposals from the Landsat contractor and contractors for the MPE information distribution systems.

B. Build stronger environmental applications and regional benefits into MPE.

- **Serve the needs of the states** to monitor and predict the rate of regional global climate change and other environmental phenomena by designing models that focus on regional impacts of global change with the states, who manage most of the resources that will be affected by climatic change. Include state resource scientists and managers in MPE research and information distribution channels.

  If existing data were made available to the states at the marginal cost of reproduction, and the Landsat environmental applications network were re-invented, state resource managers could get a head start on the data bases necessary to determine regional environmental climate change. It is possible that the network would be fully operational in enough time to have adequately prepared the states for a very advanced level of sophistication in EOS/DIS.

- o **Systematically build an applications orientation** in the MPE program office.

  (1) Amend NASA's Charter to include a mandate for applications in remote sensing.

  (2) Establish an advisory process to better identify anticipated regional and environmental applications.

  (3) Start an Applications Branch in the Mission to Planet Earth Program Office, and establish a formal applications program, with a regional grassroots structure.

  (4) Seriously examine placing jurisdiction over the National Weather Service (NWS) and the National Environmental Satellite Data and Information System (NESDIS) at NASA.

  Internalizing these programs would help NASA become more applications oriented. The Weather Service also has an established information distribution system that reaches both the science community and the public, and could help get information out to local communities.

  (5) Broaden the NASA science culture by better integrating space scientists with federal, state, international, and non-profit natural resource managers.

  Hire more ecology scientists as NASA MPE personnel. Require NASA theoretical scientists to perform 2 years of duty outside NASA in their applications field, and, require that NASA science managers must perform one year of practical research every five years.

C. Establish a Department of State mandate to immediately improve scientific literacy and access to state-of-the-art environmental resource management information in the developing world, including space-derived data.

U.S. Fortune 500 corporations presently have better access to data about many developing country's resources than do their own governments, especially where there are no roads, personnel or equipment for proper inventory. The U.S., along with other MPE participants, should build an international infrastructure based on the best available information, to elevate developing world leaders and natural resource managers to the information level necessary for sustainable development.

D. If a space station is approved on grounds strictly unrelated to Earth sciences, maximize only the most cost effective environmental remote sensing activities that can uniquely be achieved through the program.

POLICY AND PROGRAM DESCRIPTIONS

POLICY AND PROGRAM DESCRIPTIONS

I. INTRODUCTION

Space images capture and focus the world's attention. The Administration should take the lead to prepare humanity for sustainable development by systematically using the space program as an environmental education and protection tool.

Basic information gathered by Mission to Planet Earth must be fully integrated into all walks of life. Transformation of world attitude should occur from increased public awareness combined with an improved understanding of Earth system science.

To accomplish these objectives, MPE must produce information equally for science, practical applications for environmental resource management, the widest possible public education, and improved environmental science literacy in all nations. [4]

Information users must include: resource managers in the field, state and foreign governments, environmental and conservation groups, universities, the press, the public, children in the classroom, corporate interests, real estate developers, and the like.

Reaching these users will require a broadened, integrated MPE program, including: (1) massive public education, (2) a wide information distribution system, and (3) a systematic environmental applications focus.

A broad based approach to MPE will also help restore public confidence in the space program by demonstrating the practical benefits of space-derived information, and increasing return on taxpayer investment.

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[4] MPE is currently designed to serve research priorities established by the Committee on Earth and Environmental Sciences (CEES). Practical resource management and education objectives have not been methodically designed into the system. Public education efforts are fledgling. Public release of research results and current Earth photography to a wide audience has been discouraged. To their credit, NASA MPE program managers are now initiating an environmental applications program.

II. PROGRAM DETAIL

INFORMATION FOR THE PEOPLE -- How to use space-derived data for maximum public service, public education, environmental monitoring and conservation, and to establish international consensus for sustainable development.

1. Government Personnel

A. Select a NASA Administrator and NASA Center directors who will make NASA Earth science and applications the top agency priority.

Since NASA's creation, science and practical applications of space technology have always taken second place to exploration and the "manned" space program. While the exploration of space is important for defense conversion, economic stabilization and, to some extent, international cooperation, NASA's most immediate priority must be to (1) speed its contribution to the U.S. global change research program, and (2) maximize the practical applications of Mission to Planet Earth data for global change mitigation, regional resource management and environmental conservation.

We take no collective position on space station. However, cost effective Earth observations should be strongly integrated into any "manned" program.

The new Administration must appoint a NASA Administrator who recognizes the reality of the global environmental crisis, and understands that the greatest contribution NASA can make to the future of humankind is helping to preserve the Earth; using all resources under NASA's jurisdiction.

It is equally important to appoint a new Administrator with the strength and commitment necessary to overcome the inevitable resistance of the NASA centers to MPE as a priority. NASA centers have gradually acquired the characteristics of independent fiefdoms, each with its own congressional and corporate protectors. This has made it acutely difficult for central leadership to amend the agency's mission or institute structural and cultural reforms.

B. Select Congressional Liaison Personnel who are committed to Clinton /Gore policy on NASA Environmental Programs.

NASA congressional liaison has historically reflected the overall agency preference for manned space, with an unfortunate perception that if MPE becomes the agency's top priority, space station will be terminated. This prejudice has been true at both management and line levels. Congressional liaison is a key point in implementing the Vice President's policy priority for MPE.

C. Designate a strong policy oversight person at the National Space Council to assure proper agency and congressional implementation of Administration priorities for NASA Environmental Programs.

Experience with MPE policy dynamics over the last 4 years, together with observations made of Admiral James Watkin's attempts to change the cultural

attitude at DOE from bomb production to reconfiguration and environmental clean-up, indicate that if the Administration seriously intends to shift NASA agency priorities to the environment, a counter-balancing force outside the agency is absolutely necessary. Strong Space Council oversight will be necessary to accomplish the Vice President's stated priorities for NASA environmental programs.

2. Mobilize the unrealized potential of all existing space remote sensing resources to guide global environmental policies and benefit the public.

A. Establish a National Emergency Satellite Observation System.

Comprised of all federal agencies engaged in satellite and aircraft environmental and observation activities,[5] this system would, perhaps under Space Council control, provide as near real-time information as possible to aid national and local emergency response teams during hurricanes, oil spills, earthquakes, fires, flooding, drought and other emergencies around the world. Before and after images should be quickly provided to natural resource managers. Each appropriate satellite owned by the U.S. government, and perhaps other governments, should be focussed on the current worldwide emergency of the day. The existing defense emergency satellite system should be examined as a model for this service. Program planning may be as simple as broadening the definition of "national emergency" to include natural and anthropogenic disasters.

To the extent possible considering national security concerns, before and after results should also be shared immediately with non-profit group and academic environmental researchers.

The Administration should search the potential for high resolution maps to be given to local U.S. police for logistical support in 911 services in an ongoing program. Rural Texas officials are especially interested in these applications due to the difficulty of directing emergency vehicles in unfamiliar areas by dispatch.

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[5] Those agencies known to own or manage satellite observation systems include: NASA, National Oceanic and Atmospheric Administration (NOAA), Department of Defense, National Reconnaissance Organization, and Central Intelligence Agency. The Department of Agriculture and the Department of Interior use extensive aerial photography. The U.S. Geological Survey is an extensive user of both satellite data and aerial photography, but operates no satellites.

B. Formalize a Space Shuttle Global Environmental Monitoring Program.

'Each Shuttle mission brings fresh evidence of human impact on the Earth.' [6]

The Shuttle now monitors over 600 selected sites around the world, including environmental, geological, atmospheric, oceanographic, and ephemeral events. A normal Shuttle mission returns about 4,200 large format analog photographs and several hundred digital images of Earth's environmental phenomena. Data are digitized on return, then archived, catalogued, and made available to the public by electronic access using Johnson Space Center (JSC) computer nodes. This program provides the longest length record of orbital data (1961 - 1992) that is useful for documenting and assessing global environmental change.

The Shuttle's Earth observations are in full swing, and can provide important information to decision-makers and the public now, at a crucial time for environmental policy. Its easy to understand photography can vastly improve public understanding of global environmental changes over the last 11 years. Using advanced electronics and information systems, information can be passed to decision-makers around the world quickly, in many cases in time to stop environmentally dangerous activities in progress. The collective time series can also make a significant contribution to the baseline for global change data.

NASA management has historically considered Shuttle Earth observations an informal mission adjunct. Equipment upgrades have been made largely at the expense of non-NASA agencies, including the Navy, Army and Department of Defense.

Despite these restrictions, the Shuttle program has unique capabilities that are useful for environmental monitoring and high profile environmental education.[7]

Recommendations:

(1) **Formalize the Space Shuttle Earth Observations Program at JSC**, with science goals, in association with Code S at NASA Headquarters (Earth Sciences) and a budget. Immediately reverse the decision to close in the near future JSC's "Environmental Resource Satellite Analysis Facility" (ERSAF -- the global monitoring, communications and analysis facility for Shuttle photography).

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[6] Paraphrased from the video documentary entitled "Space Age: Mission to Planet Earth." Produced in Association with the National Academy of Sciences and a Centerpiece of the International Space Year, 1992.

[7] These include: uplink capability to an on-orbit crew, downlink capability of crew-acquired data; routine stereo photography and imagery capability; demonstrated polarization and bi-directional reflectance (multi-angle) imaging; routine multiple sun angle imaging; technically unlimited spatial resolution capability; receipt of near real-time satellite data and Geographic Information System (GIS) information for identifying Earth environmental conditions worldwide (volcanic eruptions, weather situations, flooding, tropical cyclones, major fires and forest fires, oil spills, etc.) Shuttle missions monitor the entire globe in real-time, using unmanned satellites to reconnaissance ahead of shuttle overpasses.

(2) Continue to place all Shuttle data in the public domain and significantly improve awareness of its availability for wide public and resource management use at the marginal cost of reproduction (consistent with Landsat policy). Either NASA or the EROS Data Center should **aggressively distribute the data**.

Assuming phase out of the Shuttle in the early 2000s, and termination of an aggressive Shuttle Earth observations program, what photography program to serve ongoing environmental education needs will replace it?

(3) Work Shuttle photography into a **national grammar school and high school curriculum** to encourage technology, computer and environmental literacy (see environmental education section), and produce **astronaut tutorial videos on Earth observations** after each mission for distribution to classrooms nationwide.

(4) After each Shuttle mission, the astronauts should conduct a **widely publicized press conference to make an ongoing "Earth Status Report"** based on observations made aloft, and using cumulative Shuttle and other remote sensing data to show change detection. **Many astronauts are eager and prepared to participate in such a program.**

(5) Expand the number of scientists and ecologists in the Space Shuttle Earth Observations Office at Johnson Space Center and **choose JSC leadership who will fully support this program.**

(6) Establish **summer internships** for college students in the JSC Astronaut and Earth Observations Offices for training in Earth observations science.

(7) Continue to **digitize and improve Shuttle Earth observation data** and mandate integration of the data into the Pathfinder **baseline for global change**.

(8) **Encourage NASA scientists to publish Shuttle research results in accessible journals with wide distribution** and in magazines accessible to the common person.

C. Establish a Landsat and EOS Precursor Satellite Environmental Applications Program [8]

Landsat should be used as the starting model for training federal, state and local government, universities, foreign governments, non-profit environmental research organizations and others how to use satellite data to formulate sustainable development policies, in preparation for EOS data.

Landsat data is available now, and an infrastructure still exists around the country, and to some extent, the world, that can use it. [9] EOS data, on the other hand, will be much more voluminous and complex, and will come later in the decade. Landsat data is also a substantial part of the baseline pathfinder data from which scientists will measure global change. The lessons learned from maximizing the practical applications of Landsat for public services / interest can be incorporated into the Mission to Planet Earth data system design.

Landsat, then, is the natural precursor to achieving maximum practical use of MPE/EOS data. NASA and other federal agencies should institute training programs, through grants, centers of excellence, and the like, to renovate the necessary infrastructure in federal and state government and in universities to assure maximum use of MPE/EOS data for practical purposes. Distribution at the practical management level will also help to bring resource management into the 20th century. Many states, for example, are far behind in computerization.

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[8] A full-fledged applications program for EOS and all remaining MPE satellites would be substantially similar to the Landsat applications program and be added later, as satellites are launched and specific applications are determined. For a full applications program description, see "Build Stronger Environmental Applications and Regional Benefits into MPE."

[9] During the 1970s and early 1980s, NASA and other federal agencies promoted use of Landsat MSS and other remote sensing data for practical applications, such as forestry and agriculture. Unfortunately, just at the time an infrastructural base of sufficient size to nourish rapid growth of remote sensing technology had been developed, and a more useful Earth observing sensor (Thematic Mapper) had been launched aboard Landsat 5, the decision was made to commercialize Landsat.

The high price of data, in combination with the marketing approach of EOSAT (the unregulated commercial monopoly established under the Land Remote Sensing Act of 1984 to market data) resulted in a precipitous decline in the use of Landsat for academic research and conservation. The chief purchasers of Landsat data are now federal agencies, especially DOD and NASA, and large corporations. Academic researchers, state natural resource managers, local government planners, public interest conservationists and small businesses have turned away from remote sensing in favor of older systems, such as aerial photography and ground based methods. In some places (such as the University of Nebraska) radiometers and spectrometers have been mounted on light planes. While research is continuing, and hundreds of new remote sensing applications have been developed since commercialization of Landsat data in 1984, the remote sensing infrastructure overall has seriously declined. Some universities that taught remote sensing a decade ago have dropped the subject.

The 1992 Land Remote Sensing Policy Act, passed into law in October 1992, brought Landsat data back into the public domain after a decade of failed commercialization. The price of data will now gradually decline to the marginal cost of reproducing a scene (ultimately about $400 - $600 U.S.). With low cost, easily available data, we have been given an important opportunity to rebuild the Landsat user infrastructure that existed in the states during the 1970s, and use it for MPE data.

Background:

Every expert agrees there is vastly more information available in Landsat and other Earth viewing satellites than we have learned to extract. This is especially true of the SAR (JERS-1 and ERS-1), now aloft. **National user infrastructure is so far behind information collection, that if the data stream from EOS and other advanced satellites were available today, widespread value would be slight. If we do not develop this infrastructure, the new armada of Earth viewing satellites will yield only a fraction of its potential for planetary stewardship.**

There is no reason to expect that an infrastructure sufficient to accommodate expanding demand will develop spontaneously during the during the interim transition period before Landsat 7's launch. If we are to grasp the potential value to conservation of the advanced instruments planned for Landsat 7, the planned EOS and EOS precursor satellites, and all existing satellite resources, it will be necessary for NASA and other federal agencies to rebuild and expand the civilian remote sensing infrastructure through a vigorous remote sensing applications program.

By rebuilding a user infrastructure around existing satellites, we will be better equipped to utilize information from EOS, Landsats 7 and 8, RADARSAT, and Almaz 2. Experience with existing AVHRR data is essential to using MODIS effectively for applications.

D. Declassify as much environmentally useful data as bonafide national security concerns will permit.

Where possible, intelligence satellite environmental data should be de-classified and incorporated into the on-line Landsat distribution and applications system.

Where de-classification is not possible, a national interpretive center should be instituted to share research and observation results for public purposes. (Perhaps modelled on the National Photographic Interpretive Center.)

E. Establish a Strong Environmental Education Mandate in the MPE Program Office and throughout NASA. [10]

Use existing information, as it is gathered and synthesized, to begin a massive classroom environmental education program that documents our impact on the planet as it is now understood, and involve school children in MPE research and applications.

Environmental, scientific and technological literacy can be improved through classroom use of space photography and satellite data about the local and global environment. MPE should promote "hands on" student experiences in a strong environmental education program. By doing this, NASA can change the way our future leaders view the Earth.

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[10] See also Shuttle program section.

Vice President Gore's proposal to use schoolchildren around the world for "ground truthing" satellite data **can actually assist global change researchers and is now in process.** [11]

Knowing the condition of the environment at the time satellites record the reflectance of ground features is important. An interactive educational curriculum can be easily developed to incorporate ground truthing principles with "hands on" computer applications.

Student involvement is uncomplicated. A remote sensing GIS training program is **currently underway in South Carolina**, directly involving secondary school students in practical research of the Congaree Swamp, including ground truthing, manipulation of remote sensing data on personal computers, and interpretation of aerial photography.

In **Maine**, 7th and 8th graders are learning to manipulate SPOT Image data on MacIntosh computers, identifying wetlands, ground cover types and endangered species habitat. The imaged sites are visited to truth their conclusions, and "close the gap" between computer screens and the natural world. Through these programs, students are also becoming familiar with map making science, problem solving, and on site investigations.

Such programs enrich the minds of youth, and provide an indispensable educational substrate for development of the kind of ecologically oriented remote sensing infrastructure that will be necessary if remote sensing is to provide answers to the critical policy questions of global change in the coming decades. [12]

Recommendations:

(1) NASA should substantially enlarge its environmental education programs in primary and secondary schools by providing **training and educational grants for integrated remote sensing projects with focus on practical applications.** Ultimately, this program should be established in every primary and secondary school in the country.

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[11] The Aspen Institute at the Windstar Foundation in Colorado has instituted hands-on remote sensing curricula, and has trained teachers from 32 states. These efforts should be supported and expanded throughout the country and in foreign nations.

[12] A problem that constantly evades school administrators and research scientists is the inability to take conventional research and apply it to instructional K through 12 problem solving exercises. Innovative curriculum programs must be developed to catch student attention and let them interactively experience what data are required for making real world decisions; such as balancing economic development and environmental protection.

To be successful, the student must first become familiar with computer technology and remote sensing applications through the use of data sets that examine their state or local community. Much of these data are currently available to the public through the U.S. Geological Survey and state agencies. Once remote sensing concepts are learned by interpreting familiar and easy-to-visit study sites, student knowledge and newly acquired capabilities can be extrapolated to study sites located in other geographic regions of the U.S. and the world. For example, both South Carolina and Nebraska have a Sand Hills Physiographic region. Students in South Carolina study the historical, economic, geographic, environmental and land use concepts of this region and then determine how the Sand Hills in the two states differ.

(2) NASA employees and principal investigators must be available to schools for demonstrations and the development of data to be used with school computer technology.

(3) NASA should integrate its educational programs with other agencies

- Environmental remote sensing studies, including ground truth activities, should be made required science in primary and secondary schools across the nation as quickly as possible. A national interactive global change research curricula should be established. NASA scientists and astronauts should be encouraged to tutor in Earth science through classroom visits, video tutorials and on-line computer communications.

- Preparation and dissemination of more educational videos (in numerous languages) should be made. Special effort should be made to supply hard copy remote sensing images, Shuttle Earth photography, (and eventually floppy disks or CD ROMs) of particular regions to libraries within those regions. NASA should make such materials available nation wide through the GPO **Federal Depository Library Program and the National Cartographic Information Centers.**

- Environmental education programs should be **continually upgraded at the** National Air and Space Museum and in space and technology museums and public display centers (eg., Park Service information centers) around the country, and abroad (e.g., through U. S. Information Agency Centers).[13] During Shuttle missions, Earth observation downlinks should be made to major museums around the country and the world for an integrated **on-site learning program.**

(4) NASA should encourage one-on-one relationships between high school students and agency Earth scientists in an **"Environmentors" program, similar to the national "Big Brothers" program.** This will both shepherd career development in Earth sciences and help to make the NASA Earth science culture more applications oriented.

(5) An Earth science education specialist should be assigned to the National Space Council, and to the offices of the new Administrator to **elevate the public education component of Mission to Planet Earth.**

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[13] Shuttle photography has already been distributed to and is on display at the U.S. National Park Service Visitors Centers at the Grand Canyon and Mount St. Helens National Parks, and at the Florissant Fossil Beds National Monument.

3. Mobilize future policy and resources for maximum environmental applications and public benefit.

A. Assure an Open Data Policy.

Environmental Space Derived Data must be low cost, user friendly and easily accessible to the public service community. Commercialization of raw or minimally processed data must be prohibited. Commercialization should be stimulated through competitive value-added services. "Open skies" policies must be strictly enforced.

The recent Landsat data policy process has established beyond rational dispute that commercialization of unenhanced satellite data has no place in a publicly financed remote sensing program. Informal studies found that the lower the cost of the unenhanced data, the greater the overall demand, and the greater the public benefit. [14]

Landsat and other EOS precursor satellites, such as Upper Atmospheric Research Satellite (UARS), and SEAWIFs, have commercial or hybrid data policies that prevent publicly financed data from immediately entering the public domain. To the extent practicable, these policies should be changed and the research results incorporated into a public domain applications program. Due to existing contract and licensing agreements, this may be difficult with UARS and SEAWIFS.

In no case should commercialization policies in any form be repeated for planned MPE satellites, despite anticipated industry efforts to the contrary. The Administration should expect continuing commercialization proposals from the Landsat contractor and contractors for the MPE EOS/DIS system.

Recommendations:

MPE/EOS data policy should --

(1) Anticipate and firmly reject efforts by contractors to commercialize and privatize publicly financed environmental space remote sensing data. All such data should immediately enter and remain in the public domain.

(2) Assure that the data is available in a timely, user-friendly fashion to practical end users. This data must be available on-line through personal computers to state based natural resource managers from the onset

[14] Well documented research shows a drastic drop in use of Landsat upon a price increase and commercialization in 1984. Informal surveys taken during the 1992 Landsat policy debate indicate that university researchers would use the data significantly more at lower cost. These sentiments were echoed unanimously by major U.S. environmental groups and over 15 state governments, (including Texas, California, Nebraska, Maryland, Florida, South Carolina, Tennessee, New York, Ohio, Kansas, Oregon, Vermont, Wyoming, Missouri and Alaska.) Dr. Robert Jenkins, Vice President for Science at The Nature Conservancy, estimated that TNC would use Landsat data up to 50 times more if it were available at the marginal cost of reproduction ($500 per scene). Jenkins' sentiments were echoed in varying degrees by Conservation International, Wilderness Society, and others.

of the Global Change Data and Information System (GCDIS), National Research Education Network (NREN) and the Earth Observation Satellite Data and Information System (EOS/DIS).

(3) Assure that the unenhanced data is available at the **marginal cost of reproduction to all users**, so long as they are willing to share research results in a timely manner with other researchers. Exclusive marketing rights should never be given to a commercial entity.

(4) Nurture and encourage the commercial growth of the value-added and software services that can aid in making MPE/EOS data-user friendly to non-global change environmental researchers and other end users. Where necessary, the federal government can **stimulate the commercial value-added sector by commissioning the development of user friendly software** that helps to accomplish U.S. public education, foreign policy and intergovernmental relations objectives.

B. Build stronger environmental applications and regional benefits into MPE.

o Building an applications orientation.

Potential remote sensing users often complain that sensors are designed for specialized research, with little thought given to practical applications. Early in the design process, NASA should begin to consider which general and regional applications an instrument might serve. It should be especially alert to ways to increase the sensor's capacity for practical applications without compromising its basic research mission.

Once the satellite is launched, NASA should hold periodic workshops to determine which applications each sensor has served, and to consider additional applications, based on the experience compiled.

A major reason the public receives so few practical benefits from space-derived data (other than information generated by weather satellites), is that public service users are largely excluded from the decisions governing both sensor and program design. If MPE is a program for the people, then, as Justice Brandeis wrote, "Sunlight is the best disinfectant."

Thus, it is extremely important that public service users be provided real input to the satellite design and policy formulation process.

o Designing models and applications that focus on regional impacts of global change.

States need to predict regional impacts of global climate change.

Mission to Planet Earth will have minimal use to policy makers unless state resource managers, who directly manage most of the nation's agricultural and coastal lands, and waterways can access information that can be used to predict regional impacts and their rates, in time to plan mitigation and adaptation measures.

One of the most important reasons for studying and monitoring global climate change is to determine its regional consequences. For example, will the state of California continue to be a major agricultural producer over the next 25 years, or will drought continue to be so severe that the U.S. should consider growing vegetables and fruit further north? What land use policies are necessary now to preserve these options? How will sea level rise affect coastlines and impact coastal land use policy? In regions dependent on hydroelectric power, will there be enough water in 20 years to sustain power grids for anticipated local population growth?

State resource scientists and managers should be included in the MPE research and information distribution channels, beginning with all existing satellites, and continuing through the life of the program.

As mentioned, NASA, together with state governments previously built resource management infrastructures with federally funded satellite information systems when Landsat data was used widely used in the 1970s.

An extensive environmental applications network was built through the outreach of NASA and its regional centers. This program included hands-on training programs

for state resources personnel. As a result, Landsat was extensively applied to state level management and environmental monitoring. Resource management was initiated into the information age. [15]

If existing data were made available to the states at the marginal cost of reproduction, and the Landsat environmental applications network were re-invented, state resource managers could get a head start on the data bases necessary to determine regional environmental climate change. It is possible that the network would be fully operational in enough time to have adequately prepared the states for a very advanced level of sophistication in EOS/DIS.

Recommendations:

(1) Amend NASA's Charter to include a mandate for Applications.

While NASA's charter limits the agency's mandate to technology demonstration rather than applications, it is clear that unless some (or all) government agencies are charged with maximizing the applications of the vast taxpayer investment in space and satellite technology, the societal improvements the public expects from technology will continue to be lost and the quality of environmental analysis will remain substandard. Perhaps the most simple way to initiate a cultural change at NASA for applications is to mandate the responsibility by statute.

(2) Establish an advisory process to better identify anticipated regional and environmental applications.

NASA is establishing a broadly based Landsat advisory committee of remote sensing experts and users, including qualified representatives from state and local government, American Indian Tribes, conservation and farm groups, the value added sector, and academic experts. The advisory committee should be kept fully informed on all technical and policy proposals affecting applications and information distribution. Decisions affecting applications should not be made before the committee has been consulted, and has the opportunity to respond. This committee should be expanded to consider applications for all MPE satellites.

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[15] Landsat has been used by state governments for (partial listing): flood hazard mapping; fire hazard evaluation; land use, water use, and water quality analysis; mapping of natural features, models for energy use, groundwater protection; air quality monitoring; tracking of natural habitats adjacent to agricultural areas to protect endangered species; siting toxic waste incinerators; timber conditions; timber supply projections; wildlife habitat suitability analysis; wild land conversion to urban and agricultural land use; range conditions, hardwood monitoring, vegetation cover, forest land habitat and rangeland residue mapping; fuel loading cartography; vegetation change detection; wilderness mapping; general cartography under contract to other government agencies; sediment transport along coastlines; sediment discharges from coastal streams; shoreline and land use changes; growth management and land use policy analysis.

During the 1970s, Landsat was running continually, feeding back data as changes in the environment occurred. Under the commercialization act of 1984, the satellite was only turned on at the request of commercial purchasers for specific geographic locations, and much continuity of data for environmental management was lost.

(3) Start an Applications Branch in the MPE program office, and establish an applications program.

The Mission to Planet Earth Program office is establishing an environmental applications branch. This effort should be approved, nurtured and **expanded to become a key characteristic of MPE.**

There are many thousands (by one estimate up to 80,000) of public service users and would be users of remote sensing data in the U.S. who have derived little or no benefit from remote sensing activities since the early 1980s. While federal agencies have largely ignored this community, the commercial entity set up to market Landsat data has actively victimized it.

An active applications program can can confer major public benefits at comparatively modest costs, and establish an infrastructure to help carry out global change research.

The program can produce maximum public benefit per dollar expended if:

- it is **nationwide**, eventually involving every state in the Union, and is focused on critical **international** problems as well,
- a **wide spectrum of users** participate in the program. These should include academic institutions, state agencies, local government units, farm groups, conservation and environmental groups, public schools and so on,
- the involved interests have **direct "hands on" participation** in the research being funded,
- the data and research results obtained and generated are **useful in a direct, immediate and practical way**, to the interests involved,
- the program builds a **lasting technical infrastructure** as it proceeds, including coordinating centers and a communications network that can serve program, policy and technical functions, and,
- a **deliberate effort is made to integrate** applications research and infrastructure development with Mission to Planet Earth research and related satellite functions.

Program Description:

A national applications program should be built around universities and other institutions with strong expertise in remote sensing, who form centers of excellence[16] to carry out research and training on behalf of user consortia.

A center of excellence would be an existing institution with a "track record" in remote sensing (for example, universities, non-profit

[16] These centers of excellence would be distinct from and should not be confused with NASA Centers of Excellence in technology transfer.

organizations or state government entities), that is willing and able to: (a) process raw, or nearly raw, data, (b) provide basic training in remote sensing applications to would be users, (c) make floppy disks and/or CD ROMs of parts of a scene for local users, (d) involve local users and students in ground truthing, (e) assist colleges and high schools in setting up remote sensing programs, (f) work out cooperative "boundary" agreements so that scenes that straddle state lines are fully used, and (g) assist in setting up electronic communications networks.

A consortia would be a group of data users, and potential users, such as state and local government units, farm and conservation groups, Indian tribes, and others, who need data but who cannot use it effectively without expert help. The research results would eventually become the joint property of the consortia and, presumably, of the involved center of excellence.

To facilitate infrastructure, every research grant should be accompanied by a node, or nodes, to an electronic communication network involving NASA as a contributor and recipient of data.

A bureaucracy would not be necessary to service centers of excellence. NASA can safely rely upon the self interest of centers and participating elements of consortia to produce the organizational features necessary in their regions. We are confident, after numerous meetings and discussions with users, that the structures suggested here can be readily organized by the users themselves.

(4) Seriously examine giving NASA jurisdiction over the National Weather Service (NWS) and the National Environmental Satellite Data and Information System (NESDIS).

The Presidential Transition Team is entertaining proposals to move the National Oceanic and Atmospheric Administration out of the Department of Commerce. Putting the National Weather Service and NESDIS under NASA jurisdiction would substantially increase the applications culture at NASA, which is a strong prerequisite to programmatic change.

This transfer is programmatically logical, as global climate change may induce severe changes in worldwide and regional weather patterns. Additionally, there is existing sentiment to consolidate all civilian satellite resources in a single agency. Public education and information distribution objectives would be served by use of the existing Weather Service information distribution systems, that already reach from scientific research to emergency services and into television, for selected purposes.

One immediate practical program change facilitated by this transfer could be a daily stratospheric ozone index report, made through the Weather Service to local television stations nationally, and perhaps world wide. The size and location of the ozone hole, along with anticipated increased in UVL could be provided to communities in real-time.

(5) Broaden the NASA science culture by better integrating space scientists with federal, state, international, and non-profit natural resource managers.

Techniques could include hiring more ecology scientists as NASA MPE personnel, requiring NASA theoretical scientists to perform 2 years of duty outside NASA in their applications field, and, requiring that NASA science managers must perform one year of practical research every 5 years.

C. Establish a Department of State mandate to immediately improve scientific literacy and access to state-of-the-art environmental resource management information in the developing world.

Developing counties are at the threshold of repeating (and exceeding) the environmental management mistakes of the developed world. The Clinton / Gore Administration should assure that the leaders and resource managers of all developing countries receive state-of-the-art data about changes in the Earth's environment to start them down the road toward sustainable development with the proper baseline of information. U.S. Fortune 500 corporations presently have better access to data about many developing country's resources than do their own governments, especially where there are no roads, personnel or equipment for proper inventory. The U.S., along with other MPE participants, should build an international infrastructure based on the best available information, to elevate the developing world to the information level necessary for sustainable development.

Background:

Conservation efforts in the developing world have been seriously hampered by a paucity of information on environmental changes within national territories. Natural resource departments lack field personnel and have inadequate budgets to conduct overflights. Some must rely on hearsay for information regarding events in remote areas. In a number of African countries, natural resource departments lack reliable maps of their own territory.

American environmental groups and universities who train resource managers in developing countries strongly support the distribution of basic Landsat and other Earth remote sensing hard copy maps on mylar (and other appropriate formats) that can be used for years in outlying areas for many purposes. Conservation International has distributed such maps, for example, with great success, throughout South and Central America, limited only by the cost of the data.

Recommendation:

Providing Landsat and other satellite data in a variety of useful forms to the natural resource agencies of underdeveloped nations, along with enough training and technical assistance to enable them to use it on a routine basis, would probably represent the most cost effective conservation directed foreign assistance possible. Providing this indispensable tool to underdeveloped nations should be a significant element of any global conservation strategy.

D. Space Station statement.

The public interest community does not advocate a space station. However, if one is built, it should be used only for environmental remote sensing that cannot be accomplished by any other means (1) in a more cost effective manner, and (2) in a manner that produces the best Earth science.

Space station cannot be justified on the basis of Earth observations, and environmental groups do not advocate a space station. However, if a space station is ultimately approved by the new Administration and Congress on grounds strictly unrelated to Earth observations, the public interest community would likely advocate maximizing station use for Earth observations that cannot be accomplished (1) in a more cost effective manner by other programs (including consideration of whole life cycle costs), and (2) in a manner that produces better Earth science and observations than any other program.

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BUILDING ENVIRONMENTAL LITERACY
AND CONSENSUS FOR SUSTAINABLE DEVELOPMENT
THROUGH
NASA'S MISSION TO PLANET EARTH

CLINTON / GORE POLICY PROPOSALS

January 6, 1993

"If we could first know where we are, and whither we are tending, we could far better judge what to do and how to do it."
Abraham Lincoln, June 1858.

'I did not understand what the United States was saying until I saw pictures of my country from space. Madagascar is bleeding into the sea.'
Didier Ratsiraka, President of the Democratic Republic of Madagascar, 1992.

SUMMARY

Vice President Elect Al Gore wrote in **Earth in the Balance**,

> "Mission to Planet Earth should be a Mission by the people of Planet Earth...specifically, involving as many countries as possible that will use schoolteachers and their students to monitor the entire Earth daily..."

We agree. **Mission to Planet Earth must be an open, broadly useful program whose equal objectives are science, practical environmental resource management applications, and the widest possible public education, including improved environmental science literacy in all nations.**

NASA must be much more aggressive in **getting the information out to the people** about Earth science and environmental and global climate change, to help the Clinton / Gore Administration build wide consensus for responsible stewardship of the planet and sustainable development policies.

The enclosed proposals will help accomplish this objective because the world responds to pictures of the Earth and data collected from space.

We propose changes primarily to existing NASA programs. [1] They have been reviewed and agreed to by individual astronauts, state government and university researchers, and public interest groups, including Conservation International, Friends of the Earth, the Sierra Club, and representatives of the Nature Conservancy.

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[1] Coordination among federal government agencies must also be seriously examined, but is outside the scope of this report.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

I. POLICY RECOMMENDATIONS --

MISSION TO PLANET EARTH MUST BE DESIGNED TO SERVE HUMANITY

Mission to Planet Earth (MPE) program design has been limited by Bush Administration policies to serve theoretical science. To realize MPE's potential for environmental protection and human betterment, the Clinton / Gore Administration must make fundamental changes.

Policy Recommendations:

(1) **Choose NASA and White House Space Council leadership and staff that will make NASA Earth science programs the top NASA priority.**

The new NASA Administrator must recognize the reality of the global environmental crisis, and understand that the greatest contribution NASA can make to future of humankind is helping to preserve the Earth.

Select **Congressional Liaison Personnel** who are committed to Clinton / Gore policy on NASA Earth sciences. Designate a strong policy **oversight person at the National Space Council** to assure proper implementation of Administration priorities for MPE.

(2) **Use the space program as a strong environmental education tool**. Encourage NASA to aggressively distribute both existing and forthcoming environmental data (Shuttle and satellite) as a high agency priority. This should be done on an ongoing basis, through Earth Science and public education programs, and the press.

(3) **Spread MPE data widely and systematically to all legitimate users,** including resource managers in federal, state and foreign governments, public interest groups, universities, public libraries and primary and secondary schools. This will serve practical natural resource management objectives, and will improve environmental science literacy. It can be accomplished through modifications to existing programs.

(4) **Establish a formal environmental applications program to maximize practical use of satellite data for resource management, with special emphasis on the needs of state governments and resource managers.**

Sensors in the EOS array are specifically designed to answer important process questions about Earth as a working system. We recognize that without TOMS [2] on the Nimbus 7 satellite, there could hardly have been a Montreal Protocol. The need, however, extends beyond dedicated sensors and pre-planned research.

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[2] Total Ozone Mapping Spectrometer.

Research applications must focus particular attention on (1) defining ecosystems and their characteristics, (2) serious ecological problems, and (3) the regional impacts of anticipated global climate change. Many important applications are anticipated including: drought management, forest impacts, severely changing storm patterns, coastal erosion, and other natural phenomena that determine government economic planning. Regional environmental modelling is essential to informed decision-making by states and smaller countries as they plan their economic strategies. Current identification of such applications is informal and ad hoc.

(5) **Formulate global environmental policy on the basis of existing knowledge,** including existing space derived data and EOS precursor missions.

MPE must never be used to postpone necessary environmental protection measures. Existing data must be quickly gathered, synthesized and distributed to support actions that minimize risk in Earth science areas we do not fully understand.

(6) **Address critical science and environmental impact issues early in the MPE program.**

Maintain the funding and schedules for those parts of NASA's environmental satellite and information programs that precede the EOS launch. These precursor satellites are scheduled for launch in the early 1990s, and offer opportunities to acquire essential data as soon as possible. NASA should give the Earth Sciences programs adequate priority in its overall budget to allow both (1) smaller or earlier environmental satellites, with accompanying data acquisition and analysis, and (2) the EOS program.

If opportunities exist for early launch of smaller, relatively inexpensive satellites that will provide key environmental or global change information, these should be pursued as a priority.

(7) **Quietly systematize and accelerate the use of space data in environmental enforcement policies.**

Space-derived data has long been used in the enforcement of environmental laws and agreements. In the 1970s, Landsat data was used to prove fault in Great Lakes water pollution litigation, and to police illegal strip mining. Skylab imagery together with aerial photography has tracked polluted water plumes. NOAA satellite data has been shared with the Brazilian government to police unpermitted forest burning and educate rural farmers.

In the last decade, the use of satellite data for enforcement has atrophied due to commercialization policies and slack environmental law enforcement by the Reagan and Bush Administrations. While some institutional reticence is expected, all federal agencies with jurisdiction over environmental laws,

treaties and agreements should now be strongly encouraged to use space-derived data in the full exercise of their duties, including enforcement. [3]

Previous use of satellite data suggests that if a system were in place to identify ecological and natural resource problems, and transmit timely information to relevant regulators, at least some potentially disastrous policies and activities might be identified and altered in time to avoid severe ecological damage and enforce existing laws.

As increasingly sophisticated sensors are placed in orbit, and as military satellites are made available for additional civilian missions, the potential for using space-derived data for enforcing environmental laws and treaties will increase.

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[3] From the time of Landsat 1, space derived data has demonstrated a capacity to resolve disputes. One dramatic early example involves the African Sahel. In the early days of Landsat, scientists analyzing data from the Sahel, which had been reduced -- ostensibly by drought -- to a veritable moonscape, encountered an anomaly; an area of several hundred square miles, with sharply defined rectangular boundaries, that produced a strong near infrared signal characteristic of vegetation. A visit to the site revealed a large, fenced enclave maintained by a French ranching company that contained an isolated, intact ground cover of grass and shrubs. This proved precisely what local scientists and observers had been saying; the loss of ground cover across the Sahel was not caused by drought, although the overall dessification of the region is of climate origin), but by ill-conceived technological intervention.

In the years preceding the disaster, U.N. agencies and U.S. AID drilled up to 1800 stock watering wells across the Sahel belt, permitting seasonal nomads, who had previously been obliged to trail their herds south out of the zone, to remain in the Sahel year round. Instead of 20 million cattle for 6 months each year, the Sahel was soon supporting 80 million cattle annually. The natural checks against overgrazing were bypassed, the equilibrium between the nomads and the land was shattered, and an ecological calamity resulted, replete with human misery.

A second example from the early 1970s concerns a U.S. federal circuit court case, in which it was alleged that asbestos laced taconite tailings discharged into Lake Superior were entering the Duluth, Minnesota water system. The accused mills denied the allegation, but Landsat imagery defined plume tailings from the Mesabi iron range extending south to the area of Duluth's water intakes. Landsat provided the definitive evidence leading to a court victory for the plaintiffs, and an order limiting the discharge.

A third example is the use of the infrared sensor aboard NOAA 11 to identify unpermitted burning in remote areas. The U.S., in cooperation with the Brazilian government, has established a system that can locate illegal burning and transmit the information to local authorities in a matter of hours after its discovery from space.

Finally, an anticipated example is the ability of the Synthetic Aperture Radar (SAR) to track seagoing vessels. Even the single-band SARs currently aloft are able to "see" vessel wakes for several hours after a ship has passed, and determine approximate vessel speed and class. Potentially, different kinds of vessels will exhibit distinctive signatures. SAR is now being investigated as a means of enforcing fishing regulations in the Bering Sea. It may be the most effective system available to locate "pirate fishing" by use of drift nets; which have been banned under U.N. resolution. Evidence exists that Taiwan plans to ignore the ban on a massive scale.

While systematic global monitoring with SAR may not become feasible until 1995, when Canada's RADARSAT is launched , with a swath width of 500 miles, there is great hope that the technology can be useful, if not crucial, for fishing treaty and regulation enforcement. Enforcement by SAR could be especially powerful if used with high resolution DOD sensors. SAR imagery will, and Shuttle mission photography already provides the ability to track oil slicks from bilge-cleaning by vessels world wide.

II. PROGRAM RECOMMENDATIONS

INFORMATION FOR THE PEOPLE -- How to use space derived data for maximum public service, public education, environmental monitoring and conservation, and to establish international consensus for sustainable development.

1. Mobilize the unrealized potential of all existing space remote sensing resources to guide global environmental policies and benefit the public.

   A. **Establish a National Emergency Satellite Observation System**, through which pictures and imagery of hurricanes, floods, fires, etc (including a before and after time series) are systematically provided in as near real time as possible to emergency response teams.

   B. **Formalize and expand a Space Shuttle Global Environmental Monitoring Program.**

   Shuttle Earth observations are in full swing and can provide important information to decision-makers and the public now. The present informal Shuttle observation project should be made an ongoing JSC program, with aggressive distribution of photographs to the public, media and schools. Photographs should be highly publicized in the press by the Administration, giving the people of the world an **"Earth Status Report"** on environmental conditions and activities around the world after each Shuttle mission. Coordination between Shuttle observations and NASA Code S Earth Sciences should be strongly encouraged; Shuttle data should be incorporated in the global change baseline.

   C. **Establish a Landsat and EOS Precursor Satellite Environmental Applications Program.**

   Landsat should be used as the starting model for training federal, state and local government, universities, foreign governments, non-profit environmental research organizations and others how to use satellite data to formulate sustainable development policies, in preparation for EOS data. A grassroots user infrastructure should be established. This will help assure maximum practical use of MPE data, and help to avoid costly errors in the Global Change Data and Information System (GCDIS), National Research Education Network (NREN) and the Earth Observation Satellite Data and Information System (EOS/DIS).

   The national user infrastructure is currently so far behind information collection, that if the data stream from EOS and other advanced satellites were available today, widespread value would be slight. If we do not develop this infrastructure, the new armada of Earth viewing satellites will yield only a fraction of its potential for planetary stewardship.

D. **Declassify as much environmentally useful data as bonafide national security concerns will permit.**

E. **Establish a strong Environmental Education Mandate** in the Mission to Planet Earth Program Office and throughout NASA.

Use existing information, as it is gathered and synthesized, in a massive classroom environmental education program to teach Earth System Science and our impact on the planet as they are now understood, and involve school children in MPE research and applications.

2. **Mobilize future policy and resources for maximum environmental applications and public benefit.**

A. Assure an Open Data Policy -- Environmental space-derived data must be made low cost, user friendly and easily accessible for practical applications to government resource managers and the public service community.

Commercialization of raw or minimally processed data must be prohibited. Commercialization should be stimulated through competitive value-added services. "Open skies" policies must be strictly enforced.

The 1992 Landsat data policy process has established beyond rational dispute that **commercialization of unenhanced satellite data has no place in a publicly financed remote sensing program such as MPE**. Informal studies found that the lower the cost of the unenhanced data, the greater the overall demand, and the greater the public benefit.

The Administration should anticipate and firmly reject commercialization proposals from the Landsat contractor and contractors for the MPE information distribution systems.

B. Build stronger environmental applications and regional benefits into MPE.

- **Serve the needs of the states** to monitor and predict the rate of regional global climate change and other environmental phenomena by designing models that focus on regional impacts of global change with the states, who manage most of the resources that will be affected by climatic change. Include state resource scientists and managers in MPE research and information distribution channels.

  If existing data were made available to the states at the marginal cost of reproduction, and the Landsat environmental applications network were re-invented, state resource managers could get a head start on the data bases necessary to determine regional environmental climate change. It is possible that the network would be fully operational in enough time to have adequately prepared the states for a very advanced level of sophistication in EOS/DIS.

- o **Systematically build an applications orientation** in the MPE program office.

  (1) Amend NASA's Charter to include a mandate for applications in remote sensing.

  (2) Establish an advisory process to better identify anticipated regional and environmental applications.

  (3) Start an Applications Branch in the Mission to Planet Earth Program Office, and establish a formal applications program, with a regional grassroots structure.

  (4) Seriously examine placing jurisdiction over the National Weather Service (NWS) and the National Environmental Satellite Data and Information System (NESDIS) at NASA.

  Internalizing these programs would help NASA become more applications oriented. The Weather Service also has an established information distribution system that reaches both the science community and the public, and could help get information out to local communities.

  (5) Broaden the NASA science culture by better integrating space scientists with federal, state, international, and non-profit natural resource managers.

  Hire more ecology scientists as NASA MPE personnel. Require NASA theoretical scientists to perform 2 years of duty outside NASA in their applications field, and, require that NASA science managers must perform one year of practical research every five years.

C. **Establish a Department of State mandate to immediately improve scientific literacy and access to state-of-the-art environmental resource management information in the developing world**, including space-derived data.

U.S. Fortune 500 corporations presently have better access to data about many developing country's resources than do their own governments, especially where there are no roads, personnel or equipment for proper inventory. The U.S., along with other MPE participants, should build an international infrastructure based on the best available information, to elevate developing world leaders and natural resource managers to the information level necessary for sustainable development.

D. **If a space station is approved on grounds strictly unrelated to Earth sciences, maximize only the most cost effective environmental remote sensing activities that can uniquely be achieved through the program.**

POLICY AND PROGRAM DESCRIPTIONS

POLICY AND PROGRAM DESCRIPTIONS

I. INTRODUCTION

Space images capture and focus the world's attention. The Administration should take the lead to prepare humanity for sustainable development by systematically using the space program as an environmental education and protection tool.

Basic information gathered by Mission to Planet Earth must be fully integrated into all walks of life. Transformation of world attitude should occur from increased public awareness combined with an improved understanding of Earth system science.

To accomplish these objectives, MPE must produce information equally for science, practical applications for environmental resource management, the widest possible public education, and improved environmental science literacy in all nations. [4]

Information users must include: resource managers in the field, state and foreign governments, environmental and conservation groups, universities, the press, the public, children in the classroom, corporate interests, real estate developers, and the like.

Reaching these users will require a broadened, integrated MPE program, including: (1) massive public education, (2) a wide information distribution system, and (3) a systematic environmental applications focus.

A broad based approach to MPE will also help restore public confidence in the space program by demonstrating the practical benefits of space-derived information, and increasing return on taxpayer investment.

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[4] MPE is currently designed to serve research priorities established by the Committee on Earth and Environmental Sciences (CEES). Practical resource management and education objectives have not been methodically designed into the system. Public education efforts are fledgling. Public release of research results and current Earth photography to a wide audience has been discouraged. To their credit, NASA MPE program managers are now initiating an environmental applications program.

II. PROGRAM DETAIL

INFORMATION FOR THE PEOPLE -- How to use space-derived data for maximum public service, public education, environmental monitoring and conservation, and to establish international consensus for sustainable development.

1. Government Personnel

A. Select a NASA Administrator and NASA Center directors who will make NASA Earth science and applications the top agency priority.

Since NASA's creation, science and practical applications of space technology have always taken second place to exploration and the "manned" space program. While the exploration of space is important for defense conversion, economic stabilization and, to some extent, international cooperation, NASA's most immediate priority must be to (1) speed its contribution to the U.S. global change research program, and (2) maximize the practical applications of Mission to Planet Earth data for global change mitigation, regional resource management and environmental conservation.

We take no collective position on space station. However, cost effective Earth observations should be strongly integrated into any "manned" program.

The new Administration must appoint a NASA Administrator who recognizes the reality of the global environmental crisis, and understands that the greatest contribution NASA can make to the future of humankind is helping to preserve the Earth; using all resources under NASA's jurisdiction.

It is equally important to appoint a new Administrator with the strength and commitment necessary to overcome the inevitable resistance of the NASA centers to MPE as a priority. NASA centers have gradually acquired the characteristics of independent fiefdoms, each with its own congressional and corporate protectors. This has made it acutely difficult for central leadership to amend the agency's mission or institute structural and cultural reforms.

B. Select Congressional Liaison Personnel who are committed to Clinton /Gore policy on NASA Environmental Programs.

NASA congressional liaison has historically reflected the overall agency preference for manned space, with an unfortunate perception that if MPE becomes the agency's top priority, space station will be terminated. This prejudice has been true at both management and line levels. Congressional liaison is a key point in implementing the Vice President's policy priority for MPE.

C. Designate a strong policy oversight person at the National Space Council to assure proper agency and congressional implementation of Administration priorities for NASA Environmental Programs.

Experience with MPE policy dynamics over the last 4 years, together with observations made of Admiral James Watkin's attempts to change the cultural

attitude at DOE from bomb production to reconfiguration and environmental clean-up, indicate that if the Administration seriously intends to shift NASA agency priorities to the environment, a counter-balancing force outside the agency is absolutely necessary. Strong Space Council oversight will be necessary to accomplish the Vice President's stated priorities for NASA environmental programs.

2. Mobilize the unrealized potential of all existing space remote sensing resources to guide global environmental policies and benefit the public.

A. Establish a National Emergency Satellite Observation System.

Comprised of all federal agencies engaged in satellite and aircraft environmental and observation activities,[5] this system would, perhaps under Space Council control, provide as near real-time information as possible to aid national and local emergency response teams during hurricanes, oil spills, earthquakes, fires, flooding, drought and other emergencies around the world. Before and after images should be quickly provided to natural resource managers. Each appropriate satellite owned by the U.S. government, and perhaps other governments, should be focussed on the current worldwide emergency of the day. The existing defense emergency satellite system should be examined as a model for this service. Program planning may be as simple as broadening the definition of "national emergency" to include natural and anthropogenic disasters.

To the extent possible considering national security concerns, before and after results should also be shared immediately with non-profit group and academic environmental researchers.

The Administration should search the potential for high resolution maps to be given to local U.S. police for logistical support in 911 services in an ongoing program. Rural Texas officials are especially interested in these applications due to the difficulty of directing emergency vehicles in unfamiliar areas by dispatch.

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[5] Those agencies known to own or manage satellite observation systems include: NASA, National Oceanic and Atmospheric Administration (NOAA), Department of Defense, National Reconnaissance Organization, and Central Intelligence Agency. The Department of Agriculture and the Department of Interior use extensive aerial photography. The U.S. Geological Survey is an extensive user of both satellite data and aerial photography, but operates no satellites.

B. Formalize a Space Shuttle Global Environmental Monitoring Program.

'Each Shuttle mission brings fresh evidence of human impact on the Earth.' [6]

The Shuttle now monitors over 600 selected sites around the world, including environmental, geological, atmospheric, oceanographic, and ephemeral events. A normal Shuttle mission returns about 4,200 large format analog photographs and several hundred digital images of Earth's environmental phenomena. Data are digitized on return, then archived, catalogued, and made available to the public by electronic access using Johnson Space Center (JSC) computer nodes. This program provides the longest length record of orbital data (1961 - 1992) that is useful for documenting and assessing global environmental change.

The Shuttle's Earth observations are in full swing, and can provide important information to decision-makers and the public now, at a crucial time for environmental policy. Its easy to understand photography can vastly improve public understanding of global environmental changes over the last 11 years. Using advanced electronics and information systems, information can be passed to decision-makers around the world quickly, in many cases in time to stop environmentally dangerous activities in progress. The collective time series can also make a significant contribution to the baseline for global change data.

NASA management has historically considered Shuttle Earth observations an informal mission adjunct. Equipment upgrades have been made largely at the expense of non-NASA agencies, including the Navy, Army and Department of Defense.

Despite these restrictions, the Shuttle program has unique capabilities that are useful for environmental monitoring and high profile environmental education.[7]

Recommendations:

(1) **Formalize the Space Shuttle Earth Observations Program at JSC**, with science goals, in association with Code S at NASA Headquarters (Earth Sciences) and a budget. Immediately reverse the decision to close in the near future JSC's "Environmental Resource Satellite Analysis Facility" (ERSAF -- the global monitoring, communications and analysis facility for Shuttle photography).

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[6] Paraphrased from the video documentary entitled "Space Age: Mission to Planet Earth." Produced in Association with the National Academy of Sciences and a Centerpiece of the International Space Year, 1992.

[7] These include: uplink capability to an on-orbit crew, downlink capability of crew-acquired data; routine stereo photography and imagery capability; demonstrated polarization and bi-directional reflectance (multi-angle) imaging; routine multiple sun angle imaging; technically unlimited spatial resolution capability; receipt of near real-time satellite data and Geographic Information System (GIS) information for identifying Earth environmental conditions worldwide (volcanic eruptions, weather situations, flooding, tropical cyclones, major fires and forest fires, oil spills, etc.) Shuttle missions monitor the entire globe in real-time, using unmanned satellites to reconnaissance ahead of shuttle overpasses.

(2) Continue to place all Shuttle data in the public domain and significantly improve awareness of its availability for wide public and resource management use at the marginal cost of reproduction (consistent with Landsat policy). Either NASA or the EROS Data Center should **aggressively distribute the data**.

Assuming phase out of the Shuttle in the early 2000s, and termination of an aggressive Shuttle Earth observations program, what photography program to serve ongoing environmental education needs will replace it?

(3) Work Shuttle photography into a **national grammar school and high school curriculum** to encourage technology, computer and environmental literacy (see environmental education section), and produce **astronaut tutorial videos on Earth observations** after each mission for distribution to classrooms nationwide.

(4) After each Shuttle mission, the astronauts should conduct a **widely publicized press conference to make an ongoing "Earth Status Report"** based on observations made aloft, and using cumulative Shuttle and other remote sensing data to show change detection. **Many astronauts are eager and prepared to participate in such a program.**

(5) Expand the number of scientists and ecologists in the Space Shuttle Earth Observations Office at Johnson Space Center and **choose JSC leadership who will fully support this program.**

(6) Establish **summer internships** for college students in the JSC Astronaut and Earth Observations Offices for training in Earth observations science.

(7) Continue to **digitize and improve Shuttle Earth observation data** and mandate integration of the data into the Pathfinder **baseline for global change**.

(8) **Encourage NASA scientists to publish Shuttle research results in accessible journals with wide distribution** and in magazines accessible to the common person.

C. Establish a Landsat and EOS Precursor Satellite Environmental Applications Program [8]

Landsat should be used as the starting model for training federal, state and local government, universities, foreign governments, non-profit environmental research organizations and others how to use satellite data to formulate sustainable development policies, in preparation for EOS data.

Landsat data is available now, and an infrastructure still exists around the country, and to some extent, the world, that can use it. [9] EOS data, on the other hand, will be much more voluminous and complex, and will come later in the decade. Landsat data is also a substantial part of the baseline pathfinder data from which scientists will measure global change. The lessons learned from maximizing the practical applications of Landsat for public services / interest can be incorporated into the Mission to Planet Earth data system design.

Landsat, then, is the natural precursor to achieving maximum practical use of MPE/EOS data. NASA and other federal agencies should institute training programs, through grants, centers of excellence, and the like, to renovate the necessary infrastructure in federal and state government and in universities to assure maximum use of MPE/EOS data for practical purposes. Distribution at the practical management level will also help to bring resource management into the 20th century. Many states, for example, are far behind in computerization.

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[8] A full-fledged applications program for EOS and all remaining MPE satellites would be substantially similar to the Landsat applications program and be added later, as satellites are launched and specific applications are determined. For a full applications program description, see "Build Stronger Environmental Applications and Regional Benefits into MPE."

[9] During the 1970s and early 1980s, NASA and other federal agencies promoted use of Landsat MSS and other remote sensing data for practical applications, such as forestry and agriculture. Unfortunately, just at the time an infrastructural base of sufficient size to nourish rapid growth of remote sensing technology had been developed, and a more useful Earth observing sensor (Thematic Mapper) had been launched aboard Landsat 5, the decision was made to commercialize Landsat.

The high price of data, in combination with the marketing approach of EOSAT (the unregulated commercial monopoly established under the Land Remote Sensing Act of 1984 to market data) resulted in a precipitous decline in the use of Landsat for academic research and conservation. The chief purchasers of Landsat data are now federal agencies, especially DOD and NASA, and large corporations. Academic researchers, state natural resource managers, local government planners, public interest conservationists and small businesses have turned away from remote sensing in favor of older systems, such as aerial photography and ground based methods. In some places (such as the University of Nebraska) radiometers and spectrometers have been mounted on light planes. While research is continuing, and hundreds of new remote sensing applications have been developed since commercialization of Landsat data in 1984, the remote sensing infrastructure overall has seriously declined. Some universities that taught remote sensing a decade ago have dropped the subject.

The 1992 Land Remote Sensing Policy Act, passed into law in October 1992, brought Landsat data back into the public domain after a decade of failed commercialization. The price of data will now gradually decline to the marginal cost of reproducing a scene (ultimately about $400 - $600 U.S.). With low cost, easily available data, we have been given an important opportunity to rebuild the Landsat user infrastructure that existed in the states during the 1970s, and use it for MPE data.

Background:

Every expert agrees there is vastly more information available in Landsat and other Earth viewing satellites than we have learned to extract. This is especially true of the SAR (JERS-1 and ERS-1), now aloft. **National user infrastructure is so far behind information collection, that if the data stream from EOS and other advanced satellites were available today, widespread value would be slight. If we do not develop this infrastructure, the new armada of Earth viewing satellites will yield only a fraction of its potential for planetary stewardship.**

There is no reason to expect that an infrastructure sufficient to accommodate expanding demand will develop spontaneously during the during the interim transition period before Landsat 7's launch. If we are to grasp the potential value to conservation of the advanced instruments planned for Landsat 7, the planned EOS and EOS precursor satellites, and all existing satellite resources, it will be necessary for NASA and other federal agencies to rebuild and expand the civilian remote sensing infrastructure through a vigorous remote sensing applications program.

By rebuilding a user infrastructure around existing satellites, we will be better equipped to utilize information from EOS, Landsats 7 and 8, RADARSAT, and Almaz 2. Experience with existing AVHRR data is essential to using MODIS effectively for applications.

D. Declassify as much environmentally useful data as bonafide national security concerns will permit.

Where possible, intelligence satellite environmental data should be de-classified and incorporated into the on-line Landsat distribution and applications system.

Where de-classification is not possible, a national interpretive center should be instituted to share research and observation results for public purposes. (Perhaps modelled on the National Photographic Interpretive Center.)

E. Establish a Strong Environmental Education Mandate in the MPE Program Office and throughout NASA. [10]

Use existing information, as it is gathered and synthesized, to begin a massive classroom environmental education program that documents our impact on the planet as it is now understood, and involve school children in MPE research and applications.

Environmental, scientific and technological literacy can be improved through classroom use of space photography and satellite data about the local and global environment. MPE should promote "hands on" student experiences in a strong environmental education program. By doing this, NASA can change the way our future leaders view the Earth.

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[10] See also Shuttle program section.

Vice President Gore's proposal to use schoolchildren around the world for "ground truthing" satellite data **can actually assist global change researchers and is now in process.** [11]

Knowing the condition of the environment at the time satellites record the reflectance of ground features is important. An interactive educational curriculum can be easily developed to incorporate ground truthing principles with "hands on" computer applications.

Student involvement is uncomplicated. A remote sensing GIS training program is **currently underway in South Carolina**, directly involving secondary school students in practical research of the Congaree Swamp, including ground truthing, manipulation of remote sensing data on personal computers, and interpretation of aerial photography.

In **Maine**, 7th and 8th graders are learning to manipulate SPOT Image data on MacIntosh computers, identifying wetlands, ground cover types and endangered species habitat. The imaged sites are visited to truth their conclusions, and "close the gap" between computer screens and the natural world. Through these programs, students are also becoming familiar with map making science, problem solving, and on site investigations.

Such programs enrich the minds of youth, and provide an indispensable educational substrate for development of the kind of ecologically oriented remote sensing infrastructure that will be necessary if remote sensing is to provide answers to the critical policy questions of global change in the coming decades. [12]

Recommendations:

(1) NASA should substantially enlarge its environmental education programs in primary and secondary schools by providing **training and educational grants for integrated remote sensing projects with focus on practical applications.** Ultimately, this program should be established in every primary and secondary school in the country.

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[11] The Aspen Institute at the Windstar Foundation in Colorado has instituted hands-on remote sensing curricula, and has trained teachers from 32 states. These efforts should be supported and expanded throughout the country and in foreign nations.

[12] A problem that constantly evades school administrators and research scientists is the inability to take conventional research and apply it to instructional K through 12 problem solving exercises. Innovative curriculum programs must be developed to catch student attention and let them interactively experience what data are required for making real world decisions; such as balancing economic development and environmental protection.

To be successful, the student must first become familiar with computer technology and remote sensing applications through the use of data sets that examine their state or local community. Much of these data are currently available to the public through the U.S. Geological Survey and state agencies. Once remote sensing concepts are learned by interpreting familiar and easy-to-visit study sites, student knowledge and newly acquired capabilities can be extrapolated to study sites located in other geographic regions of the U.S. and the world. For example, both South Carolina and Nebraska have a Sand Hills Physiographic region. Students in South Carolina study the historical, economic, geographic, environmental and land use concepts of this region and then determine how the Sand Hills in the two states differ.

(2) **NASA employees and principal investigators must be available to schools** for demonstrations and the development of data to be used with school computer technology.

(3) NASA should **integrate its educational programs** with other agencies

- Environmental remote sensing studies, including ground truth activities, should be made **required science** in primary and secondary schools across the nation as quickly as possible. A **national interactive global change research curricula** should be established. NASA scientists and astronauts should be encouraged to **tutor in Earth science** through classroom visits, video tutorials and on-line computer communications.

- Preparation and dissemination of **more educational videos** (in numerous languages) should be made. Special effort should be made to supply hard copy remote sensing images, Shuttle Earth photography, (and eventually floppy disks or CD ROMs) of particular regions to libraries within those regions. NASA should make such materials available nation wide through the GPO **Federal Depository Library Program and the National Cartographic Information Centers.**

- Environmental education programs should be **continually upgraded at the National Air and Space Museum and in space and technology museums and public display centers** (eg., Park Service information centers) around the country, and abroad (e.g., through U. S. Information Agency Centers).[13] During Shuttle missions, Earth observation downlinks should be made to major museums around the country and the world for an integrated **on-site learning program.**

(4) NASA should encourage one-on-one relationships between high school students and agency Earth scientists in an **"Environmentors" program, similar to the national "Big Brothers" program.** This will both shepherd career development in Earth sciences and help to make the NASA Earth science culture more applications oriented.

(5) An **Earth science education specialist** should be assigned to the National Space Council, and to the offices of the new Administrator to **elevate the public education component of Mission to Planet Earth.**

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[13] Shuttle photography has already been distributed to and is on display at the U.S. National Park Service Visitors Centers at the Grand Canyon and Mount St. Helens National Parks, and at the Florissant Fossil Beds National Monument.

3. Mobilize future policy and resources for maximum environmental applications and public benefit.

A. Assure an Open Data Policy.

Environmental Space Derived Data must be low cost, user friendly and easily accessible to the public service community. Commercialization of raw or minimally processed data must be prohibited. Commercialization should be stimulated through competitive value-added services. "Open skies" policies must be strictly enforced.

The recent Landsat data policy process has established beyond rational dispute that commercialization of unenhanced satellite data has no place in a publicly financed remote sensing program. Informal studies found that the lower the cost of the unenhanced data, the greater the overall demand, and the greater the public benefit. [14]

Landsat and other EOS precursor satellites, such as Upper Atmospheric Research Satellite (UARS), and SEAWIFs, have commercial or hybrid data policies that prevent publicly financed data from immediately entering the public domain. To the extent practicable, these policies should be changed and the research results incorporated into a public domain applications program. Due to existing contract and licensing agreements, this may be difficult with UARS and SEAWIFS.

In no case should commercialization policies in any form be repeated for planned MPE satellites, despite anticipated industry efforts to the contrary. The Administration should expect continuing commercialization proposals from the Landsat contractor and contractors for the MPE EOS/DIS system.

Recommendations:

MPE/EOS data policy should --

(1) Anticipate and firmly reject efforts by contractors to commercialize and privatize publicly financed environmental space remote sensing data. All such data should immediately enter and remain in the public domain.

(2) Assure that the data is available in a timely, user-friendly fashion to practical end users. This data must be available on-line through personal computers to state based natural resource managers from the onset

[14] Well documented research shows a drastic drop in use of Landsat upon a price increase and commercialization in 1984. Informal surveys taken during the 1992 Landsat policy debate indicate that university researchers would use the data significantly more at lower cost. These sentiments were echoed unanimously by major U.S. environmental groups and over 15 state governments, (including Texas, California, Nebraska, Maryland, Florida, South Carolina, Tennessee, New York, Ohio, Kansas, Oregon, Vermont, Wyoming, Missouri and Alaska.) Dr. Robert Jenkins, Vice President for Science at The Nature Conservancy, estimated that TNC would use Landsat data up to 50 times more if it were available at the marginal cost of reproduction ($500 per scene). Jenkins' sentiments were echoed in varying degrees by Conservation International, Wilderness Society, and others.

of the Global Change Data and Information System (GCDIS), National Research Education Network (NREN) and the Earth Observation Satellite Data and Information System (EOS/DIS).

(3) Assure that the unenhanced data is available at the **marginal cost of reproduction to all users**, so long as they are willing to share research results in a timely manner with other researchers. Exclusive marketing rights should never be given to a commercial entity.

(4) Nurture and encourage the commercial growth of the value-added and software services that can aid in making MPE/EOS data-user friendly to non-global change environmental researchers and other end users. Where necessary, the federal government can **stimulate the commercial value-added sector by commissioning the development of user friendly software** that helps to accomplish U.S. public education, foreign policy and intergovernmental relations objectives.

B. Build stronger environmental applications and regional benefits into MPE.

o **Building an applications orientation.**

Potential remote sensing users often complain that sensors are designed for specialized research, with little thought given to practical applications. Early in the design process, NASA should begin to consider which general and regional applications an instrument might serve. It should be especially alert to ways to increase the sensor's capacity for practical applications without compromising its basic research mission.

Once the satellite is launched, NASA should hold periodic workshops to determine which applications each sensor has served, and to consider additional applications, based on the experience compiled.

A major reason the public receives so few practical benefits from space-derived data (other than information generated by weather satellites), is that public service users are largely excluded from the decisions governing both sensor and program design. If MPE is a program for the people, then, as Justice Brandeis wrote, "Sunlight is the best disinfectant."

Thus, it is extremely important that public service users be provided real input to the satellite design and policy formulation process.

o **Designing models and applications that focus on regional impacts of global change.**

States need to predict regional impacts of global climate change.

Mission to Planet Earth will have minimal use to policy makers unless state resource managers, who directly manage most of the nation's agricultural and coastal lands, and waterways can access information that can be used to predict regional impacts and their rates, in time to plan mitigation and adaptation measures.

One of the most important reasons for studying and monitoring global climate change is to determine its regional consequences. For example, will the state of California continue to be a major agricultural producer over the next 25 years, or will drought continue to be so severe that the U.S. should consider growing vegetables and fruit further north? What land use policies are necessary now to preserve these options? How will sea level rise affect coastlines and impact coastal land use policy? In regions dependent on hydroelectric power, will there be enough water in 20 years to sustain power grids for anticipated local population growth?

State resource scientists and managers should be included in the MPE research and information distribution channels, beginning with all existing satellites, and continuing through the life of the program.

As mentioned, NASA, together with state governments previously built resource management infrastructures with federally funded satellite information systems when Landsat data was used widely used in the 1970s.

An extensive environmental applications network was built through the outreach of NASA and its regional centers. This program included hands-on training programs

for state resources personnel. As a result, Landsat was extensively applied to state level management and environmental monitoring. Resource management was initiated into the information age. [15]

If existing data were made available to the states at the marginal cost of reproduction, and the Landsat environmental applications network were re-invented, state resource managers could get a head start on the data bases necessary to determine regional environmental climate change. It is possible that the network would be fully operational in enough time to have adequately prepared the states for a very advanced level of sophistication in EOS/DIS.

Recommendations:

(1) Amend NASA's Charter to include a mandate for Applications.

While NASA's charter limits the agency's mandate to technology demonstration rather than applications, it is clear that unless some (or all) government agencies are charged with maximizing the applications of the vast taxpayer investment in space and satellite technology, the societal improvements the public expects from technology will continue to be lost and the quality of environmental analysis will remain substandard. Perhaps the most simple way to initiate a cultural change at NASA for applications is to mandate the responsibility by statute.

(2) Establish an advisory process to better identify anticipated regional and environmental applications.

NASA is establishing a broadly based Landsat advisory committee of remote sensing experts and users, including qualified representatives from state and local government, American Indian Tribes, conservation and farm groups, the value added sector, and academic experts. The advisory committee should be kept fully informed on all technical and policy proposals affecting applications and information distribution. Decisions affecting applications should not be made before the committee has been consulted, and has the opportunity to respond. This committee should be expanded to consider applications for all MPE satellites.

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[15] Landsat has been used by state governments for (partial listing): flood hazard mapping; fire hazard evaluation; land use, water use, and water quality analysis; mapping of natural features, models for energy use, groundwater protection; air quality monitoring; tracking of natural habitats adjacent to agricultural areas to protect endangered species; siting toxic waste incinerators; timber conditions; timber supply projections; wildlife habitat suitability analysis; wild land conversion to urban and agricultural land use; range conditions, hardwood monitoring, vegetation cover, forest land habitat and rangeland residue mapping; fuel loading cartography; vegetation change detection; wilderness mapping; general cartography under contract to other government agencies; sediment transport along coastlines; sediment discharges from coastal streams; shoreline and land use changes; growth management and land use policy analysis.

During the 1970s, Landsat was running continually, feeding back data as changes in the environment occurred. Under the commercialization act of 1984, the satellite was only turned on at the request of commercial purchasers for specific geographic locations, and much continuity of data for environmental management was lost.

(3) Start an Applications Branch in the MPE program office, and establish an applications program.

The Mission to Planet Earth Program office is establishing an environmental applications branch. This effort should be approved, nurtured and **expanded to become a key characteristic of MPE.**

There are many thousands (by one estimate up to 80,000) of public service users and would be users of remote sensing data in the U.S. who have derived little or no benefit from remote sensing activities since the early 1980s. While federal agencies have largely ignored this community, the commercial entity set up to market Landsat data has actively victimized it.

An active applications program can can confer major public benefits at comparatively modest costs, and establish an infrastructure to help carry out global change research.

The program can produce maximum public benefit per dollar expended if:

- o it is **nationwide**, eventually involving every state in the Union, and is focused on critical **international** problems as well,
- o a **wide spectrum of users** participate in the program. These should include academic institutions, state agencies, local government units, farm groups, conservation and environmental groups, public schools and so on,
- o the involved interests have **direct "hands on" participation** in the research being funded,
- o the data and research results obtained and generated are **useful in a direct, immediate and practical way**, to the interests involved,
- o the program builds a **lasting technical infrastructure** as it proceeds, including coordinating centers and a communications network that can serve program, policy and technical functions, and,
- o a **deliberate effort is made to integrate** applications research and infrastructure development with Mission to Planet Earth research and related satellite functions.

Program Description:

A national applications program should be built around universities and other institutions with strong expertise in remote sensing, who form centers of excellence[16] to carry out research and training on behalf of user consortia.

A center of excellence would be an existing institution with a "track record" in remote sensing (for example, universities, non-profit

[16] These centers of excellence would be distinct from and should not be confused with NASA Centers of Excellence in technology transfer.

organizations or state government entities), that is willing and able to: (a) process raw, or nearly raw, data, (b) provide basic training in remote sensing applications to would be users, (c) make floppy disks and/or CD ROMs of parts of a scene for local users, (d) involve local users and students in ground truthing, (e) assist colleges and high schools in setting up remote sensing programs, (f) work out cooperative "boundary" agreements so that scenes that straddle state lines are fully used, and (g) assist in setting up electronic communications networks.

A consortia would be a group of data users, and potential users, such as state and local government units, farm and conservation groups, Indian tribes, and others, who need data but who cannot use it effectively without expert help. The research results would eventually become the joint property of the consortia and, presumably, of the involved center of excellence.

To facilitate infrastructure, every research grant should be accompanied by a node, or nodes, to an electronic communication network involving NASA as a contributor and recipient of data.

A bureaucracy would not be necessary to service centers of excellence. NASA can safely rely upon the self interest of centers and participating elements of consortia to produce the organizational features necessary in their regions. We are confident, after numerous meetings and discussions with users, that the structures suggested here can be readily organized by the users themselves.

(4) Seriously examine giving NASA jurisdiction over the National Weather Service (NWS) and the National Environmental Satellite Data and Information System (NESDIS).

The Presidential Transition Team is entertaining proposals to move the National Oceanic and Atmospheric Administration out of the Department of Commerce. Putting the National Weather Service and NESDIS under NASA jurisdiction would substantially increase the applications culture at NASA, which is a strong prerequisite to programmatic change.

This transfer is programmatically logical, as global climate change may induce severe changes in worldwide and regional weather patterns. Additionally, there is existing sentiment to consolidate all civilian satellite resources in a single agency. Public education and information distribution objectives would be served by use of the existing Weather Service information distribution systems, that already reach from scientific research to emergency services and into television, for selected purposes.

One immediate practical program change facilitated by this transfer could be a daily stratospheric ozone index report, made through the Weather Service to local television stations nationally, and perhaps world wide. The size and location of the ozone hole, along with anticipated increased in UVL could be provided to communities in real-time.

(5) Broaden the NASA science culture by better integrating space scientists with federal, state, international, and non-profit natural resource managers.

Techniques could include hiring more ecology scientists as NASA MPE personnel, requiring NASA theoretical scientists to perform 2 years of duty outside NASA in their applications field, and, requiring that NASA science managers must perform one year of practical research every 5 years.

C. Establish a Department of State mandate to immediately improve scientific literacy and access to state-of-the-art environmental resource management information in the developing world.

Developing counties are at the threshold of repeating (and exceeding) the environmental management mistakes of the developed world. The Clinton / Gore Administration should assure that the leaders and resource managers of all developing countries receive state-of-the-art data about changes in the Earth's environment to start them down the road toward sustainable development with the proper baseline of information. U.S. Fortune 500 corporations presently have better access to data about many developing country's resources than do their own governments, especially where there are no roads, personnel or equipment for proper inventory. The U.S., along with other MPE participants, should build an international infrastructure based on the best available information, to elevate the developing world to the information level necessary for sustainable development.

Background:

Conservation efforts in the developing world have been seriously hampered by a paucity of information on environmental changes within national territories. Natural resource departments lack field personnel and have inadequate budgets to conduct overflights. Some must rely on hearsay for information regarding events in remote areas. In a number of African countries, natural resource departments lack reliable maps of their own territory.

American environmental groups and universities who train resource managers in developing countries strongly support the distribution of basic Landsat and other Earth remote sensing hard copy maps on mylar (and other appropriate formats) that can be used for years in outlying areas for many purposes. Conservation International has distributed such maps, for example, with great success, throughout South and Central America, limited only by the cost of the data.

Recommendation:

Providing Landsat and other satellite data in a variety of useful forms to the natural resource agencies of underdeveloped nations, along with enough training and technical assistance to enable them to use it on a routine basis, would probably represent the most cost effective conservation directed foreign assistance possible. Providing this indispensable tool to underdeveloped nations should be a significant element of any global conservation strategy.

D. Space Station statement.

The public interest community does not advocate a space station. However, if one is built, it should be used only for environmental remote sensing that cannot be accomplished by any other means (1) in a more cost effective manner, and (2) in a manner that produces the best Earth science.

Space station cannot be justified on the basis of Earth observations, and environmental groups do not advocate a space station. However, if a space station is ultimately approved by the new Administration and Congress on grounds strictly unrelated to Earth observations, the public interest community would likely advocate maximizing station use for Earth observations that cannot be accomplished (1) in a more cost effective manner by other programs (including consideration of whole life cycle costs), and (2) in a manner that produces better Earth science and observations than any other program.

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