Frontiers of the Future
Madmen, Methods and Massive Change

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The organizers of this session have asked me to address both methods and substance in my talk this morning: methodologies we have used, scenarios we have constructed, and key forces to which we should pay attention in our futures analyses. This agenda leads to a kind of counterpoint, a dialog, between method and substance.: madmen, methods, and massive change.

Behind my remarks lies a three-year study that the Millennium Project completed earlier this year, designed to identify science and technology developments of importance in the next 25 years and how the evolution of these developments- startling, discontinuous, capable of irreversibly changing the human condition- and their risks, might be managed. Using this study as the backbone of my talk, with the addition of a few sidebars, will give me the chance to talk about methods within the context of a real application, some important changes that seem to be in store, and as you'll see before I'm done, madmen and their possible influence on the future.

I'll start with a side bar. (sidebars appear in this text in a different and smaller typeface) The Millennium Project under which this study was conducted is a management experiment itself. Now in its eighth operational year, it is under the umbrella of the American Council for the United Nations University. The Project, first conceived by my old organization, The Futures Group, was created through a three-year feasibility study funded by the US Environmental Protection Agency, UNDP and UNESCO. The feasibility study crystallized the purpose of the Project as improve global thinking about the future and making that thinking available through a variety of media. Today, the Project accomplishes these ends by identifying and studying key global challenges. The project *is not* a one-time study of the future, but provides an on-going *capacity* as a geographically and institutionally dispersed think tank.

A particular strength of the Project is the cooperation it receives from organizations and individuals around the world. These cooperating groups are called project "nodes"; they translate and administer questionnaires and conduct policy-maker interviews in their regions. Current Millennium Project nodes are located in Beijing; Buenos Aires, Cairo; Calgary; Caracas, Helsinki, London; Madurai & New Delhi,; Maui,; Moscow ; Paris, Prague, Rome, Sao Paulo, Tehran, Silicon Valley, Columbia, Berlin, Kuwait, and Tokyo. Within their regions, these nodes translate the Projects questionnaires, administer interviews, and interpret findings in terms of local perspectives. Through their cooperation, over 1,500 futurists, scholars, decision-makers, and business planners from over 50 countries have contributed their views to the Millennium Project research.

Now to the S&T study that forms the backbone of this paper. Two principal methods were employed: a modified global Delphi using the Millennium Project's nodes and scenarios. These techniques are steps along a forecasting continuum that began with the Greeks or before and have progressed to today's methods. In a very small nutshell, forecasting has moved in overlapping waves from divine revelation, to physical signs that were supposed to reveal the future, to fictional utopias (now evolved to normative scenarios), to genius forecasting where the future sprung from inspiration and intuition, to the synthesis of expert opinion (using Delphi, for example, and in recent national foresight studies), to games and systems approaches using mathematical models beginning with Newton and progressing to non linear systems simulation. A very significant recent fork in the road came with deeper understanding of the behavior of non linear systems. Imagine a system that could be described deterministically, that is whose next points could be computed with an equation. Drive that system to near chaos and despite its deterministic structure, future points appear random. History is no indicator of the future and the pieces no longer sum to the whole. In short, for systems in chaos, forecasting is virtually impossible.

Most real systems can behave this way. With this realization, it is no longer appropriate to think about forecasting a future, or even a plurality of futures, but rather to contain our appetites to understanding ranges, uncertainties, risks, options, opportunities and threats. The next focus in this evolution of methods, I believe, is on methods that allow consideration of very large numbers of alternatives and permutations and from this and other advances in psychology and knowledge of brain processes, improved decision making. As you'll see, I consider this the frontier of futures research.

The central objective of the study of the future of S&T was to seek a broad range of international perspectives on the emerging issues and forces that are likely to influence future science and technology programs and their management within the next 25 years. It was conducted over three years, as follows:

- In the first year we asked: What are the important questions about evolving science and technology that ought to be asked and answered? The technique employed was to convene several workshops of science attaches in Washington (as far as we know this is the first time such meetings took place) and subject the principal conclusions to scrutiny and extension in a two round Delphi type study using the Project's global resources.
- In the second year we sought to identify implications of the first year's results for S&T management through worldwide policymaker interviews.
- Finally, in the third year we created scenarios to make the policy consequences of science management techniques- from lesse faire to draconian control- explicit. Here the method was an innovative 2 round questionnaire which allowed the global participants to participate in the construction of the scenarios.

Here are a few of the key questions and some answers of the panel from the first year's work:

What challenges can science pursue whose resolution would significantly improve the human condition?

- Commercial availability of a cheap, efficient, environmentally benign, non-nuclear fission and non-fossil fuel means of generating base-load electricity, competitive in price with today's fossil fuels.
- Simple, inexpensive, effective medicines and corresponding delivery systems to treat widespread diseases and epidemics.
- Improving the efficiency of water use in agriculture by 75%.
- Climate change—understanding and solutions.
- Improvements in early detection and tracking systems of pandemics.

What future applications of science or scientific research have the greatest potential for danger to human survival?

- Accidentally or intentionally released genetically modified organisms that have serious adverse consequences for the biosphere.
- Use of biotechnology to build new kinds of biological weapons of mass destruction.
- Nanotechnology to build stealthy new means of killing large numbers of people.
- Loss of biodiversity resulting from aggressive, exclusionary marketing strategies encouraging the use of genetically altered, patented varieties.
- Intelligent nanotechnology evolving beyond human control.

What are some seminal, key, or profound scientific developments that might occur during the next 25 years?

- Fusion or some other forms of cheap, abundant power with minimal adverse environmental consequences.
- Discovery of the underlying principle, "the final theory" that links quantum physics and relativity to explain the range of particles and forces that make up the universe.
- Computers that achieve awareness and can evolve.

What are the key emerging international issues in S&T over the next 25 years?

- International scientific boards that define terms, standards, and measurements for environmentally friendly technologies and their production.
- Public ownership of intellectual property critical to serve the public good.

How can science improve management of the risks induced by scientific research and its applications?

- Establish an ongoing forecasting and risk assessment system.
- Require investigators to forecast plausible unintended consequences of their research and to address the means for minimizing these developments as a routine part of their research.
- Establish UN agreements to avoid taking catastrophic risks in civil society and economic dcisionmaking, like building old design nuclear fission plants.

Some unusual expectations also came from the panel and in this discussion of forces for change should be mentioned:

- Improving collective intelligence and reducing anti-social behavior.
- Psychological /sociobiological research on violent behavior
- Developing a science and technology of governance.
- Tailored psychotropes.
- Increased private sector control of research and development.
- Radically better understanding of quantum phenomena.
- Human appendage regeneration.
- The "final theory" linking quantum physics and relativity.
- Human-computer symbiosis, brain boosters.
- Microprobes that can be deployed in extreme environments.
- Increased use of non-rocket means of low cost space propulsion.
- Altering genomes to create new or revive old species.

Another sidebar. Underlying the questions developed in the first year and the panels' answers, is the assumption that science is accelerating. And that the pace of acceleration itself is increasing. Why should this be? I believe that there are several factors causing this "take off.": new instrumentation, a remarkable synergy of disciplines (particularly nanotechnology, biotechnology, information technology, and cognitive science (NBIC), improved communications and very general availability of information. This is a global phenomenon and public awareness and attention to the possible effects of these changes have grown as well. This public attention is focused less on the "gee whiz" factors and increasingly on the unintended dangers of science, misapplications of technology, and the need for solutions from both science and technology to pressing global issues. As a result, many governments, universities, corporations, and NGOs have increased their attention to setting science and technology (S&T) policy and priorities (some by using national foresight studies) and the processes by which policies and priorities are determined. Thus far, these processes have tended to be national or limited in scope and have not taken into account priorities of others as much as seems warranted in an interdependent world.

But imagine where we stand: On the occasion of the decoding of the human genome, Craig Venter, the CEO of Celera (the commercial Human Genome project), said, "Today...marks an historic point in the 100,000-year record of humanity." Venter's counterpart at the government's Human Genome Project, Francis Collins, said "we have caught a glimpse of an instruction book previously known only to God."

Ray Kurzweil, writing in Scientific American (July, 2001) sees the progression of this meshing of computers and nanotechnology leading, by 2029 to a $1,000 PC having the capacity of 1,000 human brains. A time when 99% of all computing capacity will be non-human

Marvin Minsky of the Artificial Intelligence Laboratory at MIT describes the possibility of atomic scale assembly machines that can copy themselves and produce a billion more machines in a year, each born with the memory of the machines that went before. Talk about a population explosion: the "gray goo" problem- small machines reproducing themselves like the sorcerer's apprentice- but each "born" with all of the accumulated knowledge to that point.

There are other synergies as well giving rise to this accelerating change. Consider, for example, the junctures between:

- Pharmaceuticals, Biotech, Computers, 3 D Visualization
- Nanomedicine: Nanotech, Delivery Systems, Electronics
- Biology- Nanochips
- Brain Physiology- Artificial Intelligence
- Materials- Electronics- Carbon Nanotubes
- Genetics- Information science
- Social Science- Computer data bases
- Quantum physics, Cosmology:

Back to the study. The second year's interviews focused on future management issues. There were two schools of thought about controlling S&T risks.

> One school believed that regulations would simply drive research underground or to other countries. Regulators would have no chance to keep up with the accelerating pace of advances. The way to manage risks was to educate global opinion about S&T and to train scientists to be more ethical and to self-manage risks.

> The other school believed that the potential scale of intended and unintended impacts of S&T on the future of humanity requires that there be global systems to forecast and assess the risks from S&T and to design regulations and enforce agreements. Since the impacts can be worldwide, global systems are justified. Over the next 25 years the potential S&T dangers are clearly global; therefore the control must be global. Some threats to human security should be banned, while others should be controlled

A synthesis of these two orientations led us to form a sketch of an International Science and Technology Organization devoted to S&T risk management. It had these interdependent elements:

- OTA revisited
- Evolves from an information system
- De facto regulator
- Aspects of ISTO:
- Form international guidelines with eminent experts
- Provide access to information about risk and opportunity
- Create a global S&T fund
- Produce annual Davos-like S&T forums
- Engage media and politicians to improve S&T discussion
- Create international treaties as consensus evolves.

The third year's work was devoted to forming scenarios that depicted the S&T management issues of the future. A scenario is not intended to be a forecast, rather, it is a plausible description of what *might* occur, or in the case of normative scenarios, what ought to occur. They focus attention on causal processes and decision points. A set of internally consistent scenarios that spans a domain of interesting possibilities is useful for another reason: if policies can be found that work to advantage in all of the "worlds" depicted by the individual scenarios, these are good bets and their success may be independent of the uncertainties of the future.. RAND is currently doing interesting work in developing computer model augmented scenario models that produce a panorama of alternatives, considering as many permutations as feasible, and searching for optimum policies determined by explicit criteria, from among the thousands of possible future histories.

The scenarios in our study were created using a novel process. The method allowed the global panel to contribute to the creation of scenarios so that their perceptions about the causal links and policy issues could be reflected concisely in the final scenarios. In the first round, the panelists were asked to nominate and judge the importance of themes, that is, driving dimensions for the scenarios. The themes that were selected for use were:

- *The Government Regulation Axis*
- *The Speed of Science and Technology Axis*

- *The Public Concern Axis*
- *Whether of not the regulatory system "worked" or did not work.*

Considering only these four drivers with two possibilities each (in reality there are many more possibilities) some 16 permutations are possible. Four of these were selected as being most interesting for the initial framework.

	Centralization Of Regulation		***Public Support Of Science***		***Functioning of Regulation***		***S&T Speed***	
Scenario	High	Low	Pro	Anti	Works	Fails	Accel	As now
1. S&T Develops a Mind of Its Own		X	X		X		X	
2. The World Wakes Up	X		X		X		X	
3 Please Turn off the Spigot.	X			X	X		X	
4. Backlash		X		X		X	X	

Given these four frameworks, the respondents were presented with scenario sketches. We hoped to assure parallelism and consistency among the scenarios by using extensive checklists of potential developments from prior work. The respondents were asked to provide judgments about what changes would make the given scenarios more plausible. They were also asked to answer some specific questions, in the context of the scenarios, that would be useful in building more elaborate descriptions.

The answers to these questions are interesting in themselves. The numbers in the last two columns represent the percentage answering "yes" or "no." Approximately 115 people responded.

Question	Y	N
1.2 Are dramatic increases in collective human-machine intelligence plausible within 25 years?	70	30
1.4 Is it likely that organizations designed to regulate the course of S&T will generally fail to keep pace with accelerated advances of S&T within 25 years?	78	22
2.2 Is it plausible that weapons of mass destruction will be available to single individuals within 25 years?	72	28
2.3 Is it plausible that advances in cognitive science, information technology, and new educational systems and/or changes in older ones will be able to significantly improve tolerance for diversity within 25 years?	63	37
2.4 Is it plausible that international S&T treaties and regulations will have provisions for enforcement police enforcement or military intervention within 25 years?	67	33
3.2 Can S&T regulators and commissions be virtually free from corruption?	28	72
3.3 Is it plausible that an anti-science movement will be as or more powerful than the environmental movement?	37	63
3.4 Is it plausible that international systems (like the International Atomic Energy Agency - IAEA) will be established to monitor and regulate biotechnology, nanotechnology, and other areas of scientific research and development with enforcement powers?	75	25

4.2 When extreme unintended consequences are involved, can a cost-benefit trade-off be logically made?	41	59
4.3 Within the next 25 years, might scientists in the future unite into a global labor organization?	29	71
4.4 Can science disciplines effectively self-regulate?	42	58

In the second round, the participants were given an expanded set of scenarios, amended from the first round on the basis of the respondent's comments and suggestions. The form was partially "fill in the blanks." Participants were given the option of completing the questionnaires on line, and as before, respondents were asked to comment on the plausibility of the scenarios, how they might be improved. More than 100 pages of commentary were received.

The answers provided by the participants led to the formation of the completed scenarios that appear in the CD ROM. Compressed versions of the scenarios appear in the Appendix. Briefly, the scenarios were:

Scenario 1: S&T Develops a Mind of its Own:

The rate of scientific discoveries and advanced technological applications explodes. A global science/ social feedback system is at work: science makes people smarter- smarter people make better and faster science. Better and faster science open new doors to discovery- new doors lead to synergies and solving of old roadblocks. Removing the roadblocks creates new science that makes people smarter. S&T moves so fast government and international regulations are left in the dust. And so it goes.

Scenario 2 The World Wakes Up:

The murder of 25 million people in the mid-2010s by the self-proclaimed Agent of God who created the genetically modified Congo virus, finally woke up the world to the realization that an individual acting alone could create and use a weapon of mass destruction. This phenomenon became known as SIMAD- Singles Weapons of Mass Destruction (This is the madman in the title of this paper) Regulatory agencies and mechanisms were put into place to control the science and technology related dangers that became apparent. Education was a big part of the answer, but connecting the educational systems with the security systems is disturbing to some people. Nevertheless, individual acts of mass destruction thus far have been prevented. International and government regulations do manage the S&T enterprise to the public good

Scenario 3 Please Turn off the Spigot.

Science is attacked as pompous and self-aggrandizing, as encouraging excesses in consumption, raising false hopes, and worst unexpected consequences that can destroy us all. Particularly worrisome was accidentally or intentionally released genetically modified organisms and the potential for weapons of mass destruction. The poor were ignored. A science guru arose to galvanize the public. A global commission was established but failed because of corruption. But a new commission with built in safeguards seems to be working..

Scenario 4. Backlash

Control is low and science moves fast, but negative consequences cause public alarm. The golden age of science is hyped by the media, but it all proves to be a chimera. Some of the most valued discoveries and new capabilities have a downside and surprises abound. Rogue nations take advantage of some of these shortcomings. The level of concern rises. Mobs protest. Regulation fails. Progress stalls. And corporate (or government) scientists frequently feel pressure from within

their organization. Both corporate and government organizations cannot be counted on to self-regulate. What's next?

The completed scenarios included a number of novel concepts such as those listed below.

- Agent of God (AOG) (a SIMAD)
- An "Unplug-and-Relax" movement
- Anti-corruption strategies
- Attempts to increase intelligence of the general public
- Connecting educational and security monitoring for early detection of intolerance
- Corruption in a global science regulatory commission
- Electronic psychotropes promising escape but trapping instead
- Entertainment/education systems including "You Were There" and "Mental Orgasmatron"
- Manhattan-type projects for energy, water, and diseases
- Memes (influential contagious ideas) for tolerance and to stamp out stupidity
- Nanotech hackers creating nanotech viruses
- Policies for control of publication of potentially dangerous research findings
- Principles of Inviolability of Science autonomy
- Private funding of an international regulatory body with funds won from legal awards
- Rise of neo- McCarthy-ism in science
- Science "ISO 9000 certificate"
- Scientist's Oath
- SIMAD
- Telemerase dispersal as a weapon
- TV Two-Com for public participation in science debates
- UN Security Council intervention in science
- Uneasy relationship between SIMAD prevention and transnational organize crime.
- Utilizing artificial intelligence programs to minimize corruption in organizations
- Viewing science as triggering a meta disaster

Conclusions

A spectrum of five S&T management levels exist simultaneously at any point in time and a mix of these techniques controls the course of research. These levels are, for example:

- **Global organizations** such as the International Atomic Energy
- **National advisory commissions** that establish or advise on issues of acceptable and non acceptable research. Current example: The National Academy of Sciences (and its research arm, The National Research Council
- **National agencies of government** such as the Office for Human Research Protection which exists with the Department of Health and Human
- **The disciplines themselves**, through self regulation, control research directions; e.g. agreement among early researchers in the field of recombinant DNA at Asilomar California in 1975.
- **The individual researcher** has more or less power to choose the course of his or her research. "More or less" because the freedom of choice is to a degree a function of the field, the setting or laboratory in which the scientist operates, his or her seniority and reputation, and his or her ability to raise research funding.

We formed the opinion that it will be necessary to establish an ongoing forecasting and risk assessment system. This could be done at any level at which S&T management

occurs. Investigators should forecast plausible unintended consequences of their research and address the means for minimizing adverse developments as a routine part of their research.

Funding of S&T should include priority for research directed toward the global basic needs of humanity.

One of the scenarios created in this study described the possible advent of a single individual acting alone to create and deliver a weapon of mass destruction. This threat was given the name SIMAD. Respondents found this threat plausible and a major stimulant to the creation of safeguards and regulations limiting certain research and access to it.

When multiple scenarios describe a broad range of future possibilities, policies found to be common to each of the scenarios in the set are "good bets" since they seem to be useful no matter which setting is considered and are, in fact, insensitive to future developments.. A review of the scenarios and the policies suggested by the respondents gives rise to a number of "good bet" policies, some of which are summarized below:

- Consider SIMAD
- For some desirable technologies it may not be possible to avoid significant risks; for these, mitigation strategies should be developed in parallel.
- Engage high-profile organizations in risk analysis; e.g. Departments of Defense of most countries should perform preventative analysis concerned with "extreme tech" misuse.
- Increase visibility and public participation in setting priorities of publicly funded research and development.
- Explore alternative forms for S&T management institutions which minimize the chances that they will impede innovation, reduce risks, operate without corruption and with wisdom.
- Advanced S&T education is critical. Teach science ethics.
- Fund impact analyses as NSF is doing with respect to nanotechnology.

A final sidebar on the future of methodology. It seems to me that there are a number of frontiers that will expand to define the field of futures research in the future. Among these are:

- **Questioning Reductionism**: Why should we believe that the parts of a system can be simulated more accurately than its parts?

- **Social Epidemiology**: Given large scale social data bases, today's marketing practise of "data mining" will grown into a new kind of sociology in which "rules" of behavior will be deduced from data without the need for the formation of natural laws.

- **Computaria**: On line societies which provide environments for social experimentation with low risk.

- **Analysis of Systems Near Chaos**: Learning how to recognize and manage such systems will be important.

- **Probing the Depths of the Unknown** Just what is the map of the unknown? Why are some developments omitted when we ask "what's likely to be new?"

- **Decision-making in Uncertainty**: Decision making is very primitive. Today it means primarily cost benefit; tomorrow it may also involve psychology, particularly the psychology of risk taking, intuition (why is it that some people are intrinsically better decisionmakers, even when data are sparce?), neuropsychology, and brain physiology. It will be taught so that maybe, just maybe, politicians aspiring to high office and executives being considered for top jobs will be evaluated on the basis of their decision capability and certification: a PhD in decisions..

So, considering once again the title of this paper: madmen, methods and shaping change: the plausible madman of the near future is a SIMAD, the methods are evolving and lead to improved decision making in uncertainty, and massive change, as always are forces- known, and unknowable- stemming from synergy, greed, corruption and the lust for power. In that mix lies our future.