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Submitted to the United States House of Representatives
Committee on Energy and Commerce
The Honorable Joe Barton, Chairman

March 9, 2005

"The Implementation of GEOSS: A Review of the All-Hazards Warning System and its Benefits to Public Health, Energy, and the Environment"

Mr. Chairman, Mr. Ranking Member, members of the Committee, my name is Carroll Hood. I am the GEOSS Chief Architect for Raytheon Company. Today, I speak to you as the Lead of the Information Creation Committee of The Alliance for Earth Observations. I have been an active participant in the arena of environmental data management for over twenty years, both as a public servant and as a member of the private sector. On behalf of all of the members of the Alliance, I am grateful to have been given the opportunity to share my thoughts with you on this topic. I am confident that your thoughtful investigation of the potential benefits of a Global Earth Observations Systems of Systems (GEOSS) will reinforce our belief of the tremendous value that such a system could provide to both decision makers and the US economy.

I would like to begin by providing some context for my remarks; I will then discus some of the challenges and possible solutions within that context, and will conclude with some specific recommendations. I would then be happy to answer any questions that you might have.

Context

This is truly a unique time. Over fifty-five nations recently agreed to coordinate activities to develop and operate a Global Earth Observations System of Systems (GEOSS), collecting and sharing Earth observations data and information to help decision makers address important societal issues. The concept of sharing environmental observations is not novel; this goal has been pursued, albeit within discipline or domain stovepipes, for many years. What is unique about this initiative is the level of political will and support that has been vividly demonstrated over the past 18 months. Instead of a bureaucrat several layers down in a government agency/ministry representing his/her country, we now have ministerial level/cabinet-level visibility and participation, decision makers at the highest levels of government, to help bring this vision into reality. This is a tremendous opportunity.

Today we are talking about an all-hazard warning system, but there may be a more generic question that needs to be addressed. All-hazard warning is just one of a plethora of applications that a global system of systems would enable. The hurricane season of 2004 and the recent events in the Indian Ocean have underscored the gravity of this important issue. Human lives are at stake. When one observes the current as-is hazard warning processes, obviously there is room for improvement. We can do better. The fundamental question is, then, should we address this issue as a separate initiative or should we address it within the context of a worldwide environmental system of systems?

The answer to this question lies at the nexus of the fundamental reason why a global environmental system of systems is both desirable and economically beneficial. Currently, the US spends billions of dollars annually supporting the creation, operation, and maintenance of environment observing systems. These systems support the operational missions of various federal agencies, NOAA/NWS, DOT/FAA, EPA to name a few. Once these data have fulfilled their operational objective, can they be used to generate additional value for the US, our people, and our economy? In this case, value can be defined in a number of ways. The intelligent integration of environmental data with socioeconomic data, energy data, and health data, etc. will enable smarter, more informed decisions to be made that oftentimes can have profound economic and/or societal impacts. The impact of long-range forecasts of temperature and precipitation, for example, has been demonstrated and documented in a number of application areas such as drought mitigation, forest fire logistics planning, agricultural irrigation, transmission of vector-borne diseases, tourism, and even disaster mitigation. Witness the increase in the amount of warning time that the National Weather Service provides for severe weather events. I don't think that anyone would dispute that this improvement has saved lives. In addition to this, value can also be the measured as the impact of spawning new and innovative value-added products and services. Ten years ago, who would have predicted that the ubiquitous presence of the Internet would have spawned so many web-based applications? I live in Colorado, but can listen to the Tar Heels play basketball on the web within a few seconds of being live. That six-second lag is a far cry from the pre-ESPN days of waiting for the morning paper to check the score. In much the same way as the internet spawned the development of on-line applications, GEOSS (i.e., coordination of the collection of environmental observations plus improvements in our ability to easily discover, access, and exploit environmental data and information products) has the same potential to spawn a new wave of environmentally-related products and services. The spectrum of potential applications range from economic (when and where Colorado should invest in new reservoirs) to close to home (letting soccer moms plan their week based on more reliable five-day forecasts.) to retail (when do I introduce the fall product line in our New England stores?) to recreational (where can I catch the biggest fish today?) These represent a few examples; many of the applications that could be engendered have not even been defined yet (much the same as streaming audio of Tar Heel radio broadcasts was not a driving requirement for the advent of the WWW.)

In some sense, that's what the US Integrated Earth Observation System (IEOS) (the primary US contribution to GEOSS) represents. It is the development of the infrastructure required to maximize the value of Earth observations data and information resources. In most cases, these observations are already being collected! As we review our observing architecture and match that up against our national priorities, we may uncover observation gaps that may need to be filled. The cost of building any new observational infrastructure would need to be weighed against the value that such observations would generate. Thus, in general, the IEOS represents the marginal investment that would be required to enable better decisions on key issues and facilitate/encourage private investment in related products and services. "Marginal investment" is a dangerous phrase. In a budget-constraint environment, marginal investment may mean robbing Peter to pay Paul. This may be fiscal reality; we understand that difficult decisions based on national priorities must be made; however, we can only hope that both Peter and Paul have the opportunity to articulate their respective business cases, on a level playing field, and let the chips fall where they may. Thus, it is incumbent upon the proponents of a US IEOS to clearly define and articulate a viable business case for this marginal investment. We have the responsibility to quantify, to the best of our ability, value, in terms of both smarter decisions and economic stimulation. To date, we have done a poor job of doing this.

Challenges and Solutions

Building a viable US IEOS will require us to overcome many constraints and solve some fairly difficult challenges. These obstacles come in many flavors: business-related, technical, and cultural. In the previous section, I discussed one of the key business challenges. Creating a business model for the US IEOS and overlaying it onto the reference technical architecture will be a non-trivial task. Fortunately, US Industry has extensive experience in this area and can provide significant insight into the problem. Current methods of valuation (i.e., Contingent Value Method (CVM)) need to be examined within the context of a GEOSS-like endeavor. In a potential growth industry, such as the one that GEOSS/US IEOS hopes to engender, CVM may undervalue the potential benefits since many of the useful products and services have yet to be defined or developed.

From a technical perspective, there are a couple of key enablers that will give GEOSS the opportunity to succeed. The first has to do with the issue of interoperability across disciplines and domains; the second has to do with capacity building (i.e., enabling the developing world to share in the benefits of a GEOSS.) Fortunately, both of these areas are addressed to some degree within the reference technical architecture.

In the world of interoperability, there are three primary components: Syntactic interoperability, which refers to the structure of data and information products and services; semantic interoperability, which refers to the meaning of measurements and observations; and transport interoperability, which has to do with networks and data transmission. The GEOSS reference architecture addresses the issue of syntactic interoperability though avocation of relevant international syntax standards. The use of eXtensible Markup Language (XML) is a case in point. XML is a meta-language for creating tags to describe the structure of data. The inclusion of a meta-language within a system of systems architecture is a critically important point. This means that not every supplier of a certain type of data (e.g. sea surface temperature products) has to have the same physical format for their data and information products. (In the past, product format standardization was one method of improving interoperability.) A machine-readable XML representation of the internal structure would allow any user to understand and intelligently parse the dataset. In order for this to work properly, however, the issue of semantics must be addressed in parallel. Not only must a user understand the structure of the data, he/she must also understand what each data element actually means. Activities in semantic interoperability will enable producers to define the meaning of their products and services and for users to define their application space. Semantics, for example would enable a producer (and a user) to differentiate between bulk sea surface temperature vs. skin temperature, daily measurements vs. monthly averages, etc. all of which, to the uniformed user, fall into a single bucket called ‘sea surface temperature.’ Although not referenced explicitly in the GEOSS reference architecture, international standards for semantics also exist. XML-based Resource Description Framework (RDF) and Web Ontology Language (OWL) enable the development of a machine-readable representation of any knowledge domain. This machine-readable entity is called an ontology. The ability to create, evolve, and map ontologies will enable intelligent and optimized data discovery across disperate domains. Thus, the capability to leverage syntactic and semantic interoperability will be absolutely essential if we are to use GEOSS to discover, access, and integrate data from a variety of sources in order to make more informed decisions from a cross-domain perspective. This capability is also the key enabler for the market viability of products or services that cross or span discipline or domain boundaries.

The second big technical challenge relates to capacity building. Many issues are global in nature and will require both global data and a global response. Many developing nations have raised the concern that they may not be able to take advantage of the GEOSS due to their inability to support data collection or data exploitation activities. Once again, the GEOSS reference architecture provides a means to respond to this concern. The plan calls for the implementation of GEOSS services within a web-enabled, component-based architecture. Using international standards such as the XML-based Web Services Definition Language (WSDL) and Simple Object Access Protocol (SOAP) and registry protocols such as Universal Description, Discovery and Integration (UDDI), GEOSS information creation entities (the supply side) and GEOSS information exploitation entities (the demand side) can build a library of useful services that span the entire GEOSS life cycle. (data collection; product processing; metadata management; data discovery; data browse and visualization; and data integration and synthesis.) These services can be combined and/or connected to create specific value chains that will be able to meet the requirements of a variety of end-users.. As a result, no one organization or country will need a huge computational infrastructure to exploit GEOSS products and services. Although not explicitly referenced within the GEOSS Implementation Plan, it is expected that many of the basic services (e.g., data discovery; data access; routine processing; browse; simple, common integration tasks; ontology mapping; and perhaps more complex services that relate to fulfilling the "public good") will be in the public domain. More specific value-added services will likely be subject to normal market stimuli. This means that any country will be able to take advantage of the GEOSS infrastructure at very low marginal cost even if they have no data/observations to contribute to the collective.

The last set of challenges, and perhaps the most important, are the social and cultural issues. These may be the most important because they represent the biggest obstacle for us to overcome. We can technically architect a wonderfully capable system, but if the human or social aspects are not addressed properly, then GEOSS will fail. This includes the way that people, nations, and governments communicate and negotiate with each other; it has to do with our collective ability to establish, articulate, and focus on clear priorities; it has to do with our perception of the value of environmental information in our everyday lives; and it has to do with our willingness to embrace a new paradigm in which every person, every nation has the opportunity to become empowered, through equal access to relevant products and services, to make decisions that can lead to improvements in the quality of life.

Addressing these issues will be difficult. They cannot be solved by adopting an ISO standard or by developing the next “killer app”. That’s the bad news. The good news is that unlike technological issues, there is no bandwidth threshold to overcome. Driven by inspired leadership and an unwavering commitment to do the right thing, these issues can be addressed incrementally over time. Success breeds success. As we begin to make progress and demonstrate the value of environmental observations as both a means for improved decision making and a stimulus for economic growth, the required cultural shift will begin to move in the desired direction.

Recommendations

I have attempted to provide some context for the discussion of GEOSS along a brief characterization of a few near-term challenges. These items are relevant to any GEOSS application especially an activity like an all-hazards warning system. Thus, if we return to the fundamental question that I posed earlier, the Alliance for Earth Observations makes the following recommendations:

- Design and build an all-hazards warning system within the context of a larger system of system architecture. Develop the syntax, semantics, and services in such a way as to fulfill the operational objectives and to enable, facilitate, and encourage other value-added applications and services to be developed downstream.
- Proactively work the communication pathways to ensure that all stakeholders (primary, secondary, tertiary, etc) have the opportunity to contribute throughout the development and operational lifecycle.
- Utilize an incremental approach that provides early opportunities to prototype key functional requirements and demonstrate success. One area of focus will be services related to the Common Alert Protocol (CAP).

In terms of the development of the US IEOS, the Alliance would like to take this opportunity to make some further recommendations:

- The Government should establish an IEOS Program Office to serve as the formal Government focus for this activity. The Program Office should be a collaborative interagency initiative modeled after the US Climate Change Science Program (CCSP). We should continue to exploit DOC/NOAA’s inspired leadership, but find a way to leverage other initiatives at other US Agencies as we begin to entrain existing assets into the US IEOS framework.

- The IEOS Program Office should take immediate steps to instantiate a more formal Government/Industrial/Academic partnership through the Alliance for Earth Observations.
- The IEOS Program Office should use these partnerships to conduct some near-term activities
  - Development of a viable business plan for the US IEOS that includes accurate valuations of the impacts of improved decision-making and the stimulation of value-added economic activity.
  - Initiation of a system-engineering based analysis of the proposed reference architecture consistent with Federal Enterprise Architecture (FEA) constructs.
  - Development of focused test beds and prototypes that address key technological impact areas related to:
    - Syntactic interoperability issues;
    - Semantic interoperability issues;
    - Identification and isolation of existing functional capabilities into a FEA-compliant, service component architecture;
    - Development of robust, multi-sensor in-situ platforms;
    - Georeferencing non-georeferenced data that are likely to be integrated with environmental data;
    - Creation of decision support services;
    - Identification and mitigation of security and information assurance issues.

- Several of these issues cannot wait until FY07 to be addressed. Therefore we suggest the Government evaluate the following approach for supporting these activities in the near-term:
    - Opportunities to leverage FY05 discretionary funds (small);
    - Opportunities for FY06 supplemental funding (medium);
    - Strategies for an FY07 integrated approach (right-sized based on the cost/benefit established in the business case).

Thank you for giving me the opportunity to address this Subcommittee, I would be happy to answer any questions that you may have.

Summary

In order to address the benefits of an All-Hazard Warning System, we need to look at the GEOSS/US IEOS framework in more detail.

GEOSS/US IEOS will provide value in two ways:

- It will enable more informed decision making by bringing in the environmental context to many key issues and societal problem areas;
- It will encourage and facilitate the incubation of value-added products and services that will spur economic growth.

To date, we have not done a very good job of quantifying the entire value proposition related to GEOSS/US IEOS.

In order to implement successfully a GEOSS/US IEOS we will need to overcome some key specific challenges:

- Business Challenges
  - Generating a viable Business case for the US IEOS that fairly and accurately represents the true value to the US economy.
  - Overlaying the business model onto the technical reference architecture.
- Technological Challenges
  - Syntactic Interoperability
  - Semantic Interoperability
  - Creation of a web-enable, service-component architecture
- Social/cultural challenges
  - Communication
  - Perception
  - Paradigm shifts

Addressing these challenges in a coordinated way moves us forward in enable GEOSS and the US IEOS to maximize the value that it can create for decision makers and the US economy.

Based on this discussion, the Alliance for Earth Observations recommends:

- An All Hazard warning system should be developed within the context of a system of systems architecture.
- The US Government should instantiate a US IEOS Program Office
- Funding strategies for FY05, FY06, and FY07 should be developed to move our country forward.
- All funding decisions would be based within the context of the cost/benefit of GEOSS/US IEOS based on an improved business model/business case