

Strategic Plan

for the U.S. Integrated Earth Observation System

prepared by the
Interagency Working Group on Earth Observations



of the Committee on Environment and Natural Resources

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Executive Summary

A global system of Earth observations would provide us with tools to make national and global air quality forecasts, would help us to know in advance when droughts would occur and how long they would last, and would give us the capability to predict the outbreak of deadly diseases by tracking the environmental factors that contribute to their spread. The availability of these types of observational data would transform the way we relate and react to our environment providing significant societal benefits through improved human health and well-being, environmental management, and economic growth.

Vision Statement

Enable a healthy public, economy, and planet through an integrated, comprehensive, and sustained Earth observation system.

These and other societal benefits depend on a sustained and integrated Earth observing system underpinned by science and technology. Investments by the United States and our foreign partners over the last decade have provided unprecedented global views of the Earth as a set of complex, interacting

processes. Despite these advances, our current system of observations is fragmented and incomplete. Now, using a new integrated approach, we must improve our Earth observation system so that we realize benefits for our people, our economy and our planet.

The National Science and Technology Council’s Interagency Working Group on Earth Observations has prepared this Strategic Plan as the first step in the planning process towards the development and implementation of the *U.S. Integrated Earth Observation System*. In the context of broad, crosscutting societal, scientific, and economic imperatives, and the missions and priorities of the agencies participating in the Interagency Working Group on Earth Observations, the approach for the development of the U.S. Integrated Earth Observation System is to focus on specific and achievable societal benefits. The task is to integrate the nation’s Earth observation capabilities to address those imperatives and realize societal benefits. The planning process

will identify and integrate new capabilities on the horizon. In addition, technology and capability gaps must be identified and addressed before societal benefits can be fully realized.

Nine societal benefit areas (see green box) provide a starting place for discussion about what can be accomplished in several key areas where work is underway, and where progress can be realized most quickly. In this Strategic Plan, specific examples illustrate the link between observations and identified benefits.

1. **Improve Weather Forecasting**
2. **Reduce Loss of Life and Property from Disasters**
3. **Protect and Monitor Our Ocean Resource**
4. **Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change**
5. **Support Sustainable Agriculture and Combat Land Degradation**
6. **Understand the Effect of Environmental Factors on Human Health and Well-Being**
7. **Develop the Capacity to Make Ecological Forecasts**
8. **Protect and Monitor Water Resources**
9. **Monitor and Manage Energy Resources**

For decades, U.S. Federal agencies have been working with industry, academia, local, state, national, regional and international partners to strengthen cooperation in Earth observations. The United States will continue to work with the nations of the world to develop and link observation technologies for tracking environmental changes in every part of the globe, thus enabling citizens and leaders to make more informed decisions affecting their lives, environment, and economies.

The Earth is an integrated system. All the processes that influence conditions on the Earth, whether ecological, biological, climatological, or geological, are linked, and impact one another. Therefore, Earth observing systems are strengthened when data collection and analysis are achieved in an integrated manner. This Strategic Plan discusses the process for determining which observations should be integrated and outlines four areas of integration: Policy and Planning Integration, Specific and Issue Focused Integration, Scientific Integration and Technical Integration.

This plan recommends the establishment of a standing Earth Observation Subcommittee under the auspices of the National Science and Technology Council's Committee on Environment and Natural Resources. This Subcommittee will implement the principles and guidelines described here. The Subcommittee will be charged with continuing to pull together vastly expansive science and technical activities to satisfy the identified societal benefits.

This Strategic Plan addresses the policy, technical and fiscal components of an integrated Earth observation system.

- » The policy component identifies the aspects of Earth observations that will be defined as mandates or guidelines at the Federal level. Additionally, this policy component addresses data sharing and the identification of critical observations, and recognizes the requirement for decisions based on sound science and defined need.
- » The technical component describes the architectural approach, noting that this system will build upon existing systems. This component of the plan will also identify and document observation gaps and needs in the societal benefits areas, and, where possible, note promising new capabilities and technology developments that could address them.
- » The fiscal component points out the need for a process for identification of agency budgetary priorities within the framework of the Office of Management and Budget's research and development investment criteria, leading to overall prioritization of Earth observation activities.

The functions of the U.S. Integrated Earth Observation System include data collection, data management, data discovery, access, data transport, data archive, processing, modeling, and quality control. Because no comprehensive and integrated strategy for communicating all the current data exists, *enhanced data management* is highlighted as both an overarching need and a critical first near-term action. In addition, using tangible, achievable examples, the Strategic Plan points out some near-term opportunities of the U.S. Integrated Earth Observation System, and illustrates the observational needs and societal benefits associated with improved observations for disaster warning, global land cover, and sea level, drought, and air quality monitoring.

Finally, the plan identifies next steps, recognizing the need for establishing an organizational structure and describing the near-, mid- and long-term actions

that are needed to develop the common system architecture required for the success of the U.S. Integrated Earth Observation System.

The U.S. Integrated Earth Observation System will provide the nation a unique and innovative perspective on the complex, interacting processes that make up our planet. This observing system must continue to evolve to meet the changing needs of society and to take into account emerging technologies and scientific advances. Implementing the U.S. Integrated Earth Observation System represents an exciting opportunity to make lasting improvements in U.S. capacity to deliver specific benefits to our people, our economy and our planet.

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Introduction

A global system of Earth observations would provide us with tools to make national and global air quality forecasts in the same way we currently make weather forecasts. Think of the benefits to the millions of Americans suffering from asthma.

A global system of Earth observations would help us know in advance when droughts would occur and how long they would last. Think of the benefits to the millions of farmers who could plan their planting and harvesting with increased confidence.

A global system of Earth observations would give us the capability to predict the outbreak of deadly diseases by tracking the environmental factors that contribute to their spread. Think of the benefits to world health and economies.

Realization of these and other benefits is dependent upon a sustained, integrated, and constantly evolving Earth observation system underpinned by science and technology. Today we have sophisticated tools to increase the efficiency and effectiveness of Earth observations, unparalleled opportunities for collecting and synthesizing the vast amount of data they provide, and the

World Summit on Sustainable Development
August 2002

G-8 Action Plan on Science and Technology for Sustainable Development
June 2003

Earth Observation Summit I
July 2003

Group on Earth Observations
Established August 2003

Interagency Working Group on Earth Observations
Established August 2003

Earth Observation Summit II
April 2004

G-8 Science Ministers Meeting
April 2004

G-8 Science & Technology Action Plan/Progress Report
June 2004

Box 1: Recent international emphasis on Earth observations

expanded capability to deliver this data to end users for practical applications.

Over the past decade, the investments made by the United States and our international partners have provided unprecedented global views of the Earth as a set of complex, interacting systems. Despite significant advances in our ability to measure and understand the Earth, building a comprehensive, integrated, and sustained Earth observation system remains a major challenge. Future investments must not only improve tools and capabilities, but must focus on an integrated approach, serving a diverse set of users and ultimately realizing a wide range of benefits for our people, our economy, and our planet.

Recent progress in coordinated international planning (box 1), building upon decades of scientific and technical successes, provides a unique opportunity to plan and implement an integrated, comprehensive and sustained Earth observation system.

Building on this progress, the Interagency Working Group on Earth Observations has prepared this Strategic Plan as the first step towards the development and implementation of the *U.S. Integrated Earth Observation System*. This Strategic Plan provides a pathway towards the development of the integrated system. The scientific and technical foundations for the vision and implementation approach have been developed over the past year by

the agencies of the Interagency Working Group on Earth Observations (box 2) (terms of reference in Appendix 1).

This document responds to the guidance in the 2003 White House Office of Science and Technology Policy/Office of Management and Budget FY2005 Interagency Research and Development Priorities memorandum, which charged the National Science and Technology Council to enhance capabilities to assess and predict changes in key environmental systems.

The National Science and Technology Council, through its Committee on Environment and Natural Resources, established the Interagency Working Group on Earth Observations to develop and implement a coordinated, multi-year plan for Earth observations. This Strategic Plan builds on existing and evolving scientific and technical plans and is intended to improve our understanding, monitoring and prediction of changes to the Earth system (including atmosphere, land, fresh water, ocean, and ecosystems). We will continue to refine the Plan as technology develops and as we achieve its goals.

To continue and sustain the efforts of the Interagency Working Group on Earth Observations, this plan calls for the establishment of a standing Earth

Interagency Working Group on Earth Observations Membership

Department of Commerce

- National Oceanic and Atmospheric Administration
- National Institute for Standards and Technology

Department of Defense

- Air Force
- National Geospatial-Intelligence Agency
- Navy
- U.S. Army Corps of Engineers

Department of Energy

Department of Health & Human Services

- National Institute of Environmental Health Sciences

Department of Homeland Security

- Federal Emergency Management Agency

Department of the Interior

- US Geological Survey

Department of State

Department of Transportation

Environmental Protection Agency

National Aeronautics and Space Administration

National Science Foundation

Smithsonian Institution

Tennessee Valley Authority

U.S. Agency for International Development

U.S. Department of Agriculture

- Agriculture Research Service
- U.S. Forest Service

White House Council on Environmental Quality

White House Office of Management and Budget

White House Office of Science and Technology Policy

Box 2: Interagency Working Group on Earth Observations

Observation Subcommittee (in the National Science and Technology Council and under the Committee on Environment and Natural Resources) with responsibility to implement the principles and guidelines developed here. The Subcommittee will continue to pull together vastly expansive science and technical activities to satisfy the diverse societal benefits, leading towards an integrated, comprehensive and sustained Earth observation system—the U.S. Integrated Earth Observation System.

Purpose, Vision & Goals

A. Purpose

For decades, U.S. Federal agencies have been working with local, state, national, regional and international partners to strengthen cooperation in Earth observations. Building on this work, the U.S. Interagency Working Group on Earth Observations prepared this Strategic Plan to provide a management, planning, and resource allocation strategy for a U.S. Integrated Earth Observation System. This strategy will provide the United States a framework for participating in the international effort to develop a 10-year plan for a Global Earth Observation System of Systems. This U.S. integrated system will be based on new and existing Earth observation systems and capabilities, and will be developed to meet national and international societal, scientific, and economic imperatives.

Vision Statement

Enable a healthy public, economy, and planet through an integrated, comprehensive, and sustained Earth observation system.

B. Vision

A comprehensive Earth observation system will benefit people around the world by improving our ability to monitor, understand, and predict changes to the Earth. The United States will work with other nations to develop and link observation technologies for tracking environmental changes in every part of the globe, thus enabling citizens and leaders to make more informed decisions affecting their lives, environment, and economies. This international cooperation, along new developments in monitoring, assessing, and predicting environmental changes, will enable development of capabilities to predict droughts, prepare for weather emergencies and other natural hazards, plan and protect crops, manage coastal areas and fisheries, and monitor air quality, to name but a few direct benefits that affect our economic prosperity and quality of life.

C. Goals for U.S. Integrated Earth Observation System

To accomplish the purpose and vision of the U.S. Integrated Earth Observation System, the agencies will:

- » Identify current and evolving requirements in the full range of societal benefits.
- » Recommend priorities for investment, including new requirements, as necessary.
- » Utilize available and/or develop new technologies, instruments, systems, and capabilities to meet the identified requirements and priorities.
- » Streamline and sustain existing Earth observation systems that are necessary to achieve societal benefits.

- » Establish U.S. policies for Earth observations and data management.
- » Expand existing governmental partnerships at all levels and develop new long-term partnerships with industry, academia, non-governmental, and international organizations that further the realization of these strategic goals.
- » Develop human and institutional capacity to enable the translation of observations into societal benefits.

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Links to International Activities

International cooperation in Earth observations has already resulted in benefits greater than could be achieved by individual nations acting alone. The international scientific community, working together within key international organizations (such as the World Meteorological Organization and the Intergovernmental Oceanographic Commission), has improved understanding of environmental phenomena. Environmental observations and science are international in scope and in the very nature of their activity. International cooperation is a prerequisite for their success. Recognizing this, ministers from 34 nations and representatives from 25 international organizations met at the first Earth Observation Summit in July 2003. This meeting resulted in an international effort to develop a Global Earth Observation System of Systems.

This international effort emphasizes the importance of capacity building, as information from Earth observations is critical for developing nations. Building capacity is integral to a global implementation strategy, which includes ensuring full utilization of the data. Growing world populations with expanding economies will require access to Earth observations for a wide range of societal, scientific,

and economic needs. The development of new systems will contribute to the gross domestic product of developing (and developed) countries. International contributions are also essential for completing the data sets needed to address important U.S. national issues.

The U.S. Integrated Earth Observation System will promote international cooperation and capacity building. It will address the development of human, institutional, and infrastructure resources necessary to meet research, operational and decision support requirements, and will build on existing initiatives and sustainable development principles.

A Practical Focus for Earth Observations

Our approach for developing the U.S. Integrated Earth Observation System is to focus on specific and achievable societal benefits and to link U.S. efforts to international activities.

Based on discussions about the needs and priorities of the agencies participating in the Interagency Working Group on Earth Observations, nine societal benefit areas (box 3) were chosen as the preliminary focus. This list was then vetted and approved by the National Science and Technology Council Committee on Environment and Natural Resources. This list is not meant to be exhaustive or static. It is intended to provide a framework for discussion about improvements in several key areas where work is underway. These benefit areas are described further in the next section of this document (and detailed in Appendix 3).

1. **Improve Weather Forecasting**
2. **Reduce Loss of Life and Property from Disasters**
3. **Protect and Monitor Our Ocean Resource**
4. **Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change**
5. **Support Sustainable Agriculture and Combat Land Degradation**
6. **Understand the Effect of Environmental Factors on Human Health and Well-Being**
7. **Develop the Capacity to Make Ecological Forecasts**
8. **Protect and Monitor Water Resources**
9. **Monitor and Manage Energy Resources**

Box 3: Preliminary set of societal benefit areas

In the past, individual government agencies sought to implement and optimize their observation systems to meet their specific needs and mandates. The U.S. Integrated Earth Observation System transcends individual agency perspectives and focuses the activity on broad societal, scientific, and economic imperatives.

A. Healthy Public—Societal Imperatives

A growing world population, projected to increase by roughly 50% in the next 50 years before leveling off,¹ will place increasing demands on crucial resources like food and clean water. Populations and economic activities are shifting from rural areas to urban centers, many in low-lying coastal regions or seismically active zones. In the United States, more than half of the population lives within 50 miles of our coasts,² areas that are particularly vulnerable to storm surges and flooding. We rely upon coastal regions for healthy fisheries, and reliable transport and navigation. Increased dependence on infrastructure networks (roads, power grids, oil and gas pipelines) intensifies the potential vulnerability of more developed societies to impacts from natural disasters. Improved understanding of the complex workings of Earth systems will help us protect society and manage our resources and infrastructure in a more efficient and effective way.

B. Healthy Economy—Economic Imperatives

In pure economic terms, studies show that national institutions that provide weather, climate, public health, and water services to their citizens contribute an estimated \$20 - \$40 billion dollars each year to their national economies.³ In the United States, weather- and climate-sensitive industries, both directly and

indirectly, account for as much as 1/3 of our nation's GDP—\$2.7 trillion⁴—ranging from agriculture, energy, finance, insurance, transportation, and real estate, to retail and wholesale trade, and manufacturing. Economists have quantified the benefits of improved El Niño forecasts to be an estimated \$265-300 million annually, throughout El Niño, normal and La Niña years. Likewise, annual benefits in a small Northwest Coho salmon fishery are estimated at \$250,000 to \$1 million.⁵ The return on our investments for Earth observations has brought great benefits to the general public. However, we can do much more.

C. Healthy Planet—Scientific Imperatives

Improved management of resources and forecasting of Earth system changes cannot be achieved without a much more comprehensive and detailed understanding of the Earth. We are faced with a number of pressing science questions, such as:

- » How are all of Earth's "life support systems" interrelated?
- » How do geophysical phenomena interrelate?
- » How do social and economic factors interrelate with Earth system changes?

These questions call for an interdisciplinary Earth science approach to provide useful answers. We need to know how the parts fit together and function as a whole.

The multiple components and processes of the Earth's atmosphere, ocean and land surfaces operate interactively, as a complex, dynamic system. More importantly, the multiple "feedback loops" operating among component

processes of the hydrosphere, geosphere and biosphere determine the state of the Earth system at any given time. In order to take the “pulse of the planet,” we must establish a valid end-to-end process that will take us from observations to user-related products. Scientific needs for this end-to-end process require that we:

- » integrate observation, data management, and information delivery systems,
- » quantify environmental processes by direct or indirect observations,
- » improve coupled Earth system models that integrate the best state of knowledge,
- » assimilate the Earth observation data streams into models (eventually in real time),
- » test our Earth system models over varying time and spatial scales against observations and the geologic/environmental record,
- » understand the drivers of climate variability and change, the rates of change and the possible precursors to climate variability and change,
- » understand and explain the mechanisms underlying observed patterns, and
- » communicate that scientific understanding to all stakeholders.

Linking Observations to Societal Benefits

Connections between societal benefits and Earth observations must be clear to both decisions makers and the general public. In the following sections, we illustrate the expected linkage between observations and societal benefits in nine specific areas.⁶ In selected cases, we illustrate how this linkage is achieved today.

Figure 1 depicts the linkage and flow of information from observations to societal benefits. Although the focus is on achievable specifics, the approach

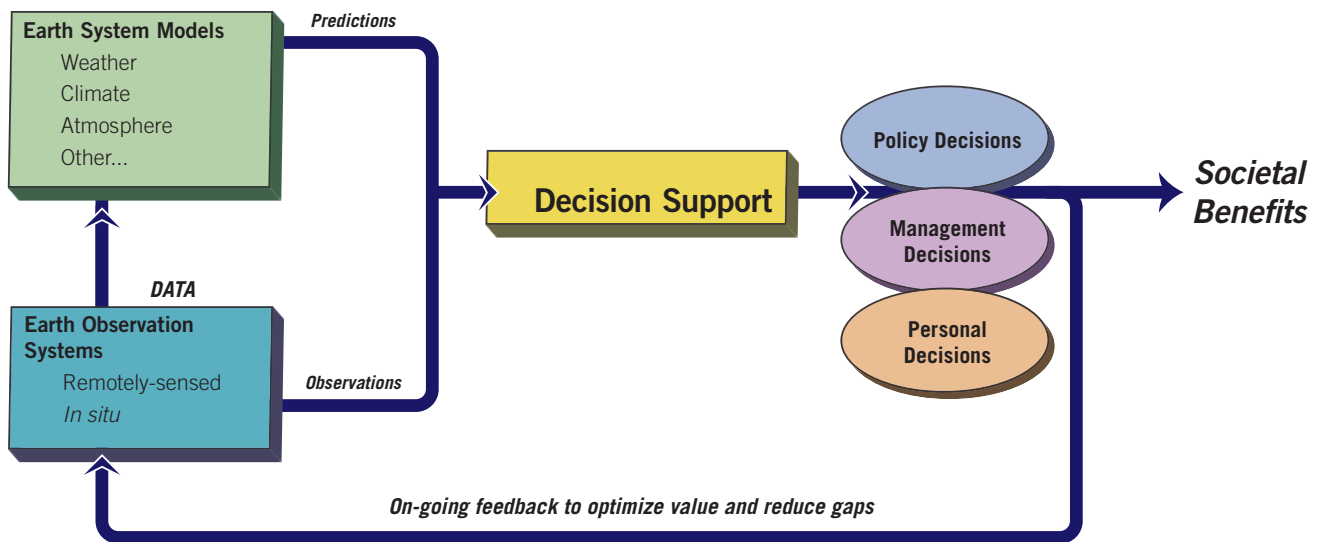


Figure 1: Linking Earth Observations to Societal Benefits

includes using a common system architecture, so that the resulting systems are interoperable and the solutions can be easily expanded, extended, and/or replicated to address future challenges.

A. Improve Weather Forecasting⁷

Weather is an important area and vital to the other societal benefits. Weather observing, along with the associated national and international data management mechanisms, is probably the most mature observing system example in wide use today. The current weather system provides billions of dollars in value to the nation in areas such as transportation safety, agricultural productivity, and energy management. Enhanced observations would greatly facilitate the weather mission in the U.S., as well as supply crosscutting information for the user requirements in the other societal benefit areas. For example, high-resolution lower-atmosphere global wind measurements from a spaceborne optical sensor would dramatically improve a critical input for global prediction models, improving long-term weather forecasting.

B. Reduce Loss of Life and Property from Disasters⁸

Natural hazards such as earthquakes, volcanoes, landslides, floods, wildfires, extreme weather, coastal hazards, sea ice and space weather, plus major pollution events, impose a large burden on society. In the US, the economic cost of disasters averages \$20 billion dollars per year.⁹ Disasters are a major cause of loss of life and property. The recent California wildfires and the Denali Alaska earthquake underline the importance of preparedness, planning,

and response. Our ability to predict, monitor, and respond to natural and technological hazards is a key consideration in reducing the impact of disasters.

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Sensors onboard geostationary satellites known as GOES supply observations used to detect and monitor forest fires every half-hour for the entire Western Hemisphere, including remote areas. This allows early detection of fires and indicates whether or not they are intensifying. During the 2001 Viejas fire in San Diego, the GOES observation product recognized the fire 15 minutes after the estimated ignition time. This product is available within minutes (<http://cimss.ssec.wisc.edu/goes/burn/wfabba.html>). To extend the fire monitoring coverage beyond the Western Hemisphere, data from the Terra and Aqua research satellites and other international polar orbiting satellites, are combined with GOES data to create a global fire map. Polar orbiting satellite data are currently used to create active fire maps for the US (<http://activefiremaps.fs.fed.us/>). Fire incident maps, generated daily for use by firefighters on the ground, require higher-resolution (usually airborne) infrared imagery, superimposed on topography of the area.
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C. Protect and Monitor Our Ocean Resource¹⁰

Ocean resources account for a significant portion of the U.S. economy, and recent estimates indicate that coastal areas provide 28 million jobs, millions of dollars in goods and services, and tourist destinations for over 180 million Americans per year. Our ability to observe and manage coastal and marine resources will continue to provide these key benefits to society. Managing ocean resources require accurate information from an integrated observing system to allow for detection and prediction of the causes and consequences of changes in marine and coastal ecosystems, watersheds and non-living resources.

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The draft recommendations of the U.S. Commission on Ocean Policy (2004), White Water to Blue Water (see <http://www.state.gov/g/oes/rls/fs/2002/15624.htm>) and other reports and studies endorse an ecosystem approach and/or a watershed approach for observation systems. These systems should be able to assess and predict phenomena such as impacts of weather events like coastal storms, oil spills, pollution, and other activities such as fishing, recreational activities, marine transportation, coastal activities and ocean drilling/exploration. Observations are needed for a wide range of physical, biological, chemical, geological and atmospheric variables within U.S. coastal regions, islands and territories, and open ocean regions. Coordination of this information obtained at various time and space scales, and from existing and planned networks, along with indicators, models and decision support systems can provide great benefits to society.
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D. Understand, Assess, Predict, Mitigate, and Adapt to Climate Variability and Change¹¹

The Earth’s climate is a dynamic system undergoing continuous change on seasonal, annual, decadal and longer timescales. Scientific evidence suggests that a complex interplay of natural and human-related forces may explain such climate variability and change. Better preparation for any impacts due to climate variability and change requires better understanding of its causes and effects. According to the National Academy of Sciences, improved global observation is a fundamental need for filling knowledge gaps in climate science. Noting that climate models are based on observations and that “the observing system available today is a composite of observations that neither provides the information nor the continuity in data needed to support measurements of climate variables,” the Academy called for creation of a long-term observing system able to fill such existing data gaps.¹² In addition, a better understanding of greenhouse gas accounting and carbon management would greatly facilitate

salinity, erosion and soil loss, fires, pests and invasive species) can help mitigate these effects on farms, ranges, and forests.

F. Understand the Effect of Environmental Factors on Human Health and Well-Being¹⁴

All the components of this integrated Earth observation system contribute to improving human health and well-being. Researchers, service providers, policy makers, and the public currently use Earth observations to understand environmental factors in order to make decisions and take actions. These decisions and actions help reduce the impact of disasters, protect and manage natural resources, adapt to and mitigate climate variation, support sustainable agriculture, forecast weather, protect areas valued for recreational, religious, or aesthetic purposes, and help prevent disease/dysfunction influenced by environmental exposures or. In the near future, the Earth observations will feed into real-time measurements of environmental factors and will further enhance the ability to predict changes in these important indicators.

The ability to predict the disease emergence and intensity has long been a dream of public health workers, economic planners and ordinary citizens. For those diseases that are influenced by environmental factors, the development of predictive models will open the door to the possibility that if one could link risk of disease with certain variables, one could eventually apply these models to predict occurrence and possibly control or prevent these diseases in human populations.

Enhanced Earth observations that lead to better air quality data and the ability to predict air pollution episodes would contribute to improvements

in human health via: reduced incidence of acute attacks and deaths from chronic respiratory diseases such as asthma; fewer air pollution-related emergency room visits; and fewer days absent from school or work. Air pollution affects the environment in many ways that ultimately impact on our health and well-being: by reducing visibility, damaging crops, forests, and buildings; acidifying lakes and streams; and stimulating the growth of algae in estuaries. Rapid development and urbanization around the globe has created air pollution that threatens people everywhere, as air pollution can travel great distances across oceans and national boundaries.



G. Develop the Capacity to Make Ecological Forecasts¹⁵

The primary goal of ecological forecasting is to predict the effects of biological, chemical, physical, and human induced pressures on ecosystems and their components at a range of scales and over time, given a certain set of assumptions. Examples of such pressures include extreme natural events, climate variability and change, land and resource use, pollution, invasive species, and human/wildlife diseases. Earth observations and relevant modeling tools help identify key cause-effect relationships. Once certain cause-effect relationships are established, the goal then is to use Earth observation information to develop management strategies and options to reverse declining trends, reduce risks, and to protect important ecological resources and associated processes. Such an approach provides critical support to long-term economic growth and sustainable development. The use of ecological indicators and forecasting will move us toward sustainable management of goods and services.

Ecological forecasting requires the acquisition of a wide range of environmental data, as well as development of models. Lifemapper (www.lifemapper.org) is an Internet and leading-edge information technology model that retrieves plant and animal records from the world's natural history museums. Lifemapper analyzes the data, computes the ecological profile of each species, maps where the species has been found and predicts where each species could potentially live. Lifemapper has been used to model and simulate the spread of emerging diseases, plant and animal pests, or invasive species of plants and animals and their effects on natural resources, agricultural crops and human populations. Environmental scientists have modeled and predicted the effects of local, regional and global climate change on Earth's species of plants and animals. Land planners and policy-makers have used Lifemapper to identify the highest priority areas for biodiversity conservation.

H. Protect and Monitor Water Resources¹⁶

The availability and quality of freshwater for humans are critical factors influencing the health and livelihood of people across the nation. Over one billion people in the world are currently without safe drinking water. Continued growth in human populations and water use, continued degradation of water supplies by contamination, and greater recognition of the needs for freshwater in order to support critical ecosystem functions could contribute to increasing scarcity and conflict over water supplies. By providing more complete and detailed water information and forecasts, people and decision-makers could make better decisions on water supplies and activities that affect humans, plants and animals.

The Great Lakes hold one-fifth of the Earth's freshwater and are one of the Nation's most important aquatic resources from an economic, geographic, international, ecological, and societal perspective. The Great Lakes continually

Chattanooga, rising from 71 degrees at 6 a.m. TVA has scheduled today's power generation based on this forecast and will bring on line a combination of hydro, nuclear, coal, wind, natural gas and oil plants as temperatures rise. It will buy wholesale electricity if that costs less than generating its own power. Gas plants are more expensive to operate than nuclear or coal, so TVA will fire up its 'peakers' only when it expects demand to be very high. If the average temperature comes in 1 degree hotter, rising to 94, TVA's customers will demand 450 more megawatts. There would be no time to fire up an idle gas plant, and the cost of last-minute wholesale electricity could skyrocket. 'There are times when electricity is \$80 (per megawatt hour) a day ahead and \$800 to \$8,000 24 hours later,' says Robert Abboud of RGA Labs, which helps utilities with complex decisions. On the other hand, if the four-city temperature comes in a degree cooler than forecast, TVA may have fired up a plant unnecessarily, or bought electricity a day in advance that will go wasted. Temperature is most important, but utilities can also benefit from accurate forecasts of cloud cover and humidity..."

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Implementation of the U.S. Integrated Earth Observation System

The development of an integrated, comprehensive and sustained Earth observation system is a challenge that requires a structured plan for development. Figure 2 illustrates the U.S. approach to implementation, which begins with the clear definition of the vision (see page 16). After considering the missions and priorities of the participating agencies, the Interagency Working Group on Earth Observations identified nine societal benefit areas. Given the vision and the societal benefits that the system will address, the next steps include definition of the functional and performance requirements (box 4) necessary to guide the development of the integrated system architecture. The final step identifies the existing and planned systems to be implemented in the U.S. Integrated Earth Observation System architecture.

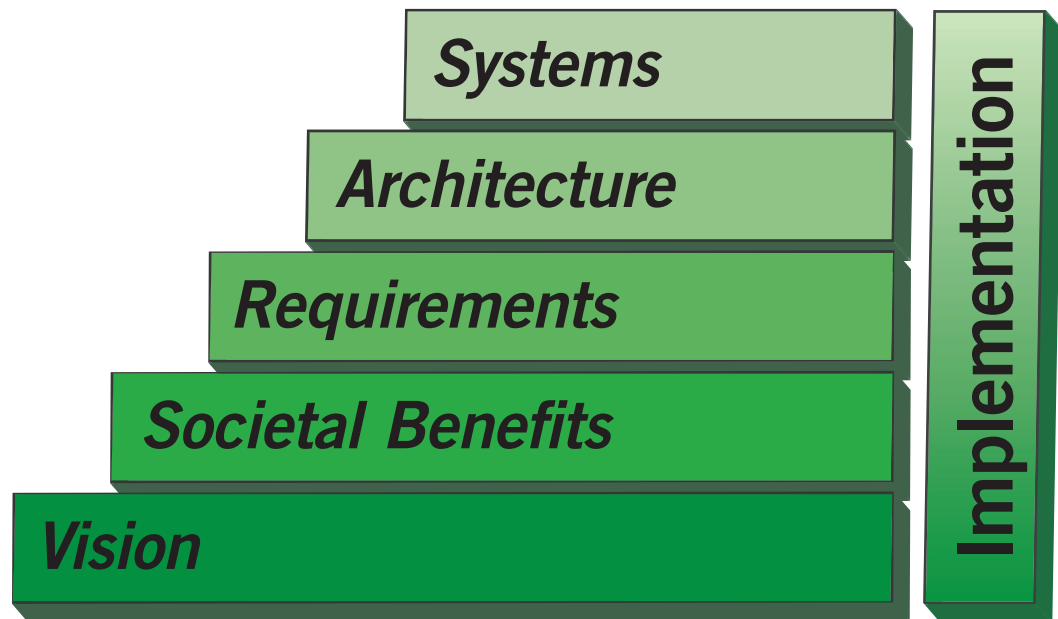


Figure 2: Approach to Implementing the U.S. Integrated Earth Observation System

- » Interface with the user community and the decision support systems they use (requirements specification)
- » Collect Earth observations (remote and in situ)
- » Manage data (includes data archiving, access, processing, communications and delivery)
- » Sustain capacity (includes research, training, and development)
- » Deliver information (tailored to the needs of the user community)

Box 4: Functional requirements.

In following this approach for implementation it is important to have a clear understanding of the scope of the U.S. effort for developing an Integrated Earth Observation System. The following bullets describe the partnerships that will be critical for the success of the U.S. effort.

- » The U.S. effort will be multi-disciplinary. It will take into consideration the interaction among multiple science disciplines, including physical, life and social sciences.
- » The U.S. effort will be interagency. It will build upon existing systems and strategies to develop a framework for identifying gaps and priorities.
- » The U.S. effort will link across all levels of government. The stakeholder capacity to use assessment and decision support tools for decision-making will be supported through education, training, research, and outreach. Building domestic user capacity is a key consideration.
- » The U.S. effort will be international. Environmental observations and science are international in scope and international cooperation is imperative both to the U.S. and global plans.
- » The U.S. effort will encourage broad participation. Many entities (public, private, and international) acquire and use Earth observations. The scope of the integrated Earth observation system will encompass the needs of these entities including the commercial Earth observation data providers, value-added intermediaries, and commercial users.

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Establishment of a U.S. Governance Structure

The joint OSTP/OMB guidance memorandum dated June 6, 2003, gave the National Science and Technology Council, through its respective agencies, the charge to “develop and implement a coordinated, multi-year plan to enhance data time series, minimize data gaps, and maximize the quality, integrity, and utility of the data for short-term and long-term applications.” To this end, a standing Earth Observation Subcommittee of the Council’s Committee on Environment and Natural Resources will be established. The Subcommittee will develop efficient and streamlined operations for the US integrated Observation System and will further the work accomplished by the Interagency Working Group on Earth Observations in leading and coordinating the implementation of this multi-year U.S. plan on Earth observations. This subcommittee will have responsibility for periodic assessment of the multi-year U.S. plan, as well as annual reports to the Committee on Environment and Natural Resources on progress and recommendations.

Consistent with the President’s Management Agenda, Federal research and development investments for an integrated and sustained system of Earth

observations will be managed as a portfolio of interconnected interagency activities, taking into account the quality, relevance and performance of each project. Working with the external stakeholder community (consistent with the Federal Advisory Committee Act), this strategy will address not only planning, management and prospective assessment, but will also seek retrospective assessment of whether investments have been well directed, efficient and productive.

The agencies, through the Earth Observation Subcommittee, will recommend priorities for investment for near-term, mid-term and long-term activities, recognizing that we may develop new requirements in addition to those already identified as critical for the societal benefit areas, and allowing for maximum flexibility as the system develops and coordination needs change. In addition, the Subcommittee will, over time, assemble its own benchmarks and metrics as self-assessment tools to effectively quantify the plan's relevance, quality and performance across societal benefits areas. The broad overlap of the societal benefits and the various agencies' missions is illustrated in Table 1, depicting agencies as users, providers, or both user and provider of relevant Earth observations.

The Subcommittee will continue to formulate U.S. positions and inputs into the Global Earth Observation System of Systems, taking into account the full range of U.S. policies and interests, and the requirements of the widest range of decision-makers, researchers, service-providers, the public, and other stakeholders worldwide.

It is clear from the data presented in Table 1 that a coordinated interagency approach to the Integrated Earth Observation System is imperative. The

participating agencies have distributed responsibilities and requirements across the nine societal benefit areas. A sustained interagency effort will ensure that effectiveness and efficiency in achieving these benefits is maximized.

U.S. Agencies Related To Societal Benefit Areas																
TABLE KEY	U.S. AGENCIES															
	DOC/NIST	DOC/NOAA	DOD	DOE	DHHS/NIEHS	DHS/FEMA	DOI/USGS	DOS	DOT	EPA	NASA	NSF	Tennessee Valley A.	Smithsonian	USAID	USDA
Societal Benefit Areas																
Weather	B	B	U	U	U	U		B	U	B	U	U	U	B	B	
Disasters	P	U	U	U	U	B	U	U	U	P	B	U	U	U	U	
Oceans	B	B	B	U	U	B			U	P	B		U	U		
Climate	B	U	B	U	U	B	U	U	U	B	B		U	B	U	
Agriculture	P		U	U	U	P	U		P	P	B		U	B	P	
Human Health	P		P	B			U		B	P	B		U	B		
Ecology	B		B	U		B	B		B	P	B		B	B	B	
Water	B		B	U	U	B	B	U	B	P	B		U	B	U	
Energy	P		B	U	U	B	P	U	B	P	U	B	U	U		

Table 1: U.S. Agencies as primarily provider, primarily user, or both provider and user of Earth observation data associated with the identified societal benefit areas.

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Policy, Technical and Fiscal Aspects of Implementation

Policy Aspects of Implementation

The strategy for implementing the U.S. Integrated Earth Observation System has three components: policy, technical and fiscal. The policy component identifies the aspects of Earth observations that will be defined as mandates or guidelines at the Federal level. Additionally, this policy component addresses data sharing and the identification of critical observations, and recognizes the requirement for decisions based on sound science and defined need. The best way to generate knowledge is through science. The critical observations are the observations essential for sound science and decision-making, and are best determined through stakeholder involvement.

A. Data Sharing

The U.S. Integrated Earth Observation System will provide full and open access to all data in accordance with OMB Circular A-130. All data (subject to applicable national security controls and proprietary rights), shall be available for the operational, research, commercial, and academic communities with minimum time delay and at minimal cost.

B. Critical Observations

The U.S. Integrated Earth Observation System will focus on collecting critical observations - elements considered of sufficient importance to mandate their collection based on their societal, economic, and scientific imperatives. Obtaining the appropriate metadata (data about the data, such as its quality and how it was acquired) will be an additional focus, enabling the effective use of all data collected. Table 2 illustrates the societal benefit areas and describes the relative importance of a selected set of specific observations.

Benefit Areas Related To Earth Observations									
TABLE KEY	Societal Benefit Areas								
	Weather	Disasters	Oceans	Climate	Agriculture	Human Health	Ecology	Water	Energy
H = High level of importance to benefit area									
M = Medium level of importance to benefit area									
L = Low level of importance to benefit area									
Earth Observations Note: This list of observations is not meant to be comprehensive									
Land Elevation/Topography	M	H	H	M	H	M	H	H	L
Land Use/Land Cover (Crops, Forests, Urban, etc.)	M	M	L	M	H	H	H	M	M
Ecosystem Parameters (Health, Diversity, etc.)	L	L	H	H	H	H	H	M	L
Fire (Detection, Extent, Severity)	L	H	L	M	H	H	H	M	L
Soil Moisture	M	M	L	H	H	H	M	H	L
Ice and Snow (Cover and Volume)	M	M	M	H	M	M	M	H	M
Land and Sea Surface Temperature	H	H	H	H	H	H	H	M	H
River Runoff (Volume, Sediment, etc.)	L	H	H	H	H	H	H	H	H
Water Quality (Contamination, Spills, etc.)	L	H	H	M	H	H	H	H	L

Benefit Areas Related To Earth Observations

TABLE KEY	Societal Benefit Areas								
	Weather	Disasters	Oceans	Climate	Agriculture	Human Health	Ecology	Water	Energy
H = High level of importance to benefit area									
M = Medium level of importance to benefit area									
L = Low level of importance to benefit area									
Earth Observations Note: This list of observations is not meant to be comprehensive									
Sea Surface Height/Topography	L	M	H	H	L	M	H	L	L
Ocean Current and Circulation	M	L	H	H	L	L	H	L	L
Ocean Salinity	L	L	H	H	L	L	H	L	L
Ocean Color (Chlorophyll, etc.)	L	L	H	M	L	H	H	L	L
Atmospheric Constituents (Ozone, Greenhouse Gases, Black Carbon, Volcanic Ash and other Aerosols, etc.)	L	H	M	H	L	H	L	H	H
Atmospheric Profiles (Temperature, Pressure, Water Vapor)	H	H	L	H	L	M	L	L	L
Wind Speed & Direction (Surface, Tropospheric, Stratospheric)	H	H	H	H	M	H	M	L	L
Cloud Cover (Properties, Type, Height)	H	M	M	H	M	L	L	L	L
Total and Clear Sky Radiative Flux	H	L	M	H	H	H	M	M	H
Solar Irradiance	L	L	L	H	L	H	M	L	L
Space Weather	L	H	L	L	L	M	L	L	H
Deformation/subsidence/ground failure	L	H	M	L	L	L	L	M	L
Earthquake and volcanic activity, Gravity, Magnetic field variations	L	H	L	M	L	L	L	L	L
Geology (bedrock and surficial) and soils	L	H	L	L	M	L	M	H	M
Species (Occurrences, density, etc.)	L	M	H	H	H	H	H	M	L

Table 2: Relative importance of an illustrative list of Earth observations to the identified societal benefit areas.

Technical Aspects of Implementation

The technical component describes the architectural approach, noting that this system will be built upon existing and planned systems and will identify and document observation gaps and needs in the societal benefits areas. Currently, most of the data and information related to Earth observations are encompassed within the U.S. National Spatial Data Infrastructure, and integration of Earth observations will be implemented within that legal, policy, and institutional framework. The technical implementation component will establish the standards, protocols, and metadata for observation systems. The strategy will also recommend the optimum operating environment and support developing the associated human and institutional capacity.

The U.S. Integrated Earth Observation System builds upon current cooperation efforts among existing observing systems (including but not limited to the physical integration of observing systems on the same platform or at the same ground site, and by sharing space platforms and observing towers on the ground for various observations), processing systems, and networks, while encouraging and accommodating new components. Across the processing cycle from data collection to information production, participating systems maintain their mandates, their national, regional and/or intergovernmental responsibilities, including scientific activities, technical operations and ownership.

For required new components, the Earth Observation Subcommittee will recommend appropriate stewardship roles. The U.S. Integrated Earth Observation System participants will coordinate with commercial, academic,

and other non-government organizations consistent with the Federal Advisory Committee Act.

A. Interoperability/Protocols/Standards

Standards (including metadata standards) and protocols will be followed for the successful implementation of the U.S. Integrated Earth Observation System. These standards and protocols will address data and metadata access, interoperability, processing, dissemination, and archiving.

Interoperability will focus primarily on interfaces, defining how system components interface with each other and thereby minimizing any impact on affected systems other than interfaces to the shared architecture. Since interoperability agreements must be broad and sustainable, fewer agreements accommodating many systems are preferred over many agreements accommodating fewer systems.

To the maximum extent possible, interoperability agreements will be based on non-proprietary standards. Tailoring of standards (profiles) will be specified when standards are not sufficiently specific. Rather than defining new specifications, system implementers will adopt standard specifications agreed upon voluntarily and by consensus, with preference to formal international standards such as those of the International Organization for Standardizations (ISO).

B. Information Assurance and Security

Services providing access to Earth observations data and products often include significant requirements for assuring various aspects of security and authentication. These range from authentication of user identity for data with restricted access, to notification of copyright restrictions for data not in the public domain, and to mechanisms for assurance that data are uncorrupted. The U.S. Integrated Earth Observation System will promote convergence on common standards for these various aspects.

C. Hardware/Software

Software capabilities will be required to support the functions described elsewhere in this document; that is, data and metadata management, data access, data transport, archive management, processing/modeling, quality control, and geospatial information systems, among others. These crosscutting functions are in addition to any software functions required to process observations.

New hardware capabilities will only be required to the extent that they fill a need for a dedicated function that is not currently provided or anticipated. From the overall system perspective, it is anticipated that several types of new or refocused data and information “centers” are possible, as follows:

- » Archive centers to acquire, preserve, and provide long-term access to Earth observation data.

- » Regional data centers to acquire and provide access to Earth observation data collected in specific geographic regions. These centers often collect a variety of physical, biological, and chemical ocean data that are used to support scientific, public, and commercial interests in the region.
- » Data assembly centers to obtain Earth observation data and provide access to it. They typically specialize in certain types of data, and often provide quality control and data products in their area of expertise.
- » Modeling centers to procure and synthesize observational data to produce products such as analyses, predictions, or hindcasts that may span a wide range of spatial and temporal scales.
- » High-performance computing centers to process anticipated high-volumes of data from next generation Earth observing systems.

D. Infrastructure/Bandwidth

The successful operation of the U.S. Integrated Earth Observation System will rely directly on the provision of a communications infrastructure sufficient to carry observations at sizes and rates ranging from point observations of a few hundred bytes to thousands of gigabytes. As a part of the inventory process that was begun by the Interagency Working Group on Earth Observations, a comprehensive sizing/timing study will be conducted to develop a multi-year communications plan. The communications plan will include milestones for rollouts of capability, including the infusion of next generation technology.

E. Human and Institutional Capacity

Support for developing human and institutional capacity is critical. The identification of user requirements and capacity gaps for the U.S. Integrated

Earth Observation System should occur early in the implementation of the plan. Capacity building efforts should build on existing local, regional, national and international initiatives. Priorities include education, training, research and outreach.

Fiscal Aspects of Implementation

The fiscal component points out the need for a process for identification of agency budgetary priorities within the framework of the Office of Management and Budget's research and development investment criteria, leading to overall prioritization of Earth observation activities. Additionally, this national strategy will address interaction with partners at all levels (interagency, state and local, intergovernmental, and private sector).

Implementation of the U.S. Integrated Earth Observation System requires specific prioritization of resources to ensure critical observation systems are developed or sustained. Prioritization of near-term Earth observation activities will be included in annual submissions to the Office of Management and Budget and the Office of Science and Technology Policy. This Strategic Plan establishes a process for the identification of agency budgetary priorities within the framework of Office of Management and Budget's research and development investment criteria (quality, relevance, and performance).

Architecture for the U.S. Integrated Earth Observation System

The necessary functions of the U.S. Integrated Earth Observation System include data collection, data management, data discovery, access, data transport, data archive, processing, modeling, quality control, and others. The development of the integrated system will be based on the following key architectural principles:

- » Supports a broad range of implementation options (driven by user needs), and incorporates new technology and methods;
- » Addresses planned, research, and operational observation systems required for participants to make products, forecasts and related decisions;
- » Includes observing, processing, and disseminating capabilities interfaced through interoperability specifications agreed and adhered to among all participants;
- » Records and stores observations and products in clearly defined formats, with metadata and quality indications to enable search and retrieval, and archived as accessible data sets; and
- » Provides a framework for securing and sustaining the future continuity of observations and the instigation of new observations.

- » Builds on existing systems and historical data, as well as existing assessments of observational needs in the specified societal benefit areas.

The Federal Enterprise Architecture Framework¹⁹ is a conceptual model that defines a documented and coordinated structure for crosscutting businesses and design developments in the government. The Earth Observation Subcommittee will develop the architecture for the U.S. Integrated Earth Observation System in accordance with the Federal Enterprise Architecture Framework.

The integrated system architecture description will be a “living” document, continuously revised under the direction of the governance process established, to account for new and evolving requirements and capabilities to meet those requirements.

Integration of Earth Observation Systems

The Earth is an integrated system. Therefore, all the processes that influence conditions on the Earth are linked, and impact one another. A subtle change in one process can produce an important effect in another. A full understanding of these processes and the linkages between them requires an integrated approach, including observing systems and their data streams. Figure 3 provides a visual overview of the integration process.

Integration is necessary and appropriate for those systems where the parts are well understood and the benefits outweigh the added scientific and/or financial costs.

The process of integration begins with these key questions:

- » Which observing systems functions are related to the identified societal benefits (a question that requires understanding user needs)?
- » What level of integration is desired and cost-effective?
- » Which observing systems functions will be integrated?

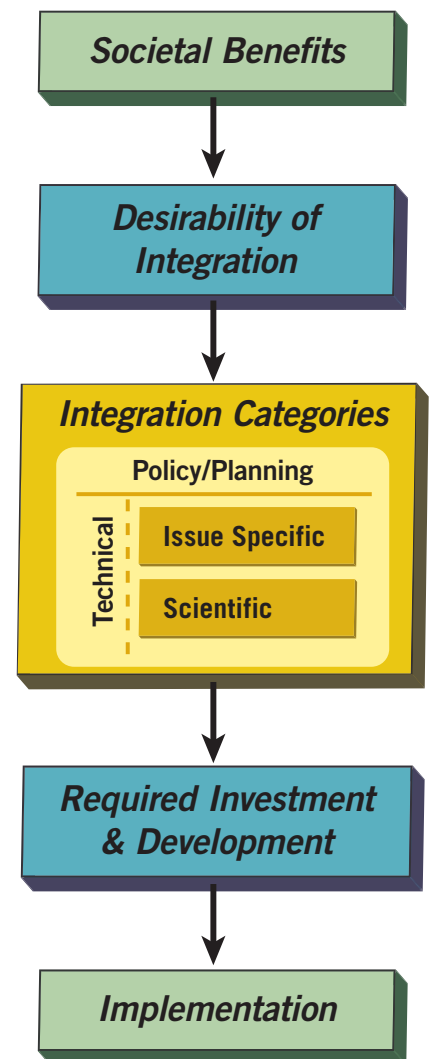


Figure 3: Overview of the Integration Process

- » Which observations need to be integrated?
- » What tools and methods will be used to accomplish the integration of the observing systems functions?
- » What plans need to be developed and implemented?

This plan starts to answer these questions by viewing integration from four perspectives:

- » policy and planning integration,
- » issue and problem focused integration,
- » scientific integration, and
- » technical systems integration.

A. Policy and Planning Integration

Policy and planning integration addresses the identification of and focus on specific societal benefit areas. In the past, Earth observing systems (research and operational) have been typically deployed for one purpose, and then adapted for other applications. In some cases, this approach has worked well, where observing systems were flexible to accommodate new users. In others, the original system design and life cycle planning have *not* matched well with secondary or unforeseen user applications, either in terms of the technical and scientific specifications or the availability of operational capabilities and capacities. The framework developed in this plan helps to lay the foundation for an integrated approach to policy development for Earth observations systems that will maximize these synergies.

B. Issue and Problem-focused Integration

Issue and problem-focused integration addresses how the U.S. Integrated Earth Observation System addresses a particular issue. In order to get from observations to societal benefits, several links in a chain need to be forged. These links include data analysis, research, process modeling, and finally development of decision support tools. The development of a decision support tool for application requires the integration of several chains of investigation of various topics. Effective communication is a crucial link between operations, science and society. The results of Earth observations need to be described in common, consistent, and understandable terms that are useful for decisions at all levels.

Drought, for instance, impacts virtually all of the nine societal benefit areas. The assessment and analysis of drought depends on measurements across many time and space scales, as shown in Table 3. Integration involves common observing, data, and analysis. The Weekly Drought monitoring reports distributed to the public, with contributions from various agencies, show how this Earth observation information is integrated across all societal benefit areas. On monthly time-scales a subset of the Table 3 data and information from three countries (Canada, Mexico, and the United States) are integrated. International integration is still in an experimental stage and considerable data and information have yet to be incorporated into comprehensive drought assessments.

Societal Benefit Areas	Important Observations	Time-scales of Interest
Agriculture	Soil moisture	Weekly
Energy	Reservoir and lake water levels	Monthly
Water resources	Ground water and lake levels/water quality	Seasonal to decadal
Weather	Circulation, water vapor	Daily to weekly
Climate	Boundary conditions	Weekly to decadal
Ocean resources	River flow	Monthly
Human health	Water availability/quality	Daily to seasonal
Ecology	Water availability/quality	Weekly to decadal
Disasters	Vegetation and wildfires	Daily to decadal

Table 3: Examples of How Drought Integrates Across Societal Benefit Areas

C. Scientific Integration

Scientific integration addresses those parts of an unresolved problem that require information across the societal benefit areas or across scientific sub-disciplines within each of the areas. An important element of scientific integration includes modeling of Earth processes.

Our understanding of Earth processes begins with scientific research. It is important that research continue to refine existing models and develop new paradigms. These models can be useful tools in defining scientific integration priorities. In some cases, research evolves in a straightforward manner to operational applications used in regularly scheduled forecasts and projections. However, when different models for the same process give differing answers, we know we have more work to do. A broader set of observations,

targeted experiments, or better knowledge of underlying mechanisms may be required to aid our understanding.

Scientific integration can be illustrated by using the example of sea level change. While measuring sea level change only requires observations, understanding why sea level is changing requires scientific integration of data from various sources. Measurements of global sea level data are needed from tide gauges and satellite altimetry. Additional data concerning the causes of sea level change include information related to the thermal expansion or contraction of the sea, which can be acquired through a variety of platforms and instruments (such as ships, satellites, buoys, expendable bathythermographs, acoustic tomography, etc.) and information related to land-ice accretion or ablation (acquired through satellites and *in situ* measurements). Data on rates of change of stored water on land are also important. To aid our understanding, all of these data and information can be integrated into land-ice models, ocean models, land-runoff models and ultimately into even broader integrated sea level models. Ongoing comparisons of model predictions with observations help improve and validate these models.

D. Technical Systems Integration

Technical systems integration addresses the coordination of observing system technology and data management systems that enable research and operational applications. Across many of the societal areas, there are common challenges that would benefit from an investment in integrated solutions. Salient among these are the following (with associated examples):

- » Information technology integration: control of the data flow (communications), processing (analysis) and standards and protocols. This includes the data protocol integration necessary for distribution of data to a variety of user applications, such as open data formats for processing data.
- » Observation platform and observation site integration: the infrastructure and the underpinning of observing systems. This platform and site integration could include: the physical integration of observing systems on the same platform or at the same ground site, such as sharing space and suborbital platforms and observing towers on the ground for various observations; and maintaining and upgrading major *in situ* networks in an orderly way.
- » Multifunctional integration: using observing platforms not only for Earth observations but also for communication. For example, the Climate Reference Network in the U.S. uses the GOES satellite to transmit real-time benchmark climate observations for a variety of applications including weather and climate.
- » Scientific and operational integration: the assurance of the continuity of the observations. Adequate mechanisms need to be developed to assure the effective transition of observation systems from research to operational status.

Integration considerations must also address observing system evolution. Observing system upgrades, new systems, system replacements, etc. all need to be considered in the context of a structured system integration approach. The significance and role assigned to models and other decision support tools in the integration process must also be considered. In some cases observing system experiments can be conducted to provide an objective, quantitative assessment of “how much something helps and contributes.” However, objective analysis is not possible in every case, and a well-disciplined subjective evaluation may be necessary.

Next Steps in Implementation

Both the establishment of an appropriate organizational structure and the development of a common system architecture are critical to the successful implementation of this Strategic Plan. The steps required to accomplish both are described below.

A. Establishing the U.S. Integrated Earth Observation System Organizational Structure

Three organizational steps must be accomplished:

- » Establish formally the Earth Observation Subcommittee (the successor organization to the Interagency Working Group on Earth Observations, whose charter terminates on November 30, 2004).
- » Commit necessary agency resources to accomplish the governance functions.
- » Implement the approved governance functions of the Earth Observation Subcommittee. The following is an initial list of governance functions that will be finalized in the Terms of Reference for the Subcommittee.
 - › Establish a process for interaction with external stakeholders, consistent with the Federal Advisory Committee Act.

- › Identify and vet requirements, both within the government and with external stakeholders, including continued review and assessment of existing and emerging societal benefit areas, architecture/ data utilization, and capacity building/ international cooperation.
- › Establish a process for prioritization of observation system investments.
- › Submit an annual report to the National Science and Technology Council that includes near-term priorities for the upcoming budget year at the end of each calendar year. Current near-term opportunities are described in Appendix 2.
- › Submit to the National Science and Technology Council the mid- and long-term activities before April of each year.
- › Establish assessment mechanisms and metrics to validate quality, relevance, and performance.
- › Assess current and potential new societal benefit areas.
- › Refine and clarify the roles and opportunities for commercial observation networks and for international systems in achieving the vision of the U.S. Integrated Earth Observation System.

B. Developing a Common System Architecture

A common system architecture is a necessary key enabler for the U.S. Integrated Earth Observation System. The following are near-, mid-, and long-term architectural steps towards the vision for the system.

The near-term architectural steps are:

- » Establish multi-year process to develop and sustain the Federal Enterprise Architecture Framework for the U.S. Integrated Observation
- » Complete an inventory of the systems included in the U.S. Integrated Earth Observation System

- » Further refine the initial mid- and long-term architectural steps.

The initial list of mid- and long-term architectural steps includes:

- » Identify candidate system solutions, consistent with the architecture framework, to deliver Earth observation information in support of the selected societal benefit areas
- » Update and maintain inventory of systems
- » Continue cooperation with the international Earth observation community and the Global Earth Observation System of Systems

The Earth Observation Subcommittee will regularly review and assess the implications of scientific and technological advances, particularly innovations that change the structure and approach to the architecture.

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Conclusion

The U.S. Integrated Earth Observation System will provide the nation with a unique and innovative perspective on the complex, interacting systems that make up our planet. This strategic plan defines the purpose and vision. It outlines a practical approach with a societal benefits focus, identifying key issues in integration and governance. This plan highlights specific opportunities ripe for near-term action by the participating agencies, and identifies the next steps in implementing the governance and system architecture.

Like the Earth, the U.S. Integrated Earth Observation System will continue to evolve. An evolving system, taking into account emerging technologies and scientific advances, is necessary to meet the changing needs of society. Implementing the U.S. Integrated Earth Observation System represents an exciting opportunity to make lasting improvements in U.S. capacity to deliver specific benefits to our people, our economy and our planet.

Appendices

Appendix 1: Interagency Working Group on Earth Observations Terms of Reference



NSTC

Committee on Environment & Natural Resources (CENR) Interagency Working Group on Earth Observations (IWGEO)

TERMS of REFERENCE

I. Purpose

The Interagency Working Group on Earth Observations (IWGEO) is hereby established by action of the Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council (NSTC). The IWGEO operates under the guidelines established by NSTC for a working group.

II. Goals

The two goals of the working group are, inter alia, (1) to develop and begin implementation of the U.S. framework and ten-year plan for an integrated, comprehensive Earth observation system to answer environmental and societal needs, including a U.S. assessment of current observational capabilities, evaluation of requirements to sustain and evolve these capabilities considering both remote and *in situ* instruments, assessment of how to integrate current observational capabilities across scales, and evaluation and addressing of data gaps; and (2) to formulate the U.S. position and input to the international *ad hoc* Group on Earth Observations (GEO) as formed at the Earth Observation Summit on July 31, 2003.

III. Functions

For Goal 1, the IWGEO will (i) examine different methodologies to develop a framework or architecture of a coordinated, comprehensive, and sustained Earth observation system and, if necessary, make recommendations to the CENR for consideration, (ii) coordinate with existing national and international bodies regarding standards for data quality and data management for U.S. contributions to a global system of Earth observations, (iii) determine what U.S. data will be included, (iv), determine gaps in U.S. data collection, and recommend actions to fill such gaps, and (v) build upon existing and evolving strategies that include an Earth observation component.

For Goal 2, the IWGEO will formulate a U.S. position and prepare inputs to the international *ad hoc* GEO. The IWG will plan and, after CENR clearance,

execute measures to implement the goals of the Earth Observation Summit and its Declaration and take all necessary steps to help ensure its ultimate success.

To carry out these functions, the IWGEO will actively solicit inputs from CENR member agencies and CENR subcommittees, as well as from other government entities and nongovernmental sources, in a manner consistent with FACA regulations.

IV. Chairs And Membership

IWGEO Co-Chairs are senior officials of NOAA, NASA, and OSTP. IWGEO membership consists of representatives from agencies with CENR membership and from other Federal government entities, as appropriate. Chairs of CENR subcommittees serve as *ex officio* members of the IWGEO, which does not exclude their possible appointment to the IWGEO by the subcommittee chair's CENR agency. The IWGEO may form a smaller Steering Group, composed of the Co-Chairs and member representatives.

V. Termination Date

Unless determined otherwise by the Co-Chairs of CENR, the IWGEO shall terminate in November 2004, upon completion of its duties to formulate and implement a ten-year U.S. framework and plan for Earth observations.

VI. Determination

We hereby determine that formation of the CENR IWGEO is in the public interest in connection with the performance of duties imposed on the Executive Branch

by law and that such duties can best be performed through the advice and counsel of such a group.

Approved:

Paul Gilman
Environmental Protection Agency
CENR Federal Agency Co-Chair

Conrad C. Lautenbacher, Jr.
National Oceanic & Atmospheric Administration
CENR Federal Agency Co-Chair

Kathie Olsen
Office of Science and Technology Policy
CENR White House Co-Chair

Appendix 2: Near-term Opportunities

Near-term Opportunities

Because there is currently no comprehensive and integrated strategy for communicating existing data, data management is highlighted as both an overarching need, and the necessary first near-term action for this integrated system. Several other near-term opportunities are identified in this section that can be supported by the Office of Management and Budget's Research and Development Investment Criteria (Quality, Performance, and Relevance), and that can be achieved in a relatively short period of time.

Clear plans have been developed for these opportunities, which are relevant to national priorities, agency missions, and customer needs. The identified observations needs are high-priority and multi-year in their goals, with tangible results easily identified. These potential outcomes cut across all societal benefit areas identified in this strategy.

A. Data Management

Requirement/Need: The U.S. needs a comprehensive and integrated data management and communications strategy to effectively integrate the wide variety of Earth observations across disciplines, institutions, and temporal and spatial scales.

Why now? There are three urgent needs for data management:

- » New observation systems will lead to a 100-fold increase in Earth observation data.
- » Individual agencies' current data management systems are challenged to adequately process current data streams.
- » The U.S. Integrated Earth Observation System, linking the observations and users of multiple agencies, compounds these challenges.

Data management is a necessary first step in achieving the synergistic benefits from the U.S. Integrated Earth Observation System described in this document.

Outcome: The expected outcome includes data management systems that are well-linked and support the full information cycle from observation acquisition to information delivery. At a minimum, the U.S. Integrated Earth Observation System must address these urgent needs by focusing on specific data management solutions:

- » Data and products will be made readily available and easily accessible by applying data management systems.²⁰ This activity will include standardizing vocabularies across agencies and developing browsing and visualization systems. Interoperability is achieved through protocols and standards agreed upon by the member agencies. These

tools will enable users to effectively locate data and information relevant to their needs.

- » The quality of earth and space-based data will be improved by building on the approaches used by previous scientific data stewardship projects (such as the satellite pathfinder data reprocessing projects) and model reanalysis projects (such as North American Reanalysis, Global Reanalysis, and Global Ocean Data Assimilation Experiments). The output of these projects can help achieve important objectives of many users: improved data integration, quality, and granularity.

Metadata will be critical to the success of any integrated data management system. Technological solutions are currently available to maximize metadata usage.²¹ Current efforts are limited to pilot projects. Emphasis must be focused on a dedicated commitment to implement these software solutions for all science and technology needs.

B. Improved Observations for Disaster Warnings

Requirement/Need: Disasters afflict all regions of the world, and improved global disaster reduction and warning is a shared, global need. Geo-hazards such as earthquakes, volcanoes, landslides and subsidence are examples of hazards where improved monitoring can provide improved forecasting. We need a complete monitoring system that supports risk assessment surveys, providing information critical to improved mitigation strategies and providing systematic and sustained monitoring of regions at risk. The greatest set of unmet observational requirements is for systematic, widespread coverage. This can best be delivered by maintaining and modernizing existing *in situ* atmospheric, ground-based, and ocean observation systems and by enhancing

our capabilities in synthetic aperture radar (SAR) and interferometric synthetic aperture radar (InSAR) systems. Applications of InSAR include robust observations of surface deformation, which complements time-continuous observations of deformation derived from GPS networks. Other major SAR hazards applications include monitoring sea ice, oil slicks, and inundation from flooding.

Why now? In many cases, *in situ* airborne and ground-based systems are not being maintained to meet research and operational objectives and are not being modernized to meet their research and operational potentials, even though plans exist for development of these systems. In the next few years, the governments of Canada and Japan will launch advanced synthetic aperture radar satellites, and there is a pressing need to work in advance on data access. Although we have demonstrated the capability through limited sporadic synthetic aperture radar (SAR) data, we currently have no operational radar satellite system that could truly help in a real-time manner, reduce hazards, help mitigate disasters, and realize goals of saving lives and reducing damage.

Outcome: Improved ground-based disaster research and warning networks, incorporating more systematic use of InSAR and exploitation of SAR's all-weather capability, will:

- » access data from existing and planned synthetic aperture radar systems by the U.S., Canada, Europe and Japan;
- » improve rapid observation of damage and landscape change caused by the geohazards;
- » provide better monitoring of land and sea ice, oil slicks, and flooding;
- » enable better forecasts, preparations, and more rapid responses to disasters; and

- » broaden access and distribution of key data sets to the relevant communities of scientists, operational agencies and decision-makers.

C. Global Land Observing System

Requirement/Need: We need a comprehensive and sustained land observing system to support land management decisions. These data are currently broadly used in a wide variety of research and management areas such as:

- » the influence of land cover on water quality,
- » the extent of urban sprawl, and
- » how best characterize biodiversity, agricultural production, forest and vegetation health, fire management, etc.

Why now? We are in danger of losing continuity of the main source of our current land observing data, Landsat, due to technological obsolescence and mission life limitations. The Landsat Data Continuity Mission has faced delays throughout its programmatic history.

Potential Outcome: A global observing system that provides sustained national and global observations of land cover and high-resolution topography from satellite, airborne and surface systems to complement the historical archive. Examples of capabilities this system should provide included:

- » High resolution digital topographic data including digital elevation maps
- » Continuity of Landsat-quality data
- » Access to commercial land remote sensing imagery

D. Sea Level Observing System

Requirement/Need: We need an operational sea level observing system to provide comprehensive and sustained sea level data and prediction of future changes in sea levels. With millions of people living near the coast, changes in sea level will be a concern to life and property, especially for barrier islands, coastal cities, river deltas, and islands. The storm surge generated by hurricanes, typhoons, and cyclones would exacerbate the effects of potential sea level rise. Improved data on global sea level rise is a high priority issue requiring strengthened international cooperation in the sustained collection of high-quality observations as the basis for sound decision-making. Currently there is no integrated operational ocean altimetry system.

Why now? We have the opportunity to transition satellite altimetry research capabilities to operational use (Jason-1). Future UAVs and other suborbital systems will provide unique opportunities to monitor processes and change in coastal regions and wetlands. Lack of timely action may prevent the effective transition of this capability to operational status. Globally averaged sea level could rise 9 to 88 centimeters over the coming century, impacting coastal infrastructure investments that are being made today.²² Alaska is already facing relocation of over 100 villages due to coastal erosion and reduced sea ice cover.²³ Critical measurements are needed immediately to validate models to properly project sea level.

Outcome: The outcome is an operational sea level observing system that allows us to:

- » Determine the rate of change in global sea level

- » Understand the interaction of factors that cause sea level rise
- » Predict future state of sea level and its impacts on coastal areas

E. National Integrated Drought Information System

Requirement/Need: Drought is a threat to the economic stability and prosperity of the Nation, and is having a \$6-\$8 billion annual impact.

Why now? We are facing the worst severe drought consequences in the western United States in 70 years.²⁴ There is an urgent national interest in better information on drought. Recently, the Western Governors' Association developed a set of requirements, through a broad-based team of Federal and nonfederal partners, for a National Integrated Drought Information System. These requirements were developed in conjunction with the National Drought Policy Commission's report to Congress and the pending Drought Preparedness Act before Congress. In addition, earlier this year, the Committee on Environment and Natural Resources Subcommittee for Disaster Reduction acknowledged its seriousness by including it as one of its eight "Grand Challenges."

Outcome: The National Integrated Drought Information System represents a comprehensive, user-friendly, web accessible system to serve the needs of policy and decision-makers at all levels—local, state, regional, and national—concerned with U.S. drought preparedness, mitigation, and relief/recovery. Research efforts seek to improve drought-related observations such as soil moisture as envisioned in National Aeronautics and Space Administration's Hydros mission. Improved drought prediction is a main emphases and outcome in National Oceanic and Atmospheric Administration

Program Plans for Climate-Weather Connections Research and Climate Prediction, and are consistent with coordinated interagency efforts, with Academic partners, to develop an integrated Earth System Modeling Framework.²⁵

F. Air Quality Assessment and Forecast System

Requirement/Need: Understanding air quality and its influence on people and the environment requires enhanced surface-based observations. Existing surface monitoring networks must be integrated with air quality observations from other platforms, including satellites, ships and aircraft, and used to develop and evaluate improved predictive models and decision support tools.

Why now? Despite dramatic improvements in air quality in the United States over the last 30 years—a period in which our population grew 39 percent, our energy consumption grew 42 percent, and our economy grew 164 percent—air quality problems have grown in many areas of the world, particularly in some fast-growing developing countries. Even with continuing air quality improvements in the United States, Over 100 million people live in U.S. counties that exceed National Ambient Air Quality Standards.²⁶ It is well known that poor air quality is harmful to the health of adults and children.

Potential Outcome: An enhanced observational system integrated with modeling and decision support tools will:

- » Improve the ability to forecast air quality across large parts of the country (and in other parts of the world) for which forecasts are not currently available
- » Provide better information about emissions and transport mechanisms on regional to the international scales

- » Provide important information to help the public avoid harmful exposures and to help air quality management better manage air pollution episodes over the short and long terms.

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Appendix 3: Technical Reports

Technical Activity Reports for the Nine Societal Benefits areas may be found at:

<http://iwgeo.ssc.nasa.gov/documents.asp?s=review>

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End Notes

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- ² Bookman, Charles A., Culliton, Thomas J., and Warren, Maureen A., *Trends in U.S. Coastal Regions, 1970-1998: addendum to the proceedings, Trends and Future Challenges for U.S. National ocean and Coastal Policy*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NOAA Oceans and Coasts, Special Projects Office, Silver Spring, MD, 1999. Also available online at http://www.oceanservice.noaa.gov/websites/retiredsites/natdia_pdf/trends_addendum.pdf.
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- ⁵ Weiher, Rodney, ed. *Improving El Niño Forecasting: The Potential Economic Benefits*, NOAA, U.S. Department of Commerce, 1997, p. 29, p. 43, for U.S. agriculture and fisheries, respectively.
- ⁶ See Appendix 3, for detailed technical reports on societal benefits areas.
- ⁷ *Ibid.*
- ⁸ *Ibid.*

- ⁹ van der Vink, G., et al., “Why the United States is Becoming More Vulnerable to Natural Disasters,” *Eos*, Transactions, American Geophysical Union, Vol. 79, No. 44, November 3, 1998, pp. 533, 537.
- ¹⁰ See Appendix 3.
- ¹¹ *Ibid.*
- ¹² Cicerone, Ralph J., et al., *Climate Change Science: An Analysis of Some Key Questions*, National Research Council, 2001, National Academy Press, pp 23, 24.
- ¹³ See Appendix 3.
- ¹⁴ *Ibid.*
- ¹⁵ *Ibid.*
- ¹⁶ *Ibid.*
- ¹⁷ *Ibid.*
- ¹⁸ Jones, Del, USA Today, “Forecast: 1 degree is worth \$1B in power savings,” June 19, 2001.
- ¹⁹ The Clinger-Cohen Act of 1996 assigned Agency Chief Information Officers (CIO) with the responsibility to develop information technology architectures (ITAs). The Office of Management and Budget (OMB) M-97-02, Funding Information Systems Investments, October 1996, requires that Agency investments in major information systems be consistent with Federal, Agency, and Bureau ITAs. The CIO Council began developing the Federal Enterprise Architecture Framework in April 1998 to promote shared development for common Federal processes, interoperability, and sharing of information among the Agencies of the Federal Government and other Governmental entities.
- ²⁰ See for instance, the Data Management and Communications System in the Integrated Ocean Observing System at http://dmac.ocean.us/dacsc/imp_plan.jsp and the National Model Access Data System.
- ²¹ Tools like Metis and Open Geospatial Data System standards are used to tie together existing observing system architecture and related metadata.
- ²² 3rd Assessment Report (2001) by the Intergovernmental Panel on Climate Change

- ²³ Robinson, Robert A., *Alaska Native Villages: Villages Affected by Flooding and Erosion have Difficulty Qualifying for Federal Assistance*, GAO Testimony before the U.S. Senate Committee on Appropriations, GAO-04-895T, June 29, 2004.
- ²⁴ See: *Climate of 2002—May Southwest Region Drought*, National Climatic Data Center, June 17, 2002, <http://www.ncdc.noaa.gov/oa/climate/research/2002/may/sw0205.html>
- ²⁵ Earth System Modeling Framework, found at <http://www.esmf.ucar.edu/>
- ²⁶ “The Ozone Report—Measuring Progress Through 2003,” EPA454/K-04-001, April, 2004.

