

IS THE VISION OF THE EARTH OBSERVATION SUMMIT REALIZABLE?

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“The United States is pleased to host more than 30 nations at the Earth Observation Summit. The participants will discuss plans for achieving the goal of building a better integrated earth observing system in the next 10 years, an objective established by the G-8 Heads of State in Evian, France, in June 2003. An integrated earth observation system will benefit people around the world, particularly those in the Southern Hemisphere. Working together, our nations will develop and link observation technologies for tracking weather and climate changes in every corner of the world, which will allow us to make informed decisions affecting our environment and economies. Our cooperation will enable us to enhance the capability to predict droughts, prepare for weather emergencies, plan and protect crops, manage coastal areas and fisheries, and monitor air quality.”

-- President's Statement on Earth Observation Summit, The White House, July 31, 2003

1. INTRODUCTION

At the Earth Observation Summit, held July 31, 2003 at the U.S. Department of State, environmental ministers from more than 30 countries joined three U.S. cabinet secretaries to plan the creation of a system for international sharing of data about the atmosphere, the oceans, and the land. The meeting grew in part out of commitments by leaders at a G-8 summit meeting in France the preceding month to build an integrated global earth environmental monitoring system.¹

In a follow-up meeting in fall, 2003, planners wrote a “Framework Document” that was subsequently adopted on 25 April 2004 at the second Earth Observation Summit in Tokyo. The document describes the principal benefits of earth observation and the fundamental elements to be included in a ten-year “Implementation Plan” to create a Global Earth Observation System of Systems (GEOSS). The plan itself will be presented at the third Earth Observation Summit in the European Union in early 2005.

The adoption of the framework document, while not binding any member or organization to any financial commitment, is intended to serve as strong indication of willingness to support substantively the creation of GEOSS. At present, financing of the “Group on Earth Observation (GEO),” the *ad hoc* working group

¹ The G-8 meeting included two additional actions on science and technology aimed at sustainable development: (1) development of hydrogen fuel cells, cleaner fossil fuels, and new-generation nuclear technologies, and (2) promotion of agricultural technologies and practices, including biotechnology, to prevent famine, enhance nutrition, conserve water and natural resources, and improve human health and biodiversity.

developing the document, is borne entirely by each member or participant. The U.S. provides administrative support. The GEO includes some 30 members and 20 “participant” international organizations (see table 1). Participant organizations represent a wide range of interests from providers of data and information such as the World Meteorological Organization (WMO), the European Meteorological Satellite Organization (EUMETSAT) and a large number of existing international cooperative observing systems such as the Committee on Earth Observing Satellites (CEOS) to entities that make use of the information for decisionmaking, such as the UN Environment Program and the Food and Agricultural Organization. The GEO works by consensus. It has established five subgroups to address architecture, capacity building, data utilization, international cooperation, and user requirements. At their initial meetings, these groups produced detailed, lengthy reports covering the scope of topics they will address (see figure 1 and table 2).

Table 1. Members, Participating Organizations, and Secretariat of the Group on Earth Observation (GEO), 2004

Source: <http://www.earthobservationsummit.gov> accessed May 2004

MEMBERS: Argentina, Australia, Belize, Brazil, Canada, China, Denmark, Egypt, European Commission, France, Gabon, Germany, India, Ireland, Israel, Italy, Japan, Kazakhstan, Mexico, Morocco, Netherlands, New Zealand, Norway, Republic of Congo, Republic of Korea, Russian Federation, South Africa, Spain, Sweden, Switzerland, Thailand, Ukraine, United Kingdom, United States

PARTICIPATING INTERNATIONAL ORGANIZATIONS: Central American Commission for the Environment and Development (SICA/CCAS), Committee on Earth Observation Satellites (CEOS), European Centre for Medium-Range Weather Forecasting (ECMWF), European Space Agency (ESA), European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), Global Terrestrial Observing System (GTOS), Integrated Global Observing Strategy Partnership (IGOS-P), Intergovernmental Oceanographic Commission (IOC), International Agency for the Development of Environmental Information (ADIE), International Council for Science (ICSU), International Geosphere-Biosphere Program (IGBP), International Group of Funding Agencies for Global Change Research (IGFA), Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Environment Program (UNEP), United Nations Framework Convention on Climate Change (UNFCCC), World Bank (IBRD), World Climate Research Programme (WCRP), World Meteorological Organization (WMO)

SECRETARIAT MEMBERSHIP: EC, Japan, South Africa, USA, Canada, CEOS, ESA, EUMETSAT, France, IGOS, IOC, Italy, WMO

Table 2. Subgroup Topics for the Group on Earth Observation (GEO), 2004

Source: Compiled from subgroup reports at <http://www.earthobservationsummit.gov> accessed May 2004

Subgroup on Architecture

- Interoperability across GEOSS
- Search capability
- Interfaces and syntax
- Quality assurance

Subgroup on Capacity Building

- Inventory of existing capacity building activities by national governments and institutions
- Education and training
- Research
- Improved infrastructure
- Communications and outreach

Subgroup on Data Utilization

- Data policy
- R&D
- Radio frequency protection
- Study of benefits

Subgroup on International Cooperation

- Coordination among countries
- Coordination among institutions
- Possible functions, objectives, criteria of a single intergovernmental group for earth observation

Subgroup on User Requirements

- User needs
- User capabilities
- User benefits

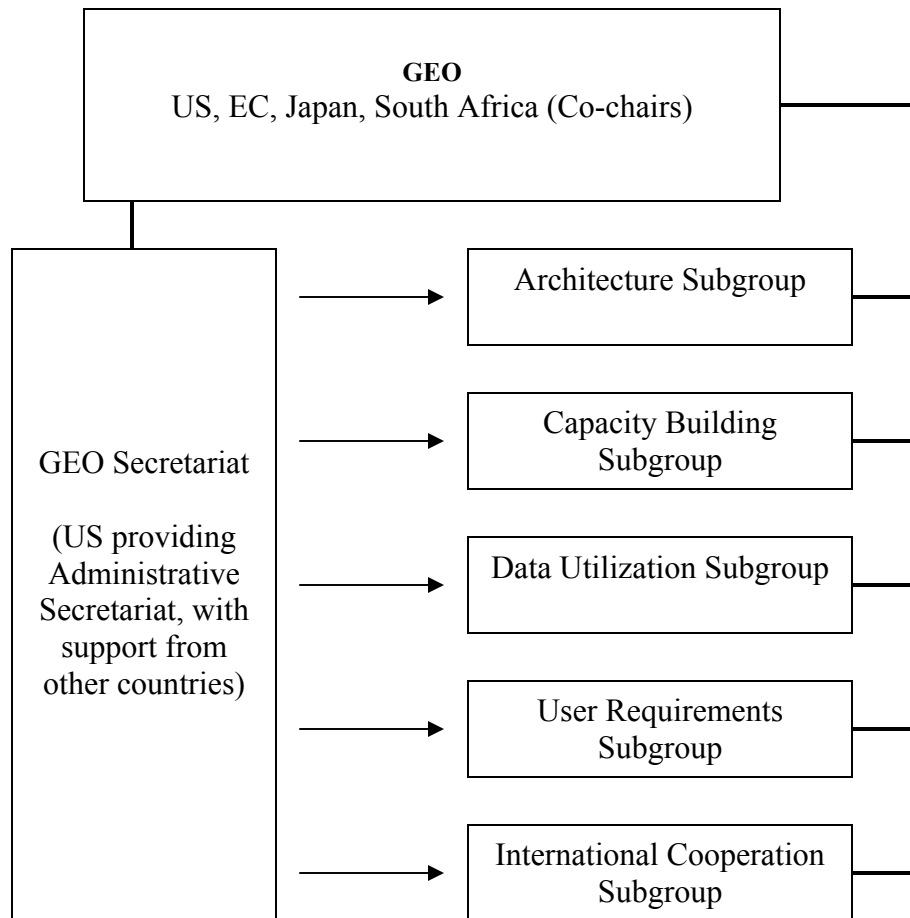


Figure 1. Group on Earth Observation (GEO) Organization
Source: <http://www.earthobservationsummit.gov> accessed May 2004.

The GEOSS is to integrate and sustain earth observations, including research and operational instrumentation, observing networks with sensors on fixed or moving platforms, communication links among measurement platforms, science modeling laboratories and applications development centers, computing capacity, and the development and provision of decision support tools, data management systems, and information products. The declaration of the 2003 Summit explicitly calls for countries to:²

- Exchange observations recorded from in situ, aircraft, and satellite networks in a full and open manner with minimum time delay and minimum cost
- Agree on the concept of an international, comprehensive, integrated, and sustained Earth observation system that will meet collective requirements for observations and maximize the utility of the system
- Establish an intergovernmental ad hoc working group to draft objectives and a ten-year implementation plan that can be revised based on periodic evaluations and updates
- Help improve observing systems in developing countries and advance the capacity building of local scientific expertise

In many respects, the objectives of the summit are hardly new and are already manifested in the charters of existing international cooperative programs on remote sensing. For example, the similarities between the goals of the summit and those of the CEOS program cited earlier as a participant in GEO working group is strikingly almost word for word (see Withee, Smith, and Hales, 2004, for detailed discussion of CEOS). CEOS was organized in 1984 as an outgrowth of the Remote Sensing from Space Working Group established by the G-7 Economic Summit of Industrialized Nations. CEOS is charged with coordinating international civil space-borne missions to observe and study earth and includes over twenty space agency members and over twenty other national and international organizational associates. Its goals are to:

- Optimize the benefits of spaceborne earth observations through cooperation of members in planning missions and developing compatible data products, formats, services, applications and policies
- Aid both its members and the international user community by serving as the focal point for international coordination of space-related earth observation activities, including those related to global change
- Exchange policy and technical information to encourage complementarity and compatibility among spaceborne earth observation systems currently in service or development, and the data received from them; issues of common interest across the spectrum of earth observation satellite missions are addressed.

Some two decades after the G-7 summit that gave rise to CEOS, the 2003 summit has revisited these goals again and returned them to a high level of international prominence after the G-8 meeting. However, the difficult challenge of realizing these goals is strongly implied by the significant effort already being expended in CEOS and other legacy programs. That the vision enunciated by legacy collaborations still remains elusive (although progress has been made) casts a sobering light on the ambitions of GEOSS.

The remaining sections of this paper discuss the rationale for and challenges of the summit's objectives. The paper is not intended to argue for or against GEOSS but rather, it considers

² See summit documentation at the summit's website <http://www.earthobservationsummit.gov> accessed spring 2004.

whether the GEOSS vision is realizable, given its stated goals, and what steps might enable further progress towards the goals. Space-derived observations seem to be the focus in summit documents prepared to date, although in-situ measurements, particularly of land surface, ecological, and human health parameters are highly important for their data content as well as their use in validating and verifying space data. Most of the examples offered in the paper use space-derived earth observation data, but the general concerns raised here about the difficulties in realizing the vision of the summit pertain to both space-derived and in situ data.

The paper also suggests a wholly different objective for the summit, namely the opportunity for GEOSS to serve as the internationally agreed technical and institutional means of *monitoring compliance* with international environmental and natural resources agreements. Such an objective is a radically different and no doubt much more politically sensitive function than envisioned at the summit. The objective is essential for global sustainable development, however, and is ideally provided by an internationally coordinated earth observing system such as GEOSS.

The next section discusses the background for GEOSS – why the G-8 found promotion of the summit to be timely during its 2003 meeting, why high levels of the US government hosted the summit, and the complications of GEOSS as a “system of systems.” The third section summarizes some of the scholarly literature on why collective action like GEOSS can fail for reasons ranging from “free riding” to fractures created by disparity among group members’ individual desires and capacities. This section also discusses the emergence of a commercial earth observation industry and its implications for and potential contribution to GEOSS. Here, protecting intellectual property by way of data access provisions is key. The fourth section looks towards the future of GEOSS in briefly addressing national security issues, frameworks for voting and financing, and the role of champions in supporting the proposed system. This section also raises the possibility of GEOSS as an international system for compliance monitoring. A few conclusions are in the final section.

2. BACKGROUND

The G-8 focus in 2003 on building an integrated global earth environmental monitoring system represents a marked increase in the level of attention paid to remote sensing during the past decade. A confluence of events is probably responsible: increasingly global environmental concern, a higher-than-ever before awareness of formerly esoteric remote sensing technology, and technological and cost-reducing improvements in space- and ground-based hardware and software. In addition, with the end of the Cold War, caution about widespread sharing of data collected from space has eroded (for example, for this perspective, see Spotts, 2003). That concern had previously extended beyond the major superpowers -- Vijay Vaitheeswaran, the environment and energy correspondent of *The Economist*, opines that developing countries “have not trusted the spy satellites of the rich world. They feared that the prying eyes in the sky would humiliate local governments by exposing the true state of their forests or, worse, would somehow help multinationals steal their natural resources” (Vaitheeswaran, 2003).

If this reasoning is correct, then the promises of the GEOSS to enhance capacity building in developing countries, as well as share data with them, will need follow-through. In particular, keeping these promises will require a commitment of financial or at a minimum, in-kind resources transferred from developed to developing countries. Financial commitments are a topic about which planning for GEOSS is silent, however. Costs appear to be deferred at this point – which also makes the initiative politically “sale-able” since it comes without a price tag.

Observers of the debate over global climate change suggest another reason for the timing of the summit. They argue that the high-level attention to the summit by the US administration (the Secretaries of Energy, Commerce, and State spoke at the summit) represented a response to criticism of having “done nothing” about global warming -- given that the administration did not support the Kyoto Protocol on climate change (see Vaitheeswaran and also, Failka, 2003). In fairness to US leadership, to the extent GEOSS is indeed able to assist efforts to resolve uncertainty over climate change, the initiative may represent a useful contribution to improved understanding of global climate and other environmental processes.

Another motivation for US government attention may be that the summit was an opportunity for the US to exercise leadership and possibly, control over an increasingly large number of earth observation organizations. By spearheading the summit, the US could use the new organization to assert national influence, support its national policy objectives, and encompass other systems -- for instance, the joint initiative between the European Commission and the European Space Agency, the Global Environmental Monitoring System.

Regardless of the mix of political, environmental and other concerns motivating support for GEOSS, it remains disturbing that GEOSS itself is dubbed “a system of systems” (in representing a grand synthesis of existing groups). A “system of systems” conjures up a potentially unwieldy collection that could easily have trouble reaching consensus, securing financial commitments, and establishing internal accountability. Members of the planning committees now at work on GEOSS acknowledge these concerns as reported in minutes of their meetings posted on the GEO web site: concerns about costs, benefits, long-term requirements, and the relationship of GEOSS with existing international earth observation groups.

3. CHALLENGES FOR GEOSS

While headline-making attention may be a necessary condition for advancing the idea of the summit, it is far from a sufficient condition for realizing its vision. Questions that underlie long-run success of the summit include

- who pays for infrastructure, training, and administration
- how common standards and protocols for technical management and coordination of systems are to be decided and financed
- how data access is to be controlled
- who is to assure continuity of support for the summit’s goals in the wake of changes in leadership over time
- what the role of the commercial sector is given its prominence in supplying remote sensing data and products to defense and civilian customers around the world.

3.1 Why collective action can fail

The concept of collective organization such as that embodied in GEOSS has a long intellectual history in disciplines ranging from economics, politics, sociology, international relations, and anthropology to biology and string theory. One of the seminal works in the social sciences is a book published in 1965 by Mancur Olson, *The Logic of Collective Action*. Olson formulated some of the first systematic hypotheses about why and how groups form (or fail to form) and whether they are likely to succeed. Olson challenged the prevailing consensus that groups simply furthered their members’ well being. Instead, he argued that groups might worsen rather than improve well being – and his reasons for this outcome are useful to consider in the context of GEOSS.

Some of the principles that can possibly serve as potential pitfalls of collective action include (see Olson, 1965, and also critique and further theoretical development in Sandler, 1992):

3.1.a. Free riding in particularly large groups. In this case, individual members may contribute less to the group than they would in a unilateral initiative for two reasons. One is because these members hope that other members will bear the burden of carrying out the organization’s aims. Another reason is because members view their own gains from membership as so small that they hold back in their contribution. In smaller groups, the actions of individual members are more easily observed by the others, reducing the incentive to free ride.

3.1.b. Fragility introduced by asymmetry or wide differences among group members’ individual desires and/or capacities.

If a member or a couple of members of the group are quite large (say, in gross national product or in earth observation technology capacity), these large members may encounter political resistance in their home country if their contribution to the system is seen as technological or financial transfers to other, “have not” or “have less” countries without commensurate benefit to the donor country(ies). The argument is much

like the argument over the U.S. participation in (and dues payments) to the United Nations (for example, see Halper, 1996 and Carpenter, 1997). Other examples are perennial questions about efficacy and fairness of the defense burden of the North Atlantic Treaty Organization (NATO) and of western alliances (the relationships among the United States, its NATO allies, and Japan) as their membership grows to include countries markedly different in wealth and military assets (for example, see O Neal, 2001; Chalmers, 2000; Hartley and Sandler, 1999; and Boyer, 1989) An alternative outcome to fragility introduced by disparities might be just the opposite effect, however. If the large group members are also the members with, say, large levels of per capita greenhouse gas (GHG) emissions or large contributions to worldwide GHG emissions, then participation in an organization like GEOSS may be politically attractive. In this case, a nation can be seen as having made a commitment to the well being of others by membership in the group. Chalmers, 2000, notes the possible benefit of a reputation effect of participation in international agreements.

3.1.c . Fractures created by interdependent choices influenced by independent, individual decisions.

Disparities among member countries in wealth, political preferences, technological capability, and in the case of climate and environmental issues, in emissions, say, can make the collective choice required of an organization highly dependent on domestic or internal decisions of the organization's members. In other words, unilateral actions by members to respond to domestic concerns and priorities can influence the group for better or for worse. The extent to which the group's objectives and actions are aligned with members' domestic preferences can determine the severity of this problem.

3.1.d. “Systematic exploitation of the great by the small” (Olson, 1965, p. 35). The examples above suggest this problem, that of the leverage that may come to be exerted by members who have less infrastructure, training, or other resources. The outcome is not necessarily bad. In fact, the President's statement on the summit, as quoted at the beginning of this paper, alludes to capacity building in the southern hemisphere as beneficial to the summit as a whole. But when disparities are thought to be leading to exploitation in the pejorative sense of that word, resentment against the organization can build within it or among outside critics.

3.2 Extending “coordination” to include the commercial sector and the experience of the WMO

The challenges of making collective action workable become additionally complex when, in addition to the government sector, relevant parties include the commercial sector.

3.2.a. Commercial earth observation. The rise of a robust commercial industry in earth observation is a relatively new development. Space-based remote sensing in the civilian sector began in 1963 with programs under the aegis of the National Aeronautics and Space Administration (NASA) and the National Oceanographic and Atmospheric Administration (NOAA). The programs focused largely on experimenting with how to build and launch spacecraft and sensors; record, transmit, and process data; and interpret data. Environmental applications of these early systems typically were to record land use, monitor the health and yields of some agricultural crops and forest stand, and identify geologic formations useful in oil, gas, and nonfuels minerals exploration. The earliest systems operated a large-scale resolution (spatial, spectral, and temporal) but new systems have the potential to be used for observing details such as chemical interactions, air particulates, and other small-scale phenomena.

The US private sector began launch of civilian remote sensing spacecraft in 1997. Foreign civilian systems are also now prominent, including programs in France, Germany, Canada, India, Korea, Japan, Russia, China, Brazil, and ESA. Most of these systems are government-owned and operated but some, such as France's Spot system and Canada's Radarsat are “quasi-commercial.” Of additional significance to an organization like GEOSS is that companies have also entered into distributorship agreements with entities in other countries. For example, Ikonos, the system operated by Space Imaging, Inc. (a subsidiary of Lockheed Martin Corp.) distributes data from Canada's Radarsat spacecraft and ESA's radar satellite. The company also has licensed Hitachi, Ltd. and Nuova Telespazio s.p.a. to be distributors of Ikonos data.

The commercial sector offers several opportunities and challenges for GEOSS. One opportunity is that the corporate sector can play an important role in R&D. William Gail, the director of Advanced Programs for Earth Science with Ball Aerospace & Technologies Group, emphasizes that a misconception is that

industry is limited in scientific understanding and algorithm development capability. He notes that industry provides a “knowledge bridge” between civil and defense capabilities, between research and operations, and to commercial technologies and processes (see Gail, 2003). This “bridge” could support several of the GEO subgroup concerns associated with ensuring realization of the socioeconomic and other value of data – of making data useful in real world application.

The advent of commercially supplied data in the evolution of earth observation expands the number of considerations for effective data policy. For example, companies have had to address the related problems of data access and data pricing to safeguard inherent proprietary intellectual property and preserve the financial viability of the companies. Two characteristics of many earth observation data may make data policy difficult to formulate in GEOSS.

The first characteristic is that for some (but not all) data, one person’s use doesn’t preclude another person’s use. Once collected and made available, weather data are “nonrivalrous,” that is, they can be shared. Some data for which this is not the case are geologic data. An oil exploration company may want to be the first to get these data and have the opportunity to drill for oil, and once that action is taken, then the value of the data for another oil exploration company may well be diminished.

The other characteristic is that once data are available, it can be hard to keep others from using them unless access is physically restricted (say, by encryption) or legally proscribed (through licensing that restricts use and resale). Data sets used by researchers can easily be placed on the Internet for other researchers to use, and excluding others from using the data can be difficult.

The problem introduced by these characteristics is how does the supplier of the data recoup their cost – ranging from the investment cost of the spacecraft, other hardware, and software to the costs of supplying the data (including, perhaps, data validation and verification). Of course, the problem of recouping cost is a problem not just for industry but also for governments facing budgetary constraints in operating earth observation systems.

These characteristics hint at a *conceptual* separation of data that are likely to be provided by the public sector from those likely provided by the private sector. The private sector may specialize in spatial, spectral, and temporal resolutions of interest to customers for which data have proprietary value. The government sector may specialize in data that have more of a public good use like measuring and modeling atmospheric temperature, humidity, radiation, and chemicals; cloud physics and tropical rainfall; earth’s gravity field; terrestrial snow and ice; sea surface temperature; and wind velocity. But in practice, the distinction between public and private data is fuzzy. Many of the phenomena in the commercial list can support civil and military applications of earth observation, and phenomena in the government sector list are useful for private customers, such as snow and ice monitoring, sea surface temperature, and wind velocity.

3.2.b. Commercially supplied data. These data are typically marketed using commercial intellectual property rules developed for images, software, and other types of information. Contracts in the US, for instance, are governed by the Uniform Commercial Code. The role of commercial data, commercial companies, and the competition and/or cooperation that arises between the commercial sector and GEOSS remains to be developed. Data with commercial value – for instance, for geologic exploration or agricultural and forestry management -- may also be of value for member countries in GEOSS but such data, because they have private value, may require protection.

GEOSS could provide an opportunity to industry for selling data to GEOSS – imagine that the US government purchases data to supply to GEOSS (see Boyer, 1989, for an interesting discussion of the western alliance as a forum in which defense suppliers essentially have new markets for trade in military assets). A less salutary outcome would be if countries in the system can supply these data or close substitutes using government systems and routinely supply the data at no charge to GEOSS. In this case, the “free” exchange of data permitted by GEOSS could cut into industry sales.

3.2.c. Existing data policy frameworks. Members of GEOSS will also find it necessary to “harmonize” different national and institutional data policies. Existing data policies range from national government

policy and policies of intergovernmental groups to United Nations principles relating to remote sensing of earth from outer space (see discussion in Pace, Sponberg, and Macauley, 1999). For example, in the US, relevant data policies include: commercial remote sensing policy such as the 1992 Land Remote Sensing Policy Act and the April, 2003, US Commercial Remote Sensing Policy issued by President Bush; the Freedom of Information Act; and NASA science policy. Taken together, these policies determine property rights and data access. They seek both to safeguard and promote commercial remote sensing.

At the international level, the remote sensing principles of the UN require that sensed states shall have access to data without any discriminatory practices and at “reasonable cost” (United Nations General Assembly, A/RES/41/65 “Principles relating to remote sensing of the Earth from space,” 3 December 1986). The principles also urge states to consult with sensed states for mutual cooperation and benefit in use of data, and that states engaged in remote sensing make technical assistance available to other interested states on “mutually agreed terms.”

Data exchange principles are also agreed upon within organizations such as the Canadian Space Agency, the European Space Agency (ESA), EUMETSAT, and the Brazilian space agency. The Canadian Space Agency retains all rights to original data from its Radarsat system and uses multi-tier pricing schemes for customers. ESA retains full ownership of rights to original data and while data access is “open and non-discriminatory,” the licenses to use the data prohibit redistribution or sales. EUMETSAT has a highly segmented pricing policy based on EUMETSAT membership, the GNP of member states, whether intended use is commercial, and whether distribution is internal or external. The Brazilian National Space Research Institute (INPE) charges prices based on recovering its cost of obtaining the data. All of these organizations are under pressure for full-cost recovery.

The members of GEOSS will need to balance simultaneously a free flow of information, the issue of data pricing and in-kind exchange of data, and for some data, strong protection of intellectual property. Each of these objectives is useful in its own right: free flow of information permits broad use, low prices permit broad use, and without intellectual property protection, commercial firms have little incentive to supply data or innovate to explore new sensors, algorithms, or other research opportunities.

3.3 A variety of solutions

To accommodate differences in publicly and privately provided data, governments participating in GEOSS could purchase, or contract for, data rights from commercial sources and then supply the data to the system, with the restriction that the data are not to be sold or made available to anyone other than “authorized” GEOSS users. Governments could contract with commercial facilities to process, distribute and archive data or to operate government instruments and spacecraft; the system could support the launch of sensors on privately owned spacecraft. GEOSS could also co-develop sensors with the commercial sector.

The World Meteorological Organization’s approach to respecting commercial data and at the same time, providing data that are exchanged without restriction or fees among nations is also a starting point for data policy for GEOSS. In the 1980s, the WMO saw two problems: the rise of commercial sector weather services and financial budget problems pressuring full cost recovery among the national weather services of member states. The organization began to formulate a data exchange policy, culminating in 1995 – more than a decade later -- in Resolution 40 (see World Meteorological Organization, 1996). Landis (2003) gives a rich discussion of the arduous nature of deliberations over the resolution.

The resolution identifies a set of essential data that members are to provide without charge and with no conditions on use; additional data on which members can place conditions on the redistribution or use for commercial purposes; and data that members are to provide without charge and without restriction for research and education but with conditions on any commercial use. Annexes to the Resolution give guidelines for the relationship between the WMO and national meteorological services (NMSs) regarding commercial activities. The annexes urge that NMSs be the point of contact for coordination between the WMO and the commercial sector. The annexes also note that NMSs with experience in working with the commercial sector should make their expertise available to other NMSs, especially those of developing countries. The annexes further request that NMSs should take into account and respect differences in legal, administrative, and funding practices of different countries or groups of countries. The commercial sector

is also requested to “respect” the international data exchange principles of the WMO; recognize the interdependence of the WMO and the commercial sector; and, interestingly, ensure that warnings and forecasts issued by the commercial sector and relevant to the safety of life and property be “consistent” with those of NMSs.

4. TOWARDS THE FUTURE

GEOSS members will need to mediate national autonomy versus regional cooperation and allay security concerns during national and international emergencies. The structure of voting and financial constraints will also come into play in investment (for instance, the GEO working group reports mention building supercomputing capacity), providing independent quality assurance or third party data validation, and capacity building in developing countries. The longevity of GEOSS will outlast most current government incumbents who are champions of the summit; accordingly, future leadership to maintain the visibility and import of GEOSS would need to be prominent. And, towards the future, the potentially crucial role of GEOSS as an international system for monitoring compliance with international environmental, natural resource, and climate agreements might be considered.

4.1 National security

On the one hand, during times of international and national security concerns, GEOSS can provide information to help settle territorial disputes, enhance regional transparency among rival states, monitor nuclear proliferation and support humanitarian relief operations. Articles in the edited volume by Baker, O’Connell and Williamson (2001) cite use of digital maps, imagery, and related technologies for boundary disputes in the Dayton peace talks in 1995 (concerning negotiations ending the conflict in Bosnia-Herzegovina) and in the 1998 peace accord between Peru and Ecuador (concerning a long-standing dispute over their border). On the other hand, these same opportunities can become obstacles depending on the nature of conflict, such as the sensitivity that might arise over use of imagery in locating nuclear test sites or the use of imagery by nongovernmental organizations during times of conflict or tension. GEOSS members could agree on security measures such as use of encryption and metadata headers both to protect distribution outside of the system for commercial sale and to invoke in times of national emergency. The system could also enter into cross-waivers such that no entity is held liable for data inaccuracy or misuse or improperly verified and validated data products.

An issue also arises when the internal national security policy of a country restricts data access. Harris (2003) notes that particularly although not only in many developing countries, the national mapping agency provides maps openly to the public and international scientists only at gross resolutions. Harris and Browning (2003) also cite the example of obstacles to exchange of data in the North Sea. Biochemical data on eutrophication associated with pollution or on accidental nuclear discharges are not shared. GEOSS will thus face the thorny issue of harmonizing its data access policy with national and other policies and practices.

4.2 Voting and financing

A controversial element in implementing any collective activity like GEOSS is the framework for and agreement upon how policies are to be advanced, resources allocated, and decisions made. Decisionmaking and voting procedures are inherently controversial, whether it is a voting system whereby each member gets one vote, or whereby votes are weighted by some criterion. In the absence of formal voting or other formal decisionmaking protocols, the default approach may be “side payments” as a means of reaching agreement -- most likely not as money but as resources in kind such as hardware, software, or training.

Financial aid will ultimately be required to fill a number of gaps in a fully functioning GEOSS – particularly if the “weakest link,” or a nation or region without adequate infrastructure, say, serves to drain the system. The unique technology of the benefits of aggregating the system as a system of systems exacerbates the weakest link problem in the architecture of the system. It can also carry over to the institutional, training, hardware, and software capacity of “have nots” and those countries that “have less.”

In addition, GEOSS will require at least minimal agreement on quality control. Harris and Browning (2003) point out that data standards are uniquely determined by the platform from which the data originate and the organization providing the data. They cite the example of Radarsat International, whose products are

radiometrically and geometrically calibrated during processing according to the company's quality standards. Data processed at other Radarsat network stations may not be certified to these same standards.

Exactly how large the costs of GEOSS could ultimately be is unknown. Information to date addresses "plugging" gaps here and there. The Canadian environmental minister reported that Canada would need some \$30 million to participate fully, including the costs of opening up a mothballed Arctic weather station (see Jaimet, 2003). Another report noted that the ARGO system of ocean monitoring buoys would need vast expansion from 825 monitoring stations to at least 3000, and that massive investment in supercomputing capability to accurately predict weather and environmental changes (see Lee, 2003). Generating any financial contribution beyond what individual members plan to finance for their own programs could be extremely difficult. In the case of the US, the forecast acute budget deficits burdened by entitlements programs such as social security and Medicare are most acute within the next ten years – the same planning horizon of the summit. Moreover, a backlash against the summit could arise once funding is requested above and beyond the discretionary accounts that support it at present.

Most international regimes use one of two approaches to financial burdensharing (for discussion, see Chalmers, 2000). One is a formula regime in which a formula is agreed and this share is contributed by each government to the overall shared budget of the organization. The other is indicative burdensharing, under which individual governments decide their contribution and spending remains under direct domestic control. In many cases, international organizations also levy an assessed contribution or tax on each member state to finance "core" activities. This gives the international organization a degree of autonomy to pursue collective interests of the members. Regardless of the approach, controversies over financing and budget allocation within international organizations are typically intense.

4.3 The role of champions

The confluence of leadership at the highest levels of government lending its support to the summit has propelled initial steps of GEOSS. This marshalling of the support of top leadership was a first for earth observation since the G-7 summit in 1984 giving rise to CEOS. Perhaps the only other precedent in a related policy and technology area was the leadership that led to the formation of the U.S. National Polar-Orbiting Environmental Satellite System (NPOESS). NPOESS was formed by the interagency merging of weather data collection satellites and facilities operated by the Department of Defense and the counterpart operated by the Department of Commerce. In that case, policymakers had considered a merger eight times before a ninth and successful attempt in 1994 (see Macauley, 2003). NPOESS marked one of the most radical institutional restructurings in the USA's government provision of critical weather information. According to D. James Baker, then Administrator of NOAA, part of the "clincher" for convergence to happen on the ninth try was not only a budgetary constraint, but the confluence of influential leadership at NOAA, DoD and the White House. In addition, leadership in the Congress supported the merger. Baker emphasized the significance of leadership by citing it as one of the most important "lessons learned" from his experience as administrator in effecting change (see Baker, 2002).

Continuing the momentum of high level leadership during the coming decade is important to realization of the goals of GEOSS. No doubt, a deepened understanding of the technology and its potential led in part to the summit. This understanding will only increase with continued innovation in the technology and in useful applications of remote sensing data, and continued cost-reducing innovation.

But other factors that initially gave impetus to the summit may diminish in influence. One is the usefulness of the summit as a politically acceptable alternative to the US's decision not to endorse the Kyoto Protocol. In fact, environmental groups argued that the summit may be intended to divert attention from the fact that the US hadn't agreed to reduce emissions of carbon dioxide and other man-made pollutants (see Fialka, 2003). If new pressures arise to endorse the protocol, critics of GEOSS may argue that the proposed system isn't adequate or fast enough as a working solution. Or, if concern for climate change and associated greenhouse gases fades from public and political agendas, and as budgetary constraints tighten, support for any climate-related initiatives including GEOSS may weaken.

4.4 GEOSS as a compliance monitoring tool and institution

In a comparison of policies for addressing global climate, Aldy, Barrett, and Stavins (2003) note that an essential criterion for achieving any policy goal is not only participation in agreements but also, compliance with them (in this case, “compliance” is the degree to which a country that is party to an agreement implements its obligations). Aldy and coauthors emphasize that this criterion is frequently ignored in environmental agreements and that in the Kyoto Protocol, it is wholly missing. Effective agreements provide either explicit protocols for monitoring compliance and penalties for noncompliance or else are designed to be self-enforcing (see Barrett, 2003, whose review of over 300 environmental agreements reveals that most have been unsuccessful because they are non-binding and therefore inconsequential. Success has only come from those with provisions for enforcing compliance). An example of a self-enforcing agreement might be one in which good behavior – that is, compliance – earns public acclaim or other reward.

By way of its supranational reach in earth observation – a reach that is both technically broad in the scale and scope of observation capability as well as institutionally supported -- GEOSS could permit closer monitoring of information that is self-reported by parties around the world and supply information for adjudicating disputes. The system could figure prominently as a means of monitoring compliance whether the policy architecture were an agreement like the Protocol or whether it included market-based policy instruments such as emissions trading, carbon taxes, or a combination of these approaches. GEOSS could provide the technical means and at least some of the data required to implement a market and conduct and monitor trades.

A related research question is the extent to which GEOSS is likely to permit monitoring, reduce significantly the costs of monitoring, compliance, and enforcement; whether the mere availability of the technologies affect incentives for regulated parties to self-report accurately, and other ways the system may change the structure and implementation of international environmental agreements. Additional questions concern the environmental conditions the technologies can sense; the timeliness, accuracy, and reliability of the technology; the implications of the ability of the technology to “observe without being observed;” and the cost-effectiveness of the technology compared with alternative sources of information (see Macauley and Brennan).

Of course, a monitoring role for the system has downsides. Governments may not be willing to grant this autonomy to an international organization serving as a supranational authority, and they may be limits on how far sovereign members are willing to give up their freedom of action.

5. CONCLUSIONS

The policy issues raised in this study may not seem problematical at this early stage of relatively low level of integration in GEOSS. At the same time, a wealth of experience – at the WMO, in data access policy, in experiences with the utility of earth observation in mediating transboundary disputes – is available for GEOSS members to tap as the planning for the system proceeds. And new opportunities for forming working and even sales relationships with the commercial remote sensing industry lend excitement to the future of earth observation in the GEOSS vision.

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