

Dr. Timothy W. Foresman testimony for NASA's Earth Science and Applications Program

1. How can NASA's Earth Science Applications Program enable the applied use of NASA Earth observation data for societal benefit?

NASA has a unique and valuable brand that facilitates connecting segments of society, nationally and internationally, with the benefits of Earth observation. This brand of credibility still retains a sense of intellectual awe that breaks through many barriers that other agencies or firms must overcome to convey similar communications and engagement. Therefore the first challenge for enablement comes with the brand.

Societal use is a broad term, well articulated in the National Research Council's 2007 report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*. This witness is in full accord with the recommendations of the reference report and its recommendations, and will therefore attempt to elucidate for highlight specific items, elements, or recommendations that are not clearly defined in the report.

Society is facing an onslaught of changes that may responsibly be labeled of "biblical proportions." These actions are occurring at such a pace and scale, that science teams are challenged to locate their research plots and areas intact from one year to the next. Many forests have disappeared, for example, while science teams were debating the carbon budget and biomass contained within them. These societal onslaughts include:

- Atmospheric build up of greenhouse gases higher than experienced from 600,000 to one-million years. Carbon dioxide in the atmosphere has passed the tipping point of 350 parts per million ¹
- Humans are witnessing the sixth massive planetary epoch of species extinction recorded for the Earth.
- Approximately one-billion people do not have access to safe drinking water.
- The 2002 Global Environmental Report (GEO 3) of the United Nations Environment Programme was not able to document one positive trend in desertification, deforestation, over fishing, arable land productivity, coral reef health, biodiversity, protection of migratory species, human security, disease vectors, or environmental sustainable practices.
- Climate change appears to be gaining momentum while coping strategies for the most vulnerable society members have not been put into place or are unknown.

NASA's Earth Science Applications Program (ESAP) has the potential to provide profound amounts of useful data and information across the litany of sectors that divide

¹ Author's analysis of trends for climate and environmental trends since the 1960s has demonstrated a consistent pattern of scientists missing tipping points until after the fact. In addition, the consensus driven process for define projections also follows a consistent pattern whereby the 'radical' projections of 20-30 years past reveal to be seen as conservative projections when realized. Examples of the Club of Rome population projections are one case in point.

the human community operations. Forestry, fisheries, farming, education, health care, disaster response, community development, and governance all fulfill separate and compartmentalized domains of local and regional operations. NASA ESAP has developed a reasonably literate understanding of how information can flow from sensor collection to decision making in the field. However, they lack the financial resources, the personnel with experience and expertise, and the requisite infrastructure to implement the process control and operations. They are limited by NASA's mandate for research, which is consistently used to set limits on the success of programs within NASA ESAP. **Therefore, major shifts in the follow arenas are recommend to be placed on the table if NASA ESAP plans to “enable the applied use of NASA Earth observation data of societal benefit.”**

- **Define the research continuum for NASA ESAP in harmony with the Department of Defense categories (e.g. 6.1 to 6.6 defines six levels of research and development, while NASA has no differentiation).**
- **Create multi-agency working groups with concrete deliverable for products, selectively rotating chair positions on an annual basis, and create funding mechanisms for shared contracting (e.g., with membership in the State Department's Humanitarian Information Unit).**
- **Break all grants and awards 50-50% into two sectors: (1) major institutions, and (2) small business and NGOs. Currently the vast major of funds go to Congressional ear-marks or distributed to larger organizations and universities with a track record of receiving funds.**
- **Require all research results to be immediately converted into no-cost, web-based Earth science curriculum for K-12 and collegiate levels.**
- **Provide for NASA science scholars program in partnership with major national coalitions, such as through the National Council for Science and the Environment's approximately 160 university affiliates.**

NASA's participation in annual conferences for major users of Earth observation data provides perhaps the most concentrated and effective opportunities for NASA ESAP to enhance enablement of data for societal needs. Annually, over 13,000 active users of satellite and spatial data, from all walks of society, attend the ESRI (Environmental Systems Research Institute, Redlands, CA) annual user conference in San Diego. The American Society of Photogrammetry and Remotes Sensing (ASPRS) annually host over 2,000 active scientists, industry and government workers who apply Earth observations data on a daily basis in their vocations. The International Society for Photogrammetry and Remote Sensing brings multinational attention to NASA's goals with global congress ever four years along with annual special focus meetings. NASA should recognize an implement an improved strategy for engaging with these communities as they represent the cadre of activist promoting and building upon the use of Earth observation data.

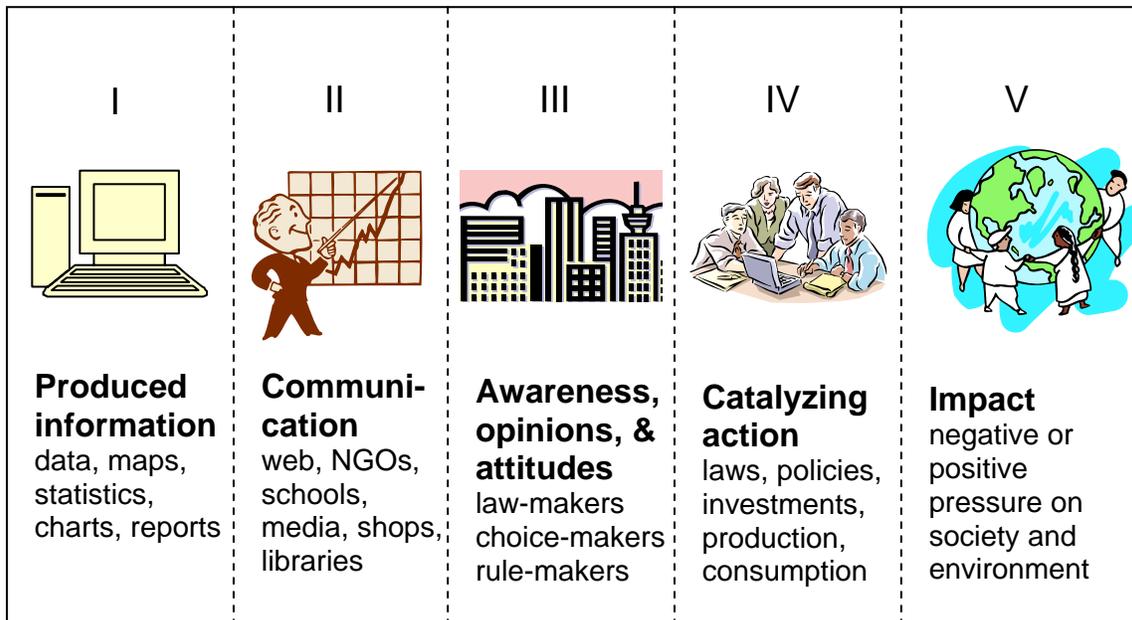
Recommendation: NASA ESAP create a comprehensive and strategic campaign to participate more fully and support the aforementioned conferences, along with a least a dozen more, for the purpose of 1) gathering intelligence on applications and user requirements for NASA Earth observation data and information, 2) foster the creation of partnerships with increased members of these communities as societal

representatives, 3) identify critical and effective educational opportunities, and 4) implement a stronger brand marketing program.

2. What is involved in translating NASA’s Earth observation data into information for decision makers in federal and state and local governments, commercial enterprises, and non-governmental institutions?

A fundamental understanding is needed as to the issue of what is referred to as “pin the tail” on the decision makers. Decisions that affect society are mostly local and made daily by the citizens of the planet. These decisions range from carrying umbrellas to applying sun screen, to where to vacation, to what type of automobile to purchase, and hopefully to what type of proposition or political candidate to vote for in an election. This subject was investigated thoroughly by a team from GRID Arendal, Norway under the leadership of Lars Kristoferson, where a diffuse and complex reality was identified regarding the pathways environmental and spatial data and information enter the decision making processes of society, Figure 1. A key finding was that visualization of science data had the most direct impact on societies and decision making. An example was given of using Landsat data for the 200-year land use change study for the Baltimore-Washington region.² This science study (a collaboration of NASA, US Census, USGS, and the University of Maryland, Baltimore County) provided then Governor Parris Glendening of Maryland with the visualization video that propelled the Smart Growth legislation.

Five Steps in Impact-of-Information Chain



² Foresman, T. “The Baltimore-Washington Regional Collaboratory Land Use History Research Program,” in Sisk, T.D., ed. Perspectives on Land Use History of North America: A Context for Understanding Our Changing Environment. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BDR/BSR-1998-0003, pp 33-42. 1998.

Figure 1-Decision Making Chain for Earth Observation Data and Information

Of the five steps define in Figure 1, NASA ESAP has been mostly attuned to Step 1, producing information. The litany of programs and data clearinghouses that have been designed, built, and attempted is beyond the scope of this document. Fundamentally, NASA ESAP has been underwhelming in its success to getting these information repositories and enterprises to push the data and information into Steps 2-5.

A compelling element of translating data and information for decision makers is in having a deep and experiential level of understanding regarding how decisions are made in various agencies, at various levels, and among industry and NGOs. This witness has a rare background that includes managing the spatial data and information enterprises or departments at the county level, at the city level, for various NGOs, for businesses, for federal agencies (DOD, EPA, NASA), for various country ministries, and for the United Nations. This experience has taught the witness that translation by federal employees is simply not an easy task and must be learned as an art form, not an engineered or scientific script. Therefore, the most efficacious approach is to incorporate into the NASA ESAP culture and operations various veteran visiting experts from different walks of society, both nationally and international, on a frequent and consistent basis. Veteran experts can be partnered with NASA ESAP staff to work on translation issues, pilots, and other exploratory techniques. Such “interns” or visiting staff will provide for a much more cost effective approach in opposition to the numerous and costly regional workshops and seminars that have been pressed into service in the past. Fact finding workshops do not translate nearly as well as having veteran experts resident at NASA, for six months or longer, in defining and testing improved translating schemas. These expert exchange type experiences provide many additional residual benefits by broadening the NASA experience base.

NGO groups are especially poised to advance the societal benefits from NASA ESAP data and information. A flush of successes were recently highlighted at the 5th International Symposium on Digital Earth held in Berkeley, California (www.isde5.org) held 5-9 June 2007. General Pete Worden, director NASA Ames, was a keynote presenter at this conference, which documented Earth observation data being used for:

- **communities working to ameliorate the negative impacts of mountain removal in the Appalachian mountains,**
- **monitoring human rights in Darfur,**
- **disaster response in Indonesia and New Orleans,**
- **disease vector monitoring and management,**
- **glacier monitoring and mapping,**
- **biodiversity assessments,**
- **land cover change dynamics in south America,**
- **forest protection through science visualization and community engagement,**
- **community peace mapping and conflict mitigation, and**
- **marine species tracking and monitoring.**

The vast majority of these examples were led by NGOs. Typically, NGOs, including those of recognized stature (e.g., Conservation International, Green Belt Movement, Heinz Center, Nature Conservancy, World Wildlife Fund) do not possess large technical staffs and rely instead on one or two geographic information system (GIS) technicians who usually import Earth observation data from various sources for their project assessments. By focusing on the functional methods to facilitate ready and free access of timely and time-series Earth observation data for locations around the planet, NASA ESAP could revolutionize its impact on society.

Success has been witnessed in a semi-random fashion regarding the educational initiatives of NASA ESAP. Many fine examples exist, including the Remote Sensing Core Curriculum (RSCC) and Conferences on Remote Sensing Education (CORSE) that were initiated in the early 1990s with seed funding from NASA ESAP. These programs were successful in part because they were based on small core groups of collaborating experts as opposed to large institutions with unwieldy bureaucracies. In addition, the education programs worked closely with other successful initiatives such as the NASA/NOAA Globe program.

3. What gaps, if any, exist between the goals of NASA's Earth Science Applications Program and the tools and processes needed to translate Earth observation data into useful applications? What, if any, improvements to NASA's Applications Program would you recommend?

NASA ESAP was once the world leader in an initiative called Digital Earth beginning in 1998. This initiative involved 17 federal agencies agreeing to cooperate, with no funds exchanged and led by NASA, on defining and creating the tools and process needed to translate Earth observation data into useful applications. The Digital Earth initiative was heralded around the country and the world, with the Chinese Academy of Sciences imbedding the program immediately into their structure and out-year planning processes. The Chinese founded the International Society for Digital Earth May of 2006 and are responsible for helping initiate the new International Journal for Digital Earth (Taylor and Francis Publishers). This sequence of international successes has been accomplished without NASA ESAP participation since 2001, due to political decisions made under the current administration. The reasoning behind NASA ESAP's decision to kill the Digital Earth initiative that NASA had created and nurtured, was due to the association of former Vice President Al Gore's name regarding a speech where he mentions the Digital Earth vision. Had the current administration followed the same logic with the Internet, Congress would be using alternative means of communications. This gap in NASA's judgment has had profound impacts on its ability to work with and lead in delivering the tools and processes necessary to translate Earth observation data.

Further testimony on this subject is provided from the witness's direct relationship with the Digital Earth community after leaving NASA Headquarters in 2000 for the position as Director of Early Warning and Assessment at the United Nations Environment Programme (UNEP). While at UNEP, the witness provided the first contract with the founders of Google Earth (then operating as Keyhole Inc. with four programmers). These types of entrepreneurial opportunities for more effective tools and processes for translating and delivering Earth observation data were therefore squandered by NASA

ESAP and have not been recaptured. Currently, as witnessed at the 5th International Symposium on Digital Earth, a suite of organizations is refining and operating Digital Earth geobrowsers (e.g., NASA's World Wind, Geofusion's GeoMatrix, ESRI's ArcGIS Explorer, Microsoft's Virtual Earth, Google Earth, Skyline's Globe) that can and will be the primary tools for delivering data and information to decision makers and citizens throughout the planet. NASA ESAP is not engaged in these works, albeit conversations with Google executives and Dr. Griffin (NASA Administrator) have been on going. The flaw in these discussions is that NASA ESAP is not engaged with the community, but rather has limited strategic dialogs with only one of the industry leaders and therefore is not demonstrating comprehensive attention regarding the requirement to engage with the community of developers as a whole, including its own NASA World Wind. NASA's World Wind geobrowser (an open source software platform), while internationally recognized for its technical prowess and performance, receives short thrift in financial and staffing support from NASA's administration.

The number one recommendation for NASA ESAP is to terminate the failed policy of linking Mr. Gore with Digital Earth (there is no factual link, only an historic footnote) and revisit the potential leadership role for the Digital Earth technical and user community both national and internationally. This recommendation will require immediate attention due to the ongoing dialog with Eric Schmidt (Google executive) and Brigadier General Pete Worden and other NASA executives for a specialized center to be created with Google funds at the NASA Ames Research facility in Moffett Field, California. A NASA Digital Earth facility with full and open access by NGOs, academia, industry, government agencies and international groups should be seriously considered to address this question (#3).

The second recommendation is for NASA ESAP to join in supporting the Digital Earth Exchange (DEX) being piloted by the San Diego State University Visualization Center. The SDSU Visualization Center, under the leadership of Dr. Eric Frost and senior scientist John Graham, has been hosting the Strong Angel Series to demonstrate and further develop the effectiveness for open-source, and interoperability standards in emergencies and disaster response to use multi-source satellite imagery and field data for operational use. This facility has advanced the understanding of real-time data exchange and decision support among a collection of leading federal, state, industry, NGO, and academic participants (including DOD and FEMA representatives). This facility and the coalition of supercomputer nodes working in alliance with SDSU, represents the epitome of cost-effective, cutting edge technologic application of Earth observation data for web-delivery of societal priority decision support needs. This entrepreneurial enterprise is filling in the major gaps that exist in NASA's ESAP technology translation and applications.

4. What changes, if any, in NASA's Earth Science Applications Program are needed to implement the recommendations of the Earth science decadal survey on applications and the transition of research into operations?

With respect to the 17 missions defined in the Earth Science decadal survey, NASA ESAP is currently below capacity with the expertise for the science missions and for the

defining the translation issues and capacity to provide adequate support. The current staff is required to perform heroic efforts in hours and stress to keep up with the demands while attempting to cope with the decreasing scope and quantity of sensors and missions. Land cover continuity has become a Sisyphean task with civil servants constantly engaging with community and industry experts to examine new alternatives, while the legacy of a 35 year Earth observation jewel for science is held hostage to programmatic shifts, budgetary cuts, and inter-agency politics (DOD's past role in Landsat is a prime example). **Climate change and land cover change scientists have demonstrated the unqualified success of having a time-series record of our planet's land surface phenomena.** There is no method to recreate this legacy and soon it will be demonstrated for its vulnerabilities under the present trajectory.

A prime example of the successful use of the Landsat time-series has been the recent UNEP publication *One Planet Many People: Atlas of Our Changing Environment*. This publication has sold more copies than any other environmental publication in the history of the UN. It has been translated for access on Google Earth and is changing the very way people view our dynamic world. A point in fact is the limited role that NASA played in this effort (exceptions noted for Dr. Martha Maiden, Dr. David Herring, Mr. Woody Turner, and Dr. Rebecca Lindsey who consulted on this project).

Recommendation: Institute major changes in NASA ESAP's plan of action in 2008 to take leadership in the development of land cover change products, atlases, and web-based information for every nation on the planet. This must be carefully coordinated with leading land cover change researchers and programs, such as those of Conservation International, Nature Conservancy, IGBP, UNEP, FAO, and Planet Action.

The litany of science missions define in the decadal survey portrays a serious lack of instrumentation for column measurements of greenhouse gases. Instruments have recently be identified, with solid understanding of the physics, by Dr. Robert Corell (The H. John Heinz III Center for Science, Economics and the Environment) and colleagues that would attend to the measurements and monitoring of column CO₂ and other greenhouse gases. These measurements are proving critical as the science of natural and anthropogenic gas emissions and fluxes advances. NASA's cutbacks in sensor development and missions has curtailed, if not sequestered, the introduction of new and economically feasible greenhouse gases monitoring missions and programs.

Recommendation: NASA ESAP conduct a rapid review workshop with leading geophysicists, atmospheric scientists, and instrumentation engineers to ascertain the feasibility and scoping of new instruments and missions for climate change research beyond those discussed in the decadal survey.

5. Based on your experience as a "user," and your experience in working with users, what are the most important steps NASA should take to expand the application of NASA's Earth observation data to meet social needs?

NASA will require a reinvention, or reestablishment of its mission, to include Earth as it primary planet of study and Earth sciences at its core. This shift in mission will

enable the staff and collaborating agencies and entities a freer rein on educating, engaging, and enabling the real-world user communities that can benefit from NASA data, information, and services. Currently, the mission and philosophy of the Agency, demonstrated by reductions in funding and other resources, is crippling NASA's potential in these areas.

Morale of Earth science personnel has been witnessed to be significantly degraded from that of the previous years in previous administrations. It would be trivial for Congress to validate these statements by inviting various witnesses from the Goddard Space Flight Center and NASA Headquarters, or any number of other NASA facilities.

To propel NASA onto a positive stage for engaging with the user community on both a widespread and deeply integrated fashion, the following initiatives are recommended for consideration and further engagement beginning no later than FY 2008. These initiatives are not exhaustive of the opportunities available, but have been identified due to the persistence and growth in sophisticated use of Earth observation data by the user communities and for their highly visible and marketable value.

- **Green Belt Movement** – Launched by Dr. Wangari Maathai, Nobel Laureate for Peace, to help upgrade the plight of women and communities throughout Africa and the world. The Green Belt Movement (GBM at www.greenbeltmovement.org) has initiated a one-billion tree planting campaign that directly applies the satellite technology to investigate the areas of deforestation and land use degradation that require priority attention. GBM's use of satellite data and information can be directly linked to a litany of key application areas, including:
 - reforestation
 - water resources,
 - disease vector monitoring,
 - disaster mitigation and response,
 - food security,
 - women and girls education, and
 - biodiversity protection and management, as well as
 - the burgeoning enterprise of carbon for poverty reduction (CPR).

The world stature of Dr. Maathai and the potential impact of GBM is of such importance that **NASA should consider this a priority focus for engagement and support in 2008.**

- **Planet Action** – Launched on the 5th of June by Spot Image (see attached flier www.planet-action.org), this initiative, to focus on climate change research, relies upon application of multiple decades of time-series satellite data. Projects and programs to be associated with Planet Action will require a research component and connection with local communities impacted by challenges of climate change. Results from projects will be shared through an open, Digital Earth Exchange platform. The focus areas include:
 - Vegetation, biodiversity & ecosystems
 - Oceans
 - Ice & snow cover
 - Drought, desertification & water resources
 - Human dimensions & habitation

Currently, this initiative is engaged in collaboration dialogs with strategic partners, including the Environmental Systems Research Institute, World Wildlife Fund, Conservation International, Digital Globe, GeoEye, Heinz Center, the European Space Agency, and many others. Planet Action will be operated by a separate non-profit entity beginning in 2008.

- **Millennium Water Alliance** – This alliance was formed four years ago to enable collaborative actions for delivering safe drinking water and sanitation to the two billion people lacking access to both (www.mwawater.org). The leading water NGOs are cooperating but lack the technical infrastructure to enable field coordination and effective knowledge of geo-hydrologic regimes around the planet. This alliance represents a prime target for NASA to engage with and begin making real progress in applying its data and information into the existing global community.

It is sincerely hoped that through the committee's oversight and hearings that a significant shift in focus and effectiveness can be brought to a previously renowned agency. Leadership and demonstrative results, as well as strategic engagement with key enterprises around the nation and the world, are clearly needed in NASA. Making science knowledge actionable should become the proud tradition of NASA and the ESAP. Hopefully, the input provided by this witness may help contribute to this goal.

Respectfully,

Dr. Timothy W. Foresman