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FEATURE ARTICLE

STANDARDS FOR A SMALL PLANET

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Abstract: Traditional standards address fixed problems, and therefore are (and must be) unchanging to be useful. Environmental and resource issues, in contrast, are by their nature dynamic, and the purpose of regulations and standards in this domain will be to change, or prevent change, in such systems. A new level of data collection will be required to create such standards, and to create the type of feedback loops that will be needed to confirm and fine tune their effects. Finally, the standards that will be required in order to meet the challenges of finite systems and a growing global population will also require that new factors – cost, political feasibility and social equity – be taken into account, using new infrastructures yet to be devised in order to reach workable solutions. Such solutions might be called "Standards for a Small Planet."

Introduction: Humanity today is facing the reality that resources are finite, as is the capacity of the world to absorb the punishment that we are inflicting upon the environment. Having passed the point where the earth's resiliency was equal to our impact, we must now achieve an understanding of the workings of the environment that is sufficient to bring our effects back within the bounds of that resilience. Doing so will be a matter of unparalleled complexity, and will require an endless process of data gathering, integration, modeling, regulation, and then monitoring to determine whether the desired effects have been achieved.

Each of these steps may require the development of new standards, but the types of standards that will be needed may not be the same as those that have been sufficient to address previous challenges. Nor, perhaps, will traditional standard setting organizations be appropriate to develop them.

Standards have historically addressed discrete tasks: from defining weights and measures in millennia past to baud rates and interfaces today. Because the problems these standards were created to solve were finite, they could be (and were) useful in isolation, often needing no coherent connection to any other standards at all, even in the case of weights and measures, as in the chaotic, ad hoc English system that evolved over time. Even where such relationships were coherent, as in the Metric system, the base ten relationships between the various weights and measures were provided for convenience rather than out of actual necessity.

The creation of standards, not surprisingly, has therefore been accomplished in discrete settings, either by governments from the days of Hammurabi to the present, in the case of weights and measures, or inside individual standard setting organizations in modern times, sometimes formed to create a single specification, or at most to develop standards for a well-delimited technical or business domain.

Today, this insular, distributed system is already being challenged by many forces, most obviously by the convergence of information and communication technologies (ICT) within the same network, and even the same device. No longer can a single standard exist in a business and technical vacuum. Instead, it may be invoked by a mobile device that may not only provide for voice communication, but also may include camera, video, Web browsing, PDA, music and other functions as well. The demands for versatility on a standard may also transcend technical compatibility issues, to involve economic and business concerns as well. For example, a standard originally designed for use in a royalty-tolerant commercial setting may now be needed in another where royalties are not tolerable, and open source licensing terms are mandated.

Standards thus increasingly have meaning within larger and more complex contexts, forcing those that create a standard to accommodate new demands, and to re-balance the concerns that would have been considered in defining the same type of standard only a short time ago with ones that have only recently emerged. Since convergence and innovation will continue, care will also be demanded to anticipate the future use to which a standard may be put.

Still, even in this broader context, a given standard typically remains only a part of a single module within a larger system. For example, the U.S. Department of Defense desires to create a global ITC infrastructure that will support the "network centric operations" of the combined armed forces of the U.S. and its allies wherever located, anywhere in the world. In this model, the data from a single source (e.g., a battlefield sensor) would become not only accessible, but would also identify itself, to those users out of more than a million individuals with network access that have the credentials to receive that particular type -- and source -- of data.

Such a vision, while imposing, still represents the pursuit of traditional ICT standards goals writ very large, since each of the standards required to meet this grand design needs only to interact with other standards in time-honored ways. Thus, while the vision may be grand and the task of creating such standards will become more complex, the nature of the demands placed upon an individual specification will remain familiar.

The traditional standards infrastructure, then, has proven itself capable of scaling very impressively. Doubtless it will continue to do so, but only to meet the increasing complexity of traditional challenges.

Today, however, significant environmental challenges are emerging that involve multiple, changing variables, and for which traditional static standards will prove inadequate. To meet this type of need, webs of standards that are dynamic rather than fixed will be required, with each individual standard interconnecting with and adjusting as required by changes in independent variables. Some of these standards, rather than serving the network, would in a sense become the network itself.

Agreeing upon and utilizing such standards will demand a new type of infrastructure as well, requiring new types of international relationships in order to marshal the means and the will to tackle issues that may only be solved through determined, collaborative action. These standards may appropriately be referred to as "standards for a small planet."

The need for a new type of standard: The definition of a standard has never been static. From weights and measures, to standards that achieve physical interoperability (e.g., train gauges and screw threads), then safety (e.g., pressure standards for boilers), performance (e.g., tensile strengths for airframe materials), and finally virtual interoperability (e.g., radio frequencies and software interfaces), the concept of the commonly agreed upon tools we call standards has continued to expand and evolve.

Most of these tools, however, could and often have incorporated somewhat arbitrarily determined characteristics, since what was needed was any, rather than a specific standard for a weight, or for the distance between railroad rails, or even for a radio frequency, so long as the exact parameters chosen lay within certain bounds of practicality. And most importantly, once fixed, the utility of a standard has historically been based upon the assumption that it would never change.

But static standards are only useful in unchanging circumstances. Indeed, a standard relies on the assumption that the physical world and the natural laws that govern it will not change. But can such a standard be useful when the goal is in fact to change, or limit the change, of the physical world as part of a continuing process, or must such a standard also adjust, adapting as the desired results are achieved (or not)?

Over the last several decades there has been a growing appreciation that the world's resources, as well as the earth's capacity to absorb abuse, are both finite. From this realization have come many new and difficult questions that raise social, geopolitical and equitable questions. If resources are finite, how should they be allocated, and who should be entitled to make such a judgment? If given actions can damage common, global resources, or result in deleterious effects such as global warming, how can this damage be prevented or moderated, and does one nation have a right to influence the actions of another? If not, how will such restrictions be agreed upon and enforced?

As yet, there are no wholly satisfactory answers to such questions when the actions required extend beyond national boundaries, although the need for such answers grows more urgent by the day. But if international consensus on these questions could be achieved, how will we decide what specific actions need to be taken, and how will we know whether they are working? And as among a variety of actions that could be taken, would we be able to determine which would be the most economical and present the most acceptable burden upon society?

Solving these problems will involve ever more sophisticated modeling that will utilize available data to project what actions will have what results (both positive and negative) on a factor by factor basis (e.g., will carbon dioxide rise or fall if we do X?), and, in turn, what those reactions will have on other factors (if carbon dioxide levels can be made to fall on average by .003% between latitudes 75 and 80 north between May and June of each year, what else changes?)

Because such downstream effects can only be estimated, there will be a need for intensive data collection in order to measure the effects of environmental protection actions taken in order to learn, in part by trial and error, what effects human actions and policies are having. As importantly, there will also need to be formulae – variable standards – that utilize these data in a feedback loop in order to indefinitely adjust regulations and policies on a constant, periodic basis. These standards will need to balance not only scientific data, but political and economic feasibility as well, in order to determine the most expedient and achievable means to the required ends.

In other words, unlike traditional standards that answer only to fixed, direct physical and cost issues, new environmental and sustainable resource standards will need to be developed via a process that incorporates not only scientific data, but accommodates forces as non-empirical as arguments for social equity between developing and developed nations – as has already been witnessed in the rancorous debate over the Kyoto Protocol on global warming.

The current state of the art: Designing such standards will involve acquiring skills that we currently largely lack. While science continues to provide grater understanding of natural processes, actual attempts to achieve sustainability have been limited to discrete resources, such as in the management of commercial fishing stocks and populations of game animals. In the case of game, there has been reasonable success. But game animals can be counted in the field and at harvest, and the legal take can be limited on an annual basis through managing the length of seasons and the number of licenses issued. Fishing stocks are harder to estimate and can be more difficult to monitor, and the ecological webs involved within which they exist are complex and hidden as well. As a result, success to date in this area has been limited at best, and many of the forces resulting in recoveries and declines remain largely a black box.

The concept of sustainability seems to have found its greatest purchase in the area of "sustainable development," which conjoins recognition of current human needs with environmental concerns and seeks to reconcile the two in a fashion that does justice to the needs of our descendants. The concept has received the formal support of the United Nations (which published the report of the Brundtland Commission in 1987 on this topic), as well as recognition by several nations (for example, France acknowledged environmental responsibility in an amendment to its constitution in 2004, as did Poland in Article 5 of its 1997 constitution).

Other activity has been taken by private industry, non-governmental organizations and other non-profits. Examples of these efforts include initiatives in areas such as ethical investing and enabling environmentally responsible purchasing (e.g., certifying that lumber products have been harvested in a sustainable, environmentally-friendly fashion). But since compliance with such standards is elective, their impact has to date been limited, relegating the role of such efforts to one of leadership rather than meaningful and systemic change.

The role of government: It would seem obvious, then, that global environmental and resource problems can only be solved through international governmental action. The leading effort to date in this area, of course, has been the multi-year effort to agree upon curtailment of global warming via the negotiation and execution of the Kyoto Protocol, which the United States has thus far declined to ratify. Despite this setback, the fact that widespread agreement was achieved at all represents a hope for the future. And while the Federal government of the United States has not committed the nation as a whole to comply with the Kyoto Protocol, individual states (such as California and Massachusetts) have moved forcefully to set environmental laws that are more strict than their Federal analogs.

Given the near-unanimous ratification of the Kyoto Protocol and the growing scientific consensus that human actions are contributing to a process of global warming, it seems likely that efforts to curtail green house gases will increase. With the commitment of governments comes the possibility of affecting real change, but the question then arises of what specific changes should be required. In the short term, the obvious answer is to seek any reductions in the most pernicious gases and substances that are politically achievable, since at this juncture in history only a reduction, rather than the elimination, of the impact is feasible.

But in the long term – ten, twenty or fifty years from today – there will need to be better and more calibrated goals that permit the maximum environmental protection to be achieved at the minimum economic cost. With more precise measurements and understanding of industrial causes and environmental effects, better calculations of the true avoided cost savings of various types of actions, such as development of new alternative energy infrastructures, will also become possible.

The concept of such an evolution in strategies for attacking environmental and resource challenges would be roughly analogous to the evolution of cancer therapy in modern times. Following decades when surgery and radiation were the only treatment options, the first efficacious chemical agents were discovered. However, the pathology of cancer at the cellular level was poorly understood, leading to the shotgun application of a limited number of harsh chemotherapy regimes to all patients that were diagnosed with a single type of cancer, identified only grossly by the organ of origin (e.g., liver or pancreas). More recently, it has become clear that in fact there are many different variations within what were previously thought to be single types of cancer, and that many of these varieties have unique points of vulnerability. With the discovery of new drugs based upon new treatment theories derived to exploit these points of opportunity, doctors are beginning to utilize more highly-targeted and efficacious therapies that match a given drug regime with the specific sub-type of cancer involved.

Working towards such a goal in the case of resource utilization and environmental protection is neither unreasonable nor impossible. Already a variety of different greenhouse gasses have been identified, and more is learned all the time which ones are most potent, and in what ways the various components of the atmosphere react with each other to reach specific end results. As more is learned, more "treatment options" will therefore become possible, as well as the prioritization of the benefits and costs of controlling specific agents.

When one takes the long view (e.g., the world that our great-grandchildren will inhabit), there is little choice but to raise the level of restrictions on our activities until equilibrium is reached, and ideally to work towards recovering lost ground. But maintaining equilibrium in a system as complex as the earth's biosphere will be a challenge indeed. Even here, however, there are analogies to be found, such as today's efforts to control national economies through the actions (in the case of the United States) of the Federal Reserve, which closely monitors and seeks to influence the vastly complex fluctuations of the marketplace through a constant process of interest rate adjustments.

As with the economy, there will need to be regulations and standards applied that are not fixed, but variable. A standard that is applied in one year may not be appropriate for even the next, as other variables change, or as the monitoring of causes and effects permits the refinement of the standards and regulations being applied.

What is to be done: If the concept of empirical and dynamic global sustainability standards is to be pursued on a systemic basis, it would require an effort of a magnitude and type not previously attempted, and would involve tasks such as the following:

Data identification: Data of may types will be required in order to support a growing global population on a sustaining basis. The following provide a representative sample of the questions that must be answered through the gathering of such data:

- ***Global warming:*** What are the existing percentages of the various substances that contribute to global warming (gas, particulate, etc.)? What is the magnitude of the effect of each, both alone and in combination with other agents? How fast are production levels of these agents changing, and who is producing them?

- ***Non-renewable resources:*** What are the technically and economically available stocks of hundreds of non-renewable resources, both energy-producing as well as raw materials for production? What percentage of each of these resources is recoverable without unacceptable degradation of the environment? What will our future needs be, and can alternatives be found as resources become exhausted?

- ***Renewable resources:*** To what extent can we continue to harvest non-domestic flora and fauna without imperiling their survival? How do human activities impact the environments upon which such species depend? How can forests be harvested in a manner that is both sustainable and environmentally acceptable?

- ***Impacts:*** What are the environmental impacts and remediation costs of the thousands of processes upon which modern society depends, from mineral extraction to processing to final disposal?

- ***Food resources:*** What is the carrying capacity of arable land? What land can be utilized within the limits of locally available water resources? What will be the impact of altering existing vegetation on the carbon dioxide cycle? What will be the transportation costs and energy demands of distributing this food, and what practical limits will such costs impose on where people can live?

Data acquisition and integration: Once identified by type and purpose, the data would need to be acquired, presumably through international cooperation and/or via new global institutions, and then integrated in a way that permits the use of that data for multiple purposes. New GIS and other standards would play a key role in this process.

Theorizing and technical modeling: When collected, the data would be utilized to generate models that would test the effects of modifying individual variables against all outcomes of concern (both positive and negative, on a systemic basis).

Economic and geopolitical evaluation: While the technical feasibility of modifying certain industrial outputs would be the first step, the economic impact and geopolitical feasibility of actually mandating such behavior would be equally vital, as would reliable, long-term public funding, immune from the impacts of changes of administrations.

Achieving consensus: Once the best alternatives were identified, they would need to be "sold" to the global community. This would involve not just buy-in to absolute goals, but resolution of the type of issues that complicated the Kyoto process as well, such as whether restrictions should apply equally to all nations (the U.S. position), or should impact less developed countries less severely than nations those that have already modernized (the Protocol's approach).

Monitoring and Enforcement: Public agreement may be more easily achieved in the future than actual compliance. Mechanisms would therefore be needed to monitor human behavior as well as the environment. Contemporary experience under existing treaties, such as the WTO and those intended to avoid nuclear arms proliferation, indicates that this will be an ongoing challenge. On a positive note, such existing mechanisms can provide a precedent for future action.

Data updating and integration: Monitoring the success or failure of regulatory restrictions at achieving desired results will be essential, because evidence of positive effects will only become clear very slowly. Thus, if limits are set too low or permitted resource utilization levels are too high, many years of damage may become inevitable before readjustment can be agreed upon and remedial actions take effect. Similarly, if controls are set strictly, the ability to prove positive results as quickly as possible (however minor) will be vital in order to maintain the global will to accept such restrictions.

Standards readjustment: Over time, the system will need to be adjusted on a periodic, ongoing basis, as normal variables take effect (e.g., natural weather cycles), as global development occurs in unexpected ways (e.g., regional population spikes and dips), as catastrophic events (e.g., volcanic eruptions) have temporary impacts, as new industrial processes are devised which have new environmental effects, as data collection efforts become more sophisticated, and as the interrelationship between variables becomes better understood.

System requirements: What would be required to enable such an effort? At minimum, the following:

- ***Critical Mass:*** Participation by a sufficient number of nations, measured by aggregate impact, would be essential in order to ensure that the effort could be successful rather than merely symbolic. This participation would involve not only the willingness to accept restrictions, but cooperation in data collection as well.

- ***Methodology:*** Agreement would be needed on whether globally mandated restrictions or nationally determined strategies would be utilized. The answer might vary on a problem-by-problem basis. For example, a cod is a cod, but various gases contribute to a single problem, and one nation may find one more economically palatable to curtail than another.

- ***Authority:*** The participants would need to agree to permit international inspection and monitoring of compliance, as well as agree to submit to sanctions for a failure to comply.

- ***Structure (political):*** Either a United Nations agency, a new treaty organization, or a body of a wholly new design would be required to provide the venue within which agreement could be reached and through which compliance would be enforced.

- ***Structure (science):*** A global organization, or alliance, would be needed to collect, integrate and update data, as well as to perform modeling and ratify recommendations for political adoption, as well as to fine-tune the standards derived and approved over time. Ideally, a single organization (rather than each nation individually) would perform this function and release the data upon which restrictions would be based, to lessen the likelihood of disputes. Such an organization would need to be apolitical and immune from external influence to the greatest extent possible.

- ***Structure (standards):*** At every step of the way, there would be the need to identify and use existing standards, as well to create traditional and dynamic standards for data measurement, analysis, limitations, and monitoring. Creating and integrating these standards will likely require not only the creation of new standard setting organizations, but also a level and type of cooperation between existing standards organizations and governments that has not been required to address historical problems.

Conclusions: Is such a process so Herculean as to be unimaginable? The first reaction would be to say yes. But the more sobering reflection is whether we have any choice but to undertake it. Even if global populations were to stabilize in the future, it is hardly probable that stasis could be achieved at a number that is not billions higher than at present. Certainly there can be no doubt that, absent significant changes in our behavior, our existing resources and the resilience of our environment would be insufficient to withstand the onslaught of nine billion people, each hoping to enjoy the life style of a typical American.

On a more hopeful note (depending upon one's point of view), the challenge we face is not monolithic, but rather a host of nested imbalances that need to be redressed. While global warming has garnered the lion's share of recent headlines, there are countless smaller issues within the over-all fractal pattern of environmental degradation and resource depletion, from the die-off of coral reefs to the destruction of rain forests. Although each of these issues represents its own set of challenges that must be understood and resolved, each also represents its own test bed from which much generic expertise will grow and transferable discoveries will be made in a new discipline that may come to be known as "sustainability science."

As such experience does grow, scientific tools and standards will be devised to make use of this experience. Hopefully the necessary political will and international structures will evolve as well. Perhaps as the simpler challenges are successfully addressed, public determination will grow, and the mores of society will permanently settle into a state where maintaining sustainable balances will become an unquestionable mandate.

And if not? That is not a question with an answer that is pleasant to contemplate. Truly, the credo of NASA is one that might usefully be appropriated for this effort: Failure is not an option.

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