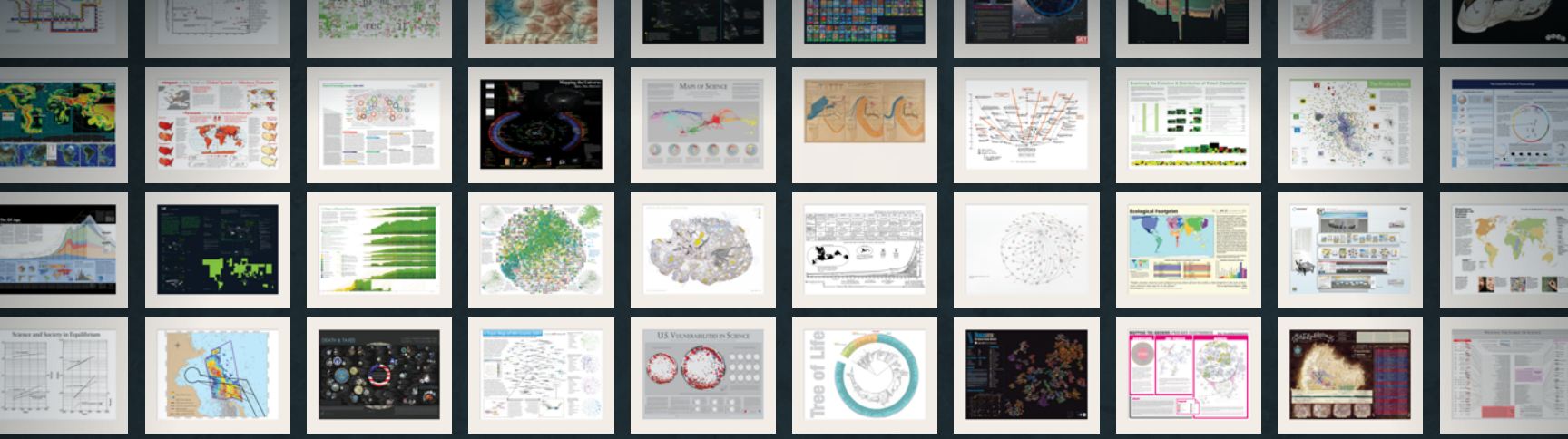
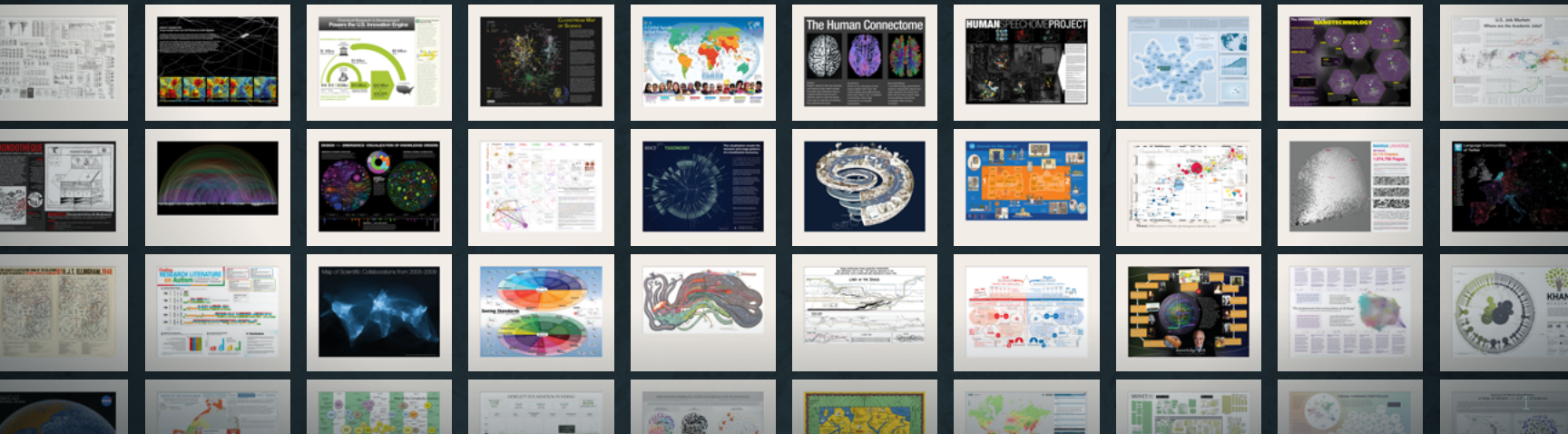


PLACES & SPACES
MAPPING SCIENCE

10 YEARS OF MAPPING SCIENCE

ANNUAL REPORT 2014

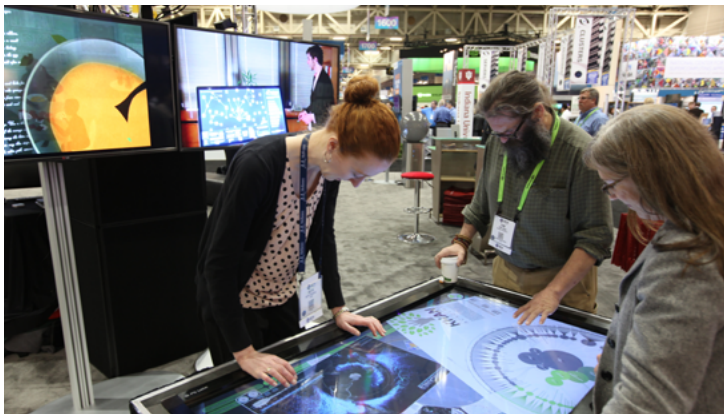


Introduction

For much of human history, travelers over sea and land—be they 17th century Dutch merchants in sailing vessels or 21st century American vacationers in minivans—have relied upon geographic maps as essential tools of navigation. But even in less utilitarian terms, maps give their viewers the intellectual and imaginative thrill of rendering vastness visible. Maps are the product of physical exploration, careful calculation, and, at times, informed conjecture. They provide an encompassing view of something that we, as individuals bound by time and space, can only see partially and imperfectly.

Today's maps of science perform a task similar to their geographical counterparts by providing an aerial view of an intellectual territory far too vast to be understood from ground level. Maps of science depict knowledge and expertise as a visible location and in relationships of contiguity and distance. We are able to see territories well traveled—those ideas that have attracted the attention of scholars over time—as well as those areas recently discovered and bursting with activity. And, like those masses of land marked "Parts Unknown" on some of our earliest maps of the world, we see that which is imperfectly understood and ripe for exploration. In short, maps of science both collect and illustrate intellectual achievement and point towards intellectual opportunity.

The Visionary Approaches Timeline from the *Atlas of Science* on display at the Mundaneum Museum, Mons, Belgium



Places & Spaces maps on a touch table at the *International Conference for High Performance Computing, Networking, Storage, and Analysis*, New Orleans, November 16-21, 2014

For the past decade, *Places & Spaces: Mapping Science* has brought together the best examples of this kind of intellectual cartography. Each and every map in this collection represents the human desire to bring order and understanding to the complex forces that shape our existence. Briefly put, maps like these attempt to answer questions such as: How do our actions affect the natural world and the lives of future generations? Where should we spend our time, resources, and compassion? What decisions can we make to most benefit those in need? What knowledge have we accumulated and what remains unknown?

These questions, and many others, have occupied the minds of mapmakers and have provided the impetus for the 100 maps that now comprise the *Places & Spaces: Mapping Science* exhibit. Created by leading experts in the natural, physical, and social sciences, scientometrics, visual arts, and the humanities, the maps in *Places & Spaces* allow us to better grasp the abstract contexts, relationships, and dynamism of science, technology, and collective intelligence. Individually and as a whole, the maps of *Places & Spaces* allow data to tell stories which both the specialist and the layperson can understand and appreciate.

Now completing its tenth year, the exhibit has traced the evolution of science maps, featuring the best examples of knowledge-domain mapping, novel location-based cartographies, data visualizations, and science-inspired artistry.

Filmmakers Norbert Herber, Ying-Fang Shen, and Katy Börner discuss their award-winning film *Humanexus* at the Indiana University Cinema, September 8, 2014

Along the way, *Places & Spaces* has featured historically significant firsts in science mapping, including the very first automatically generated map of science, Henry G. Small's "1996 Map of Science" (see Iteration I, Number 5 of the exhibit), the first map of "Science-Related Wikipedian Activity" (see III.8), and the first "Clickstream Map of Science" (V.8). The exhibit has also brought to life the history and evolution of data visualization with Charles Joseph Minard's landmark "Napoleon's March to Moscow" (I.4), Wattenberg and Viégas' "History Flow Visualization of the Wikipedia Entry on 'Abortion'" (II.6), the SENSEable City Lab's "Mobile Landscapes: Using Location Data from Cell Phones for Urban Analysis" (V.4), and the more recent exploration of national mood as reflected by Twitter activity, "Pulse of the Nation" (IX.4).

The process of selecting the exhibit's pieces begins each year with a call for maps corresponding to a particular theme or addressing the needs of a particular audience. Once the submissions have been gathered, a team of international reviewers and exhibit advisors select the ten most stunning and innovative maps for entry into *Places & Spaces*. Next, the chosen maps are prepared for viewing by a general audience through large-format, high-resolution printing. Since many of the exhibit's maps were originally designed for inclusion in scientific papers, PowerPoint slides, or online tools, this can be quite a dramatic transformation. Finally, the maps are printed and framed for public display at libraries, (science) museums, national science academies, and other venues.

Overseeing this process is an exhibit team comprised of two curators and an exhibit manager based at Indiana University in Bloomington, Indiana. The team manages the map submission and review process, coordinates the display of maps at various venues worldwide, organizes workshops and events, and facilitates the archiving of the exhibit maps at major libraries around the world. In all of these activities, the exhibit team benefits from expert input by an international advisory board.

Letter from the Exhibit Team

The exhibit team: Lisel Record, Katy Börner, and Todd Theriault

For the *Places & Spaces: Mapping Science* exhibit, 2014 marked a year of completion and renewal. One short decade ago, a group of individuals with a deep interest in and enthusiasm for science mapping proposed the idea of bringing maps of science to the general public. Since then, audiences worldwide have come to share in the wonder of scientific thought made visible, and experts have started to innovate science maps at a pace that resembles a Cambrian explosion.

The year 2014 saw the completion of the exhibit's goal of collecting 100 maps that illustrate in a professional yet highly aesthetic fashion the inner workings of science: how one innovation in a particular field leads to another (often unexpected and unpredicted) breakthrough in another area of research; how individual actions that may seem isolated and disconnected follow particular patterns; how human activities in one area can lead to misery in another—and, conversely, how human efforts can be used more wisely and efficiently to increase the well-being of people around the globe.

Any generalized description of the *Places & Spaces* exhibit cannot do full justice to the wide scope of topics and concerns covered by these 100 maps. And the breadth of subject matter in *Places & Spaces* is now matched by the physical immensity of the exhibit itself: placed side by side, the maps and their accompanying labels would span nearly the length of a football field (105 yards or 96.5 meters). Of course, the exhibit can also be viewed in a much more compact format from the comfort of your own computer screen at the newly redesigned website

All 100 maps on display at the University of Miami in Florida from September 4 through December 11, 2014 (courtesy University of Miami Communications)

Advisory Board member Stephen Uzzo with Katy Börner at the *Science Centre World Summit* in Mechelen, Belgium, March 2014

(scimaps.org). Here, all 100 maps are available for enjoyment and education. And just as viewers of the physical exhibit can move in closer to get a better look at particular sections of a map, online viewers are able to zoom in on features of any map they wish to examine in greater detail. The website also provides access to scholarly articles that describe the maps and feature expert interpretations.

The title of the exhibit's 10th and final static map iteration is highly appropriate: "The Future of Science Mapping." It is a title that encourages us to look forward, to speculate about possibilities, to dream of new opportunities. We are excited to see where this new direction will take us over the coming decade as we endeavor to retain the high level of intellectual and creative excitement that people have come to expect from *Places & Spaces*.

Of course, for both our past and our future, we have and will continue to depend upon the support and goodwill of the many friends of the exhibit. It is always deeply rewarding to work with, meet, and hear from individuals who are enthusiastic about *Places & Spaces* and the pedagogical and research missions it performs. Over the years, many individuals and institutions have assisted us greatly in communicating their excitement to others, thus spreading the impact and influence that this exhibit has enjoyed. And so on that note, we would like to thank the members of our advisory board, experts in their field all, whose deep knowledge and wisdom have helped shape the vision of this exhibit. We would also like to thank our team of international ambassadors, whose tireless work in promoting, communicating, and, at times, even physically transporting the exhibit give new meaning to the phrase "above and beyond."


Maps on display at the European Commission, DG Research and Innovation, Brussels, Belgium

Letter from the Exhibit Team

Our gratitude goes out also to the staff here at *Places & Spaces*, those individuals who are deeply aware of the challenges that arise from organizing an international exhibit of ever-increasing scope and who rise to meet those challenges with talent, hard work, and grace. Thanks also to those individuals we have met at conferences, exhibit openings, workshops, and online who have taken the time to express their enthusiasm for *Places & Spaces* (or even simply to "like" us on Facebook). These words of encouragement do not go unnoticed and are always taken to heart. Last but not least, we thank all the many mapmakers whose work

Maps fueling policy discussions at the UNESCO Institute for Statistics, Montreal, Canada

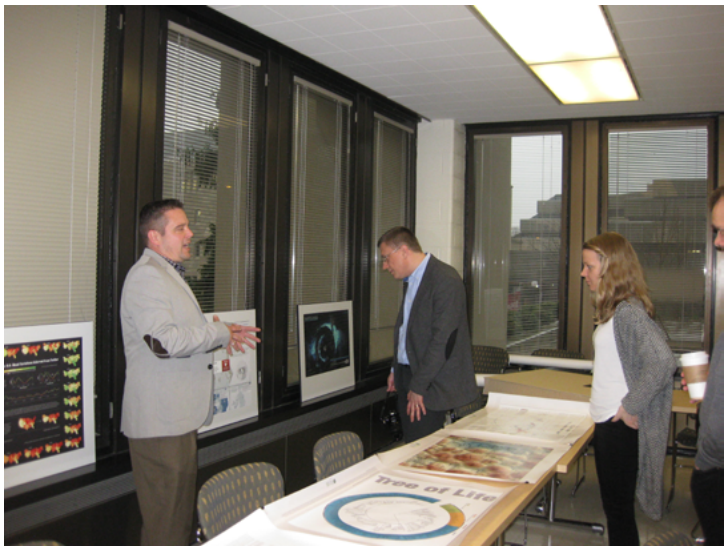
Exhibit advisors and ambassadors are instrumental in bringing *Places & Spaces* maps to venues around the globe

has challenged, engaged, and enlightened audiences around the world. Without the ability of these extraordinary individuals to convey the power and extend the potential of the craft of mapmaking, there would be no *Places & Spaces*. To all of those mentioned above we extend our deepest appreciation.

We would like to end this letter by stating one of our deepest convictions about maps in general and about these 100 maps in particular, a conviction we are certain that viewers of *Places & Spaces* will come to share. It is this: whatever we as humans consider as constituting reality—the forces of nature, the power of social networks, the consequences of geopolitical decisions—maps such as these are not passive reflections of that reality but active shapers of it. Though maps can

be sources of intellectual stimulation or aesthetic appreciation, they are first and foremost utilitarian objects, working tools that individuals use to achieve real-life goals that have real-world consequences. To be sure, maps trace out for us the contours of intellectual, social, and natural phenomena, but they do so in order for that information to be put to practical use. The maps of *Places & Spaces* have shaped public policy, dictated S&T funding decisions, contributed to political debate, enhanced public safety, protected wildlife and natural resources, spurred global initiatives, and much more.

Jax and the Big Data Beanstalk, a Science Museum of Minnesota theater piece funded by the NSF, introduces museum visitors to big data visualizations and science maps



A delegation from Chalmers University of Technology in Gothenburg, Sweden discusses the maps with curator Todd Theriault

Recently, in celebration of its cartographic division's 100th anniversary, National Geographic made the following claim about the exemplary work of that department: "Our maps haven't just chronicled history; they've made it." This is a wonderful summation of the power of maps to act as agents working within the complex forces that touch all of our lives. It is our hope that the 100 maps in the *Places & Spaces: Mapping Science* exhibit will not only change how one thinks but also improve one's daily decision making and actions to the benefit of us all.

10th Iteration: The Future of Science Mapping

The 10th and final iteration of Phase I of the exhibit is devoted to maps of science that point to the future of the practice itself. In our call for maps, we posed a number of questions that we asked mapmakers to consider. For instance, how does the structure and dynamics of science evolve? How can maps of science achieve more extensive and accurate coverage, and how can they be updated in near-real time? In what ways does science overlap with other areas of human endeavor and interest? How do predictions of scientific developments impact the course of history? How can self-fulfilling prophecies be prevented, and how can we avoid the mistakes of the past? And always a key concern with the exhibit: how can crucial developments in science and technology be communicated to a general audience?

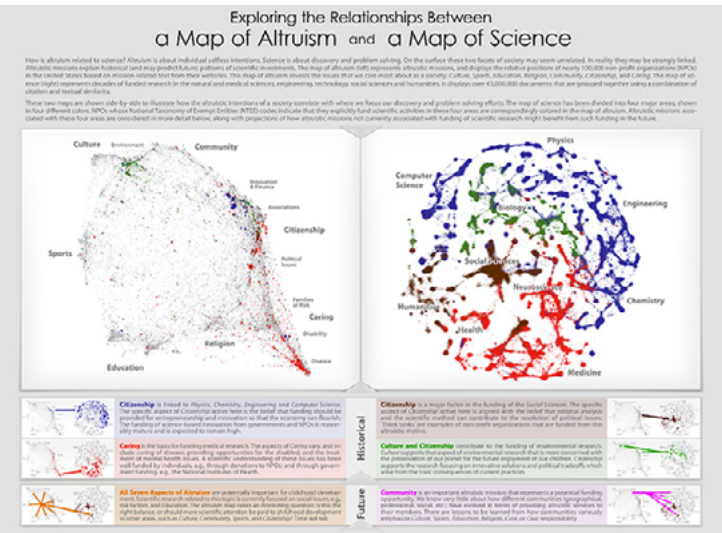
In assessing maps for the 10th iteration, we looked for innovation on topics such as: new data sources, such as social media, stock market reports, philanthropy information, and other data reflecting S&T activities; new hardware and software setups, including multi-modal man-machine symbioses that combine analog human wet-ware and digital computer hard and software to achieve superior capabilities; and validation verified by the results of user evaluation and algorithm cross-validation studies. We also sought maps that utilized well-defined, widely shared data formats, analysis and visualization workflows, and readable visual languages.

What makes the 10th iteration unique is the way it turns attention back upon the act of mapmaking itself. In the first nine iterations, maps were selected based on how well they fulfilled a particular function (e.g., Iteration I: The Power of Maps, or Iteration III: The Power of Forecasts) or how well they met the needs of a particular audience (e.g., Iteration VI: Science Maps for Scholars, or Iteration VIII: Science Maps for Kids). This time, maps were chosen primarily for the ways in which they utilize methods or engage in subjects that point to where mapmaking might go in the future. Regardless of what the maps are "about," the primary consideration was the extent to which they offer a glimpse into possible new directions in mapmaking.

Katy Börner debuts the exhibit at the University of Miami, September 4, 2014 (courtesy University of Miami Communications)

For example, to create "Mapping Graphene Science & Development," the mapmakers developed a mapping kit that enables the creation of overlay maps using Pajek and VantagePoint. And while they use the research and development of graphene as an interesting case study, the tools and methods used to create the map have broader future applications for policy making, corporate research and development, and business-competition analysis. Elsewhere, "The Linguistic Context of Citations" shifts the focus of citation analysis from the more common quantitative approach to examine the positionality of citations within the structure of the text itself. The work is an important step towards a more nuanced analysis of citations, and it is the product of the mapmakers' ongoing development of more sophisticated tools for textual navigation.

In "Exploring the Relationships Between a Map of Altruism and a Map of Science," Richard Klavans and Kevin W. Boyack utilize science-mapping tools to better understand the mission of non-profit organizations. In doing so, they highlight hitherto unrecognized connections between altruism and the motivations, practices, and products of scientific inquiry. Given the enormous social, political, and environmental challenges our world faces, such a comparative analysis represents a step towards more effective problem-solving and provides a catalyst for future studies of how scientific power can best be harnessed to address issues of global importance.



Exploring the Relationships between a Map of Altruism and a Map of Science, by Richard Klavans and Kevin W. Boyack

Concerned also with the non-profit sector, "Interstitial Organizations as Conversational Bridges" combines network and discourse analysis to better understand and identify those organizations that escape neat categorization. Understanding that websites are a key point of self-representation for many organizations, the mapmakers employ descriptive terms and hyperlinks to analyze organizational self-identity and connectivity. Examining the interstitial organizations reveals the ways in which communities can develop languages and ways of thinking that are both familiar (as they employ the terminology of existing categories) and novel (as they recontextualize those terms to address problems in ways that might escape the attention and capacities of more traditionally categorized organizations).

Taken as a group, the maps of the 10th iteration form an impressive collection of cutting-edge techniques and avenues of inquiry that reflect fruitful directions for science mapmaking in the future. We hope that the new tools, techniques, and topics will inspire audiences to view the world of data anew and to create their own maps that reflect the concerns dearest to them.

At the end of 2014, that hope of spreading the exhibit's message concerning the power and potential of science mapping was further realized by the featuring of *Places & Spaces* in a special issue of the *Bulletin of the Association for Information Science and Technology* 41 (2) (see asis.org/Bulletin/Dec-14). Five of the mapmaking teams who produced work for the 10th iteration contributed essays elaborating on the methods used to create their maps, the challenges they faced, and the utility of their maps for future inquiry. This group of short papers was opened by a prefatory essay introducing the *Places & Spaces* exhibit, demonstrating the uses and usefulness of science mapping, and outlining the key opportunities and challenges for science mapping in the future.

Accomplishments

Venues

In terms of travel and display, 2014 marked the busiest year yet for the exhibit. Even a quick glance at our schedule of events (scimaps.org/exhibitions) will indicate that hardly a day of the year went by when *Places & Spaces* was not featured at an important venue somewhere around the world—oftentimes in several locations at once. Thanks to our dedicated staff and supporters, *Places & Spaces* appeared before appreciative audiences in the U.S.: Chicago, New York, Houston, Berkeley, Washington, D.C. and other cities. The exhibit also travelled to many international locations: Paris, France; Copenhagen, Denmark; Antalya, Turkey; London, U.K.; and elsewhere. In March, the exhibit was displayed at the Science Centre World Summit held at the Technopolis in Mechelen, Belgium. And in December, *Places & Spaces* made its first ever visit to South Korea, appearing at the International Science and Creativity Conference in Seoul.

Furthermore, we were honored to have the University of Miami host the debut of the exhibit's 10th iteration from September through December 2014. This monumental undertaking brought 100 maps, several additional exhibit elements, and a group of distinguished speakers to students, faculty, and members of the wider Miami community (visualization.miami.edu/ps). The event was a huge success and it is an accomplishment in which we can all take a great deal of pride. Perhaps the most wonderful thing about the Miami exhibit is that it both captured a moment in time and represented the culmination of a decade of effort, dedication, and passion on the part of so many.

Perhaps the most sensational venue (certainly the most celebrity-filled) of the year was enjoyed by one of the exhibit's additional elements: the animated short film *Humanexus*. The film, created by *Places & Spaces* curator Katy Börner, artist Ying Fang-Shen, and musician Norbert Herber, spent much of 2013 winning numerous awards at major film festivals around the world. In 2014, however,

International Science & Creativity Conference, Seoul, Republic of Korea, December 3-7, 2014

Some of the awards *Humanexus* has won, overlaid on still images from the film

Humanexus stepped on the stage of the world's most prestigious film showcase: the Festival de Cannes. The film was shown at three different Cannes venues, including the AVIFF-Art Film Festival, where *Humanexus* won third place. *Humanexus* was also shown at the IU Cinema, and the subsequent discussion with all three movie makers is available at cns.iu.edu/humanexus.

Translations

This year, we continued our efforts to make *Places & Spaces* map descriptions available in as many languages as possible to enlarge and inform our global audience. In conjunction with the exhibit's residency at University of Miami, experts there produced a Spanish-language version of the map labels to better serve the needs of Miami's large Spanish-speaking population. Several iterations of the exhibit have been translated into German, and translations into Korean, Persian, Polish, and Chinese are currently in progress.

Archival

The year 2014 also saw our continued efforts toward archiving the exhibit's maps, accompanying books, and digital files in major map libraries around the world. Since 2006, *Places & Spaces* maps have been part of the New York Public Library's collection (Call # Map Div. 06-1420), and those maps originally part of the David Rumsey collection were moved to Stanford University's archive in 2009. More recently, the University of Michigan's Hatcher Library (GA 190.P53 2006), the American University of Beirut, and the Library of Congress (G1046.C1 P5 2012) have all added *Places & Spaces* to their collections. This will ensure that interested patrons can examine high-resolution prints up close and that the maps are preserved for future generations of map enthusiasts and scholars.

Katy Börner and Norbert Herber attend a screening of *Humanexus* at the Festival de Cannes, Cannes, France, May 20, 2014

Accomplishments

New Website

A major accomplishment of 2014 was the creation of a completely redesigned, much more user-friendly exhibit website at scimaps.org. The new site has all the features that visitors to our old site have come to know and love: exhibit maps that can be magnified for close inspection, information about and photos of past exhibit events, details about hosting the exhibit, and more. However, the updated site offers several new features: a beautiful new design, more intuitive site navigation, and a simplified process for ordering exhibit maps online. In addition, the new site now features increased content about exhibit mapmakers and other contributors, including profiles and video interviews (scimaps.org/mapmakers). Finally, exhibit news is constantly updated to keep followers abreast of what's happening with *Places & Spaces*. There are also links to our Facebook page and Twitter feed where visitors will find information about *Places & Spaces* events, items concerning the mapmaking community, and general news involving our many talented mapmakers.

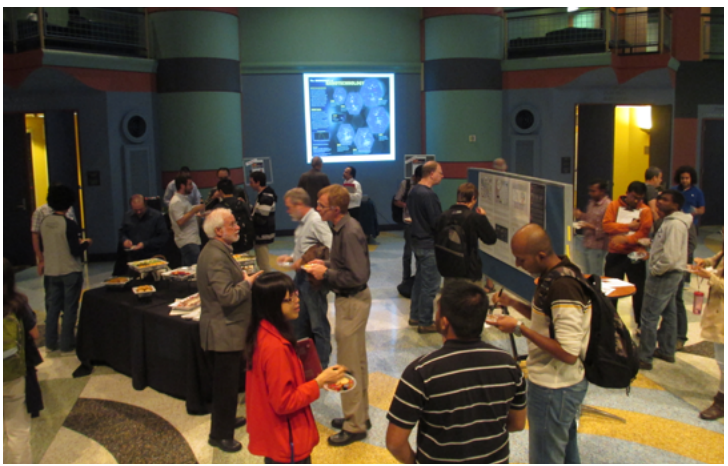
Redesigned scimaps.org now features additional mapmaker content

Workshops

During her sabbatical in 2014, *Places & Spaces* curator Katy Börner worked as a Science, Technology and Innovation (STI) Visiting Research Fellow at the Organization of Economic Co-operation and Development (OECD) in Paris, France. She presented at the *OECD-Experts Dialogue on Scientometrics: Improving the Use of Bibliometric Indicators and Analysis for Policy-Making* workshop and compiled the results of that event. The workshop was hosted by the STI Directorate at OECD and brought together experts from 12 countries as well as representatives from leading data providers such as Elsevier and Thomson Reuters.

In May 2014, Börner and Elizabeth (Libby) Lyons, a senior adviser at the Department of State, organized a workshop held in Washington, DC, entitled *Linking International Databases to Build Strategic Academic Partnerships in Science*. The event—which brought together policy-makers from key government agencies such as NSF, NIH, DOS, and AAAS, representatives from publishing companies such as Thomson Reuters and Elsevier, and experts from Harvard University, Weill Cornell Medical College, Duke University, and elsewhere—was designed

to discuss strategies for developing a platform to help universities find key international partners in science, technology, and innovation. This nongovernmental platform, currently called PEGASCIS (the Platform for Enhancing Global Academic Strategic Collaboration in Science), would make information on U.S. academic institutions easily available to foreign institutions seeking to collaborate. A key goal of the project is to ensure that PEGASCIS is compatible with and adoptable by many nations, including developing countries, thus enabling U.S. institutions to find appropriate foreign partners. This workshop was followed up by a PEGASCIS Scoping Meeting at the Department of State in July 2014 where Börner presented an invited talk on "Open Source Data and Tools for Global Science Decision-Making."



Rice University's Ken Kennedy Institute for Information Technology, Houston, November 11, 2014

Methodological Issues in the Evaluation of Interdisciplinary Research Programs Workshop at NSF in Washington, D.C. on October 3, 2014

The final workshop of the year was held in November at Indiana University. Always popular, the *Plug-and-Play Macroscopes* workshop is designed for programmers and power users of major visual analytics/science-of-science tools to discuss improved integration and collaboration between existing tools and developers. Key goals of the workshop included identifying currently unmet user needs and anticipated novel use cases that future tool or service developments should address, and discussing synergies among efforts and possible joint funding applications.

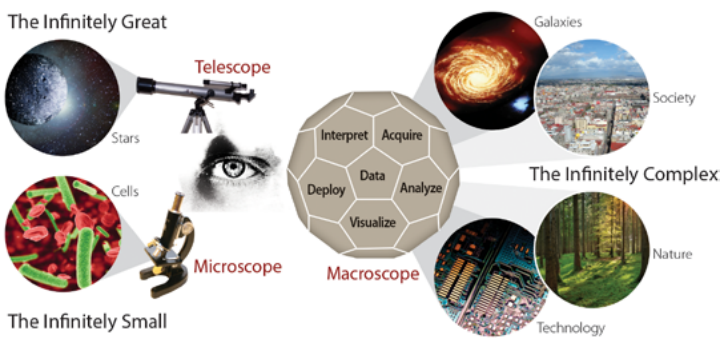
For details on past and planned events see cns.iu.edu/workshops.

Goals for 2015

Places & Spaces Phase II

While Phase I of *Places & Spaces* has introduced the power and utility of science mapping to many, it has also raised new questions: How can we demonstrate the power of data analysis and visualization techniques not only to plot static data but to monitor and support science as it evolves over time? How can we improve data visualization literacy globally and for all ages? How can we empower individuals to make their very own maps? Phase II of the exhibit aims to address these questions by shifting the focus of the exhibit from maps to macroscopes.

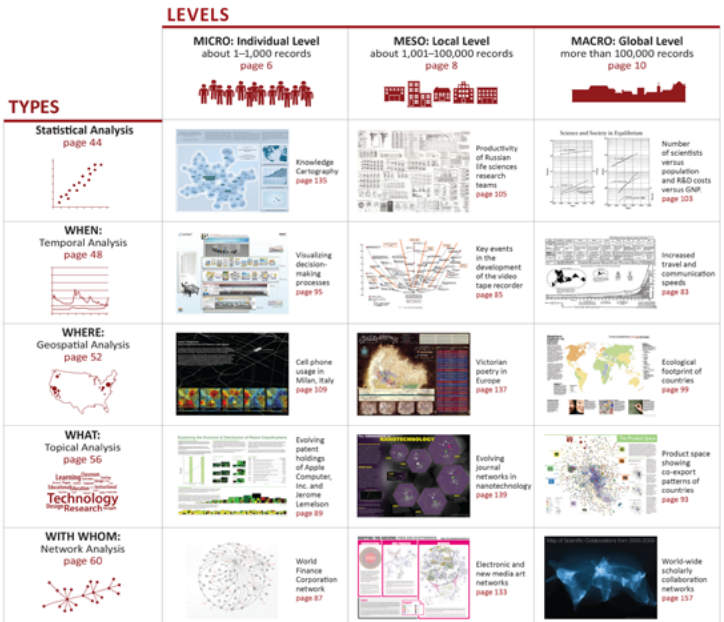
The term macroscope was first coined in 1979 by Joël de Rosnay in a book entitled *The Macroscope: A New World Scientific System*. In it, he observes that a current challenge for humanity is its constant confrontation with the infinitely complex. "We are confounded," he asserts, "by the number and variety of elements, of relationships, of interactions and combinations on which the functions of large systems depend." To meet the challenges posed by the abundance, diversity and complexity of information, de Rosnay proposes the macroscope, a "symbolic instrument made of a number of methods and techniques borrowed from very different disciplines." For de Rosnay, the macroscope would be the symbol of "a new way of seeing and understanding," a tool "not used to make things larger or smaller but to observe what is at once too great, too slow, and too complex for our eyes."



Macroscope tools help us see things that are too great, slow, or complex to view unaided

New Trends in eHumanities Research Workshop at the Royal Netherlands Academy of Arts and Sciences, March 27, 2014

With these needs and insights in mind, Phase II of the *Places & Spaces* exhibit will invite and showcase interactive visualizations—our own exemplars of de Rosnay's macroscope—that demonstrate the impact of different data cleaning,



Explanation and exemplification of task types and task levels used in creating data visualizations featured in the *Atlas of Knowledge*

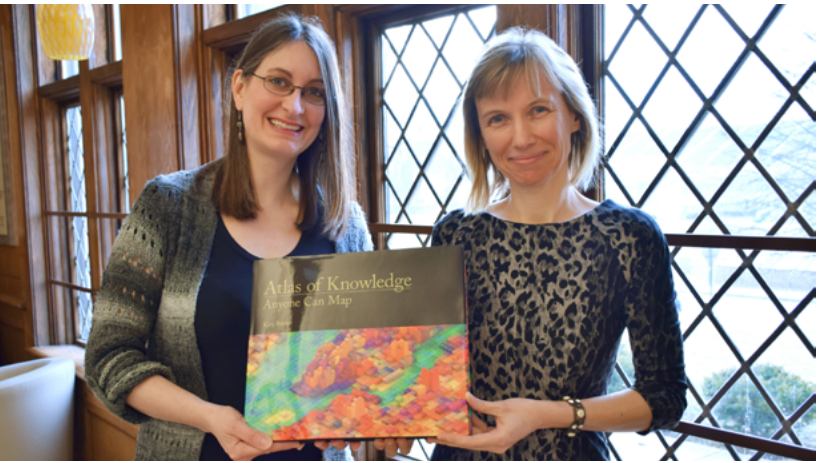
analysis, and visualization algorithms. It is our hope that this view of the "behind the scenes" process of data visualization will increase the ability of viewers to gain meaningful insights from such visualizations and empower people from all backgrounds to use data more effectively and endeavor to create maps that address their own needs and interests.

Apart from this shift in focus from maps to macroscopes, Phase II will operate in ways similar to those that made Phase I so successful. Each year will begin with a "Call for Macroscopes," and from those submissions, the curators and advisory board will select the most interesting, exciting, and useful examples for display later in the year. The tools and maps will then be made available for formal education purposes in schools and for more informal encounters in (science) museums, libraries, and other public spaces. Despite the new direction, *Places & Spaces* will continue to adhere to the highest standards and will remain an exhibit you will be proud to visit and promote.

Improving data visualization literacy, whether through maps or through macroscopes, remains at the core of *Places & Spaces* (courtesy University of Miami Communications)

Goals for 2015

Atlas of Knowledge: Anyone Can Map



Tracey Theriault and Katy Börner holding a copy of the *Atlas of Knowledge*

In 2015, The MIT Press will publish Katy Börner's follow-up volume to her popular and award-winning *Atlas of Science: Visualizing What We Know*. Like the previous volume, the *Atlas of Knowledge* is lavishly illustrated and includes large-scale, full-color maps from *Places & Spaces* (in this case, those maps featured in iterations IV through VII of the exhibit). While the first *Atlas* introduced readers to science mapping and traced the evolution of the craft over time, the *Atlas of Knowledge* is more concerned with the "how" of mapmaking: ways to best address the demands of particular tasks and the needs of users; strategies for collecting, analyzing, and visualizing data; and methods of interpreting data visualization. Drawing on 15 years of research and tool development, the *Atlas* introduces a theoretical visualization framework meant to empower anyone to systematically render data into insights. The framework covers major types and levels of analysis; it identifies and explains different types of insight needs, data scales, visualizations, graphic symbols, and graphic variables; and it deeply integrates statistical, geospatial, topical, and network analysis and visualization. Brimming with useful knowledge and practical illustrations, the *Atlas of Knowledge* will prove to be a valuable resource both for those seeking to understand the mechanics of mapmaking and for those interested in making their own maps of science.

IVMOOC

In January 2015, CNS will again offer its popular Information Visualization MOOC (ivmooc.cns.iu.edu) to those interested in learning more about current practices and methodologies in data visualization. The IVMOOC, which in its initial run in 2013 attracted participants from more than 100 countries, provides

Participants from more than 100 countries registered for the IVMOOC in 2013 and an even larger turnout is expected in 2015

Exhibit maps and Ingo Günther's *WorldProcessor* globes on display at Duke University

an overview of information visualization and teaches the process of producing effective visualizations that take into account the needs of users. The course was one of the first MOOCs offered by Indiana University and the first to offer opportunities for students to work in teams with actual clients. In this valuable real-world experience, students collaborated with researchers interested in understanding data patterns and trends, government agencies developing visual interfaces for data holdings, industry representatives looking to maximize return on investment, medical doctors seeking cures, and not-for-profit organizations hoping to communicate impacts and achievements. In 2014, the accompanying textbook *Visual Insights: A Practical Guide to Making Sense of Data* by Katy Börner and David E. Polley was published by The MIT Press and now serves as a useful companion to the material covered in the IVMOOC.

Upcoming Venues and Workshops

After finishing its residency at the University of Miami, *Places & Spaces* will spend much of 2015 working its way north. Beginning January 12th, the exhibit will be on display at Duke University in Durham, NC, until April 15th. After that, it will travel to Chicago where it will be featured at Northwestern University's Galter Health Sciences Library from May 1st through September 30th.

In other news, the 2015 AAAS Annual Meeting will feature a symposium entitled *Visualization Insights from Big Data: Envisioning Science, Engineering, and Innovation*. Organized by Katy Börner and Joseph E. Sabol, this interdisciplinary event will include experts from the areas of science policy, engineering, chemistry, and the visual arts. The session will highlight the ways in which data mining and visualization can be instrumental in maximizing return on investment, locating emerging topics of research, and forecasting trends in science and technology.

Linking International Databases to Build Strategic Academic Partnerships in Science Workshop held at AAAS in Washington, D.C. in May 2014

Exhibit Advisors

Gary Berg-Cross is a cognitive psychologist (PhD, SUNY–Stony Brook) who has taught at a number of institutions over his career (SUNY, Widener, University of Delaware, George Washington, George Mason University, and others). Currently, Berg-Cross is a Co-Principal Investigator on a four-year, NSF-sponsored study entitled Spatial Ontology Community of Practice: An Interdisciplinary Network to Support Geospatial Data Sharing, Integration and Interoperability (SOCoP-INTEROP Project). [Potomac, MD, USA]

Bob Bishop is chairman and founder of BBWORLD Consulting Services Sàrl and president and founder of the ICES Foundation. In addition, Bishop is involved in a range of global initiatives: he is a Fellow of the Australian Davos Connection (ADC), an elected member of the Swiss Academy of Engineering Sciences (SATW), and serves on the advisory panels for the École Polytechnique Fédérale de Lausanne's Blue Brain Project and Human Brain Project. [Geneva, Switzerland]

Kevin Boyack is president of SciTech Strategies, Inc., where his work centers on developing more accurate global maps of science. He has published nearly 30 articles on various aspects of science mapping and related metrics. Current interests include the detailed mapping of the structure and dynamics of science and technology, the application of full text to science mapping and bibliometrics, and the identification of emerging topics. [Albuquerque, NM, USA]

Donna J. Cox is the first Michael Aiken Chair, director of the Advanced Visualization Laboratory (AVL) at the National Center for Supercomputing Applications, and director of the Illinois eDream Institute, all at the University of Illinois at Urbana-Champaign. She is a recognized pioneer in Renaissance Teams and supercomputer visualizations for public outreach, and in 2006 she was selected by the Chicago Museum of Science as one of 40 modern-day Leonardo da Vinci's. [Urbana-Champaign, IL, USA]

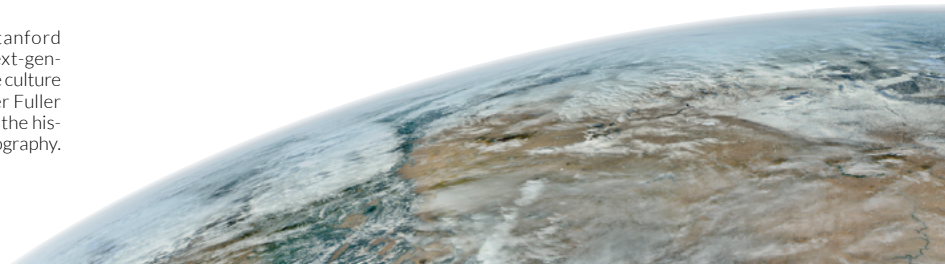
Bonnie DeVarco is a Media X Distinguished Visiting Scholar at Stanford University. She writes and lectures on design science, virtual worlds, next-generation geographic information systems, information visualization, and the culture of cyberspace. Currently, DeVarco is completing a book on Buckminster Fuller entitled *Invisible Architecture II*, co-authoring *Shape of Thought*, a work on the history and evolution of visual language, and co-editing a book on Ludic Cartography. [Palo Alto, CA, USA]

Sara Irina Fabrikant is a professor of geography and head of the Geographic Information Visualization and Analysis (GIVA) group at the GIScience Center at the Geography Department of the University of Zürich, Switzerland. She is the elected chair of the Cognitive Visualization Commission of the International Cartographic Association, and she serves on the editorial boards of eight of the leading journals in GIScience and cartography. [Zürich, Switzerland]

Marjorie M.K. Hlava is president, chairman, and founder of Access Innovations, Inc. She has served as president of several organizations in the international information arena, including NFAIS, ASIS&T, ASIDIC, and Documentation Abstracts. In 2014, she released The Taxobook, a three-part series on the creation and implementation of controlled vocabularies. That same year, she was awarded the ASIS&T Award of Merit for her work in information technology application.

Peter A. Hook is an Assistant Professor of Library and Information Science at Wayne State University in Detroit, MI. He received his doctorate from the School of Informatics and Computing at Indiana University where his primary research focus was information visualization, particularly the visualization of knowledge organization systems, concept mapping, and the spatial navigation of bibliographic data in which the underlying structural organization of the domain is conveyed to the user. [Detroit, MI, USA]

Manuel Lima is a Fellow of the Royal Society of Arts, a senior user experience design lead at Microsoft Bing, and the founder of VisualComplexity.com—a visual exploration of mapping complex networks. Nominated by *Creativity* magazine as "one of the 50 most creative and influential minds of 2009," Lima is a leading voice on information visualization and a frequent speaker at conferences and schools around the world. [New York, NY, USA]



Deborah MacPherson works in specifications and research at Cannon Design, an architectural/engineering firm specializing in healthcare, research laboratories, universities, and sports facilities. She is also projects director for the 501(c)(3) nonprofit organization Accuracy & Aesthetics, and immediate past president of the Northern Virginia Construction Specifications Institute (CSI) chapter. [Vienna, VA, USA]

Lev Manovich is professor at the City University of New York (CUNY) Graduate Center and author of several books on digital culture, including the recent *Software Takes Command* (Bloomsbury Academic, 2013). In 2007, Manovich founded the Software Studies Initiative in order to develop a new paradigm of Cultural Analytics through data analysis and interactive visualization of patterns and trends in media and visual cultures. [New York, NY, USA]

Carlo Ratti, an architect and engineer by training, practices in Italy and teaches at the Massachusetts Institute of Technology, where he directs the SENSEable City Lab. Ratti has co-authored over 200 publications, exhibited his work at venues around the world, and holds several patents. He has been included in *Esquire* magazine's "Best and Brightest" list, *Blueprint* magazine's "25 People Who Will Change the World of Design" and *Forbes* magazine's "People You Need to Know in 2011." [Cambridge, MA, USA]

Eric Rodenbeck is founder and creative director of the San Francisco-based design and technology studio, Stamen Design. Since 1997, he has worked with interactive design to extend the boundaries of online media and live information visualization. In 2008, he was named one of *Esquire* magazine's "Best and Brightest" new designers and thinkers, and one of *i-D* magazine's top 40 designers to watch. [San Francisco, CA, USA]

André Skupin, professor of geography at San Diego State University, is interested in the application of geographic metaphors, cartographic principles, and computational methods to the visualization of non-geographic information. His research is interdisciplinary, aimed at increased cross-fertilization between geography, information science, and computer science. Recent work includes novel methods for visualizing human movement and demographic change as trajectories in n-dimensional attribute space. [San Diego, CA, USA]

Moritz Stefaner is a freelance designer on the crossroads of data visualization, information aesthetics, and user interface design. With a background in cognitive science and interface design, Stefaner's work beautifully balances analytical and aesthetic aspects in mapping abstract and complex phenomena. In 2010, he was nominated for the Design Award of the Federal Republic of Germany, and his work has been exhibited at SIGGRAPH and Ars Electronica. Portfolio at moritz.stefaner.eu [Lilienthal, Germany]

Stephen Uzzo is vice president of science and technology for the New York Hall of Science where he works on exhibit and program development projects related to STEM learning, scientific visualization, sustainability, and network science. Uzzo also serves on the faculty of the New York Institute of Technology Graduate School of Education, where he teaches STEM teaching and learning. [Queens, NY, USA]

Caroline Wagner holds the Wolf Chair at Ohio State University's John Glenn School of Public Affairs and is an expert in the field of science and technology and its association to policy, society, and innovation. She has served as a professional staff member for the U.S. Congress Committee on Science, Space, and Technology, the Congressional Office of Technology Assessment, and the State Department and as advisor to the European Commission, World Bank, U.S. National Science Foundation, and others. [Columbus, OH, USA]

Benjamin Wiederkehr is founding partner and managing director of the Zürich-based design and data visualization studio, Interactive Things. He is also part of the Open Government Data task force in Switzerland and helps to facilitate open access to government data for everyone. On Datavisualization.ch, Wiederkehr provides insight into his research and working process and documents topical use cases in the field of data visualization. [Zürich, Switzerland]

Bring the Exhibit Home

Bring *Places & Spaces* to Your Institution

Put your institution on the map by hosting *Places & Spaces* at your university, museum, or library. The exhibit consists of 100 framed high-resolution maps and accompanying labels and introductory panels. Included as well are additional elements such as the Illuminated Diagram, Ingo Günther's WorldProcessor Globes, the Hands-on Science Maps for Kids, and the award-winning film *Humanexus*. Exhibit curators will be happy to speak with you about the benefits of hosting *Places & Spaces* and the logistics involved in doing so.

Share these educational science maps with your whole institution by becoming an official exhibit host!

Potential hosts concerned about space should know that while the exhibit is quite impressive when displayed as a cohesive whole in a continuous space, it has also been presented to great effect as smaller conceptual units in separate (but not too distant) spaces. We can discuss with you the arrangement that best suits your situation in order to arrive at the perfect communion between exhibit and venue.

Over its ten-year history, *Places & Spaces* has appeared at some of the world's most renowned institutes of knowledge and learning, including the National Academy of Sciences, the New York Public Library, the Chinese Academy of Sciences, the Royal Netherlands Academy of Arts and Sciences, and many more universities, libraries, and museums around the globe (see scimaps.org/exhibitions for a complete list of venues). Contact us at cns@indiana.edu today to begin the process of bringing *Places & Spaces* to your own cherished institution.

Katy Börner and Petra Ahrweiler installing posters at the *Simulating the Social Processes of Science Workshop* held in Leiden, The Netherlands, April 7-11, 2014

Places & Spaces on the media wall at the *ACM Web Science Conference* at Indiana University in Bloomington, June 23-26, 2014

Think Outside the Frame!

Our designers have worked with IT experts from universities around the country to create an exhibit experience that is truly larger than life. The *Places & Spaces* Digital Display is a dazzling showcase for these stunning maps of science, taking the viewer through the evolution of science mapping from its earliest beginnings to its most cutting-edge developments.

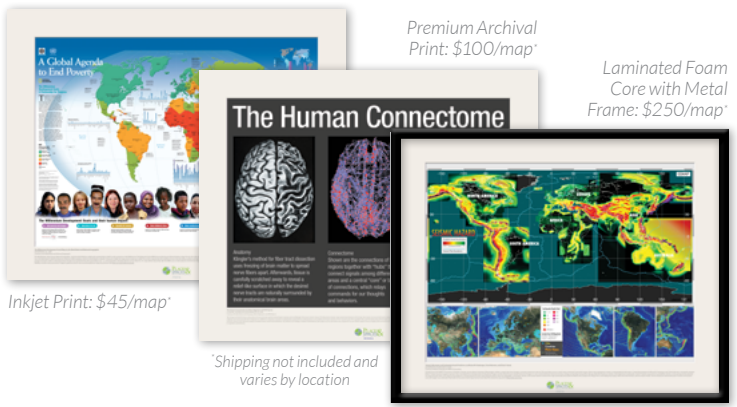
Don't have enough wall space for the physical exhibit? You can display all 100 maps on a single wall!

In bringing the exhibit to the big screen, great care has been taken to preserve the maps' rich color and clarity. Thus, the large-screen display offers a presentation that is grand in scale, but doesn't sacrifice the qualities that audiences have come to expect and treasure. You can display the maps on your institution's digital wall, or project them onto a light surface for an equally impressive experience. We will work closely with you on customizing the display to perfectly fit your space.

This unique production debuted in 2012 at the IQ-Wall in the Herman B Wells Library at Indiana University. It has also been on display at Brandeis University, Israel's Weizmann Institute of Science, Rice University, Duke University, and North Carolina State University's state-of-the-art Immersion Theater. The digital display was also showcased on a touch table at the *International Conference for High Performance Computing, Networking, Storage, and Analysis* in New Orleans this fall and will make its European debut at this year's International Science Festival in Gothenburg, Sweden. To learn how to bring the *Places & Spaces* Digital Display to a screen near you, contact us at cns@indiana.edu.

Purchase a Map of Science

Any visit to the *Places & Spaces* exhibit is sure to be memorable, but many attendees find themselves wanting to take with them something more tangible than memories. Those individuals will be delighted to learn that the majority of our exhibit maps are available for purchase at our online store (scimaps.org/store). All maps are 24" x 30" (61 x 76 cm) and can be ordered as inkjet prints, high-quality archival prints, and framed prints.



*Inkjet Print: $45/map**

*Premium Archival Print: $100/map**

*Laminated Foam Core with Metal Frame: $250/map**

**Shipping not included and varies by location*

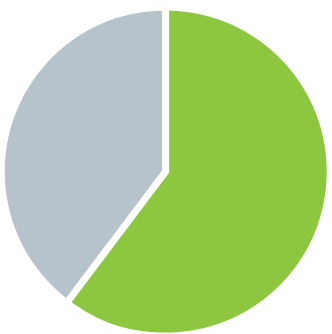
In addition, some fans of the exhibit find the theme of a particular iteration especially relevant to the interests of their institution. To meet this need, poster versions of each iteration are also available at the *Places & Spaces* online store. They consist of two posters per iteration, with each poster measuring around 67" x 36" (170 x 92 cm). The posters feature all ten maps from the iteration, their descriptions, colorful photos, and interesting exhibit information.

Finances & Numbers

Finances

Exhibit finances are managed by the Cyberinfrastructure for Network Science Center at the School of Informatics and Computing, Indiana University. Shown below are exhibit income expenditures for 2014. Exhibit revenues come from map sales, venue contributions, and support by the Cyberinfrstructure for Network Science Center.

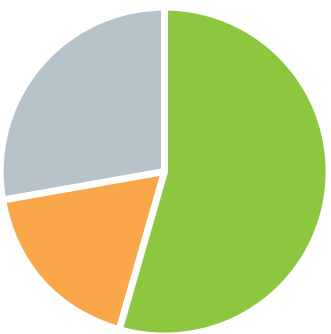
2014 Expenses*



Total: $75,001.51

Salaries	$45,404.88
Design & Venue Acquisition	$25,596.63
Workshops & Events	N/A

2014 Revenue*



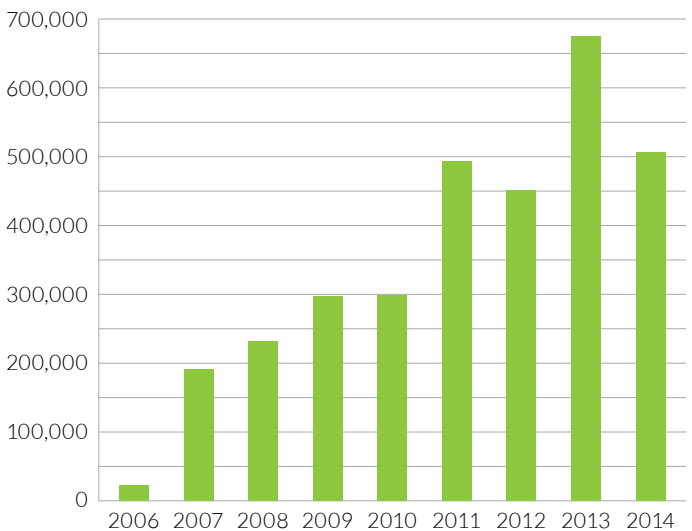
Total: $75,001.51

CNS Support	$40,851.82
Venue Contributions	$20,657.19
Map Sales	$13,492.50

Exhibit in Numbers (since 2005)

Exhibit Maps: 100
Map Makers: 215
Map Maker Countries: 16
Map Maker Cities: 68
Display Venues: 290
Press Items: 186
Workshops Organized: 30
Website Visits: 3,597,536

Visits to scimaps.org



*This report covers the exhibit's 2014 fiscal year: Jan 1 - Dec 31, 2014.

References

Books & Essays

Börner, Katy. 2010. *Atlas of Science: Visualizing What We Know*. Cambridge, MA: The MIT Press. (scimaps.org/atlas1)

Börner, Katy. 2015. *Atlas of Knowledge: Anyone Can Map*. Cambridge, MA: The MIT Press. (scimaps.org/atlas2)

Börner, Katy, and David E. Polley. 2014. *Visual Insights: A Practical Guide to Making Sense of Data*. Cambridge, MA: The MIT Press.

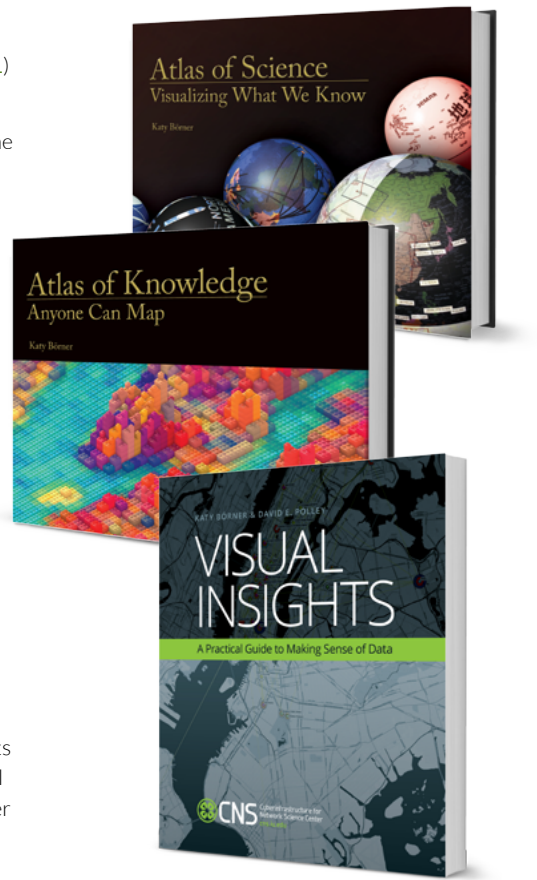
Boyack, Kevin W., and Katy Börner, eds. 2014. "Mapping Science." Special issue, *Bulletin of the Association for Information Science and Technology* 41 (2).

de Rosnay, Joël. 1979. *The Macroscope: A New World Scientific System*. New York: Harper & Row.

Newman, Cathy. 2015. "100 Years of National Geographic Maps: The Art and Science of Where." National Geographic Society Online. Accessed February 18.

Scharnhorst, Andrea, Katy Börner, and Peter van den Besselaar, eds. 2012. *Models of Science Dynamics: Encounters Between Complexity Theory and Information Sciences*. Berlin: Springer-Verlag.

Shiffrin, Richard M., and Katy Börner, eds. 2004. "Mapping Knowledge Domains." Special issue of *PNAS* 101 (Suppl. 1).



Tools

Science of Science (Sci2) Tool (sci2.cns.iu.edu) is a desktop application that was specifically designed for the study of science. It supports the temporal, geospatial, topical, and network analysis and visualization of data sets at the micro (individual), meso (local), and macro (global) levels.

Data

The Scholarly Database (sdb.cns.iu.edu) provides easy access to more than 26,300,000 papers, patents, and grants from major databases such as MEDLINE, U.S. Patent and Trademark Office, National Science Foundation, National Institutes of Health and National Endowment for the Humanities Awards as well as Clinical Trials. Users can register for free to cross-search these databases and to download result sets as dumps for science of science research and science policy practice.

Connect With Us

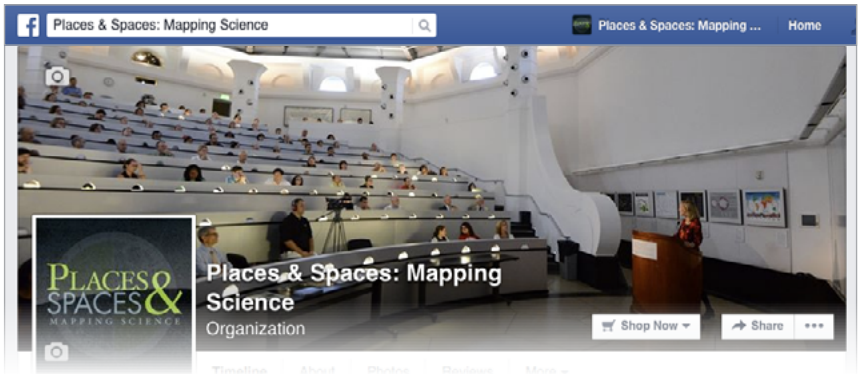
Places & Spaces: Mapping Science
Cyberinfrastructure for Network Science (CNS) Center
School of Informatics and Computing
Indiana University
Wells Library 020, 1320 E. 10th Street
Bloomington, IN 47405, USA

PHONE 812.855.7034 or 812.855.5120
FAX 812.855.6166
EMAIL cns@indiana.edu
WEB scimaps.org

Funding for *Places & Spaces* is provided by the National Science Foundation under grants IIS-0238261, CHE-0524661, IIS-0534909, and IIS-0715303; the James S. McDonnell Foundation; and Thomson Reuters. Additional funding comes from the Cyberinfrastructure for Network Science Center, University Information Technology Services, and the School of Informatics and Computing—all three located at Indiana University. Some of the data used to generate science maps is from Thomson Reuters and Elsevier. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or other sponsors.

Friend us on Facebook!

/mappingscience



Follow us on Twitter!

@mappingscience