A ROAD LESS TRAVELED (WITH APOLOGIES TO ROBERT FROST)
The 2010 CODATA International Prize Lecture

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INTRODUCTION

Allow me to spend a few minutes with you talking about how I got to where I am and sharing some thoughts on the future of digital science. It is a story of juxtapositions, some predictable, others not. But above all, it is a story of a road less traveled.

Like many of you working in science, I have lived my professional life in the future. It was not always so. My first university degree was in world history, the intellectual journey through the past. And even in my higher degrees in law and international relations, the academic focus of my courses was primarily retrospective. Despite my curiosity about what transpired before me, however, I was motivated by Santayana's maxim and preparing for working in the future.

It was not until law and graduate school that I began to concentrate on my career interests. It was also during that time that I decided to work in the public policy arena. I had spent three years between college and law school in the private sector, first cooking at my family's restaurant in New York City, then translating from Czech to English for an outfit in Washington, and finally working at a big law firm as a legal assistant in San Francisco, defending major corporations from antitrust lawsuits.

Each of those jobs taught me something invaluable, which was what not to do with my life. Although I love to eat well and to cook, my stint at the restaurant convinced me that I would rather work in an intellectual career and in one where I have the freedom to travel. My translation job showed me that my language skills were a means to an end, not an end in itself. And working at a large corporate law practice made me realize that making a lot of money to make the rich get richer was not a way I would prefer to use the skills I would acquire in law school. Rather, I wanted to use my knowledge in the public interest, rather than in a law practice engaged in defending corrupt and criminal corporate interests.

The other major influence in the formation of my career choices was more positive and came from my intensely political and internationally oriented family background. My parents and grandparents all immigrated to the United States from Czechoslovakia, where my grandparents had been top members of the democratic government and leaders in the fight against the fascists in WWII and the communists afterwards.

The decision to focus my career on the future of science, technology, and law, however, began in law and graduate school, where I decided to specialize in the public international law of outer space. I also wrote my Master's thesis on the strategic, political, and legal implications of ballistic missile defense systems in space.[2] It was at the beginning of the so-called "Star Wars" missile defense scheme proposed by the Reagan Administration in 1984. I was extremely concerned about the potential destabilizing effects such technology could have on international relations in the Cold War context. I went to Washington as soon as I graduated, thinking I might work in space-based arms control.

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[1] The views expressed in this essay are those of the author and not necessarily those of the National Research Council.

[2] "The Reagan Administration's Proposal to Build a Ballistic Missile Defense System in Space: Strategic, Political and Legal Implications," Paul F. Uhlir, University of San Diego, 220 pages, 1984, available from the author.

Instead, I got a job in civil space law and policy at the National Oceanic and Atmospheric Administration in the Department of Commerce. My initial task out of law school was to draft the first Landsat regulations, specifically, the 1986 regulations for the licensing of private land remote sensing space systems.[3] The NOAA general counsel told me, "Here, write up these new regulations for the (unprecedented) licensing of remote sensing satellites. And do it fast."

So I got my wish, working in the public international law of outer space, right out of law school. It was interesting, but not easy. Other exotic tasks soon followed. I co-authored an article on "Wilderness and Space" with William Bishop, the Deputy Associate Administrator for NOAA.[4] I worked on various international agreements for meteorological and remote sensing satellites, including the first exchange of weather data between the United States and the Soviet Union. I served on the first committee in 1986-1987 to develop the international legal principles for the future space station.[5] And I chaired a study at the American Institute of Aeronautics and Astronautics on the technical and legal aspects of regulating orbital debris, which unfortunately is as relevant today as it was two decades ago.[6] Within a year I was recruited to work at the Space Studies Board at the National Academy of Sciences, where I managed committees and studies focusing on robotic solar system exploration and earth remote sensing from space. We advised NASA on research priorities and spacecraft missions, some of which are still sending back data 20 years hence.[7]

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[3] "Regulations for the Licensing of Private Land Remote Sensing Space Systems," NOAA/NESDIS, 1986.

[4] Uhlir, Paul F., and William P. Bishop, "Wilderness and Space," in *Environmental Ethics and the Solar System*, Eugene C. Hargrove, ed., Sierra Club Books, pp. 183-210. For a summary of the volume, see http://www.univelt.com/univeltdist/1-aerospace-astronautics/BEYOND%20SPACESHIP%20EARTH.doc.

[5] Background documents available from the author.

[6] Uhlir, Paul F., *et al.*. *Orbital Debris Mitigation Techniques: Technical, Legal, and Economic Aspects*. American Institute of Aeronautics and Astronautics, 53 p. 1992, available from the author.

[7] I served as director of the following reports published by the Space Science Board (SSB, presented from most recent to oldest, and all freely available online from the National Academies Press):
Assessment of Satellite Earth Observation Programs--1991, Committee on Earth Studies, Space Studies Board (SSB), 67 p., 1991; available at: http://www.nap.edu/catalog.php?record_id=12322.
Assessment of Solar System Exploration Programs--1991, Committee on Planetary and Lunar Exploration (COMPLEX), SSB, 36 p., 1991; available at: http://www.nap.edu/catalog.php?record_id=12323.
The U.S. Global Change Research Program: An Assessment of the FY 1991 Plans, special study prepared for the White House Office of Science and Technology Policy, 108 p., 1990; available at: http://www.nap.edu/catalog.php?record_id=1606.
Strategy for the Detection and Study of Extrasolar Planetary Materials: 1990-2000, Committee on Planetary and Lunar Exploration, SSB, 121 p., 1990; available at: http://www.nap.edu/catalog.php?record_id=1732.
1990 Update to the Strategy for Exploration of the Inner Planets, Committee on Planetary and Lunar Exploration, SSB, 57 p., 1990; available at: http://www.nap.edu/catalog.php?record_id=12329.
Strategy for Earth Explorers in Global Earth Sciences, Committee on Earth Sciences, SSB, 55 p., 1988; available from the author.
Space Science in the Twenty-First Century: Mission to Planet Earth, Task Group on Earth Sciences, SSB, 121 p., 1988; available at: http://www.nap.edu/catalog.php?record_id=753.
Space Science in the Twenty-First Century: Planetary and Lunar Exploration, Task Group on Planetary and Lunar Exploration, SSB, 111 p., 1988; available at: http://www.nap.edu/catalog.php?record_id=754.
A Strategy for Exploration of the Outer Planets: 1986-1996, Committee on Planetary and Lunar Exploration, SSB, 100 p., 1986; available at: http://www.nap.edu/catalog.php?record_id=12345 .
I also was the director and co-author of SSB advisory "letter reports" to NASA on the following topics:
"Assessment of the research applications of the Landsat program," Committee on Earth Studies (CES), 10 p., September 1991.
"Space Studies Board Position on the NASA Earth Observing System," Space Studies Board, 8 p., June 1991.
"Assessment of the scientific impact of the proposed descoping of the Comet Rendezvous/ Asteroid Flyby (CRAF) mission," Committee on Planetary and Lunar Exploration (COMPLEX), 14 p., July 1990.
"Review of the combined Comet Rendezvous-Asteroid Flyby and Titan Probe-Saturn Orbiter (CRAF/Cassini) FY1990 proposed new start," COMPLEX, 7 p., September 1988.
"Assessment of the scientific impact of the proposed descoping of the Mars Observer mission," COMPLEX, 23 p., July 1988.

In the early 1990s, I decided to shift my focus from outer space to cyberspace and became director of the U.S. National Committee for CODATA at the Academy, among other things. In many ways, cyberspace and outer space are very similar. Although the universe is physical and the web is a virtual representation of our collective synapses, both are infinite frontiers. Both challenge our creative juices, providing unprecedented opportunities for discovery and the implementation of new ideas. Both have visionary allure and the power to shape our cultural and political relationships. And, both demonstrate the importance of factual information—the data—in developing policy as well as the importance of policy in the management of data. It is the latter two aspects, the policy of data and data for policy, on which I would like to focus the remainder of this essay, for they are equally fundamental to the work of CODATA.

POLICY FOR DATA

The policy of regulating and managing data activities is the easier of the two although I certainly do not wish to minimize the difficulty of getting that right. The law is always in the position of having to catch up with scientific and technical developments. Revolutionary technological advances outpace the ability of evolutionary social systems to manage them most effectively. This is certainly true in cyberspace and digitally networked data activities, but it is also true of any advanced technologies with major social implications, including space, energy, medicine, and so on.

So, starting in the early 1990s, I undertook studies at the Academy on various aspects of the management and law of scientific data, improving the integration of environmental data,[8] developing principles for scientific data archiving,[9] and identifying seminal issues in globally networked access to scientific data.[10]

It was also in the mid-1990s that I began another thematic focus of my work within the area of policy for data—the theoretical and applied intellectual property law in digital databases. I stumbled upon this with my long-time collaborator and friend Jerome Reichman, a professor of intellectual property law, now at Duke University Law School. The practical or applied aspects of this area of law follow the familiar trajectory that I have already identified; that is, it seeks to manage *ex post facto* the new legal relationships in using the rapidly developing area of digitally networked technology.

Unfortunately, this has been done very badly by the powers that be. The instruments of applied law are international agreements and treaties and national legislation and regulations, and there has been no shortage of bad ideas and corrupt policies that have been proposed and frequently implemented in the digital domain. The main and well-known reason for this is that the law-making process is captured both nationally and internationally, not by the public interest or private-sector innovators but by entrenched monopoly business interests. In the case of digital information law, it is the motion picture, music, software, and publishing industries that have sought to implement legal rules to protect their dominant economic positions and their pre-digital business models, although some of this finally may be changing. The interests of public science and scientific data management, though, are barely considered unless the research community makes its voices heard.

"Assessment of the Earth remote sensing research instruments for measuring stratospheric ozone, carbon monoxide, and primary ocean biological productivity levels," CES, 2 p., May 1987.
"Review of the proposed Comet Rendezvous-Asteroid Flyby mission," COMPLEX, 5 p., May 1987.
Review of the proposed Lunar Geoscience Observer, Mars Aeronomy Observer, and Near Earth Asteroid Rendezvous missions, COMPLEX, 6 p., May 1986.

[8] *Finding the Forest in the Trees--The Challenge of Combining Diverse Environmental Data*, Committee for a Pilot Study on Database Interfaces, U.S. National Committee for CODATA, 129 p., 1995; available at: http://www.nap.edu/catalog.php?record_id=4896.

[9] *Preserving Scientific Information on Our Physical Universe--A New Strategy for Archiving the Nation's Scientific Information Resources*, Commission on Physical Sciences, Mathematics, and Applications, 1995 (2 vols); available at: http://www.nap.edu/catalog.php?record_id=4871.

[10] *Bits of Power--Issues in the Transborder Flow of Scientific Data*, U.S. National Committee for CODATA, 250 p., 1997; available at: http://www.nap.edu/catalog.php?record_id=5504.

As a result, most of our efforts in the applied legal domain related to scientific information law and policy have been an exercise of triage. That is, we and others who share our perspective have sought to stop the most egregious legal developments from occurring, focusing only on those that we consider amenable to a reasonable chance of successful intervention. Most important from the perspective of scientific data, we have joined forces with other public-interest groups, such as the universities and libraries, as well as more progressive digital industries, such as internet service providers.

We spent over six years battling unprecedented legal restrictions and the expansion of intellectual property rights in factual information that was previously in the public domain. We first fought this trend at the World Intellectual Property Organization (WIPO) in 1996—successfully, I might add—being primarily responsible for neutralizing the U.S. Patent and Trademark Office (PTO) support of the WIPO Database Treaty and thereby killing the treaty itself. We wrote a letter to the Secretary of Commerce, signed by the presidents of all three U.S. Academies, questioning the substantive and procedural validity of this new legal approach.[11] We copied everyone in Washington on that letter, which got it the attention it deserved and forced the PTO to retract its support of that Treaty. We then spent the next five years on the legislative database wars in Congress, lobbying on behalf of the Academies, also with success. At the same time, we devoted a great deal of effort on analyzing why the EU Directive on the Legal Protection of Databases is bad law and bad for science, although with considerably less effect.[12]

However, such protective, damage control action is at best intellectually unrewarding and very stressful to boot. The agenda and schedule are set by the proponents of the flawed law, requiring opponents to react on a moment's notice to new proposals lest they be enacted as is at the behest of well-heeled interests. It is an inherently negative process, seeking to prevent egregious things from happening, rather than positive, in the sense of improving dysfunctions with new approaches. I therefore also have spent a lot of time on more forward-looking theoretical law, seeking to develop novel legal theories, public policies, and institutional frameworks for more effectively managing intellectual property rights in scientific databases and literature.[13] This has been much more interesting and personally gratifying.

Over the past decade, we have worked on the use of private-law agreements—that is, contracts, licenses, and grants—in modulating public intellectual property laws, such as digital copyright and database protection law. In 2003, Jerry Reichman and I published a seminal treatise, entitled "A Contractually Reconstructed Research Commons for Scientific Data in a Highly Protectionist Intellectual Property Environment."[14] This publication and

[11] Letter from Bruce Alberts, Wm. A. Wulf, and Ken Shine to Mickey Cantor, Secretary of Commerce, October 9, 1996 (on file with the author).

[12] "Database Protection at the Crossroads: Recent Developments and their Impact on Science and Technology," with Jerome Reichman, 14 Berkeley Technology Law Review 793-838, 1999, available at: http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=2230&context=faculty_scholarship; see also, National Research Council, *A Question of Balance: Private Rights and the Public Interest in Scientific and Technical Databases*, Paul F. Uhlir, ed., National Academy Press, 158 p., 1999, 2 vols., available at: http://www.nap.edu/catalog.php?record_id=9692; and Paul F. Uhlir, "Intellectual property rights in databases: an American perspective," in *Building and Owning Biotechnology Databases*, BTSF, Edam, Holland, 1998, available at: http://ebiomics.org/ws3uhlir.htm.

[13] See, e.g., Paul F. Uhlir, "Policy Guidelines for the Development and Promotion of Governmental Public Domain Information," UNESCO, 49 p., 2004, available at: http://www.fas.org/sgp/library/unesco_govinfo.pdf; "The Emerging Role of Open Repositories as a Fundamental Component of the Public Research Infrastructure," in *Open Access: Open Problems*, Polimetrica, 2006, available at: http://eprints.rclis.org/bitstream/10760/9656/1/OpenAccess.pdf; National Research Council, *The Socioeconomic Effects of Public Sector Information on Digital Networks*, Paul F. Uhlir, ed., 92 p., 2009, available at: http://www.nap.edu/catalog.php?record_id=12687; as well as notes 14-16.

[14] "A Contractually Reconstructed Commons for Scientific Data for Science and Innovation in a Highly Protectionist Intellectual Property Environment," with Jerome Reichman, 66 Law and Contemporary Problems 315-462, Duke University School of Law, Winter/Spring 2003; available at: http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1283&context=lcp. See also, National Research Council, *The Role of Scientific and Technical Data and Information in the Public Domain*, Julie M. Esanu and

subsequent work spawned several major new initiatives, including the Science Commons subsidiary of the Creative Commons and the CODATA Global Information Commons for Science Initiative, or GICSI.[15]

We are now working to expand these legal concepts in new institutional and governance frameworks, which I refer to as "open knowledge environments" in the digital context.[16] This approach seeks to deconstruct the print-paradigm, scholarly communication process and reconstruct it more holistically and effectively in the digitally networked context.

Also over the past decade, I have reoriented my career to pursue my lifelong interest in international cooperation on these issues, particularly in developing countries, and to implement more positive solutions to the sharing of scientific and public sector data and information. I have worked with many colleagues in various countries and agencies to help form national scientific data policies in those nations and organizations, which also has been personally very rewarding.[17]

DATA FOR POLICY

Finally, I would like to explore briefly the other side of the policy and data nexus—the use of scientific data for the formation of public policy. In many ways this is the much more difficult and important aspect. It was already highlighted by two of the keynote speakers at the 22nd CODATA Conference in Stellenbosch.

A necessary, but not sufficient, condition for the use of factual information in policymaking is openness. Those who are acquainted with me and my work know that I preach the mantra of openness and the sharing of public information wherever I go. I am an evangelist of open access and believe it is essential, not just for scientific progress but for promoting social justice and welfare, economic growth, and political transparency. Conversely, excessive secrecy, particularly in the public sector, can ultimately lead to suspicion, conflict, and tyranny. Openness should therefore be the default rule, particularly for factual information in the age of digital networks.[18]

But although openness is an essential pre-condition for well informed policymaking and a host of other positive goals and values, it is not in itself enough. Data in particular need to be validated and prepared in a manner that is relevant to decision making, focused on the problems that need to be solved, effectively visualized, and then accepted and appropriately applied by the decision makers.

Paul F. Uhlir, eds., National Academies Press, 226 p., 2003, available at: http://www.nap.edu/catalog.php?record_id=10785; and National Research Council, *Open Access and the Public Domain in Digital Data and Information for Science: Proceedings of an International Symposium*, Julie M. Esanu and Paul F. Uhlir, eds., National Academies Press, 183 p., 2004, available at: http://www.nap.edu/catalog.php?record_id=11030.

[15] "Global Information Commons for Science Initiative," with Paul A. David, in *Past, Present & Future of Research in the Information Society*, Wesley Shrum, *et al.*, eds., Springer, p. 107-110, 2007, available from the author. See also http://www.codata.com.

[16] *Global Intellectual Property Strategies for the Microbial Research Commons: Governing Digitally Integrated Genetic Resources, Data and Literature*, with Jerome Reichman and Tom Dedeurwaerdere, Cambridge University Press (forthcoming 2013).

[17] I have been either a paid and unpaid consultant to the European Commission and several of its externally funded projects, as well as in Canada, Chile, Peru, Uruguay, South Africa, Senegal, Egypt, Japan, and especially China. In the United States, I have served as an unpaid private sector consultant to the Department of State for both phases of the World Summit on the Information Society (2003 and 2005), and for the Organisation for Economic Co-operation and Development's Recommendation on Data from Research with Public Funding (2007) and the Ministerial Recommendation on Public Sector Information (2008). Finally, my work at the National Academy of Sciences since the early 1990s has focused on providing advice to the U.S. federal government on public research data management and policy.

[18] For example, see my essay on *Information Gulags, Intellectual Straightjackets, and Memory Holes*, CODATA Data Science Journal, 2010; available at: https://www.jstage.jst.go.jp/article/dsj/9/0/9_Essay-001-Uhlir/_article.

An original example of the use of data for policymaking was in an article I wrote in the early 1990s, "From Spacecraft to Statecraft: The Role of Earth Observation Satellites in the Development and Enforcement of International Environmental Agreements."[19] It built on the model of space-based "national technical means" of verification (i.e., deep black remote sensing satellite programs) in the development and enforcement of arms control agreements, but in an open process, using civil environmental satellites. A successful instance of such development and subsequent monitoring was in the agreement on stratospheric ozone depletion, which was found to be the result of the use of chlorofluorocarbons. I argued that similar applications could be made in the national and international regulation of land and water uses, such as the mitigation and response to large-scale pollution, deforestation, and other environmental problems.

While the observational satellites and sensor systems in many cases already exist for defining and monitoring such environmental problems, the political will to apply them does not. This is the result of bureaucratic inertia and willful avoidance and denial to deal with these issues. Inconvenient truths abound. Yet the amelioration of many of humanity's greatest challenges, such as the effective management of climate change, ecosystem degradation and species extinction, food and water security, and the spread of infectious diseases is dependent to a large extent on the systematic collection, broad dissemination, and effective collaborative use of high-quality data.

Organizations such as CODATA thus have a heavy burden to improve the application of scientific data in the policymaking process to address these problems before they become crises. Developing countries, in particular, can benefit the most from such data production,[20] access, and use, but all too often their governments are the most secretive with such factual information. The pursuit of basic knowledge for knowledge's sake is not enough. The use of data in support of policy formation is thus the most urgent challenge and greatest need that CODATA can address in the years ahead.

In closing, I must say that in many ways I have been very fortunate. I may not have made the kind of money that I would have if I had stayed in the private sector. But then again I would not have had the freedom to forge a career that has been so intellectually challenging and rewarding or to work with the great people in the CODATA community and beyond. I therefore deeply appreciate the honor that has been bestowed upon me with the 2010 CODATA International Prize.

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[19] Available in *GIS Law*, January 1995, and from the author.

[20] See, e.g., *Crop Modeling and Related Environmental Data—A Focus on Applications for Arid and Semi-Arid Regions in Developing Countries*, P.F. Uhlir and G.C. Carter, eds., CODATA, 256 p., 1993; available from the author.