Introduction

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An encyclopedia reflects a design and a process that not only determine its content but also limit and enhance its usefulness. In addition to providing a comprehensive description of the intellectual design of *Cartography in the Twentieth Century*, this introduction situates volume 6 as part of the larger *History of Cartography* series and concludes with practical advice for users. It begins with a concise overview of the importance of the twentieth century as a period that saw broad changes in the form, use, and circulation of maps. At the end of the volume a brief processual history describes the complex process of implementing the logic and systematic strategy described below.

Mapping in the Twentieth Century

Despite deep roots in the mapping practices of the nineteenth century and earlier eras, the period 1900 through 2000 was a distinct and coherent era in cartographic history characterized by six key themes that together revolutionized both the form and the use of maps (e.g., Monmonier and Puhl 2000):

1. *Diverse Impacts of Mapping on Society.* Whether driven by technology, state formation, imperialism, or other forces, mapping assumed new or greatly enhanced roles in the twentieth century, notably in entertainment, environmental protection, growth management, weather prediction, hazard mitigation, and other arenas with clear social impact. Dramatic change is most notably apparent in the transition from paper to digital media and in related changes in data acquisition, map compilation, representation, and dissemination (Foresman 1998; Monmonier 1985, 1996). This unprecedented upheaval alone is a strong argument for the twentieth century's importance as a pivotal period and thus a coherent focus of historical enquiry. Moreover, the century witnessed not only a relative "democratization" of map use and associated improvements in cartographic literacy but also an increased awareness of ethical considerations in the design and use of maps: by century's end maps and mapping were subject to unprecedented questioning, counter-maps were challenging the author-

ity of official delineations, and participatory mapping was a recurrent theme at academic conferences.

Indeed, as mapping practices pervaded all parts of the globe and all levels of society, and mapping became more important as a tool for coping with complexity, organizing knowledge, and influencing public opinion, scholars recognized the need (belatedly perhaps) for a critical appraisal of the use, misuse, and effectiveness of maps for exploration, regulation, management, planning, and persuasion. Understanding the importance of maps as tools also demands a conscientious effort to disentangle significant, demonstrable impacts like those described in volume 6 from assumptions based largely on theory or conjecture. During the twentieth century simplistic notions of the map as an objective representation of reality have given way to a broader grasp of how the map's respectability as a scientific tool makes it a target of political manipulation (see the entry "Geopolitics and Cartography"), a broader and deeper appreciation of the diverse ways in which maps can be read and understood (see "Social Theory and Cartography"), and a broader, more nuanced understanding of the role of cartographic visualization in the packaging of ideas (see "Persuasive Cartography"). The changing boundaries between cartography and other endeavors were also apparent in the growing participation of humanists, literary scholars, and art historians at academic conferences on map use and map history as well as in the adoption of the geographic information system (GIS) as an analytical tool in archaeology, environmental biology, and public administration, among other fields.

2. *Overhead Imaging.* Technologies for imaging earth from aircraft, satellites, balloons, and rockets enhanced the efficiency of mapping and surveillance and had diverse scientific, social, military, and political impacts, exemplified in the early twenty-first century by an increased use of unmanned aerial vehicles as tools of surveillance and weapons of attack. Improved technologies for capturing image data and extracting cartographic features spearheaded a proliferation of geospatial databases, which in turn fostered a revitalized use of maps in older, more traditional fields of application

such as energy exploration, transportation, and urban planning. During the twentieth century, aerial mapping and photogrammetry extended the reach of large- and intermediate-scale topographic mapping so effectively that terrae incognitae no longer meant the absence of any modern maps but a relative dearth of the censuses, detailed land use surveys, and environmental assessments essential to the Western world's managed spaces. In addition, remote imaging of other heavenly bodies helped redefine exploration.

3. *The Electronic Transition.* Another dramatic development was the far-reaching conversion of geographic information to electronic media, which allowed the creation of interactive and dynamic maps. While the products of this technology were not necessarily less expensive or more reliable, GIS and the Internet radically altered cartographic institutions and lowered the skill required to be a map author, and satellite positioning and mobile telecommunications revolutionized map-based wayfinding. Moreover, web-based technology not only undermined the traditional role of the state in topographic mapping but also made zooming in and out a widely pervasive and intrinsically interactive means of changing map scale—an extension to everyday use of the elegant but static bird's-eye views that had begun to proliferate in the nineteenth century. Connections with earlier periods of map history are also apparent in the increased role of government in collecting, mapping, and using scientific data; the heightened concern for data quality; the rise and decline of truly mass production in the twentieth century; and the conflation of geographical, thematic, and topographic mapping whereby users could toggle between different layers or "coverages" while interactively manipulating map scale. Astute implementation of digital technologies, though never straightforward and far from complete by century's end, had moved cartography farther beyond description and delineation and closer to the more ambitious goals of seeing and knowing.

4. *Maps and Warfare.* The twentieth century witnessed the increased salience of the longstanding relationship between cartography and warfare. Along with the greater efficacy of precisely targeted cruise missiles and the trickle-down of military technology into civilian applications, this development brought impulsive aggression, the diversion of funds from beneficial public investment, and a reduced reliance on diplomacy. Accompanying this technology-inspired reconfiguration of military mapping were new notions of territory that a nation-state might claim as well as new prohibitive cartographies to protect these claims (Monmonier 2010). Chief among these prohibitive genres is aeronautical charting, which arose during the twentieth century to produce, reproduce, and regulate navigable airspace and

later became a defensive strategy through the declaration of no-fly zones, actively enforced in some cases but largely rhetorical in others. Radar, a new mapping tool adept at tracking aircraft, became a strategy for enforcing other kinds of no-fly zones, including airspace restrictions above coastal waters and dynamic temporary flight restrictions (TFRs) that could emerge or expand suddenly in accord with the movements of top officials. The growth of prohibitive cartography during the twentieth century is also apparent in increased maritime restrictions, including the widening of most territorial seas from three to twelve nautical miles and the delineation of Exclusive Economic Zones (EEZs), which gave coastal nations new authority over fishing and subsurface mining within two hundred nautical miles of their shoreline. The advent of offshore drilling and submarine warfare led to a broader, more intensive mapping of the sea floor as well as the discovery of a multitude of seamounts (submarine volcanoes), which triggered a round of aggressive naming reminiscent of the seventeenth century. Mapping had an inevitable if not indispensible role in dividing the seas and shrinking international waters.

New mapping technologies strengthened the bond between national defense and cartography and underscored the unintended consequences of technological innovation. Cold War fears of nuclear weapons and intercontinental ballistic missiles inspired the development of artificial satellites useful not only for monitoring weapons development and launch sites but also for mapping terrain and monitoring weather systems. More exact representations of the planet's shape and gravity anomalies, originally intended to guide intercontinental ballistic missiles toward precisely pinpointed targets, provided a more accurate geodetic framework for geographic information of all types, civilian as well as military. In addition, the prospect of low-altitude unmanned bombers guided by the automated comparison of altimeter readings with onboard electronic terrain maps led to digital elevation models, which by century's end were supporting civilian applications as diverse as geographical mapping, landscape architecture, and commercial forestry. Moreover, the global network of seismographs sensitive to underground explosions— essential for ensuring compliance with nuclear test-ban treaties—proved useful in studying continental drift and modeling seismic risk. And finally, the Global Positioning System (GPS), intended as a more reliable way to route cruise missiles, became a commonplace tool for navigation, field measurement, land survey, and location tracking—and an ominous implementation of prohibitive cartography when linked through the wireless network with no-go areas stored in a GIS.

5. *The Paradox of Globalized Practices and Customized Content.* While the globalization of mapping tech-

nology and cartographic practice diminished international differences among cartographic products, fuller customization of map design and content fostered a broader range of cartographic applications, an unprecedented diversity of map types, significant changes in the form and appearance of maps, and the increased prominence of maps in the mass media. The globalization imperative already apparent in commercial and institutional arenas at the end of the nineteenth century (see the entry "International Map of the World") intensified after World War II (see "Emergency Planning" and "Hazards and Risk, Mapping of"), and new cartographic genres emerged when distinct consumer communities adopted standardized aesthetics (for examples, see "Soils Map" and "World Aeronautical Chart") that ran from the highly formal (see "Marine Chart" and "Orienteering Map") to the aggressively informal (see "Advertising, Maps as" and "Political Cartoons, Maps as"). The coexistence of global standardization and increased customization is epitomized by infectiously innovative designs instantly recognizable to map collectors and cartophiles worldwide; some were distinctively functional (see the entries "London Underground Map" and "Raisz, Erwin [Josephus]") while others were preeminently ideological (see "Air-Age Globalism" and "Peters Projection"). The trend toward customization is also apparent in an increased diversity of map projections.

Digital technologies intensified these trends, but globalization often superseded customization. Although illustration and map projection software encouraged map authors to customize their designs for specific audiences, GIS software and web-based mapping typically constrained graphic style while simultaneously supporting flexibility in content and geographic scope (see the entries "Environmental Systems Research Institute" and "MapQuest.com"). Moreover, the growing ascendancy of digital technologies hastened the standardization of data structures and the adoption of exchange formats required for efficient communication among data providers, software developers, and mapmakers (see the entries "Metadata" and "Standards for Cartographic Information"). Stylistic homogeneity increased when new organizations emerged to promote data sharing internationally (see "Comité Européen des Responsables de la Cartographie Officielle") and within governments (see "Report of the Committee of Enquiry into the Handling of Geographic Information"). By century's end online mapping applications with a rich toolbox of standardized symbols and layers promised unprecedented customization in content and relevance.

6. *Maps as Tools of Public Administration*. Although maps were used in urban governance during the nineteenth century, they assumed greater importance during the twentieth century in local and national public administration, regional planning, and the representation of national identity. Key roles at the municipal level include land use planning and code enforcement; emergency response; the delineation and publication of election district boundaries; the delivery of regionalized municipal services; the assessment, taxation, and sale of real property; the design, management, and promotion of public transit networks; the analysis and control of crime; the management of networked infrastructure for electronic communication, energy distribution, water supply, and sewage; and the delineation of historic districts established to preserve a city's architectural heritage. Effective municipal administration came to depend heavily on reliable large-scale maps. At regional and national levels, mapping activities evolved during the twentieth century to include map-intensive systems for monitoring weather and water quality, predicting environmental disasters, and planning and orchestrating evacuations. Numerical simulation models became particularly important in mitigating flooding, seismic activity, and other hazards through land use regulation and insurance. Accompanying this increased usage of maps was a growing awareness among scholars of the map's value as an instrument of persuasion, empowerment, and resistance.

Despite numerous improvements to mapping technology during the twentieth century and an increased pervasiveness of mapping activity, maps became neither ubiquitous nor democratized in the sense of being fully and readily available to all citizens. A careful reading of entries in volume 6 will reveal that progress was seldom steady, advances were sometimes troublesome and rarely complete, and consequences were often unpredictable. These caveats in no way diminish the century's significance as a momentous epoch in map history.

The History of Cartography Project: Overview

This section provides a short overview of the History of Cartography Project, of which *Cartography in the Twentieth Century* is the sixth volume, and discusses the Project's stated goals, its working definition of *map*, the endorsement of earlier volumes by the scholarly community, and the rationale for switching from the long-essays approach of volumes 1, 2, and 3 to the encyclopedic strategy adopted for volumes 4, 5, and 6, each comprised of several hundred individual entries (or articles) ranging in length from 500 to several thousand words and including a short bibliography roughly proportional to wordage. Readers are also encouraged to consult Matthew Edney's entry on the History of Cartography Project in this volume.

One of the pivotal events in the academic specialty

known as the history of cartography occurred in May 1977, when David Woodward was visiting his friend Brian Harley at Harley's home in Newton Abbot in Devon, U.K., and they decided to organize and edit a multivolume history of the processes, institutions, and societal impacts of mapmaking (Harley and Woodward 1983; Woodward 1994, xxiii; Woodward 2001). Their goal was to enhance the specialty's scholarly identity with an authoritative reference work that would reverse the marginalization of map history by integrating existing knowledge of mapping practices and institutions—as they observed in the preface to volume 1, the history of cartography occupied a "no-man's land among several paths of scholarship," most notably bibliography, geography, and history (Harley and Woodward 1987, xv). Their "general history" of one million words would be apportioned among four volumes, with the entire set completed by 1992, an optimistic target date that conveniently coincided with the five-hundredth anniversary of the "discovery" of America by Christopher Columbus. As the experiences of Harley, Woodward, and subsequent editorial collaborators have amply demonstrated, predicting the time required to prepare a comprehensive history of mapmaking requires optimistic enthusiasm as well as a mixture of quiet resignation and dogged persistence, and early estimates of an adequate word count were similarly underestimated. Simply put, there's much more to the history of cartography than Woodward and Harley had originally imagined, nearly four decades ago.

How much more is itself a telling tale. The original plan apportioned the period through the beginning of World War I into four volumes, respectively covering prehistory through ca. 1470, ca. 1470–1670, ca. 1670–1780, and ca. 1780–1914. By the early 1980s a fifth volume had been added, for the period 1914 to "the present" (Harley and Woodward 1983, 587). When the founders recognized there were people who could write about mapping in indigenous and non-Western societies, they inserted a new second volume, which ballooned into three separate books—*Cartography in the Traditional Islamic and South Asian Societies* (1992), *Cartography in the Traditional East and Southeast Asian Societies* (1994), and *Cartography in the Traditional African, American, Arctic, Australian, and Pacific Societies* (1998)—and inspired increased respect for a "mapping impulse" in Islamic and South Asian cartography that is different from the scientific cartography of Europe (Harley and Woodward 1992, xxi) as well as for the "performance cartography" of other traditional societies that are distinct from Western material cartography (Woodward and Lewis 1998, 4–5). In contrast to volume 1, *Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean* (1987), which covered the

earliest period with just over 350,000 words and 292 black-and-white illustrations on 599 pages plus 40 color plates, volume 3, *Cartography in the European Renaissance* (2007)—originally budgeted for only one-million words—exceeded 1.3 million words and comprised 960 black-and-white illustrations in 62 long essays (chapters) on 2,180 pages, plus 80 color plates, and had to be split into two separately bound "parts."

In planning their project Harley and Woodward drew up four broad criteria that have guided the selection of content for all six volumes. Foremost was a definition of the map "that is neither too restrictive nor yet so general as to be meaningless."

> Maps are graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world. (Harley and Woodward 1987, xvi)

Among the key elements of their definition, "graphic representations" is essential and obvious, "spatial" obviates pointless restrictions to phenomena on planet earth, "understanding" demands at least minimal intellectual relevance, and "things . . . the human world" rules out microscopic and molecular relationships and focuses on consequences for individuals and society. Moreover, the focus on spatial understanding helps balance a reconceptualization of "graphic" in volume 6 to include electronic storage: whether a geographically structured database meets the threshold for "graphic" becomes moot when an electronic representation of mappable information is considered a tool for making graphics that enhance spatial understanding.

Harley and Woodward were less specific in defining *cartography,* an early nineteenth-century neologism (Krogt 2006) that also delimited the scope of the *history of cartography* (Harley and Woodward 1987, xv). In calling for a much more catholic definition for cartography, they embraced what might be paraphrased as the study of the art, science, and technology of making, using, and studying maps, and they soundly rejected efforts to narrow the definition to map design and production, the prime subject matter in the early 1980s of college courses titled "Cartography." Their new definitions of *map* and *cartography* lay behind, of course, the inexorable growth of the initial volumes and the massive scope of each of the last three volumes, including volume 6.

Their other three criteria proved similarly serviceable for later volumes. The second criterion, a "commitment to a discussion of the manifold technical processes that have contributed to the form and content of individual maps," recognizes the importance of technology as both a facilitator and a hindrance, while the third, "recognition that the primary function of cartography is ulti-

mately related to the historically unique mental ability of map-using peoples to store, articulate, and communicate concepts and facts that have a spatial dimension," places a much-needed emphasis on communication, outcomes, and the intellectual consumption of maps. By contrast, their fourth criterion, "the belief that, since cartography is nothing if not a perspective on the world, a general history of cartography ought to lay the foundations, at the very least, for a world view of its own growth," calls for a critical self-examination of map history and the questions it asks as a scholarly endeavor (Harley and Woodward 1987, xviii). Collectively these four criteria not only set an agenda for the history of cartography as an academic specialty but also define the scope of a meaningful history of mapmaking and map use.

Additional editors were recruited because Harley and Woodward needed their expertise. This need became particularly acute after non-Western cartography was hived off into its own volume, which in turn was split into three separate books. For volume 2, book 1 (*Cartography in the Traditional Islamic and South Asian Societies*), Harley and Woodward recruited Joseph E. Schwartzberg, a respected South Asian scholar, and Gerald R. Tibbetts, an expert on Islamic cartography, as associate editors and Ahmet T. Karamustafa, another Islamic specialist, as assistant editor. For book 2 (*Cartography in the Traditional East and Southeast Asian Societies*), Schwartzberg served as associate editor; Cordell D. K. Yee, who specialized in Chinese cartography, was named assistant editor; and Schwartzberg and Yee each contributed six of the book's twenty-one chapters and collaborated with Woodward on the "Concluding Remarks." Following Harley's death in 1991, Woodward coedited book 3 (*Cartography in the Traditional African, American, Arctic, Australian, and Pacific Societies*) with G. Malcolm Lewis, whose research focused on mapping by indigenous peoples.

Timely completion of the last three volumes required further appointments. My own involvement with volume 6 goes back to the early 1980s, when I was editor of the *American Cartographer*, David Woodward was my associate editor, and he and I occasionally discussed the twentieth-century volume and its contents. In December 1984 Woodward and Harley asked me to be their coeditor for volume 6, and in 1985 we drafted a detailed outline in accord with the long-essay strategy. Because of the escalating demands of the other volumes, that effort was put on hold, but in early 1997 Woodward was ready to move forward with me as lead coeditor of volume 6. Focusing his own effort on volume 3, he also announced his intention to find coeditors for volume 4 (*Cartography in the European Enlightenment*) and volume 5 (*Cartography in the Nineteenth Century*). In 1998 he appointed D. Graham Burnett, Matthew H. Edney,

and Mary Sponberg Pedley to edit volume 4 and initiated annual meetings—semiannual after April 2004—of his four volume editors with Project staff in Madison. Concern about length and publication cost precipitated the decision to limit volumes 4, 5, and 6 to one million words each, and to produce them in an encyclopedic format. Woodward was actively involved with the Project until a few weeks before his death in August 2004, and Edney, who became project director the following year, oversaw completion of volume 3. Burnett stepped down in 2005, and Edney appointed Roger Kain editor of volume 5 in 2008.

The intellectual apparatus and organizational structure Harley and Woodward established for volume 1 has benefitted all subsequent volumes. As publisher of the series, the University of Chicago Press has proved an enduring source of moral support, academic prestige, and literary continuity. Woodward set up a project office in Madison, Wisconsin, at the University of Wisconsin campus, where he was a full professor and, after 1995, the Arthur H. Robinson Professor of Geography. The Madison office worked with satellite offices in Exeter, U.K., and Milwaukee, Wisconsin, when Harley was on the faculties of the University of Exeter (until 1986) and the University of Wisconsin–Milwaukee (from 1986 until his death in 1991), as well as later satellites at the home institutions of subsequent volume editors. Experienced staff in Madison afforded a high level of editorial support for manuscripts and illustrations, including fact and reference checking, stylistic continuity, and the acquisition of images and necessary permissions, as well as effective coordination of communications and fund raising through government grants and private donations. Beginning with volume 1, the Project has relied heavily on boards of expert advisors, who have assisted with the design of contents, the selection of contributors, and the vetting of manuscripts.

Supportive book reviews and numerous awards have recognized the excellence of volumes 1 through 3. As examples, the Professional and Scholarly Publishing Division of the Association of American Publishers (AAP) named volume 1 the Best Book in the Humanities for 1987. In 1992 the AAP gave volume 2, book 1, its R.R. Hawkins Award for Best Scholarly Book, and in 1999 the American Historical Association awarded volume 2, book 3, its James Henry Breasted Prize for the best English-language book in any field of history prior to a.d. 1000. Accolades like these reinforce the Project's high standards.

The Shift to an Encyclopedic Structure

By the later 1990s it became clear to Woodward that something had to be done to control the growth of the

History's volumes. Even as the Press insisted, in the face of the changing economics of academic publishing, that each of the last three volumes could contain no more than one million words and one thousand illustrations, the tremendous, cumulative growth in cartographic activities after 1650 meant that those volumes would quickly burst this limit if they were to follow the initial, comprehensive long-essay approach. Woodward also identified several related issues concerning the content of the final volumes. First, the persistent increase in cartographic activity after 1650 was not matched by a concomitant growth in historiographic treatment. Indeed, as Harley and geographer M. J. Blakemore first documented, only 4.71 percent of the articles published between 1935 and 1978 in *Imago Mundi*, the premier international journal of map history, addressed topics from after 1800. The journal's "overwhelming emphasis," they observed, was "given to maps of the early printing press and of the great 'Age of Discovery.' Little needs to be said other than the obvious caution that this chronological distribution cannot be seen as representative of the development of cartography as a whole" (Blakemore and Harley 1980, 15–16, quotation on 15). A marked upswing in interest in modern cartography after 1980 has meant that this situation has been somewhat remedied: for the period 1935–2010, 12 percent of all articles (13.7 percent by page count) in *Imago Mundi* dealt with post-1800 topics (Edney 2014a, 2014b). Even so, this increase does not represent a significant historiographic gain: sufficient work might have been accomplished to support long essays in volume 4, but it was clear that volume 5 and certainly volume 6 would lack the trove of scholarship available to contributors writing for the earlier volumes. Furthermore, mapping technologies became increasingly globalized after 1650. Even as mapping processes, practices, and formats became more diverse after 1900, each also became more homogeneous across national boundaries. Whereas it makes some sense at least to structure volume 3 and volume 4 around the European states, this is not the case for volume 6. As a result, there was a need to progressively redesign the last volumes.

Woodward's solution to these issues of size, inverted historiography, and shifting national contexts—informed by the work of his friend, historian Paul Boyer (1935–2012), on the *Oxford Companion to United States History* (2001)—was to reconfigure the *History*'s modern volumes as interpretive encyclopedias. The encyclopedia approach has many benefits. It permits close control over the size of entries. The entries can be readily defined and arranged in the volume to adjust to shifting national contexts. It requires the combination of interpretive entries with shorter, more factual ones; the latter are especially suited to topics for which the literature is small or nonexistent. Indeed, editors can distribute the scholarly load, as it were, by inviting many more contributors to handle smaller portions of the overall work and so take advantage of their diverse expertise and viewpoints. Indeed, volume 6 has made up for the pressing need for new research and for the scarcity of scholars working on mapping and map use in the twentieth century, by drawing on the memory of contributors who lived through, and in some cases even influenced, the electronic transition of the latter half of the twentieth century.

The Design of this Volume

The design and content of each of volumes 4, 5, and 6 are the outgrowth of an intensive process that integrated consultation with expert advisors into a philosophically sound, logistically realistic conceptual framework known as *hierarchically integrated conceptual clusters*. This framework was implemented with guidance from Linda Halvorson, former editorial director of reference books at the University of Chicago Press and an experienced coordinator of encyclopedias. The process is, in principle, simple. The encyclopedia's subject matter is divided into conceptual clusters, which is to say coherent areas of thematic content. A general encyclopedia of U.S. history, for example, might be divided up into clusters for social history, cultural history, military history, environmental history, and so on. Editors and expert advisors identify specific topics within each cluster that deserve attention; they identify not only low-level (focused) entries on particular people and events, but also mid-level entries on trends and themes and upper-level (interpretive) entries addressing the cluster itself. That is, the entries within each conceptual cluster are hierarchically integrated. In the final work, users can move between entries in order to move to broader or narrower treatments as desired.

Difficulty comes, however, in defining meaningful conceptual clusters. For the last volumes of *The History of Cartography*, the clusters are defined, according to principles developed by Matthew Edney, by six overarching types of context, each related to a particular facet of cartographic practice in the early modern and modern periods. Several of the contexts were further divided by specific *modes of cartographic practice* (Edney 1993) as well as *institutional endeavors* in which multiple cartographic modes are employed. (For further discussion see the entry "Modes of Cartographic Practice.") As the following list illustrates, the eleven modes and five institutional endeavors defined broadly for all the remaining volumes are easily integrated with a hierarchy of historiographic, representational, method-

ological, political, and spatial contexts, which becomes inclusive when clusters are added for individuals and institutions.

Historiographic Context (how twentieth-century cartography has been studied)

Representational Contexts
   Larger-scale representations based on direct observation and measurement, by mode:
      Property Mapping
      Boundary Surveying (political, not real estate)
      Topographical Mapping
      Urban Mapping
      Overhead Imaging
   Smaller-scale representations based on compilation to show broad geographical patterns and situations, by mode:
      Geographical Mapping
      Celestial Mapping
      Thematic Mapping
      Marine Charting
      Dynamic Cartography

Methodological Contexts
   Art, Craft, and Cartography
   Science and Cartography, including the mode:
      Geodetic Surveying

Political Contexts
   Public sphere of commercial cartography, by endeavor:
      Map Publishing
      Map Collecting
   Institutional mapping, by endeavor:
      Administrative Cartography
      Military Cartography
      Academic Cartography

Spatial Context (within which cartography of all sorts was practiced)

Individuals and Institutions (exceptional or exemplary, such that they warrant special treatment)

This hierarchy provided the intellectual framework within which the editors identified and refined the particular entries to appear in each volume. It has been especially useful in identifying a wide range of potentially relevant entry titles while avoiding redundant entries. The conceptual clusters helped identify subsets of entries particularly relevant to the expertise of individual advisors. The ultimate implementation of these clusters is shown in the endpapers at the front and back of each part of each volume. A careful perusal of the endpapers in this volume will confirm that the six themes of twentieth-century cartography listed at the beginning of this introduction had a marked influence on the development of specific entry titles.

Note that primary emphasis within the intellectual framework is placed on different kinds of cartographic activity; this in turn permits each volume to account for the progressive globalization of cartographic practice. Thus, whereas the first volumes of the *History* considered each cultural and state context in turn, and then the different kinds of mapping undertaken in each, the encyclopedic volumes consider each mode or endeavor and only then significant regional variations. Cartography's globalization has the effect of reducing the need for separate entries for individual countries. For example, whereas volume 4 is anticipated to have twelve entries covering map collecting in various spatial contexts—the Austrian Monarchy, Denmark and Norway, France, the German States, Great Britain, the Netherlands, the Ottoman Empire, Portugal, Russia, Spain, Sweden-Finland, and Switzerland—volume 6 covers map collecting explicitly in only two: one for Canada and the United States and the other for Europe.

Once the content of the encyclopedic volume was generated within the clusters—from overarching themes to particular topics—all entries were then assigned to *categories* according to their subject matter. For example, in volume 6, the entries "Land Use Map" and "Physiographic Diagram" were developed in the clusters for administrative cartography and topographical surveying, respectively. But because both are specific types of map artifact, they should have similar content, especially by comparison to the content found in an entry about an individual person. By grouping entries into precise categories that transcend subject matter clusters, editors are able to offer contributors precise guidance about the content of their entries in the form of generic *scope descriptions* for each category. In addition to providing a basis for these general instructions, the categories serve two other purposes in shaping content. First, they help identify conspicuous omissions as well as topics too minor to warrant separate entries. Second, they provide a rational and consistent basis (along with length, of course) for determining the number of bibliographical references and illustrations (if any) for each entry. To explain to the contributor the anticipated content of entries dealing with modes and endeavors, a *context description* was prepared for each. And as noted in the processual history at the end of this volume, the instructions for many entries also included a *specific guidance* listing details that the editor thought should or must be included.

Finally, the instructions to contributors included guidance on how to understand the term "twentieth century"

in constructing their entries. Historians are well aware that periods of history, however convenient for organizing courses, textbooks, and encyclopedias, are fundamentally arbitrary, though some are arguably less arbitrary than others (Maier 2000). Although political and social historians might have preferred volume 6 to begin with 1914, the initial year in Harley and Woodward's original plan for the series, starting in 1900 usefully includes an ample sampling of the nineteenth century's legacy and promotes coherent coverage of a vast technological, institutional, and intellectual revolution. In a different vein, the year 2000 not only conveniently capped Harley and Woodward's "the present" in the midst of dramatic technological change but also dampened the inclination of some contributors to treat volume 6 as an up-to-date reference manual, rather than a history.

For these reasons, contributors to volume 6 were explicitly told that the years 1900 and 2000 were approximate but not absolute boundaries for their entries. On the front end, they were encouraged to select a starting date appropriate to the subject of an entry, going back as far as 1885, and to mention briefly any key developments before that date as relevant. They were equally urged not to arbitrarily end an entry at 2000 if the subject matter included important developments that occurred after that date.

Inevitably there are gaps in the coverage, but we have striven to produce a work that is informative, reliable, and beneficial to future scholars. From the outset we knew that putting volume 6 into a million words would be a daunting task: selection is inherent, after all, and not everything fits. No doubt different contributors would have produced some entries markedly different in facts and emphasis, and our acute awareness of word counts no doubt excluded material otherwise useful. Even so, our insistence on a representative set of relevant references partly mitigates the necessary constraint on wordage: inspired users will know where to look for further information.

Using This Volume

Several types of complementary lists provide access to information in volume 6. The front matter of each of the volume's two separately bound parts is a list of entries in order of appearance, useful in confirming a particular entry title. Entries can be found alphabetically within the volume, with the aid of headings at the top of each page. The volume's conceptual structure, as outlined on the endpapers in the list of entries organized by conceptual cluster, can be helpful in identifying one or more promising entry titles. This entries-by-cluster list is based on (though not identical to) the hierarchically integrated conceptual clusters and the modes and endeavors of

mapping and map use discussed above. A user interested in what might seem either a minor aspect of mapping or map use, or a particular person, firm, or government entity not accorded a separate entry, should refer to the index, at the end of part 2. Individuals are listed in the index with the year of their birth and death if known, rather than repeating this information throughout the volume. The index is also particularly useful as a starting point for persons, institutions, techniques, and phenomena likely to be covered in multiple entries. At the end of each entry, a *See also* list points to one or more related entries, but these lists of cross-references are necessarily broad and less helpful than the index when the topic of interest is specific or narrow. The list of tables at the beginning of part 1 (pp. xvii–xviii) is also useful.

Where several articles are closely connected, they are brought together as a *composite entry.* For example, in the composite entry "Hydrographic Techniques" a general entry on technologies used for coastal and undersea mapping in the early twentieth century precedes entries that treat in greater detail the particular practices of aerial imaging, hydrographic sounding, satellite sensing, and GPS, all of which developed later in the century. In two of the composites, "Marine Charting" and "Topographic Mapping," a comparatively long overview introduces a series of entries that examine developments in specific countries or regions. Each composite begins with a list of constituent entries in their order of appearance. Five of the composites ("Geodesy," "Military Mapping by Major Powers," "Military Mapping of Geographic Areas," "Perception and Cognition of Maps," and "Property Mapping Practices") are preceded by a brief synopsis.

Among the thirty-one composites, only six ("Atlas," "Drafting of Maps," "Globe," "Labeling of Maps," "Relief Depiction," and "Wayfinding and Travel Maps") were consciously ordered alphabetically. An appropriate logic or rough approximation was adopted for the others. For instance, among the ten entries under "Projections," small-scale general reference applications account for the first, second, and third positions; "Regional Map Projections," in fourth place, refers to a slightly larger scale; "Projections Defined for the Ellipsoid" logically precedes "Projections Used for Topographic Maps," which is followed by "Projections Used for Military Grids," typically added to existing topographic maps; and positions eight, nine, and ten refer to application domains with generally smaller scales. In addition, twelve of the thirty-one composite entries are broken down by region or country, and for these the sequence of constituent entries follows a roughly left-to-right sequence, starting at the 180th meridian in the west, as on many world maps.

Illustrations in volume 6 have been numbered con-

secutively, from 1 to 1153. Because each illustration's number appears at the beginning of its caption, users should have little difficulty finding an illustration placed with another entry farther forward or backward in the volume.

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