The Atlas Cookbook

Ten ingredients how to edit an atlas

A publication by the
ICA Commission on Atlases

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Print ISBN 978-3-033-09794-0
E-book ISBN 978-3-033-09795-7

DOI 10.3929/ethz-b-000599956

Printed by Print Simply GmbH, D-60437 Frankfurt am Main, Germany
www.mybuchdruck.de

Published by ICA Commission on Atlases, Zurich
Publishing date 2. April 2023

Supported by ETH Zurich, Institute of Cartography and Geoinformation
Technical University of Munich, Chair of Cartography and Visual Analytics

INTRODUCTION

In the field of Geosciences – namely in cartography and geography –, atlases played and still play an important role as an effective communication channel for well-founded and curated cartographic data visualization. By means of cartographic techniques and multimedia elements, they present visible and non-visible facts and processes in a dedicated user-friendly context. Thus, atlases serve as a spatiotemporal and sociocultural compendium to display, explore, compare, and analyze topographic and thematic information in order to gain novel knowledge.

The idea of an "Atlas Cookbook" has been discussed for a long time in the ICA Commission on Atlases. All around the world, there are many groups working with geodata, but lack specific knowledge how to edit a map or even an atlas. The intention of the cookbook therefore was to give advice to atlas authors in a general way:

- to give an overview over the realization stages,
- to show how to start a new atlas project (which is always the most difficult part),
- and how to deal with conceptual, organizational, graphical or publishing issues.

The term "cookbook" in the title was chosen intentionally. Indeed, making and editing an atlas can be compared in an allegorical way to operating a restaurant and cooking for guests:

The reason why

In an everyday situation, there is a fundamental need for food. In the case of atlas authoring, this corresponds to the users' need for orientation, or more generally, the need for geo-information.

The restaurant

Here, the concept of the restaurant and its location are important factors for success. The concept of the atlas determines the atlas type (topographic atlas, thematic atlas), the region(s) to be treated (world, country, specific locations), and many more.

The cooking team

The cook and her/his team members are those who bring the restaurant alive and keep it running. The same is with the atlas team; the project manager is the chef, and each member has its specific skills, competences and tasks.

The idea

It is important to spend some time for good ideas. This is the case for inventing special meals, but also for novel thinking with atlases. This could evoke interesting map themes, new tools, and new presentation forms.

The menu card

The menu card presents all the offers available in a restaurant. There should not be too many menu offerings, but also some surprising dishes/meals. Working with atlases, the menu card corresponds to the thematic content of the atlases and to the map themes, respectively.

The ingredients

Whether the restaurant offers international or local cuisine, vegan or meats: in every case, the most important is good quality of the food. In a figurative sense, the data should come from reliable sources, quality-checked, and their sustainability/reproducibility should be ensured.

The recipe

Now it's also important how to deal with the ingredients. If the recipe is well written, the meals might be prepared more efficiently and more enjoyable. In an atlas environment, this corresponds to the workflow. The workflow should be tailor-made and customizable for future adaptations.

The preparation

Food preparation and doing the cooking corresponds in atlas cartography to techniques applied and data integration. After this step, everything should be ready to serve.

The menu

The combination of compatible ingredients on a plate and the succession of starter, main dish, dessert, etc. make up the menu. In the same sense, atlases offer the combination of map layers or related maps, and also the integration of multimedia elements (text, sound, pictures, videos).

The mise en place

The menu has to be presented in an appealing way. The same is the case with atlases, where data visualization should result in appealing maps by means of cartographic principles.

The cutlery and the place mat

For dinner, different kinds of cutlery (spoon, fork, knife) and drinking glasses, presented on a place mat, are necessary. This corresponds to atlas tools and the GUI, enabling good interactivity and usability.

The guests

The visitors of the restaurant have to be welcomed, seated, and served. If the restaurant crew knows the main preferences, the offers fit the taste of the clients more likely. The atlas team should also try to find out what their community, the users, would expect. Never forget the user and their needs!

The bill, the invoice

After dinner, someone has to pay the check. Sometimes, it's not clear whose turn it is to pay, and this may give uneasy feelings. In an atlas project, the financial (and political) sustainability should already be clarified during the planning stage.

The feedback

Do the clients come back? How intense is their interest? Answers to these questions might help to optimize the product. Moreover, it's most important to give quick response on user demands or complaints.

The publicity

Attracting new clients resp. new atlas users by means of advertisement, professional articles, social media, blogs, television appearance, etc. is a never-ending task. Use the right information channels for your product to evoke maximum visibility and attentiveness.

These 15 issues may help to decide whether the conditions to start and maintain an atlas project are fulfilled, or whether some of these points have not yet been considered.

The "Atlas Cookbook" is written on a management level, not in a technical way. Since all of the authors are engaged in running atlas projects, the time span from the very idea of making such a book to the publishing date was more than 15 years. The cookbook project was started during the ICA chairmanship of Tim Trainor, further developed during the chairmanship of Peter Jordan and finalized under the chairmanship of René Sieber.

Nevertheless, most of the comments and recommendations are applicable for current and new digital technologies, but many sections are also valid and useful for editing printed atlases. The cookbook can be read as a whole, but also only a single chapter can help.

We organized the "Atlas Cookbook" in ten chapters, which reflect a feasible and practicable way to conduct an atlas project. The cookbook starts with Organization and Marketing [Eric Losang], followed by a chapter on Editorial Aspects [Hartmut Asche]. After the administrative issues are settled, the book focuses on Atlas Use [Ferjan Ormeling and Corné van Elzakker], Thematic Content [Károly Kocsis, Mátyás Márton and Peter Jordan], Data Management [Tim Trainor], and Multimedia Elements [Vit Vozenilek and Rostislav Netek]. Further components to be considered in the atlas process are Atlas GUI [René Sieber], Map Design [Ernst Spiess], Interactive Functionality [René Sieber and Juliane Cron], and finally Prototyping and Evaluation [R. Eric Kramers].

Five arguments, which makes it reasonable to start an atlas project:

1. a serious interest or demand of the society for the atlas compilation
2. a project team capable to produce the atlas
3. enough content (data) qualitatively and quantitatively
4. a guarantee of atlas sustainability (producing and maintaining)
5. available time and money to compile and support the atlas.

To conclude, we want to express our thanks to all the authors, who spent many hours of their leisure time to elaborate their chapters. A special thanks goes to Juliane Cron, who did the book layout, the graphics and the content compilation, to Manuela Schmidt who designed the book cover, and to Stefan Räber, who was co-responsible for the final finishing work and printing.

Enjoy the book, and perhaps you and your team are motivated to start a new atlas project!
The cartographic community and the ICA Commission on Atlases would be happy to hear from it.

René Sieber,
Chair of the ICA Commission on Atlases

Vit Vozenilek,
Vice-Chair of the ICA Executive Committee

Zurich and Olomouc, 2022

CHAPTERS

1 ATLAS ORGANIZATION AND MARKETING

ERIC LOSANG

Today more atlases are published in medicine than in geography, mapping the body rather than the geographical space. The atlas model fits both, since the human body is an enclosed and measurable space just like the celestial body of the earth. This article focuses on geographical and non-natural atlases – such as historical or social atlases – that emphasize the depiction of geographical space as underlying concept.

This chapter encompasses elements of all further chapters. Wherever possible, the reference to those chapters are given. However, duplicates are sometimes necessary for the understanding of the text.

FIGURE 1.1

Africa in atlases

[Africa Descriptio – General map of Africa. Shows kingdoms and territories. Mercator/Hondius: Atlas Minor 1607].

1.1 INTRODUCTION: ORGANIZATION – PRODUCTION – MARKETING

The production processes of atlases have changed considerably over the time since Mercator, Lafreri and Ortelius created the first atlases in the 16th century.

From the much-loved school atlas over the enormous reference atlas, purchased to develop travel plans and the coffee-table atlas one buys for hedonistic reasons to digital road or statistical atlas we consult over the internet – the uses of atlases and their ascribed values have diversified over time and so did their production modes.

The scale of present atlas productions varies in personnel situations, financial means and circulation figures. Distribution and selling channels expanded vastly e.g., facilitating the success of otherwise hidden gems. In addition, the availability of the internet widened the possibilities for digital atlases. However, some projects only produce special printed editions for atlas enthusiasts.

In every example, the making of an atlas involves numerous management processes from the idea to the production, publication and distribution to the point in time, when to decide if an atlas will be continued in an updated/extended edition or not.

These processes are compiled in the American Marketing Association's definition of "Marketing" as „the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large" [AMA 2019]. At first glance the concept of atlases as "offerings" seems unnecessarily vague, but considering the different funding and distribution models, it comprises the majority of publishing activities related to print and digital atlases.

This article will focus on the topic of *Atlas Project Management (APM)*, summarizing general considerations on production and publication environments and financial and organizational settings. It draws attention to direct and indirect founding opportunities for atlases before turning to comprehensively outline an ideal-typical atlas manufacturing process with special emphasis on organizational and marketing aspects. The more practical issues of production management, quality control, dissemination channels and distribution methods will draw on the importance of reaching distinctive (economical) goals. The last two sections spotlight the importance of sustainability in atlas production settings by outlining different marketing strategies and the challenges for future atlas projects in a rather fast developing and changing interdependency of technological advancement, users demands and distribution frameworks.

1.2 THE EVOLUTION OF ATLAS PRODUCTION ENVIRONMENTS

The production of atlases has transformed considerably since their origins. However, some aspects are still dominant and effecting – besides others – their content-related, technical and functional diversification.

In 1570 Abraham Ortelius revolutionized the already ubiquitous map trade by publishing a book of maps, uniform in size and (map-) design. The *Theatrum orbis terrarum* was not only the first atlas to reform the concept of mere editions of Ptolemy's *Geographia*, it marked the starting point of modern map marketing (and a shift in cartographic power). Ortelius, unlike his friend Mercator, was a modern atlas publisher rather than a scholar or cartographer. He did not focus on making perfect maps himself. Instead, he critically selected the best maps available to include in his comprehensive "showcase of the world". As map seller, Ortelius established his atlas as a successful state-of-the-art publication, producing forty-one editions over the next 42 years, always keeping to principles like maps uniform in size and style designed for the respective edition and citing the authorities employed [Crone 1968:111]. Maybe even more important was his dedication to produce a sustainable product, thus producing subsequent issues of "Additamenta" (amendments) to update older editions, that quickly became an important selling point.

Marketing and dissemination of atlases no longer focused on an undefined scholarly use but on the rising demand for information on the newly discovered parts of the world. In combination with changing production processes and the growing number of cartographers applying new methods of construction and depiction, publishers started turning atlases into a booming publication type.

FIGURE 1.2
Africa in atlases
[Blaeu: Atlas Maior 1665].

In the mid-17th century Willem Blaeu and his competitor Johannes Janssonius started a "race" to produce the most comprehensive atlas of that time in which the former succeeded. Blaeu published the 12 volumes (French) edition of the Atlas Maior in 1665 – comprising 595 maps and 3368 pages of text, that sold in different layouts for around 40.000€ a piece in today's money, thus turning atlases into a plaything for wealthy customers. The luxuriousness and sheer weight instead of accuracy and practicality marked their value and atlases gained a reputation as status symbols. It is not clear, if Blaeu or Janssonius ever made any profit from their atlases. They might have used the normal map production and trade to help finance the rather expensive flagships of their work. The scale of their projects reflects the advancement of economical cartography at the end of 17th century and marks a shift from scholarly controlled map-making to a manufacturing economy [Keuning and Donkersloot-de Vrij 1973].

The atlas paradigm over the centuries shifted between scientific and educational purposes and the burgeoning demand for the democratization of geographic information, leading to major advances in their production (material, print techniques, design patterns, formats, etc.) (Figures 1.1 and 1.2). When digital dissemination hit the stage, traditional atlas making as well as publishing and distribution were questioned and had to be adapted. With the renaissance of spatial information in everyday life following the ubiquitous use of online map services, and the rather humble aesthetics of online cartography, a new kind of atlases, published as coffee table books that cover rather unusual geographic foci (e.g., Atlas of Cursed Places, Atlas of Improbable Places, The Atlas of Imaginary Places or An Atlas of Countries That Don't Exist) that started the latest successful diversification of the atlas concept.

FIGURE 1.3
Africa in atlases
[Raisz: Atlas of Global Geography 1944].

1.3 ATLAS PROJECT MANAGEMENT (APM) IN THE 21ST CENTURY

Since the days of Willem Blaeu's *Atlas Maior*, atlases and their production modes have successively improved – besides shifting relevance of geographic topics – in technical terms, from copperplate to computer, from handmade paper to hologram. The development mirrors the advancement in cartography (and geography) and represents a significant expansion and diversification in terms of content with ever more diverse disciplines involved.

Investigating this constant, sometimes far-reaching development steps in atlas publications one can identify key aspects of atlas advancement and diversification that interdependently fitting together in a framework showcasing advancements and challenges of modern atlas makers (Figure 1.3 and Figure 1.4), that can be taken as schema to identify organizational shortcomings of planned atlas projects.

FIGURE 1.4

Africa – Population development 2000–2020 from the ArcGIS Living Atlas of the World [https://livingatlas.arcgis.com].

Content

Content often determines the atlas type and chosen concept et vice versa. Whether it is topographical knowledge, statistical information or rather use and user driven hybrid information is only one perspective. Over the last years new content became the basis of rather different atlases e.g., on literature, on globalization, on prejudices. In addition, interdisciplinary, multi-perspective and participatory approaches lead to new content-related foci, sometimes altering established atlas concepts and production processes.

Dissemination Techniques

Today we distinguish between analogue and digital dissemination, which influences not only the applied map-making techniques but also organization and publication models that drive the project. With users in mind, primarily there are still classic *"print only"* or *"digital only"* approaches (today mainly internet, e.g., National Atlas of Switzerland) in use.

However, as digital technology is no longer considered a disruptive force both publishing concepts are more and more intermingled strengthening hybrid concepts:

- As combined publishing: Same content published on different media, e.g., printed atlases published online as pdf.
- As complementary publishing: Content published complementary using the media that serves best for dissemination either using combined or separate scenarios. In this respect most school atlases change to a model with a classic print edition accompanied by a website covering interactive elements or easy-to-use GIS applications (e.g., Diercke Weltatlas, Swiss World Atlas in Figure 1.5).
- As integrated publishing: Linking the content of digital and analogue editions, utilizing the advantages of the respective media to improve user experience and usability.

Visualization Techniques

The multitude of possible ways to visualize information often leads to a pre-defined range of visual methods applied in atlas projects. The standardization of these depiction modes helps to avoid complex production environments by focusing on a defined range of personal skills and manageable stacks of means used in one project. The latter often works in different directions, since tools and their modes of use determine the look of maps and atlases thus often not maximizing potential of the provided information.

Publishing Business

Whether the atlas project is solely public funded, subject of a public-private partnership (e.g., compilation of the atlas public funded, but published and distributed by a publishing business) or a private economic venture and thus (in most cases) profit-oriented, strongly influence production efforts and marketing.

Reader/User

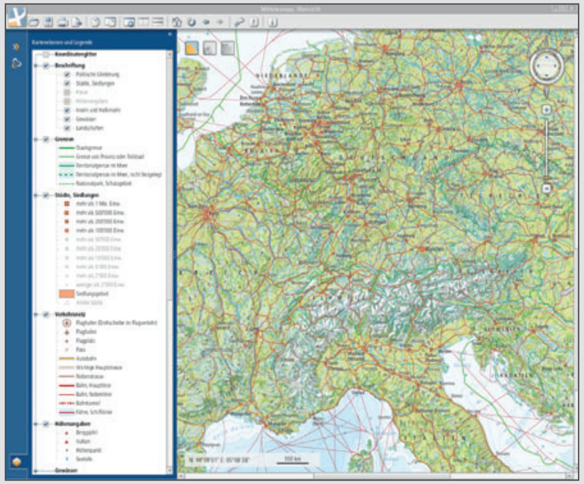
Without readers/users to address, atlases have no purpose to be published – except for possible self-realization or self-expression of the publisher. Direct (market segmentation) or indirect (e.g., obligatory authorization of School atlases) target group (audience) orientation is the key to success and should be considered in every step of the APM. Setting up these target groups helps to further analyze market determinants (e.g., competitors and their products, access restrictions), or define adequate and resource effective production process (e.g., under 25's at the moment prefer digital publication via internet or e-book solutions), and finally supports establishing the right setup for advertisement and sales organization.

Resources

Unless the project focuses non-profit or solely non-monetary representational purposes without financial restrictions or follows a mere *l'art pour l'art* concept, this aspect is the core element of the APM. In marketing terms, the optimal allocation, organization and use of resources help to cut production costs (technical endowment, human resources, and publication effort). The organization of these resources will be referred to later.

FIGURE 1.5

Central Europe – interactive map taken from the online supplement of the Swiss World Atlas.



1.4 PROCESSES IN ATLAS PROJECT MANAGEMENT

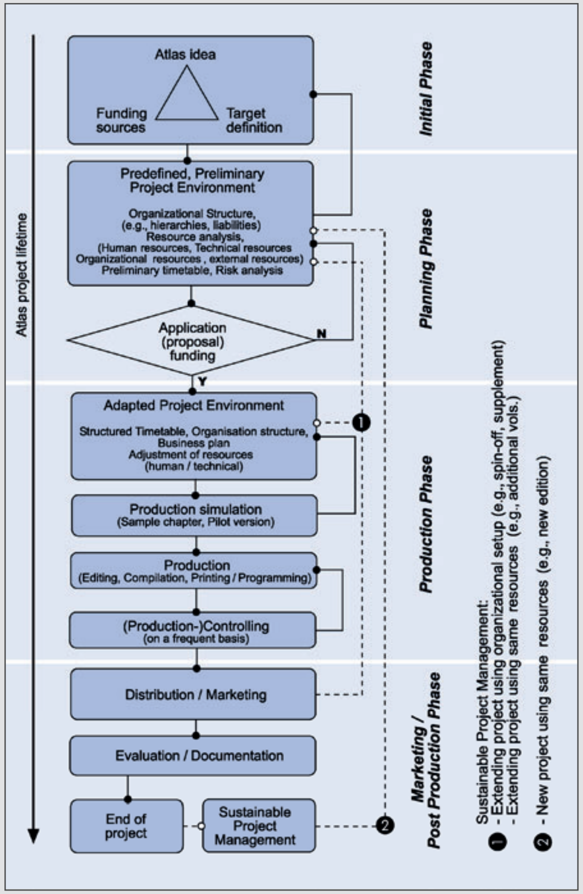
Since WWII a deluge of atlas definitions postulated particular atlas (production) paradigms such as completeness and accuracy, the dominance of graphic elements over text, the uniformity of map format design and the standardization of arrangement and composition. Each decision (e.g., in challenging the completeness paradigm) influences not only the publications success but also production effort and expenses. Thus, the general elements of professional management in media production should apply to atlas projects, whether print or digital.

Elements of Project Management

For this article, every atlas product is considered as the outcome of an atlas project*. There are several definitions of the term "project" often following some international standards, such as ISO 21500:2012, DIN 69901 (GER), the PRINCE 2-Standard (UK) or the Project Management Body of Knowledge (PMBOK, US). Referring their rationale, a project is an individual enterprise determined by unique conditions, such as target sets, time frame, financial and personnel limitations or specific organizational aspects.

FIGURE 1.6

Schematic outline of atlas project management phases.



Whether a single publication, the creation of a multivolume national atlas, a print or digital product or an updated, enhanced or completely revised edition of an existing atlas – an atlas project for this article is defined by a certain project management effort. Thus the process covers a certain sequence of (manufacturing) steps, which secure the successful launch of an atlas.

Project Phases

In Figure 1.6, the facets of the atlas production process are put in a simplified project flow map. Considering diverse atlas project frameworks, this should be understood as a generalized schema, covering core phases from idea to published atlas.

Initial Phase

The initializing phase comprises three interdependent vital aspects that have to be discussed before setting up a business or management plan:

- *Idea:* At the beginning of every atlas project, be it public or private funded, stand the core issues of what the atlas should contain (topics, data), what it is good for (planning, reference, in depth knowledge transfer etc.), a loosely defined audience and appearance/presentation. However, the realization of these ideas has to be negotiated by taking resources and business goals into account, so, often some objectives have to be declined accordingly.
- *Funding Sources:* Financial resources are essential. In this respect a distinction must be drawn between atlas projects, that are public funded (e.g., most scientific atlases, national atlases, atlases provided by government agencies as statistic or official topographic atlases), private sector projects (e.g., school atlases, road atlases, atlas publications with a dominant economic focus) and projects realized employing a public private partnership business model cooperation e.g., with a publishing house that takes on the printing/ publishing, distribution and marketing costs. All funding possibilities situate the project in appropriate frameworks with direct and indirect control mechanisms and a certain amount of flexibility often according to the project's financial scale. This is why the use of public funding needs to be considered in respect to principles of funding lines, such as flexibility of resource use, renewal options, cooperation possibilities and restrictions.
- *Target Definition (Business/Project Goal):* Often overseen but crucial to the AMP is the precise definition of a business goal which should emphasize the central motivation for the atlas project. Maybe it is an economic success, achieving its possible distribution or scientific excellence. In defining what is most important helps to consider compromises in secondary fields. However, often requirements may exclude each other. As an example, we take the publication of a national atlas. It's defined main goal, a nationwide distribution to make the information as widely available as possible, often contradicts maximizing economic success. These discrepancies often occur in public private partnership projects, where the publishing company is supposed to maximize the economic success. The preliminary negotiation helps to define an achievable long-term goal. The deviating significance of these aspects needs to be dicussed for every atlas project.

Planning Phase

Having formalized main idea, purpose, form and financial terms of the project leads to the planning phase which lays the foundations for timing, layout of the project framework, resource allocation, that also will be part of a project proposal seeking funding. The phase reflects the negotiation of goals in the magic triangle (Figure 1.7), that describes the interdependencies between the three most important factors within a project: Scope/ Quality – Time – Cost [Atkinson 1999]:

- *Scale of the Project:* The dimensions of the atlas project influence the extent of planning steps and organization issues, e.g., for national atlas projects: (1) Limited extent (e.g., one volume), short term, no continuation (e.g., Atlas Nacional de México 2007); (2) Multiple volume, medium term, no continuation (e.g., National Atlas of Germany 1999–2007, Atlas de France 1995–2001); (3) Multiple volume series, long term, envisaged continuation (Atlas of Sweden 1984–); (4) Digital project, extended (data supplements), medium term, discontinued when technically outdated (e.g., National Atlas of the United States 1997–2014); (5) Digital project, extended (data supplements, development), long term, continuation in adapted media (e.g., Atlas of Switzerland 2010–).
- *Organizational Structure:* Organization management is defined as "The process of organizing, planning, leading and controlling resources within an entity with the overall aim of achieving its objectives" [Project Management Institute 2013; PMBOK® Guide, p. 67]. Whether adapting a hierarchical or a matrix organization structure this codifies the framework in which the organization defines how tasks are divided. Depending on the scale of the atlas project this structure can be more or less complex. In general, an editorial board is established, resembling the main tasks of editing the atlas. Often the editor-in-chief takes on the project management, in larger companies he is to report to project coordination and management group. Dividing the responsibilities in the editing process depends on the scale of the atlas project – with the core tasks of overall editing and layout, map editing, data editing and in case of a digital product the task of programming a visualization framework.
- *Externalization:* Some of these tasks are matched by external service providers, who often take over responsibilities for parts of the project, e.g., programming meta-infrastructures for visualization or content management (e.g., contractor for typesetting and printing in Figure 1.8). This externalization, besides factoring in the efforts for contract conclusion and communication, becomes more and more popular, for two reasons: (1) Reduction of effort – no staff needs to be hired, little personnel administration and planning or organization of workspace, no regulated min./max. employment times, no responsibility for work

Core Phases of atlas projects:

- Initial Phase
- Planning Phase
- Production Phase
- Dissemination and Marketing
- Post Production

FIGURE 1.7

Magic triangle of project management.

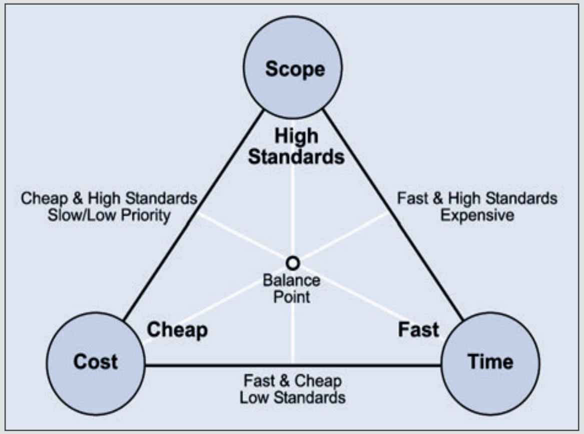
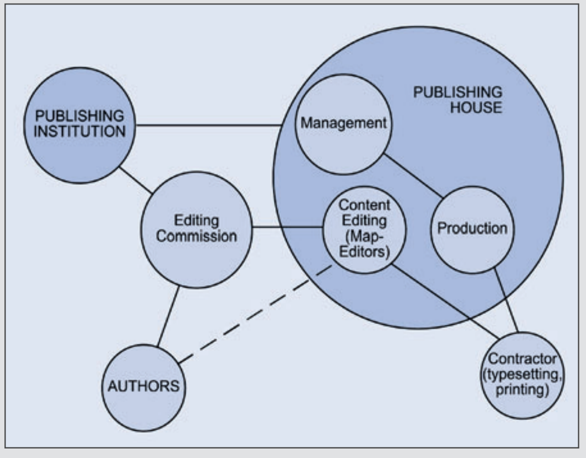


FIGURE 1.8

Ideal-typical organizational structure showing extensive externalization and the distributed assignment of a variety of production tasks. Especially the separation of publishing house and publishing institution – e.g., realized as public private partnership – may cause frictions because of deviating business goals (e.g., scientific vs. economic success).



performance of team members. (2) Externalization of costs (outsourcing) – no additional technical effort, no personnel downtimes to care for. Liability according to the specification in contracts.

Of course, externalization won't apply, if the executing institution/company provides all services internally. In most cases staff needs to be extended (cost efficiency) or the institution is supposed to develop the projects human resources according to funding requirements. Obviously, the liability of external partners needs to be thoroughly checked before commissioning.

- *Important Partners:* Often, the editorial board reflects the organization of working units (departments). The overall personnel composition of editorial boards should also reflect nature and structure of the project. Thus, the inclusion of special representatives, e.g., governmental authorities (national atlases), educational authorities (school atlases) or special stakeholders (regional and thematic atlases) often facilitates project communication and marketing.

One type of external partners stands out and always needs to be included in the atlas project organization – data providers. For most atlases, the underlying base maps and statistical data are provided by either regional/national (often governmental) or international (e.g., Eurostat, United Nations) institutions. Whether data sets need to be purchased (private publishing companies) or are freely available (either through institutional cooperation contracts or as open data), data check, processing and editing are the core part of the visualization process. However, especially data processing (e.g., aggregation, analysis, classification) is often carried out using default routines of the GIS/visualization software (e.g., natural breaks as default classification method of ArcGIS), thus, to avoid overseeing important details, it is recommended to have a work unit, that deals with the data providers (internal/external) and take on the task of data preparation for the visualization process.

Figure 1.9 depicts an ideal-typical situation where the atlas project is embedded in the context of a private company or a scientific institution (research institute, university). Thus, some infrastructure provided by these hosting institutions needs to be considered as resources (marketing/public relations department for advertising campaigns, administration/finances and legal department) but can also restrict otherwise freely made decisions by employing an external steering and controlling group (often in private enterprises).

Depending on the scale of the project the installation of an external (scientific) advisory board is recommended. It normally secures the involvement of stakeholders (e.g., education authorities in school atlas projects), acts as external knowledge resource, provides unbiased opinions from an unpersuaded point-of-view or evaluates the scientific impact. In some cases, the funding or the hosting institutions have to be considered for membership in the board, which should emphasize entities, that are, in one way or another, important for accomplishing the project (e.g., data providers, external partners, governmental authorities). Figure 1.9 depicts the organizational structure employed by VEB Haack in the production of the Atlas zur Geschichte [1973–1981] and Haack Atlas zur Zeitgeschichte [1985]. Figure 1.10 illustrates the organizational structure of the National Atlas of Germany [1999–2008], published by Springer, produced at the Leibniz Institute for Regional Geography and funded by different political/cultural institutions.

- *Human and Technical Resources:* The decisions about human and technical resources are often made considering facilities and personnel configuration of institutions hosting the project. With regard to the development of the atlas project, special technical (e.g., IT) skills are often required, leading to recruitments, that should fit into recruitment policy and company personnel planning to improve the sustainability, since short term employment often leads to losing developed capabilities after the project. All recruitment needs to meet the requirements of the project. Thus, e.g., cartographic expertise in the scheduled parts of the workflow is key.

FIGURE 1.9

Ideal-typical organizational structure.

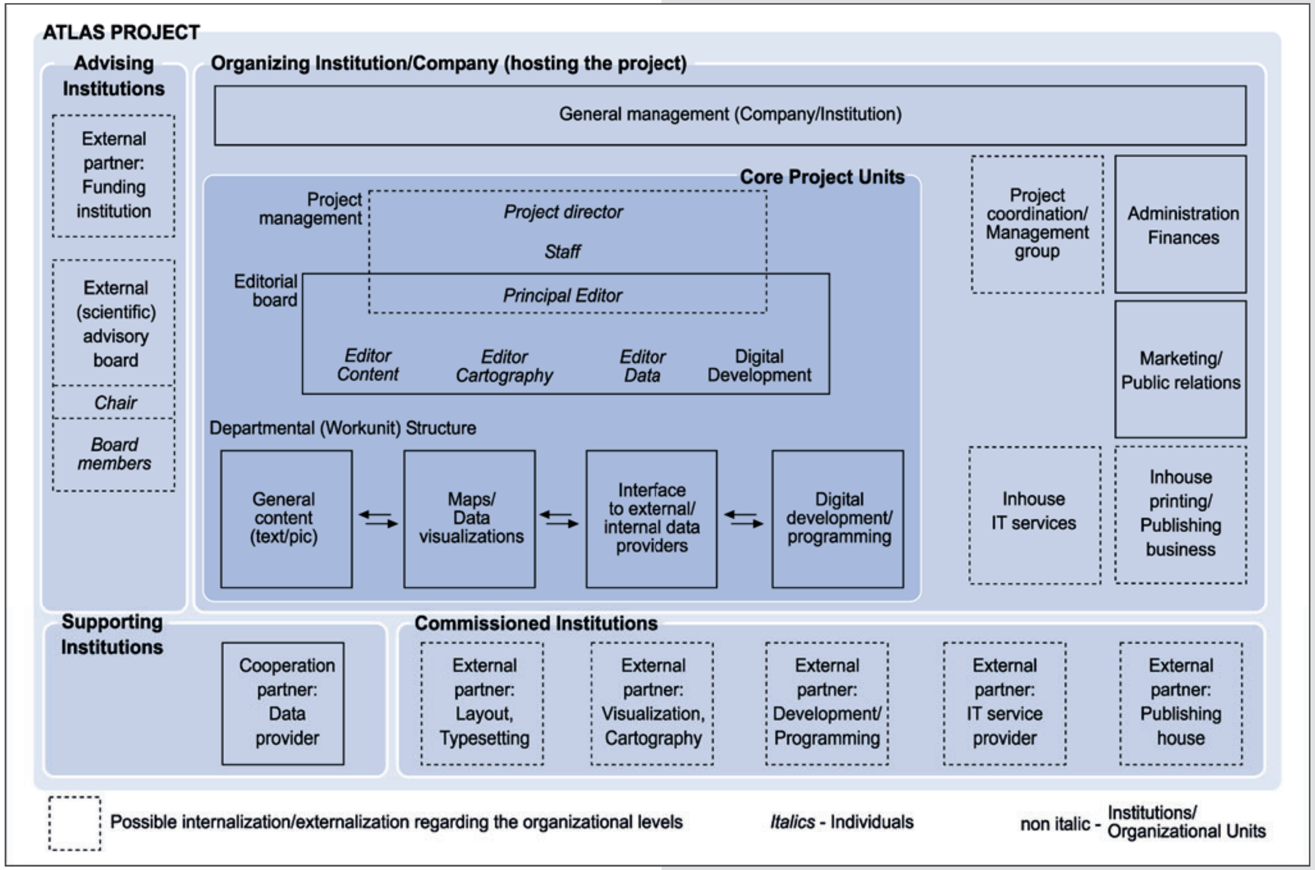
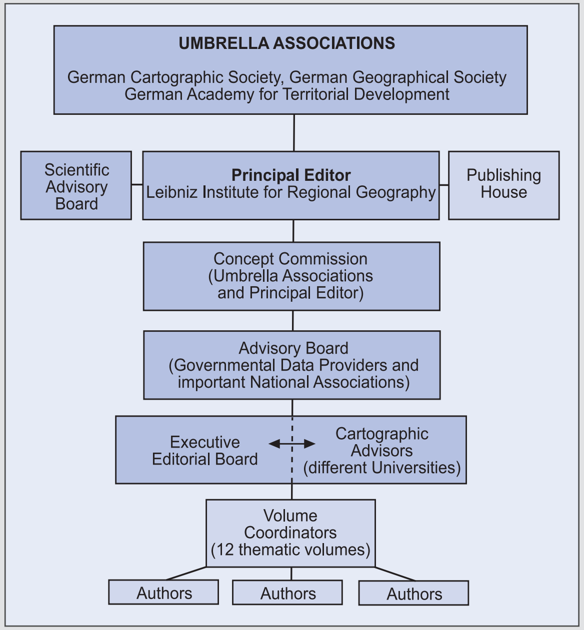


FIGURE 1.10

Atlas Organization, National Atlas of Germany.



Essential contents of a (atlas project) business plan:

- Mission statement and general business description,
- Background analysis (competition, success),
- Operational and financial plan,
- Advisory support,
- Profit and loss projection, SWOT, sustainability considerations,
- Timeline, milestones, deliverables.

Whether technical resources are already in place or need to be acquired – they should reflect the character of the upcoming production conditions.

Some aspects regarding a sustainable use are often overseen [Losang 2016]: (1) As far as possible all resources should fit in and consider already existing elements of the company's/institution's technical portfolio. (2) Technical equipment (hardware/software) needs maintenance, service and training opportunities to be considered monetarily. (3) To keep technical resources up to date over at least the projects running time, follow- up costs are to be regarded.

- *Timing the Atlas Project:* On the basis of different key factors, such as financial resources or deadlines for publishing, the duration of an atlas project is generally limited. These factors can be charged up against each other in short and medium-length projects, where available resources are sufficient to finish at an agreed deadline, or the publishing date is determined by the available means. For long-term projects (e.g., the Atlas of Eastern and South-eastern Europe initiated in 1987 by the Austrian Federal Ministry of Sciences and Research and completed in 2013) resource-planning and timing need to be adjusted according to changing circumstances (organization, finances, changing staff, changing workflows). In this respect gradual or periodical extended loose-leaf atlas projects tend to have longer production durations, but sometimes missing finalization. Same pattern but a different outcome can be stated for internet-based digital atlases – e.g., the National Atlas of Switzerland – that can be extended until technological or organizational foundations become outdated as with the National Atlas of the United States (nationalatlas.gov) in 2014.
- *Risk Analysis*: The ability to produce and finalize the atlas is the basis for funding. For commercial products and even PPP projects, a preliminary risk analysis assures this foundation.

A simple risk analysis comprises time and definition of business goals (e.g., publish an atlas for primary schools in Bavaria with maximum economic profit for start of the term 2019/20). It focuses the probability that the atlas runs out of resources before publishing or missing of a well-defined business goal (Figure 1.11). High risk projects with indistinct goals and open end are often subsidized projects that do not aim primarily at making a profit, such as atlases issued by governmental bodies. For an in-depth investigation of the project including market opportunities or strategic positioning of the atlas, a further SWOT analysis (strengths and weaknesses, opportunities and threats) might be the instrument of choice.

- *Round-up the Planning Phase – The Business Plan:* The aforementioned aspects of atlas planning have roughly focused satisfying investors and sponsors demand for in depth information on a project to decide their monetary involvement. All elements are crucial when applying for public funding, but also for initiating an atlas project in a private business. To bring these widespread thoughts together it is crucial to formulate a business plan which is to be attached to proposals and applications and forms the basis for project management of time and resources.

FIGURE 1.11
Risk analysis matrix with examples.

Vaguely defined goal	**Medium risk** "Historical Atlas of Oregon"	**High risk** "Living Atlas of Australia"
Well defined goal	**Low risk** "Diercke School Atlas", "Swiss School Atlas"	**Medium risk** "National Atlas of Switzerland" (online)
	Closed-ended	**Open-ended**

1.5 FUNDING, FINANCIAL RESOURCES

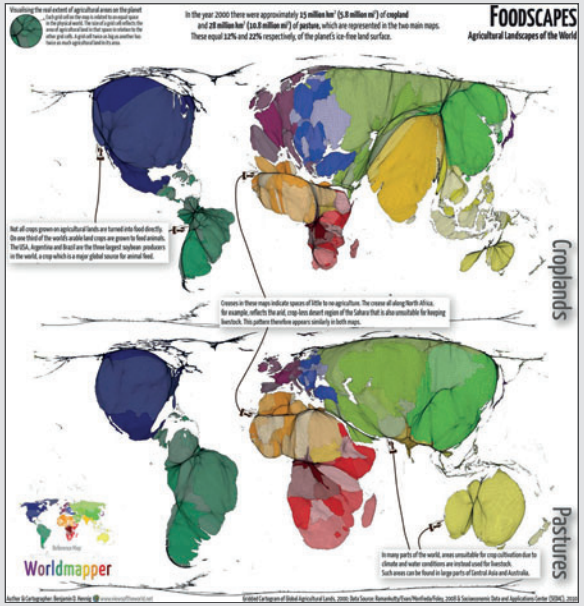
Having proposed the business, the management in private businesses or the reviewers of public funding applications will decide whether the project is to be realized. Three possible decisions lead to further action:

- Funding supported leads to turn planning into the real project
- Funding supported with cutbacks in resources leads either to adapting and re-calculating for a new proposal or accepting these resources and adapting the business plan accordingly
- Funding denied leads to either drop the project at all or adapting and re-calculating for a new proposal.

Often adapting and re-calculating for a new proposal is just done by cutting on resources but not adapting ideas or the business goal. This leads then to not adequately financed projects, often requiring co- or cross-funding towards the end.
The next phase comprises the project setup. Having received financial resources, the organizational patterns of the business plan are put into practice.

FIGURE 1.12

The makers of the website guerrillacartography.org describe themselves as "a loose band of mapmakers, researchers, and designers' intent on widely promoting the cartographic arts". The curation task of their participatory atlases is to find, choose and organize cartographic contributions of different origin. A map of the current "FOOD: an atlas" derives from the inventory of the Worldmapper Project.



1.6 PRODUCTION PHASE

Production Organization

Over centuries the classical pattern of print production dominated the execution of atlas projects, whichever manual, mechanical, photochemical, optical or digital method of mapping was chosen [Robinson et al. 1995].
As for all production processes the formulation of the work breakdown structure, the project sequence plan and a final time schedule is indispensable.

Functional Organization
As seen in Figure 1.6 the structure of the involved parties gives a hint of the scope of integration and organization of work tasks. The work breakdown structure defines all tasks and subtasks according to that structure ascribing them to persons or teams.

Process Organization
The definition of event-driven process chains (EPC) by identifying process and organization units' events, functions and their connection and relationship lead to a sequence plan (usually depicted in a flow chart) that ideal-typical comprises all tasks from production start to product realization. By using standardized workflows and templates (throughout the project) it is easy to keep an overview of the production progress.

Templates
One often-used production organization resource is the use of templates that for atlases fit into their organization of content (see Chapter 2). Templates are both boon and bane. On the one hand they chain you to pre-defined visual concepts (e.g., color schemes, page divisions, digital depiction technique) thus neglecting topic-related design opportunities. On the other hand, they simplify data preparation and handling, visualization, correction, proofreading.

Production Standards

Most handbooks on media production contain a part that has been expanding over editions since the millennium. As earlier claimed, the abstract production organization of atlases hasn't changed much over centuries, when publishing on paper was predominant. Today's publication channels vary and even start influencing curation modes of atlases (e.g., participatory atlases or the atlases of guerrillacartography.org). We can choose to download an atlas as PDF-file for free or buy the same information in a thoroughly elaborated print volume. We can be an editor without knowing much of 400 years of atlas production. Thus, "the standard" for production seems no longer existing. New standards establish with new technologies, new atlas-consuming behavior, and new data curation models. The challenge (and goal) is to get the information to atlas-users in a – for them – convenient way. User-centered design, social media, participation and innovative madness are the buzzwords that lead to ever new dissemination forms (Figure 1.12).

Changing Production Requirements

As more and more data providers (topographic information, statistics) distribute their data over self-established (digital and analogue) channels (e.g., the map oriented statistical yearbook of the Swiss Federal Statistical Office, the Publications of Statistics New Zealand, the open data initiatives of national surveying offices in the European Union or the strongly linked map services of Google, Microsoft and Apple), geographical atlases need to focus geographic questions that only can be answered by combining data related to more recent problems. Thus, the role of cartographers changes significantly either focusing strongly on programming or supervising programmers to ensure adapted visual communication goals.

1.7 DISSEMINATION AND MARKETING PHASE

Distribution / Dissemination

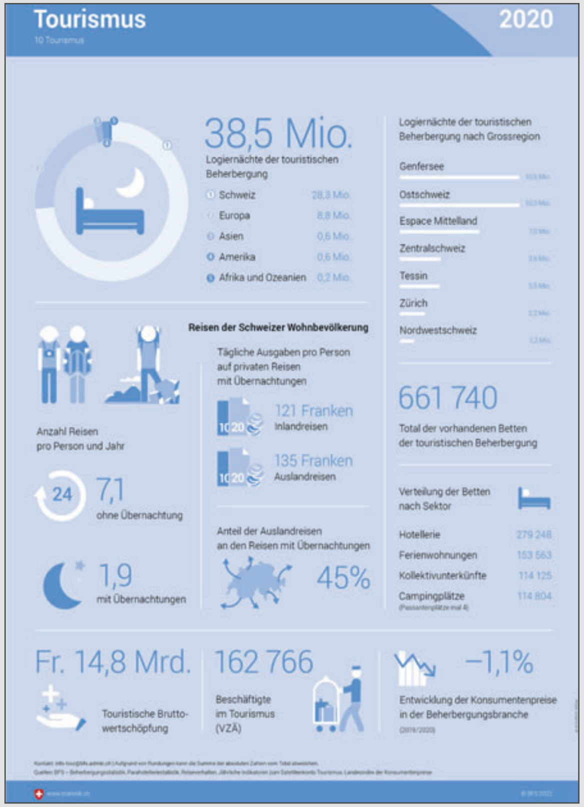
The crucial question for standard atlas production is to find one or better multiple dissemination methods, to conveniently distribute the product to users. This often starts during production by distributing parts to customers in advance (e.g., by publishing/distributing a sample/teaser chapter/part). Distribution channels should always be determined in the planning stages.

Direct selling is recommended if the publishing institution has already set up own sales channels (including advertisement) and is normally used for low circulations. Whenever possible, the use of traditional sales channels (booksellers – in situ and online) is recommended for higher circulations of printed atlases. This is not easy to set up. For independent atlas projects considering the cooperation with a publishing house and the use of their marketing setup is always recommended.

For digital (online) atlases, the main distribution factors are technical (server-)infrastructure (bandwidth, storage, performance) and maintenance issues, e.g., for the supplement of the National Atlas of Germany an in-house server with limited bandwidth was used, which completely broke down when a leading computer magazine had twittered the address. Online publishing, whether as map service or download opportunity of e-book versions always requires a reasonable estimate of users per month and the need to calculate derived maintenance costs.

FIGURE 1.13

The free of charge SwissStats-App – which has all the characteristics of a statistical atlas – produced by the Swiss Federal Statistical Office connects with users by asking for user tracking to refine the application and to announce updates on recently added new topics.



Online Atlases – Free of Charge?

As production costs are mainly staff costs, online publications of atlases can often be accessed free of charge. This can be due to the nature of funding covering costs on condition of free access:

- *Complete free access* without registering, which gives you no possibility to address the users later.
- *Access with registration* allows for possible newsletters and information to engage with users, keep them informed and bind them to the project (e.g., free of charge Apps).
- *A (small) registration fee* always helps to add a symbolic value to an atlas. Something you bought (even for 1,99$) is in general kept on a tablet/phone/computer. This offers the opportunity to keep in contact with the user, either through permanent updates content or after sales support (Figure 1.13).

Modern Atlas Marketing – Advertisement, Promotion and Communication

As mentioned above marketing of print atlases is strongly related to the book market, thus well-established publishers can be strong partners to address the consumer using their advertising channels in classic media such as magazines or newspapers (Figure 1.14). Besides that, specialized publishers (e.g., Rand McNally, Westermann) are well known for their well-established atlas products and only a few take on new projects if they fit in their portfolio (e.g., les atlas Autrement). However, the evolving digital age shifted focuses not only to digital atlases but also towards digital marketing, thus passing limitations of classic print and broadcast media. To name just a few:

- *Social media:* Social media open the opportunity to build a community online where to engage with target audiences, and share original and third-party content. These platforms allow for reaching people one may not be able to reach through traditional marketing channels. In addition, they are free to set up and save the high expenses they usually apply for printed advertisements. However, the quality standards in social media channels becoming higher and may require a professional service. Social media channels often care for one special audience (e.g., Pinterest has 70% female users), so a quick check is helpful. Additionally, some channels provide professional services that require payment (Twitter ads, Advertisement Pins on Pinterest), which regarding the quality of the service is worth considering. Try to update information on the project as often as possible to attract customers/users.
- *Project/institutional Website:* For atlas projects it is crucial to create a project website, whether you are cooperating with publishers or prefer direct marketing. For the latter it will be your display window and store. A bad and undetectable website doesn't reach people.

  Try to set up a site as professional as possible, e.g., by hiring a web design service and consider to spend resources on search engine optimization (SEO) to increase website traffic, click-through and conversion rate.

- *Pay Per Click Advertising (PPC):* We all noticed classic advertisement like billboards or flyers in our post box. The new way is to advertise on available space on webpages or in social media. For most atlas projects too much effort, but for high circulation print projects a possible addition to the marketing toolbox since you can focus on target groups by choosing the right channels.

The biggest challenge for effective atlas commercialization is to ensure continuous marketing efforts, since most atlases are products with a long half-live period. Adapting the right strategy-mix to the respective needs of the product life cycle is crucial.

FIGURE 1.14
Advertisement from 1899, taken from the Geographischer Anzeiger, offering a considerable refund when exchanging outdated world atlases for the new edition of Stieler's Handatlas.

FIGURE 1.15

With the 4th release, the Atlas of Switzerland changed for a free available application that loads its content via internet. In contrast to the earlier CD-/DVD-based versions, the user now gets frequently updated content when opening. This allows for new content types like the “Map of the Week” (Karte der Woche) that interested customers automatically get when using the atlas. Thus, the extending content and the introduction of new visualization forms has generated a steadily growing user community that contributes to the success and sustainability of the atlas project.

1.8 POST-PRODUCTION PHASE: STAY IN CONTACT

After Sales Activities

Traditionally, atlases have been sold without thinking of engaging with the buyer after sale. Digital or Digital/Print atlases open up the opportunity to do exactly that and stay in contact with the user. Software updates for installed atlas editions, supplements to local databases, connection to services on the Internet were often employed during the period of CD/DVD publishing. Online publishing (direct via website/service or internet connected app) always facilitates extending the communication, with the customer becoming a frequent user/customer (Figure 1.15). Either by extending the online content or further development of functions keeps users/customers involved.

Customer Bonding

The methods of customer bonding also apply to users of free of charge services, thus helping to keep up with projects goals (maximize users/customers). To name just a few [Patton and Bluel 2000]:

- *Awareness:* Earning customers “share-of-mind” involves creating an impression of personal identification with the atlas and is the weakest aspect of a relationship, only based on the user’s perception.
- *Identity:* The user/customer identifies the atlas as meeting personal needs, such as self-fulfillment. A customer may perceive the atlas project as having values and preferences similar to his own, e.g., the interest in the home country that is met by a national atlas project (e.g., the ongoing publication of the National Atlas of Sweden or thematic extension of the Atlas of Switzerland).
- *Relationship:* At a certain point the user/customer starts to exchange wishes for functions, proposals to extend the atlas. A positive response to demands then helps to form a community.
- *Community:* Building a user community who’s feedback steadily helps to improve functions and content or to develop follow-up products (e.g., special issues, supplements, extended functions in an extra app) may guarantee the sustainability of the atlas project. At a certain point further work on the atlas project can be justified solely by the demand for the atlas. It may also lead to participatory products in the atlas project (users map of the month, etc.), see Coleman [2018].

Licensing – Extending the Usage

An often-successful sales point is the licensing of complete or regional/thematic parts of atlases, which will be published as thematic inserts in various publications or as complete atlases (e.g., Goode’s World Atlas, produced by Rand McNally and completely licensed by Pearson, the world biggest multinational educational publishing company) [Coleman 2018].

1.9 CHALLENGES TO FUTURE ATLAS PROJECTS

Challenges – A Framework of Analysis

As the atlas concept evolves and is further used in different contexts and disciplines, many outside the geographic realm, the definition of what an atlas is starts to change too. Moreover, the challenges of new project terms and production modes, such as participatory atlases, will lead to new organizational forms, facing challenges of information overload, post-truth, galloping technical development and shifting demands for content. Thus, to organize a sustainable atlas project needs considering aspects from additional chapters of the Atlas Cookbook.

Figure 1.16 summarizes important future challenges to atlas projects, of which a few were addressed in this chapter.

Sustainability

A central goal of marketing products is to extend the growth and maternity phase of its life-cycle as much as possible without modifying it. There are several approaches, whose successful application depends on the nature of the product [Westkämper 2000]. For atlases the sale/online distribution of reprinted/unchanged editions marks a successful product-cycle-management. The duration of these phases changes according to the topicality of included information. Thus, statistical atlases may be out-of-date the next year or only after a periodical census whereas historical and topographical atlases may sustain their relevance for a decade or more. For the latter a supplement strategy could add to the longevity of the project.

Changing Producers, Changing Focus

More and more data providers (topographic information, statistics) distribute their data over their own (digital and analogue) data-driven web-portals or web-atlases (e.g., the Regionalatlas Deutschland compiled by the Federal Statistical Office and Federal Agency for Cartography and Geodesy, Figure 1.17). Thus, geographical atlases that traditionally disseminated the same data now need to focus geographic questions that only can be answered by combining data related to more recent problems with visualizations that follow current information demands of (new) user groups.

Cannibalization

In the evolving era of post-factual information, atlases and printed encyclopedia seem to remain reliable "stores of knowledge". However, the growing secondary use of maps in different thematic contexts may lead to unforeseen problems, besides possible use fees. A map simply showing the proportion of foreigners in a city may be cited in a political statement against receiving refugees.

FIGURE 1.16

Framework of advancement and challenges in atlas projects.

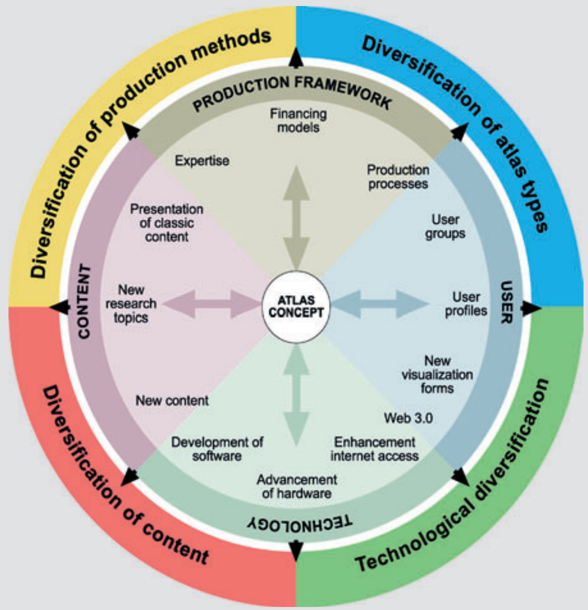
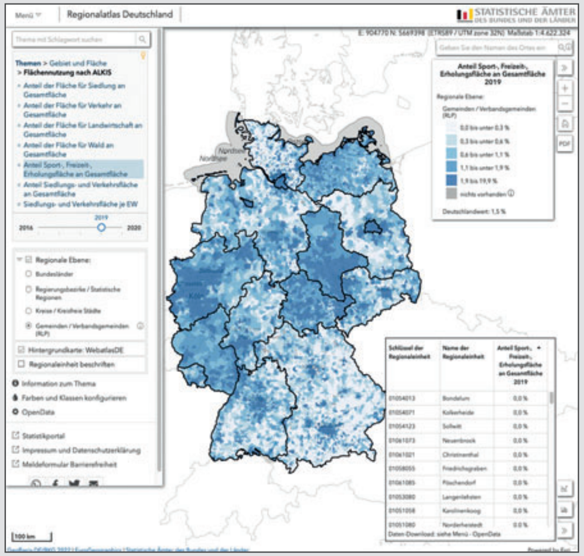


FIGURE 1.17
The web service Regionalatlas Deutschland (Regional Atlas Germany) focusses on the visualization of existing statistical data compiled by the Federal Statistical Office. The geometric data is obtained from the Federal Agency for Cartography and Geodesy, the technical platform is provided by ESRI (https://regionalatlas.statistikportal.de/).
The maps are part of the data-driven technical portal that depicts datasets as choropleth maps only.



1.10 CONCLUSIONS

The organization of production processes and marketing of atlas products can be considered similar to any trading business. Over the last centuries atlases have mainly been produced as goods to be sold. The extension and transformation of business models in the information age reflects the importance of atlases as information medium made for readers/users that do not necessarily have to pay for it. Thus, thorough planning of production needs to acknowledge a shift from the quality of the physical product to the quality of information disseminated. In this respect new forms of marketing will rapidly follow with changes of atlases and their underlying concepts.

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2 EDITORIAL ASPECTS

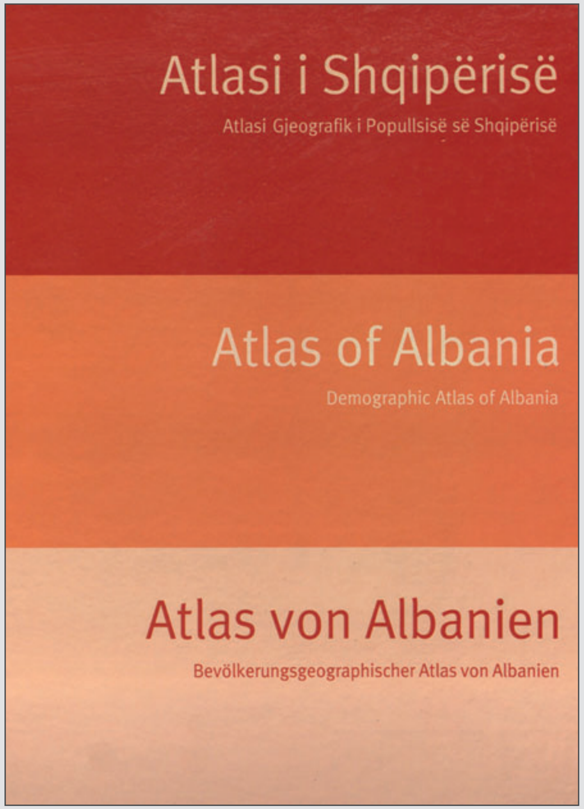
HARTMUT ASCHE

No atlas is created without a detailed and good recipe, as this atlas cookbook wants to show. The reason for this truism is simple: too much effort, too high costs, and considerable expertise required. Anyone planning a geographic atlas is therefore faced with a number of questions that apply to almost every atlas. They have to be solved before the actual editorial and production process begins. In this chapter, the topics discussed are considered from the editorial perspective. It will be shown that developing and editing an atlas can not be done by a single person nowadays. It is a collaborative effort involving various experts in data processing and modeling, map design and composition, and technical production. As with almost any printed or digital product or publication, an atlas project is subject to external influences on the editorial process as a whole, as well as the necessary decisions to be taken at different stages. Thus, any cartographer or atlas editor will act within this organizational, financial, and technical framework (Chapter 1). It is not only the principal task of the editor to develop and edit an atlas decided on, but also to monitor, steer and manage the complete large parts of the production process.

This chapter will explain the editorial tasks in the atlas production process and will take on topics, such as target audiences, atlas types and formats. Where appropriate, selected editorial tasks are illustrated using the example of editing a demographic atlas [Atlas of Albania 2003] (Figure 2.1).

FIGURE 2.1

Cover of the Atlas of Albania [Demographic Atlas of Albania].

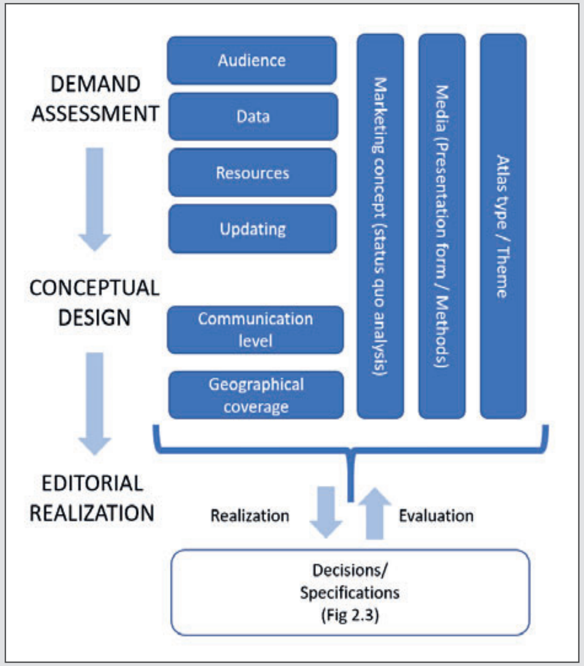


2.1 EDITORIAL PROCESS

The taken multi-stage top-down approach reflects both the responsibilities and decision-making power of the external and internal actors involved in atlas creation, while at the same time assigning extensive control of the editorial process to the atlas editors [Asche and Engemaier 2011]. In the following, a brief overview of the editorial process is given (Figure 2.2). Subsequently, selected tasks and task packages will be addressed in more detail.

FIGURE 2.2

Editorial process scheme.



Demand assessment

The top level of atlas creation comprises an assessment of the general demand for a planned atlas. In this first and fundamentally important stage, the demand for a specific atlas of a particular type, topic, area, and presentation platform for a particular audience is determined.

Establishing the need for an atlas is part of the atlas management process (see Chapter 1), that requires the provision of financial resources, manpower and means of production. Numerous (often non-cartographic) stakeholders are regularly involved in the assessment process and specify important issues such as:

- Atlas type and theme,
- targeted audiences,
- product platform, dissemination methods,
- data requirements,
- data availability,
- resources (human, technical, financial).

In the case of a commercial product, the needs assessment also comprises a study of the atlas market in terms of:

- Unmet demand,
- potential customers,
- apparent market niche,
- competing atlas products,
- rival market players.

The demand assessment is a crucial and complex task that later strongly influences all decisions and involves external and internal actors, the latter led by the atlas editor(s). External actors include commissioning, funding institutions and publishing companies or scientific boards and commissions. In many cases, the external players take the initiative to produce an atlas and frequently have a final say in deciding whether, how, and on what terms. During the whole production process, it is the atlas editor's task to drive and moderate the assessment process.

Conceptual design

At this stage, key objectives and overall features are specified within the defined production framework. Of particular relevance are:

- Atlas theme,
- atlas presentation form(s),
- geographic coverage (country, region, world) and map projections,
- level of communication, information transfer, geospatial visualization,
- intended atlas use (reference, information, spatial analysis and/or research),
- updating requirements,
- supplementary material.

The most important of these topics are examined in more detail in the following.

Atlas theme: This category defines the subject domain of the atlas. Atlas themes can be assigned to different top-level domains, such as:

- Topography,
- Natural environment,

- Social/cultural environment,
- Economic environment,
- Planning space.

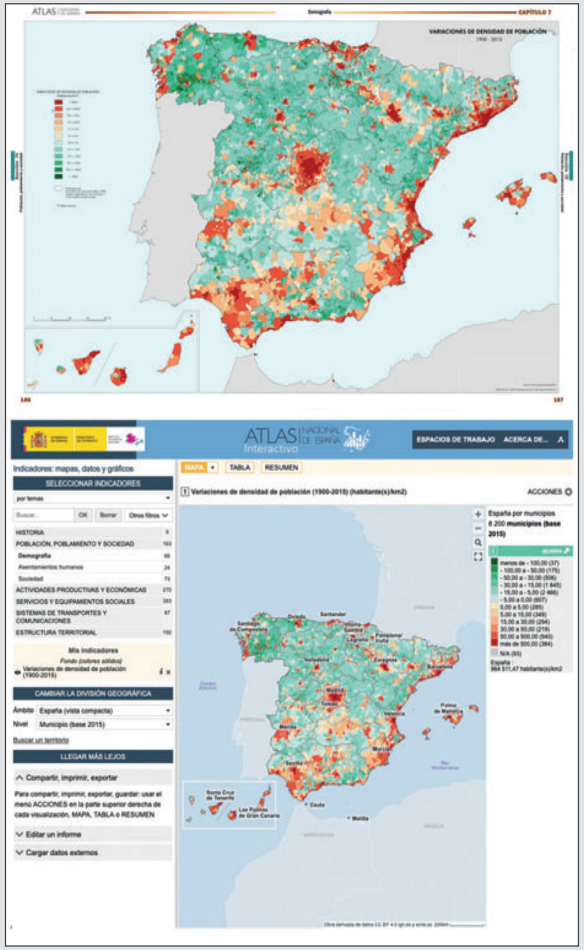
Each of these domains can be further subdivded into more detailed categories. It is important to know in which domain a planned atlas falls into, since every domain has its requirements, conventions, and respresentation methods. If, e.g., a topographic atlas conforms to the fundamental requirements defined in the topography domain, this atlas can be easily and distinctly be recognized as a topographic atlas in terms of content, topographic accuracy, map scales, symbolization, generalization, and cartographic representation.

Geographical coverage: In this category, the geographical space represented in an atlas is determined. Geographical coverage can range from a global representation of one or a number of topics to a very limited geographical area, such as a city. Atlas categories based on geographical coverage include:
- World atlas: the globe,
- Country/National atlas: a country, a national state,
- Regional atlas: a region, defined either politically as a part of a country, such as a province or a federal state, a trans-border region, such as the Saar-Lor-Lux region (GER, FRA, LUX) or Tyrol (AUT, ITA), or a region defined in terms of common thematic characteristics, such as political, economic or cultural alliances or institutions, e.g., the European Union,
- City atlas: an urban area, defined either by its administrative boundaries or thematic characteristics.

Audience: When conceptualizing an atlas, it is essential to consider the target audience of the future product. In general, atlas users are a large, heterogeneous collective differentiated by age, mental disposition, previous experience, social and educational background, professional position, or physical constraints, such as visual impairment. All of these characteristics have an impact on the selection of atlas/map themes, map symboliza-tion, map generalization, map composition and layout, ancillary information as well as atlas interaction and use. It is therefore important to define the targeted user group as precisely as possible.
This task is faced with some difficulty, since useful information on the characteristics of user groups in general and specific user groups in particular is often lacking. There has been some empirical research on map and atlas user groups, but only a fraction of it has been published [e.g., Schnürer et al. 2015, O'Dea et al. 2011]. At least some rough assumptions can be made about the targeted audience in terms of:
- Age span of atlas users,
- level of education,
- experience with maps and atlases,
- atlas use environments, e.g., classroom, private desk.

FIGURE 2.3

The National Atlas of Spain as an example of hybrid atlas production. Top: Thematic map of population distribution from the printed volume “Spain in Maps” [2019].
Below: The same map from the atlas information system available online [https://interactivo-atlasnacional.ign.es].



The above assumptions provide a general starting point for the editorial work. However, it is important to keep in mind that attributed user group settings often serve as substitutes for the lack of empirical evidence of real user group chacateristics.
Atlas audience specifications may vary from project to project. In order to generalize project-specific assumptions about atlas users, it is useful to compile synthetic profiles that define potential atlas user groups (user personas; see Chapter 3). User group profiles help to define the thematic focus of an atlas, data generalization and map visualization, as well as atlas use scenarios, such as viewing, exploration, or analysis.

Presentation form: This category defines the physical characteristics of the atlas. Traditional printed atlases were produced either as a book or a looseleaf edition. Present-day atlases come in various analog, digital and hybrid forms (e.g., the National Atlas of Spain, Figure 2.3). Clearly, the decision to produce, e.g., a traditional analog paper atlas or a digital, web-based atlas information system has implications for the specification of atlas topics, data used, map scales, symbolization and atlas access.

Atlas use: In addition to the audience targeted, an atlas, like any product, is produced to serve a defined purpose. Both audience and purpose are critical in determining the intended atlas use. To ensure the best match between a cartographic product and its use, it is crucial for the atlas editor or cartographer to consider the intended use. Specification of the intended use of an atlas product directly impacts the following issues: atlas topics, generalization, cartographic representation, symbolization, presentation scale, and updating as well as the publication platform. Typical atlas uses include:

- Cartographic documentation of space-related themes in a defined geographic area (e.g., national atlas),
- information extraction (e.g., reference atlas),
- educational purposes (e.g., school atlas),
- spatial exploration, evaluation and analysis (e.g., thematic atlas),
- or lately infotainment (e.g., coffee table atlas).

Taking the example of the demographic atlas, four hints for effective map reading and exploration directed at the general public are given:

1. Each map comprises the actual map itself and the legend.
2. To appraise the map, see the map title and the explanation of the map symbols which decipher the map content.
3. View the map representation, scrutinise the details, e.g., quantities, by using the legend.
4. Compare details within the map with other maps on this theme. Compare the maps with related themes to identify structural and spatial correlations.

It is important to note that determination of a particular atlas use does not exclude other, albeit unintended uses. Such, school atlases that remain on the user's bookshelf for decades are often used for general geospatial reference although boudaries and placenames may have changed over time.

Updating: The decision to create an atlas must also consider how the atlas will be updated in future. From an atlas producer's perspective, the demand for updating an atlas is mainy driven by its thematic content, publication/dissemination platform, and/or market requirements. Resources (human, financial, technical) available for updating are also an important factor. Thus, the decision for regularly or episodically updating an analogue atlas product is often overlooked when planning the project – an issue that can easily be met by today data driven online atlases. Regarding several topics (and atlas types), the need of updating seems inevitable. In addition, from an economic perspective, updating helps to protect the investment made in developing and producing an atlas. It is also contributing to the sustainability of the product (Chapter 1).

2.2 EDITORIAL WORK

Given a successful completion of the preceding atlas development stage, the assessment process leads to the editorial work stage. From an atlas editor's perspective, this is the very core of atlas editing in the strict sense of the term. At this stage, the editor needs to specify task packages (Figure 2.4). These are often realized in the given order. However, since all tasks based on each other, an iterative approach is needed, e.g., adapting the list of map themes to data availability.

Map themes: Within the framework of atlas type and theme defined, the editor compiles a complete list of all topics presented in atlas maps. It is advised to arrange map themes according to subject areas. Imagine the objective is to develop a demographic atlas for a specific region. The themes presented in the atlas can be grouped into the following sections: Population distribution, natural population development, geographic population development, population dynamics, and population structure. Each of these sections comprises a number of maps visualizing single topics. For instance, the section population structure may include the following map themes: Age structure, employment structure, employment/unemployment (different temporal reference), ethnics and religion.

Atlas design and layout: In order to achieve a uniform appearence of the future atlas, map and text representations have to be determined by general graphic design and layout specifications. Atlas and map layout include the organization of map display area, color schemes, labels, etc. outside and inside the map area.

FIGURE 2.4

Process scheme of editorial task packages.

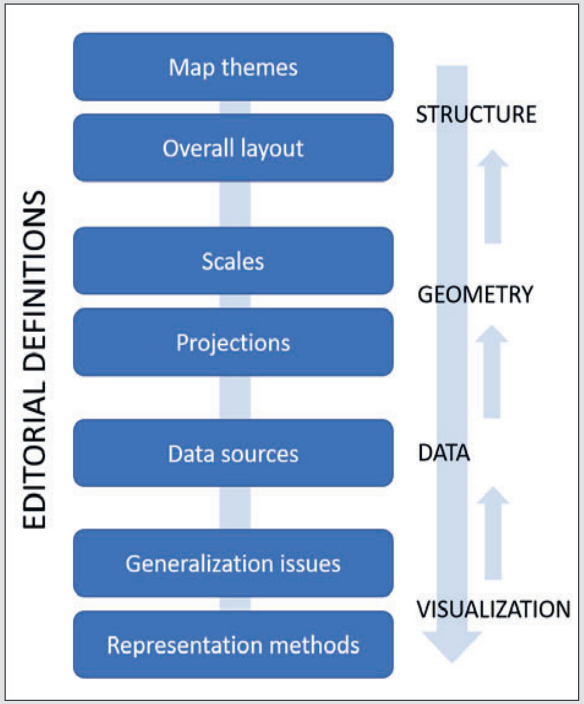


FIGURE 2.5

General map, position of Albania in Europe (1:4 500 000) [Demographic Atlas of Albania].

It is obvious that any layout and design considerations must consider the technical specifications of the chosen atlas presentation form (print atlas, digital atlas, web atlas/atlas information system). Layout and design specifications can be either strict in the form of a set of rules or less binding in the form of design/layout guidelines. This editorial task frequently involves contributory work by (external) graphic design specialists.

Map projections, map scales: The selection of suitable map projections for the atlas is influenced by physical parameters, such as the presentation format (display/page size), and semantic factors, such as atlas objective, atlas theme, geographical coverage and intended map use. Area-related atlas or map themes, focusing on areal comparisons, require equal-area projections. When measurement of distance or direction is focused, as in topographic maps and atlases, conformal projections are an obvious choice.

The choice of map scales used in the atlas will equally be determined by atlas type (thematic, topographic, school atlas, etc), theme and geographical coverage (country, region, etc.), as well as by the presentation format and size. Numeric map scales should show easily understandable rounded numbers that can be compared with the principal scale by simple multiplication or division. Only a limited number of scales should be employed in an atlas to facilitate comparisons of maps with identical and smaller or larger scales. The number of scales used largely depends on atlas type and geographical coverage. It is highly recommended to group the selected map scales in a well-defined, easy to compare series of scales. In the example of a demographic atlas, the series of scales is as follows: 1:4 500 000 (country position in region), 1:1 500 000 (principal scale, outline maps country level), 1:750 000 (detailed maps provincial level), 1:75 000 (detailed maps city level) (Figures 2.5–2.8). Digital atlases and atlas information systems facilitate map scale changes, either through application software or hardware/operating system functions.

Source data: Collecting, selecting and processing the geographic data to fit the atlas theme and subsequent map modeling, is a critical, complex task. Editorial acitivies include discovering, collecting, inspecting, filtering (cleaning, transforming, modeling) as well as validating the geospatial, thematic, and temporal data reference. As with other editorial tasks, collection and processing of source data often is a collaborative effort with the participation of data handling specialists.

Source data comprise thematic data relating to the atlas theme and base data for geospatial reference. The kind, amount, granularity and precision of the source data are determined by the atlas topic, audience, intended use and updating. For thematic atlases, the vast majority of data is acquired from secondary sources, such as statistics, digital databases or existing maps. The atlas editor will have to consider that data acquired from existing data collections or databases were originally compiled for other purposes than the creation of specific atlas maps. Such secondary data need further processing to be usable for subsequent visualization in the defined atlas maps. The aim is to prepare the data in such a way that the spatial information they contain is transformed into matching map models without information loss.

Data processing or filtering starts with an assessment of the substance of semantic and geometric information in the data according to the typology of measurement scales (nominal, ordinal, interval, ratio scales). Data are subsequently classified and/or generalized for graphic transformation and successive mapping. For many thematic purposes, data can be obtained at all levels of measurement. However, if it is necessary to aggregate data, it is important to understand that data of different measurement levels can only be merged at the lowest common measurement level. In any case, the filtering of source data directly affects the representation method and the symbolization measures applied to the visualization of a map theme. Therefore, it is an important editorial task to determine the appropriate data filtering procedures required for specific map representations in the atlas.

It needs to be stressed that the proper selection and filtering of the source data is the basis for the subsequent determination of object-sign-reference in the following symbolization task.

FIGURE 2.6

Left: Map on communes 2001 (1:750 000)
Right: Map on religious composition 2001 (1:1 500 000)
[Demographic Atlas of Albania].

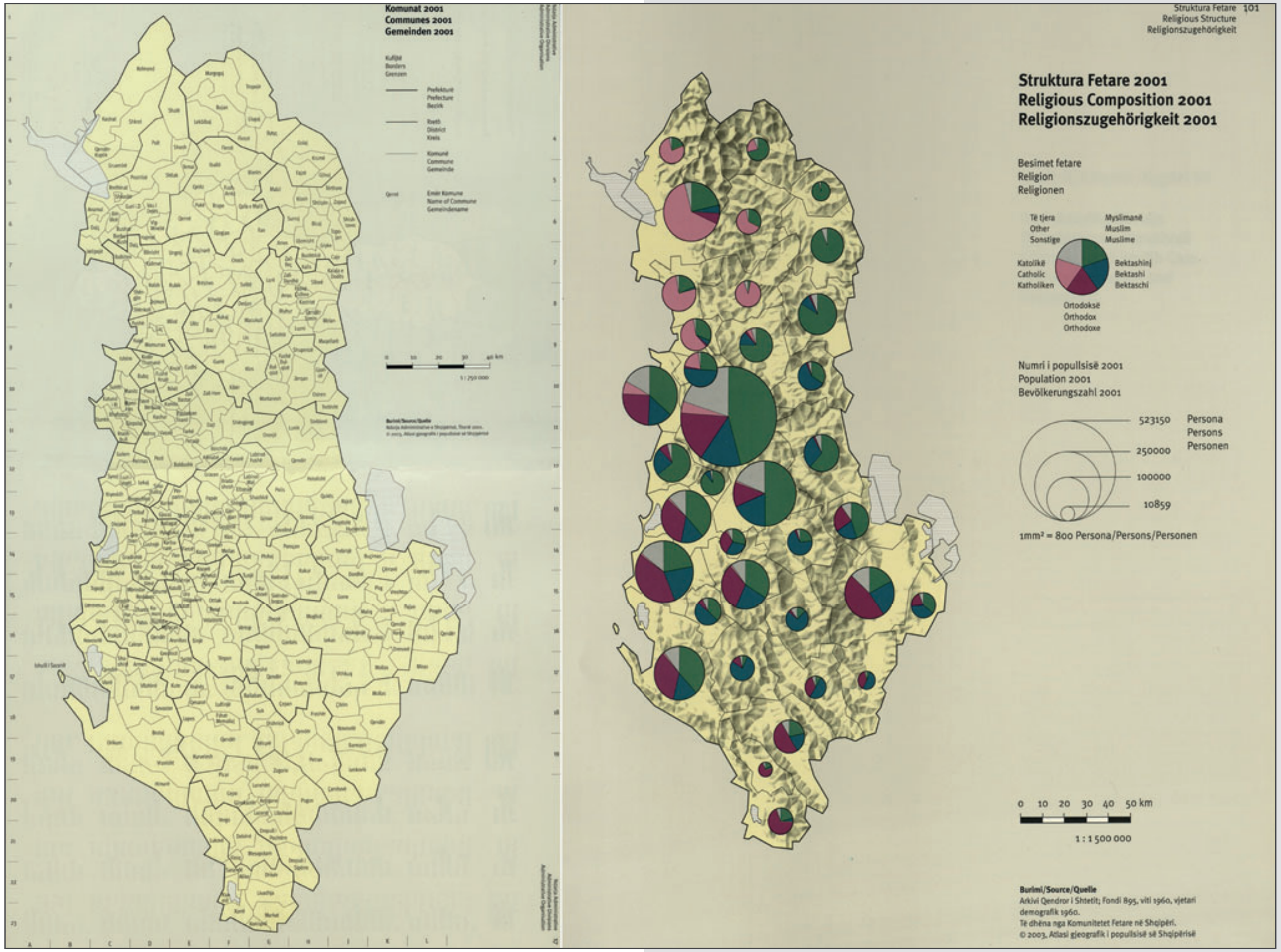
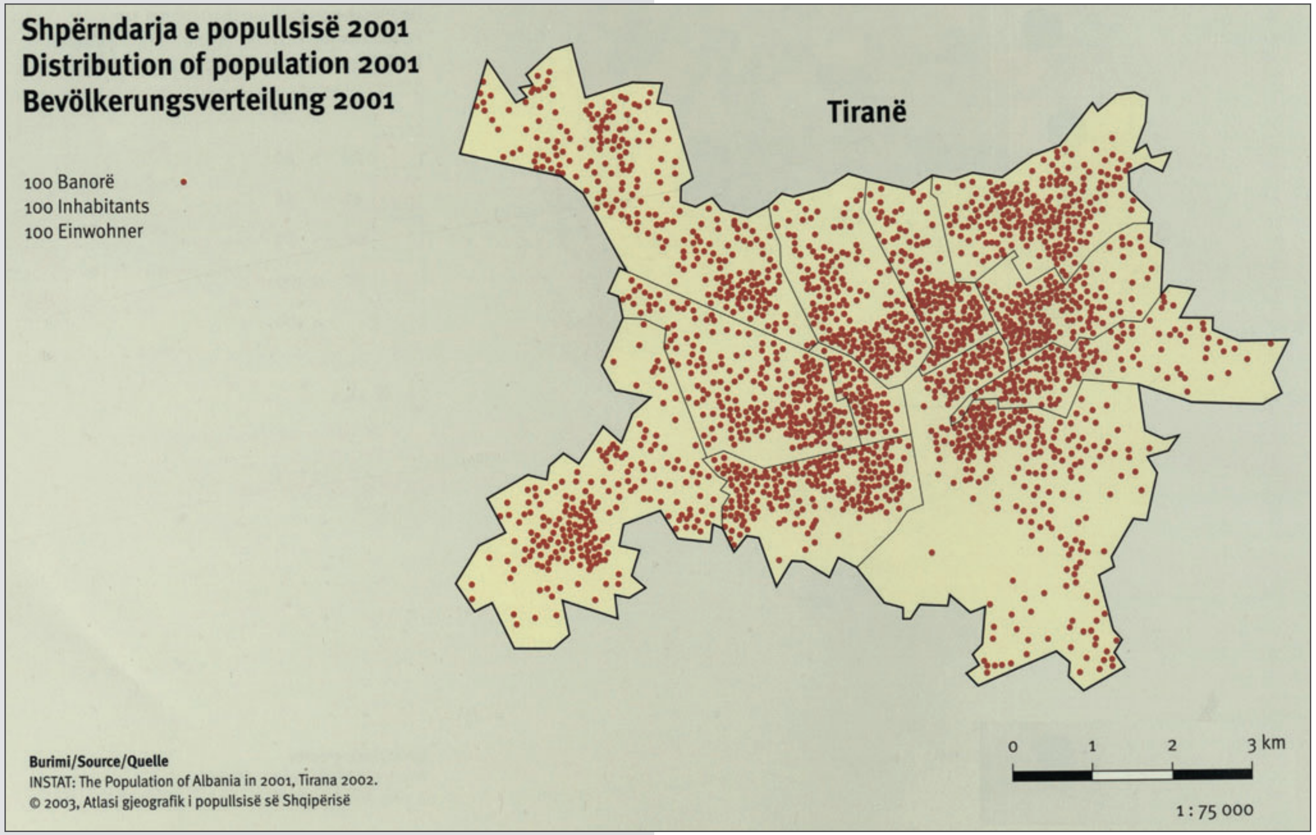


FIGURE 2.7

Map on population distribution in Tirana 2001 (1:75 000) [Demographic Atlas of Albania].



Representation methods, symbolization: Based on the themes list and the data provided, at the same time considering both targeted audience and intended atlas use, the editor selects the cartographic representation methods employed to visualize the map themes. At this stage, the preprocessed non-graphic source data or, in case of atlas information systems, digital data models are transformed or "mapped" into appropriate cartographic models. Cartographic models can be generated for the theme groups represented in the atlas by matching the appropriate data with the relevant representation method(s) in compliance with the symbolization and generalization guidelines. Execution of this task package aims at presenting the non-graphic information in meaningful cartographic models to communicate geospatial information in visual form effectively.

The selection of suitable representation methods is primarily determined by the geometric primitives of the map data to be visualized. Geographical phenomena percieved as points require point-related methods, such as point symbols, point diagrams, or dot maps (Figure 2.7). Proper visualization of linear phenomena necessitates linear respresentation methods, such as simple or dynamic linear symbols. Areal phenomena are visualized employing areal methods, such as qualitative area symbols, diagram maps, or choropleth maps. Since they occur at discrete locations, point, line and area data are considered discrete. Volumetric phenomena represent continous 2.5/3D phenomena, occuring throughout a defined region. Appropriate representation methods include isoline/isarithmic maps, or statistical surface maps. Taking the topics of a demographic atlas as an example, source data for the population dynamics section relate to quantitative areal phenomena.

Hence the respresentation methods selected comprise choropleth and/or diagram maps (Figure 2.6). Choosing a relevant cartographic representation method generally determines the selection of the appropriate cartographic symbolization for a specific map topic. Symbolization tasks comprise:

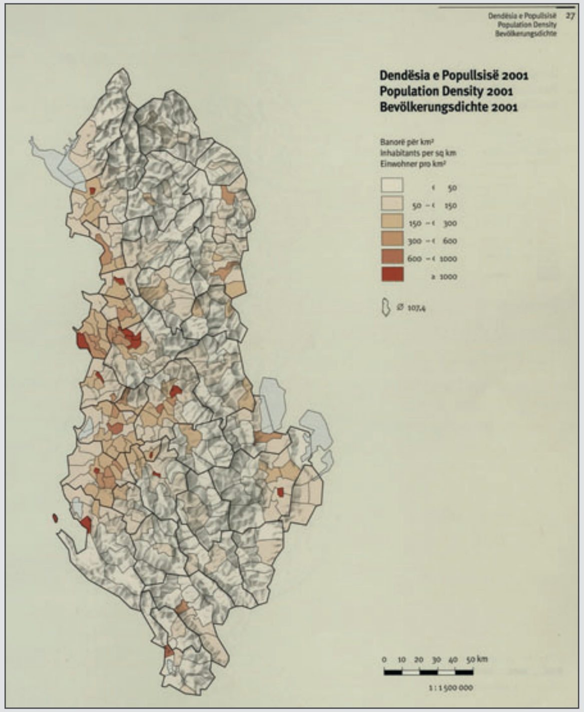
- Object-sign-reference (correlating data characteristics with graphic features),
- iconicity specification of map symbols (mimetic, abstract symbols),
- level of measurement (qualitative, quantitative),
- cartographic generalization.

When selecting the appropriate symbolization measures, the geometric and semantic features of the data to be visualized and also the target audience and intended map use must be considered. In the example of the demographic atlas, area-related quantitative phenomena, such as population density, age or employment structure, can effectively be symbolized by range-graded area tints resulting in simple choropleth maps (Figure 2.8). In the case of more than one area-related quantitative data features, such as urban/rural population, area-referenced range-graded diagrams are used for visualization to produce diagram maps.

Once all task packages at the editorial work stage have been completed, all parts of the atlas exist in some virtual form. Today this is a set of digital data files or a digital database, traditionally this has been a paper prototype with key maps in design quality and representation scales. At this stage, the atlas is ready for production. Before commencing the production stage, the prototype is thoroughly checked against the initial demand assessment and conceptual development stages. It is important to note that this comparison is the final opportunity to terminate the editing and production process if substantial discrepancies are found between aim, objective, cornerstones and prototype.

FIGURE 2.8

Map on population density 2001 [Demographic Atlas of Albania].



2.3 PRODUCTION PROCESS

Once the atlas prototype has been accepted for implementation, the actual production process is triggered. In a collaborative environment, the actual production of the atlas is the work of specialists. The atlas editor's role is to monitor, validate, and approve the technical production of all atlas components as determined at the demand assessment and conceptual design stage. In this way, conformance of the final product with the original atlas concept, as laid down in the specifications at each process stage, is ensured.

Present-day atlas production starts with the preparation of all digital data generated in the course of the editing process for the defined atlas presentation platform. This can either be a printed or a digital product, or a web-based atlas information system. For printed atlas this means producing the print templates. Digital atlases may require an adjustment of the digital prototype map and text components before stored on electronic data devices or servers. In the past, print and electronic atlases have occasionally been derived from an identical database. The essential difference is the adaptation of the printed atlas for digital storage and distribution. Turning a print atlas into digital form often results in a read-only version of the print product [Ormeling 2010]. However, these static digital atlases can be supplemented by interactive elements, that faciliate the use and understanding of rather complex printed maps.

2.4 CONCLUSIONS

In this chapter, basic information on the editorial tasks and processes in atlas development and production were assembled. A process is presented, especially for beginners, covering all editorial tasks relevant to atlas generation, from needs assessment to map modeling, layout, product assembly, and the actual production of an atlas. Atlas editing, as shown, is a sequential process consisting of a certain number of editorial tasks that can be grouped into task packages. Task packages are assigned to a limited number of sequentially ordered stages or phases.

In a sense, the above outline of the editorial process and its elements (tasks) can be considererd a general guide for the development and production of atlases. Just like a recipe, the process outlined must be adapted to the specific circumstances under which an atlas project is realized.

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3 ATLAS USE

FERJAN ORMELING AND CORNÉ VAN ELZAKKER

In the previous chapters we have set the conditions under which the atlas can be acquired in order to make it a valid business proposition. Thus the access by specific groups is guaranteed. But if we want to generate a product that can be acquired, is desired and easy to use by the intended user group, we must see to it that we get to know the relevant characteristics of this user group, find out about their requirements regarding the information they need and the way in which they will get that information from the atlas.

This chapter intends to show how to acquire the relevant data. These data, in turn, are needed for a next phase, the evaluation of the atlas prototype.

This chapter will give separate attention to use contexts and tasks to be executed with the atlas and for users and their preferences and characteristics. In short: we pay attention to the "external" use and user requirements after Chapter 2 has dealt with the "internal" business requirements.

3.1 USER GROUPS

Who are the "personas" (in UCD-speak this are the typical representatives of the various user groups that can be discerned, and of which characteristics and preferences can be described) of the atlas? We can work this out logically by assessing when we came into contact with atlases ourselves.

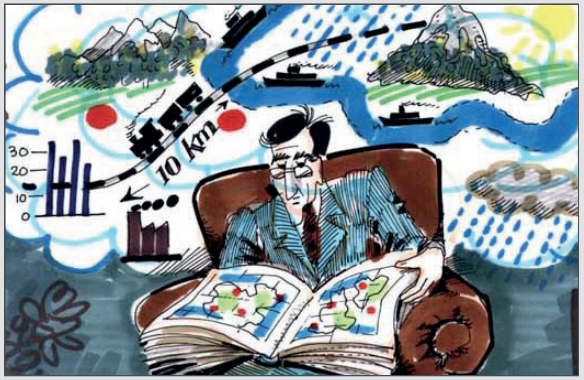
At an early age we start using school atlases that would become more complex with our age. When we learn to drive (before the advent of navigation systems) we used to learn to deal with road atlases. And when establishing our own home, we would still consider buying a reference atlas, even if the information contained in the atlas can also be retrieved from the Internet, through Google Earth or Wikipedia. The reason why atlases still provide an essential contribution is because the information in them has been processed in a systematic way. Our success in querying information from the web is based on our learning to deal with geographical concepts through our school atlases. Later, when we specialize either in our work or in our hobbies, we will go for more specialized topical atlases. As professional users

User groups that may be discerned [Bakker et al. 1987]:
- school children and their teachers,
- navigators,
- interested laymen,
- commercial and professional users and
- dedicated scholars.

The main atlas use purposes are:
- reference,
- education,
- navigation,
- management and
- scientific exploration.

FIGURE 3.1
Premeditated search.

FIGURE 3.2
Unpremeditated browsing.



we might, for instance, depend on the storage function of atlases, e.g., showing all the accessible sand deposits in the underground close to a proposed highway extension; as scientists we would be able to derive knowledge of new relationships between datasets.
In an ideal world we would be able to describe all the characteristics and preferences of these user groups, but these have been insufficiently analyzed. Wright [1999] has given some insight in the user preferences of the online National Atlas of America. Kramers [2007] refers to an analysis of user characteristics for the topographic maps contained in the National Atlas of Canada, but not to a more general user group characterization. Clearly more research is needed here.

3.2 ATLAS USES

The main atlas use purposes to be discerned are reference, education, navigation, management and scientific exploration (by mapping phenomena one also visualizes the gaps in one's knowledge of these phenomena).

A general consideration for producing atlases would be their ease of handling (just compare handling topographic map sheets or paper road maps with handling topographic atlases or road atlases or visualizing their contents on the screen of one's laptop!).
An even more important consideration is that one is able to select and compare different views on geographical information through atlases: to compare different topics for the same area, different snapshots in time for the same area and topic, or even compare different areas for the same topic and time frame. This requires representation of the data on the same scale, rendered with the same degree of generalization and with similar cartographic modeling techniques.

Selection and comparison can take place during premeditated search activities (Figure 3.1, for instance when consciously looking for maps of other themes (such as height above sea level, vegetation, soil) that have similar patterns as a population density map), or during unpremeditated browsing (Figure 3.2).

3.3 ESTABLISHMENT OF THE ATLAS CONTENTS

As soon as the purpose is set, the contents of the atlas can be selected. The most important aspects here are:

- the area depicted (will the atlas portray only one city or one country or a continent or the whole world?),
- the topic depicted (is it to be a road atlas, a reference atlas, or a city planning atlas?),
- the scale or level of detail (for a reference atlas we expect much detail on large-scale maps, a primary school atlas will only contain small-scale maps showing only the most important items).

Do our users expect to compare all kinds of relevant map topics (as in a national atlas) or only a restricted group of interrelated topics, such as in an atlas of the environment? Or do they expect a standard set of topics, mapped for all the individual areas portrayed?

Another important question is, whether the atlas users would need a nation-wide overview of a topic as well as the possibility to zoom in on specific areas, providing an information increase on the selected topic while zooming in. The latter set-up would call for additional information to be visualized or suppressed when passing specific scale thresholds.

It might also be relevant for the users to be provided with a reference to their home country, so that they can better compare the situation in foreign parts with that at home. If so, small reference maps of the home country situation can be depicted in the margin of the map.

3.4 USE CONTEXTS

How an atlas can be used depends very much on its physical aspects: is it printed or does it exist in digital form? More important might be a subdivision of atlases into:

- *view-only atlases:* paper atlases or digital ones that cannot be changed,
- *interactive atlases:* digital atlases where the users can adapt the presentation of the map contents to their preferences,
- *analytical atlases:* in which users can combine different data sets contained in the atlas.

Amongst electronic atlases, those offered for a desktop environment would have better opportunities for overview maps, while mobile devices used in the field have a major task, while zooming in or out, in keeping the user's awareness of their environment, because of their small screens. For on-line atlases an Internet connection is required, and part of the use context is the waiting time for the data, depending on the bandwidth of the desktop's Internet connection.

FIGURE 3.3

Scale index of a reference atlas showing which areas are depicted on which scales. Germany, where this atlas was produced, is shown on the largest scale [Bertelsmann Atlas International 1963].

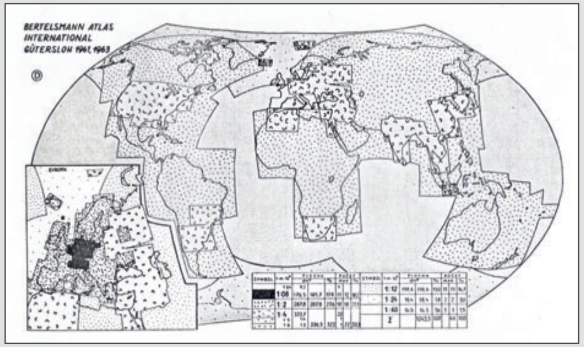


FIGURE 3.4

Atlas access aspects.

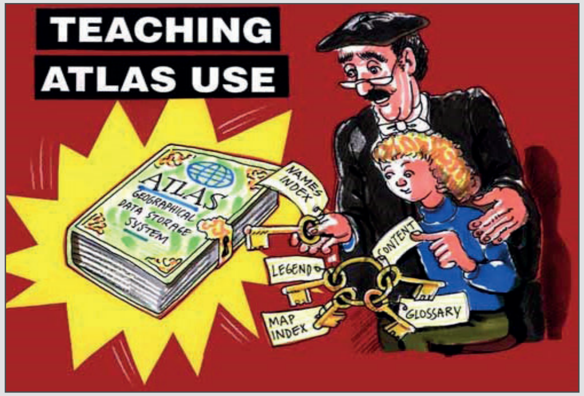


FIGURE 3.5A

Dot map: Population distribution in East Africa. One dot equals 10 000 inhabitants [Wolters-Noordhoff 1981].

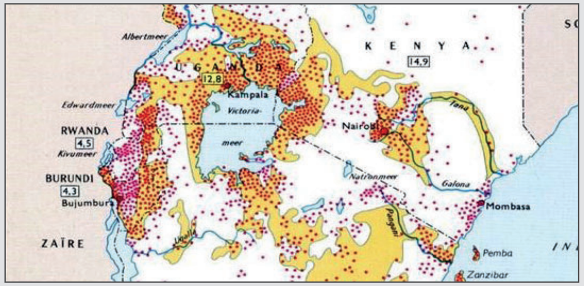


FIGURE 3.5B

Flow map: Japanese import of natural resources [Bosatlas].

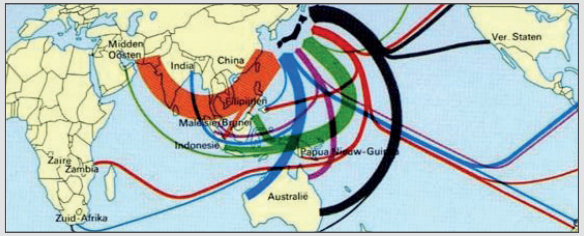


FIGURE 3.6

Atlas and map use analysis through eye-tracking and thinking aloud [Photo by Van Elzakker].

The use of atlases presupposes knowledge of geographical concepts (world, sea, land, continent, boundary, country) at different scales, as well as the names they go by.
Learning these concepts and the provision of a topographic frame of reference would prepare users for individual study and analysis of geographical relationships (Figure 3.4).

Wiegand [2006] has provided insight in map use learning processes for children and Ormeling [1993] has touched upon the specific use of atlases, highlighting the teaching of atlas access techniques (through knowledge of atlas structure, geographical names and thematic indexes, map index sheets, legends and glossaries) and map comparison.

Paper school atlases still play an important role here, as the teaching of geographical concepts requires a controlled environment, less found in digital atlases that are visualized on different monitors with different zoom factors.

Apart from the technical and educational aspects, use contexts also depend on the complexity of the task. This can be simple way-finding task aimed at finding one's correct direction, or it can be a regional exploratory study in which an area must be subdivided into more or less homogeneous units that can be described on the basis of specific characteristics. The aim of atlas consultation can also be to get an idea of spatial processes, such as commuting or weather fronts moving fast, of spatial relationships (dependencies, correlations or conflicts) or of spatial patterns (differentiation or anomalies: why is population density much lower there than here, despite its adjacency to that big city?). Looking into changes over time would add another dimension to these studies.

3.5 GEOGRAPHICAL QUESTIONS POSED

This section on the geographical questions posed by the users is the most important part of this chapter.
Systematic categorization of the most important use and user questions that will have to be answered by the atlas as a whole and the individual maps in it provides the best framework for assessing whether the atlas endeavor has been successful or not. Questions should be linked up to the users, uses and use contexts discussed above and lead to the section on atlas use scenarios discussed below.

For this purpose one needs to discern different levels of questions or levels of atlas use. For example, comparing spatial patterns on different atlas maps is of a higher level than looking up a settlement on an individual map (Figures 3.5a and 3.5b).

We presume that digital users, even when they are merely browsing a digital atlas, are always busy trying to find answers to the geographical questions they have (wittingly or unwittingly, see Figure 3.6). These questions may have a different level of complexity and may be coupled to specific *use tasks*, which may be expressed by means of verbs. For example, for the specific purpose of regional exploratory studies (gaining understanding of, and insight in, the geography of a particular region, Van Elzakker [2004] discerned the set of geographical questions and related use tasks shown in Table 3.1.

In essence, the use tasks distinguished in Table 3.1 are already *map* use tasks, i.e. tasks that can be executed once users already have a map display in front of them. It should be realized that, in the context of a digital atlas, these tasks are preceded by a number of atlas use tasks, based on user questions which are usually NOT of a geographical nature. For example: Is there a digital atlas that can help me answering my geographical questions? Where is that atlas? How can I get access to it? What information does that atlas contain?, etc. Examples of the way these geographical questions and the tasks needed to answer them are given below. A more complete description is found in Ormeling [2008].

TABLE 3.1

Use tasks (right) with relation to the geographic questions addressed (left) [Van Elzakker 2004].

Elementary	
What is there?	- to *recognize* objects (external identification)
At a given place, what is there?	- to *identify* objects (internal identification)
At a given place, how much is there?	- to *estimate* amounts
Where is that geographic object?	- to *locate* an object
Intermediate	
What is near that geographic object?	- to *position* with respect to other objects
What is the distance to similar/other objects?	- to *define* relative / absolute distance
Is that geographic object linked to other objects?	- to *encounter* spatial linkages
Why is a geographic object there?	- to *explain* a location
What is the spatial distribution of that object?	- to *find* order, patterns or spatial anomalies
Where is the most / least?	- to *quantify* spatial anomalies
Where are the limits of a spatial distribution?	- to *delimit* a distribution
What comes in / what goes out?	- to *connect* a region to the outside world
Temporal	
Has that geographic object always been there?	- to *determine* changes
Have the spatial distribution patterns changed?	- to *establish* trends
Which spatial processes are taking place?	- to *detect* processes
Overall	
What are the influences from outside the region?	- to *contemplate* spatial context
What relevant patterns are there?	- to *recapitulate* the found patterns
Are there relationships between spatial patterns?	- to *discover* correlations / dependencies / conflicts
Which factors cause the regional structure?	- to *structure* the geographic information
Can different (sub-)regions be identified?	- to *regionalize*
What are the region's geographic characteristics?	- to *obtain* insight into and overview of the region

FIGURE 3.7

Relationships between patterns: Comparison of numbers of persons dependent on an ambulance and its average travel time [Nationale Atlas Volksgezondheid 2007].

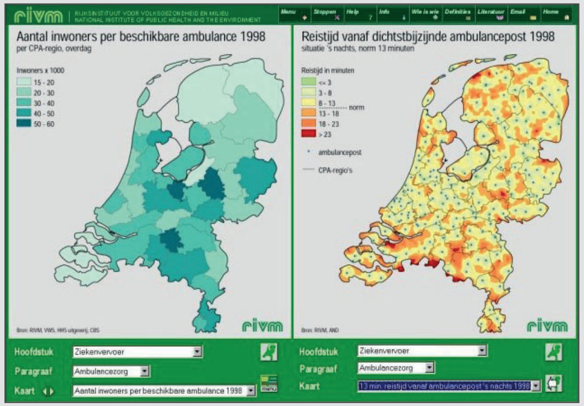
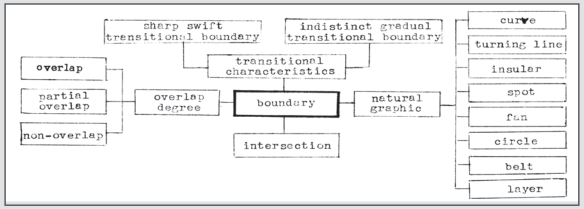


FIGURE 3.8

Different boundary characteristics [personal communication by Liao Ke].



Question I. What is there? What occurs at a specific point location?

Why would we bother to look for that specific point location in a digital atlas? Because it would be a place where the most detailed information on that country/area could be found. Very detailed spatial information would also be retrievable from the primary dedicated datasets on which the map data were based (such as statistical tables), but in the atlas this kind of information can be found quicker as it allows for geographical searches. So, starting from a feature or object with a specific location on the map, which can be assessed in geographical or map coordinates, we are able to retrieve the information valid for that location from the symbols or signatures present at that location, and retrieve their meaning from the legend. Here we must take account of the map scale, as because of generalization the level of detail and accuracy of the information read from the map decreases with the map scale. An example of a required functionality would be to show the geographical coordinates of the cursor position.

Question II. What is the overall pattern of that phenomenon?

Here we start from the phenomenon instead of from the location. First the kind of information searched for is defined and translated into a map topic and scale. When the relevant map has been accessed, the extent or shape of the distribution of the phenomenon can be assessed and its pattern can be described.

Important questions here are how the various regions can be delimited (sub-regionalization) what the spatial anomalies are, whether there is a spatial structure or hierarchy, and where the highest or lowest values or densities are located. This can also be termed its *horizontal relationship*.

Question III. What are the relationships between these patterns?

Here we turn to *vertical relationships*. For assessing them one should first define the datasets needed and find the corresponding maps at the required scales or resolution levels, zooming in on the area studied. Then the datasets are combined from the map sheets and their correlation or their degree of overlap is measured, and one checks whether the phenomena show the same trend from high to low values (Figure 3.7). One would be interested in dependencies here, and in finding out whether phenomena have similar distributions. The functionality required here would consist of correlation computing.

In order to answer the question we have to define the relevant area (a natural, administrative or economic unit area), draw all the data pertinent to this area from the various atlas sheets or underlying datasets, combine and characterize these data, taking account of the diverse characteristics of the boundaries used, and the different weights assigned to them (Figure 3.8).

3.6 ATLAS AND MAP USE ACTIVITIES

In order to answer the geographical questions posed in section 3.5, specific activities have to be undertaken. For the use of maps not combined into an atlas, Van Elzakker [2004] distinguishes here between:

- selection activities,
- reading activities,
- analytical activities,
- adjustment activities and
- construction activities.

To these can be added the functionalities of digital atlases, as distinguished by Simon van Leeuwen [1996]:

- atlas functions (comparison, find map with largest scale where a specific name occurs), database functions,
- cartographic functions,
- educational functions,
- navigation functions,
- general computer functions (import, export, print),
- map functions (pop-up legend, highlight legend class, link to hotspots) and
- map use functions (annotate, measure, buffer, overlay).

This combination may result in a list of atlas and map use activities as shown in Table 3.2. This list of use steps is more or less sequential, although in practice the individual order of execution may be different and loops (going back to earlier steps) are possible as well. It should also be noted tha we do not consider this list to be a generic and complete one. Like Table 3.1, this Table 3.2 has also been drawn up with the example of regional exploratory studies in mind. It is also assumed that the digital atlas itself has already been selected.

TABLE 3.2

Atlas and map use activities for regional exploration [Van Elzakker 2004].

Searching	- to search for a geographical object (index, gazetteer) - to search for a particular theme (list of contents) - to search for a moment in time (date / year) - to search for a particular map
Selecting	- to select from maps available (browsing) - to select a theme - to select a moment in time (date / year) - to select an aggregation level - to select a geographic extent - to select a map scale - to generate a map from a spatial database - to import data / map from elsewhere
Reading	- to look at the map title / legend - to view the map image - to click on a map symbol (to retrieve attribute data)
Analysis	- to measure on the map - to count symbols - to annotate a map - to highlight a(n) (category of) object(s) - to buffer - to juxtapose and compare map displays
Adjustment	- to overlay (to add layer(s) to a map display) - to switch off a layer - to change the method of classifying attribute data - to pan - to change the level of aggregation - to zoom in (make the map scale larger) - to zoom out (make the map scale smaller) - to change the map projection system - to change the map orientation - to change the snapshot in time - to change the symbology
Construction	- to change the mapping method - to generate a new map - to export data / map - to print a map - to click on a map symbol (to retrieve attribute data)

FIGURE 3.9

Cartoon of Nils Holgersson flying over Sweden, sitting on a goose while looking down [drawing by A. Lurvink].

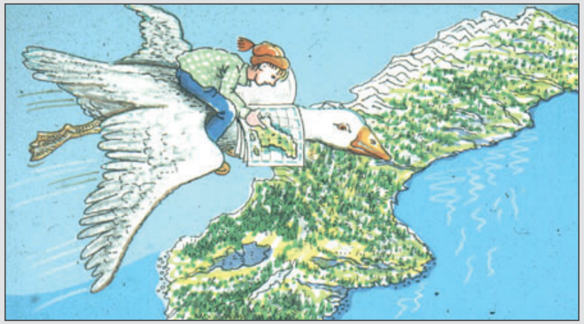
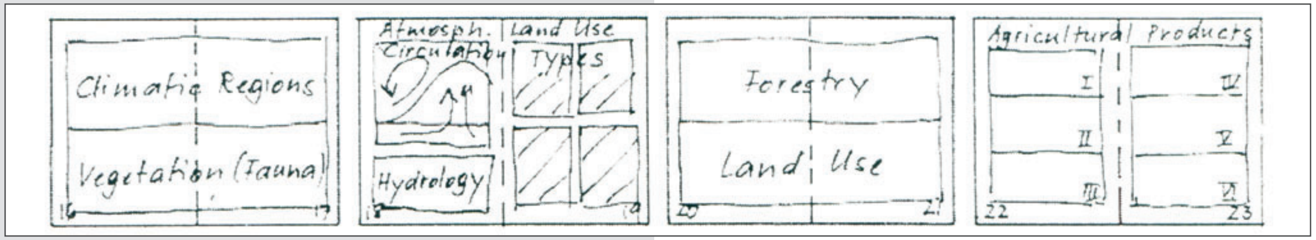


FIGURE 3.10

Color coding atlas sheets for better access [Nationale Atlas Volksgezondheid 2007].

FIGURE 3.11

Atlas story board excerpt [Freitag 1998].



3.7 ATLAS USE SCENARIOS

We have seen geographical questions and related them to map use tasks in Table 3.1. In Table 3.2 these map use tasks have been related to specific activities. Specific activities, in turn, can be linked to desirable functionalities in the digital atlas. On the other hand, a sequence of geographical questions can be combined into an atlas use scenario.

An example of a school atlas use scenario could be the story of Nils Holgersson: a naughty farm boy magically turned into a dwarf, who is taken up by wild geese, riding on their back while they are crisscrossing over his country, Sweden (Figure 3.9). This would be simulated in an atlas: by selecting a location in the atlas wherever they want, the students can look down with Nils and zoom in on the local land-use, wild-life, environment and population. The atlas would need an imagery database, as well as matching sets of topographic, land-use, population density and economic maps and the functionality to switch between them for a specific location. In this way, a digital atlas designer will know which functionalities are required.

The scenario will also make it possible to prioritize between these functionalities and to work out the conceptual design of the atlas.

Browsing out of curiosity (unpremeditated browsing) is one special kind of use scenario, which should be mentioned as well. Known and ready-made atlas frameworks or scenarios might be preferred as this would make an introduction superfluous and would immediately allow for exploration and analysis of the atlas contents (Figure 3.10).

The idea behind devising an atlas scenario is that first the questions that need to be answered by the digital atlas to be designed are formulated and listed, together with their related use tasks and that these are opposed to the atlas functionalities and map use activities that need to be carried out in order for the digital atlas users to be able to answer their geographical questions or execute their use tasks (Figure 3.11).

By means of another example, a use scenario for regional exploratory studies is presented in Table 3.3. The first matrix in this use scenario (3a) links the essentially non-geographical questions of prospective atlas users to atlas use activities (functionalities) that precede map use proper, or come after that map use (e.g., exporting a map). The second matrix (3b) links map use activities with the use tasks based on the geographical questions to be answered. Symbols in the matrices indicate what activities are required for meeting the desired atlas purposes. Prioritization would perhaps be possible as well. It should be clear that Table 3.3 is just an example to demonstrate the approach. Similar matrices may be drawn up for different overall atlas purposes and the way the matrices are completed will to quite a large extent be based on decisions by the atlas producer / designer.

TABLE 3.3A

Digital Atlas Use Scenario linking non-geographical questions to atlas use activities.

Atlas use activities	Demands regarding overall atlas functionalities
Searching	
Geographical object (gazetteer)	Is this geographical object stored in the atlas database?
Theme (attribute)	Are there geographical data on this particular theme?
Date / year	Are there geographical data of this particular date / year?
Map	Is this particular map readily available?
Selecting	
Browsing: random	Is it possible to randomly browse through the maps and select?
Browsing: structured	Is structured browsing possible (narrative / hierarchy)?
Theme	Is it possible to select a theme from a list of contents?
Date / year	Is it possible to select a date / year from a list of contents?
Aggregation level	Can I select a particular data attribute aggregation level?
Geographic extent	Can the geographic extent be defined with a bounding box?
Map scale	Which pre-defined map scales can be selected?
Cartographic visualization	
Generate map from database	Can the user produce his / her own map from the database?
Animations	Is it possible to produce cartographic animations?
Import/export	
Import of other data	Can the user import his / her own data?
Export	Is it possible to export maps / data for use in other applications?
Printing	Is it possible to print a map?

TABLE 3.3B

Digital Atlas Use Scenario linking the activities with the tasks.

		Map use activities	*Reading*			*Analysis*						*Adjustment*											*Construction*
			Look at map title / legend	View the map image	Click on map (symbol)	Measure on the map	Count symbols	Annotate map	Highlight object(s)	Buffer	Compare map displays	Overlay	Switch layer on / off	Change classification	Pan	Change aggregation level	Zoom in	Zoom out	Change map projection	Change map orientation	Change snapshot in time	Change symbology	New mapping method
Use tasks	Elementary	Recognize	●	●									●										
		Identify	●	●	●												●						
		Quantify / estimate	●	●	●		●							●			●						
		Locate		●					●								●	●				●	
	Intermediate	Position		●		●				●			●		●		●					●	
		Define distance		●		●				●					●			●	●			●	
		Encounter spatial links		●				●				●						●				●	
		Explain location		●								●	●										
		Find pattern		●														●				●	
		Quantify spatial anomalies		●		●	●							●		●		●				●	●
		Delimit distribution		●				●							●			●					
		Connect to outside world		●				●							●			●					
	Temporal	Determine changes		●								●	●								●		
		Establish trends		●								●	●								●		
		Detect processes		●								●	●								●		
	Overall	Contemplate context		●											●			●					
		Recapitulate patterns		●							●			●									●
		Discover correlations		●							●	●	●										
		Structure information		●							●												
		Regionalize		●				●			●	●											●
		Obtain insight		●							●			●				●					●

3.8 CONCLUSIONS

In this chapter a characteristic of the personas, an analysis of their needs and the tasks needed to answer those is given (existing of use activities), ending in scenarios. The scenarios postulated above should, in fact, be tested with (representatives of) real end users in the requirement analysis stage of the User Centered Design approach.

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4 THEMATIC AND GEOGRAPHIC CONTENT

KÁROLY KOCSIS, MÁTYÁS MÁRTON (4.1–4.4) AND PETER JORDAN (4.5)

This chapter outlines the prototype of atlases, presents suggestions on compiling the thematic content and selecting the geographical area to be represented as well as choosing the map face, projection and base map, and attaining the inner balance of the major structural atlas elements (maps, illustrations, explanations). This chapter also includes important information on the use of geographical names. For lucidity, it is practical to distinguish three types of atlases. This division is more or less independent of whether it is a traditional (printed), electronic (download) or web atlas (available on the internet), and also of whether the atlas is a general geographic atlas or it presents some thematic content. The three atlas types are as follows:

- world atlases;
- country, national and regional atlases;
- city atlases.

4.1 THEMATIC ISSUES / CHAPTERS

The atlas is a uniform series of individual maps, in which the maps follow a specific order that serves the purpose of the atlas best. For instance, the guiding principle for designing a historical atlas may be the chronological order; or for geographical atlases, the progress from the larger units (Universe, Earth) towards the smaller areas (continents, regions, countries, country districts). As for the web and most digital (electronic) atlases, the order of presented themes has no particular role, because the users can take "adventure tours" among the maps and topics according to their interest.

A *world atlas* portrays the whole Earth: the map pages display the Earth, continents and countries (regions) as well as major districts or provinces. The map scales change according to the size of these areas. The most consequent series of scales is perhaps used in The International Atlas [1982]: maps of the World (1:75 million), oceans (1:48 million), continents (1:24 million), and major land regions (1:12 million). Groups of countries, countries and parts of countries with a physical-geographical background are mapped at 1:6 million, 1:3 million and 1:1 million. The detail of depiction is in harmony with the importance of the represented region.

Finally, the atlas shows the major metropolitan areas and capital cities at 1:300 000.

World atlas maps often follow this order: Old World (Europe, Asia, Africa) and the New World (North, (Central) and South America). Australian maps usually come after Asia or Africa, occasionally after South America. These atlases show the polar regions (Artic, Antarctica) and they may contain city maps too. The Grosser Atlas der Welt [1998] by Bertelsmann is an example of this type.

The Times Atlas of the World [2000] follows a different logic. It opens with a spectacular series of satellite maps of the continents: Australia and the Pacific islands, Asia, Europe, Africa, North and South America, and the Antarctica. After presenting the world on thematic maps, the atlas goes round the Earth "step by step" from the East to West.

The structure of world atlases may depend on the publishing country [Grande Atlante Geografico De Agostini, 1982] or the country of the intended audience [The Macmillan World Atlas, 1996]. Such atlases favor the representation of the publishing country and perhaps its surroundings by depicting them at larger scale and on more detailed maps (e.g., Italy or the USA with Canada, respectively). This solution meets the needs of a wide range of users who want visibility into their nearby regions to understand their cultural and historical connections in a globalized world.

The *geographical atlases for schools* are great examples of the latter type, because they follow the above guidelines of atlas design. For instance, the Dorling Kindersley Student Atlas shows the British Isles, and the National Geographic Student Atlas of the World [2005] describes the USA, Canada and Mexico.

The educational atlases reflect the typical themes of maps and their sequence in atlases. Although the thematic order is mostly set by the national curriculum of the country, the themes logically built on one another cover the following three subjects all over the world:

1. Orientation in space and time;
2. The geography of geospheres (lithosphere, hydrosphere, atmosphere, climate and geographical zones);
3. The geography of societies (population, settlement, economy).

The map content in the interactive versions of these atlases is divided into well-graded map layers, allowing users to create their own map view by gradually adding new layers. Unused map layers can be hidden, making the map clearer and easier to interpret geographical features and phenomena. The maps that are static in print become dynamic by adding interactivity. Animations and photos may advocate the understanding of geographical processes.

Each *national atlas* is a *regional atlas*, but not every regional atlas is a national one [Lehmann 1978]. A national atlas is a series of maps usually accompanied by various illustrations, textual explanations and targeted at citizens and interested foreign readers. The maps show in detail the natural, economic and social conditions of a country. A national atlas follows a logical and balanced structure of maps with relatively uniform cartographic style in defined scales. In addition to portraying the country's natural and socio-economic spatial patterns, national atlases play an important ideological role at home and abroad: they express and strengthen the national identity deeply rooted in their history [Jordan 2002]. Many countries of the world have a more than a thousand-year old history, while others' history goes back just a few years or decades. Therefore, the latter countries are ambitious to develop their identity. Several (mainly the developed) states issued their national atlases in the 20th century, while numerous countries still have not published any. In the latter case, the thematic content of the national atlas may be a traditional "inventory", the structure of which became fixed and generally accepted in the second half of the 20th century [Sališčev 1960]:

1. Introductory maps,
2. Natural environment (geology, geophysics, relief, climate, hydrology, soils, vegetation, wildlife),
3. Population,
4. Economy,
5. Culture,
6. Politics.

When the developed countries prepared the new edition of their national atlases in the past few decades, they did not wish to make a simple inventory; they – depending on the motivation and target audience of the atlas – aspired to present the challenges concerned by the whole society in a modern and captivating way as much as possible. This is due to the recognition that such logically related thematic topics (vertical relations) can be very well complemented by the aspect of time (horizontal relations) and the possibilities of the synthesis approach [Ormeling 1994]. Consequently, the conventional natural, economic and social spheres, which have been presented separately so far, are strongly mixed in order to present the interrelations more clearly (e.g., physical environment, settlements, agriculture; natural and transformed environment, natural resources, economy; land-use, urbanization, regional planning). Increasingly, socially important topics are being added to the traditional topics: everyday life and its milestones, life-style and free time, observation and understanding of the environment, usage of space, labor and standard of living, enterprises and markets [Nationalatlas Bundesrepublik Deutschland, 2000–2006]. The constantly growing thematic information necessitates the publication of national atlases in several volumes; this is exemplified by the volume Natural Environment of the National Atlas of Hungary (NAH 2018).

FIGURE 4.1

Insular map form. Central Europe, Farming and land use [Student Atlas 1998, extract p. 62].

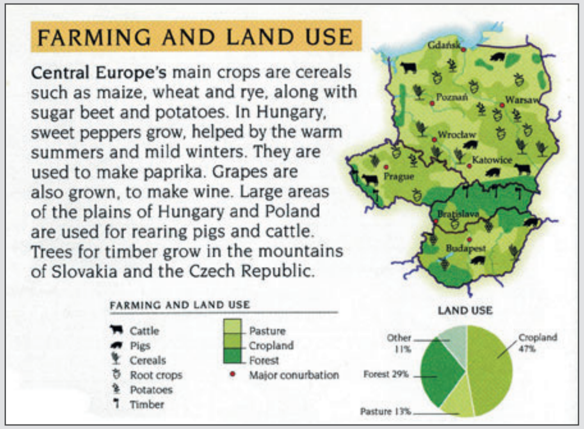


FIGURE 4.2

Partially insular map form. Annual precipitation amount [NAH 2018, extract p. 62].

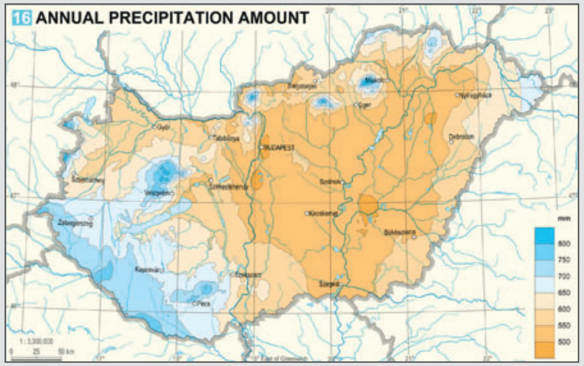
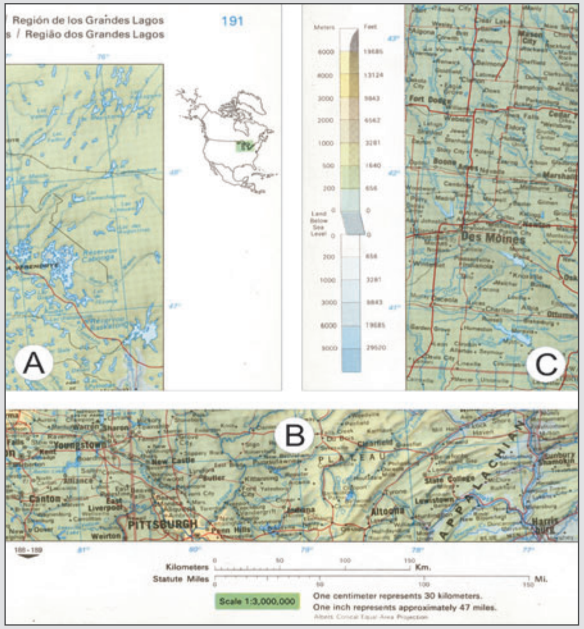


FIGURE 4.3

A: Small scale map indicating the location of the main map; B: Linear scale; C: Scale of layered relief and bathymetry [The International Atlas 1982, extract p. 191].



As there are extremely great differences in the size of countries, some large countries (e.g., USA, Australia, former Soviet Union, Germany) published numerous regional atlases (atlases of districts, partial "national atlases") in the last century. Using another approach, all those atlases that show several countries, whole continents or parts thereof can be considered here [e.g., Kocsis 2005, 2007]. The conventional and modern demands on topics and recommendations for subjects are practically the same as for the national atlases.

In *city atlases*, the maps follow a sequence indicated on the overview map. This index of map pages is usually placed on the first pages of the atlas, which may be followed by larger scale maps of the inner city or popular areas (e.g., zoo and botanical garden, major public parks). The order of themes and subjects cannot be generally described in these hard copy, digital or web atlases or in the products of global service providers (Google Maps, OpenStreetMap).

4.2 GEOGRAPHIC AREA, MAP FACE, PROJECTION, AND TOPOGRAPHIC BASE

Hard copy atlases contain map sheets, which usually bear maps on both pages. The map face is placed on the pages of the map sheet, within the map frame. If a publication is printed, the map sheet has the size of the bound paper; in the case of digital and web atlases, the size is given by the display screen. The difference in these publishing surfaces postulates different concepts of defining the map face: the format is mostly upright in the first case, and mostly landscape-oriented in the second case (naturally, there may be exceptions in both). In the case of hard copy atlases, it may happen that a pair of opposite pages forms the map face: the (half) map area almost extends to the spine. The map face must always be elaborated so that the central meridian of the graticule falls on the center of the map. If the graticule is not indicated, the map must be oriented to north, and if the map is not oriented to north, the symbol of North must be indicated.

The geographical space to be represented may not always fill the map frame. The topic may be shown only within the borders or somewhat extended in narrow bands (Figure 4.1), or the theme may be fully drawn in the map area, but the map content outside the target area is limited to the major elements only (Figure 4.2).

World atlases may include such types of maps [e.g., Student Atlas 1998], though it is far from typical. The Earth may be covered by maps with uniform scale based on an almost regular sheet system [The Macmillan Atlas 1996]. However, atlases normally present the Earth first, followed by continent maps without a regular sheet system and with less consistent scales [The Times Atlas of the World 2000].

Atlas maps often have an overview map at the page margin indicating the location of the map; this helps identifying the represented area in the world (Figure 4.3a). Orientation in the geographical space is supported by a linear scale (Figure 4.3b) and by the color scale of altitude (hypsometry) of altitude and depth layers (Figure 4.3c), if necessary [The International Atlas, 1982]. The consistent placement and display of these tools in one of the corners of the screen is also useful in digital or web atlases.

The maps on the computer screen are usually generated from the complete map of continents and not from predefined map extracts. Thus, island-like representations of maps or individual map sheets are rarely displayed. We can search by navigating on the map (zooming, scrolling), or by entering a place name of the interested area in the search engine, after which the closer environment of the object appears in the center of the screen.

Publications of national atlas type concentrate on the area of a country or a district. These products extensively use maps in island-like or partially island-like form. However, the presentation of maps of continents or the world may also be important to demonstrate the relationship of the target area to neighboring countries or the rest of the world.

Publications of city atlas type limit their interest to the area of a settlement. In traditional cartography, a map covering the whole area of the place is made first. (Sometimes, the map is completed with a larger scale inset map of the city center, a thematic sketch showing the public transportation network, etc.) In the next step, the city map is divided into map sheets, which form pairs of opposite pages like in an atlas. There are overlapping bands (they may be marked) between the sheets so that the users can follow the line work (e.g., the continuation of a street). These map sheets make up the series of atlas maps (Figure 4.4).

It is common that the screen images of digital and web atlases of cities are generated from one coherent map, just like in the case of continent maps of world atlases. We can find a place by scrolling or using the search function entering the name of a street, sight, office or any POI's, and the wanted object with its environment appears in the middle of the screen. The Google Earth images are excellent examples of viewing the area of a town (Figure 4.5).

Selecting the right projection is controlled by the purpose of the map and the users' interest. Here are a few examples to illustrate the projections for purpose:

- Conformal projections have to be used in air navigational or nautical publications, because conformity is a basic requirement.
- If we want to compare the size of areas, equal-area projections have to be used.
- For showing the time zones, Mercator's projection is ideal, because the meridians

FIGURE 4.4

Overview map [Riesenplan Wien 2016, extract].

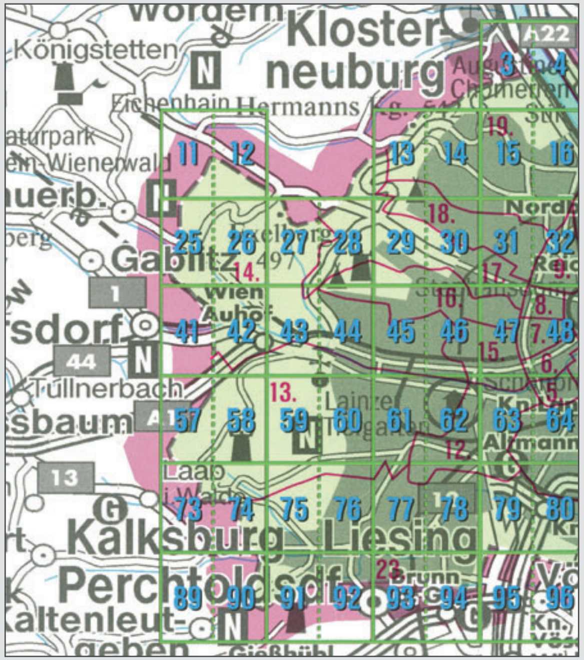


FIGURE 4.5

Extract of Budapest map with POI's. Széchenyi Chain Bridge over the Danube River [Google Earth 2019].

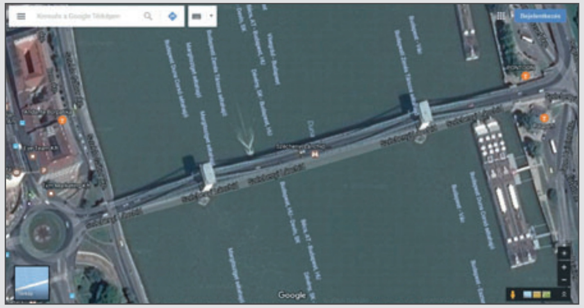
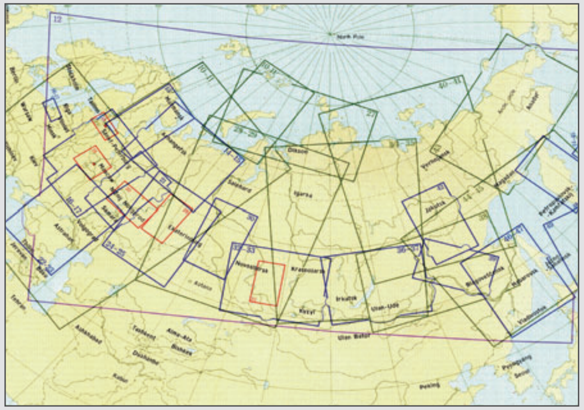


FIGURE 4.6

Time zones [National Geographic Student Atlas of the World 2005, extract 52–53].

FIGURE 4.7

Overview map of Russian sheets (indicates the use of a phylactic and equal-area projections). This is a good example of emphasizing the publishing country in a world atlas. [The World Atlas 1999].



are straight and parallel lines, and the zones can be easily noticed (Figure 4.6).

Of course, we have to use different projections for the maps in a *world atlas*, because they portray the world, continents, countries, regions and, sometimes, specific areas. In general, the editors use cylindrical projections to illustrate the equatorial areas (e.g., Mercator's projection), conical projections for the lands between the tropics and the polar circles (e.g., Lambert Conformal Conic Projection or Albers Conical Equal-Area Projection), and azimuthal projections (e.g., Lambert Azimuthal Equal-Area Projection) for depicting the polar regions. It is advisable to use aphylactic projections (which preserve the shapes well) for the maps of continents and larger regions (Figure 4.7) [The World Atlas 1999]. Mercator's projection is often used in atlases to portray the continents [The Macmillan World Atlas 1996] when the whole Earth is presented on a system of sheets (Figure 4.8). This projection has the benefit that the lines of latitude are straight. It easily answers the general question which geographical object lies further north than another object. The disadvantage of Mercator's projection is that the areas away from the Equator are increasingly exaggerated. Therefore, tangent or secant azimuthal projections are applied for the polar areas.

The "error" of considerable area distortions in digital or web atlases can be easily eliminated by programming the visualization: The local scale of the displayed map (which may be continuously indicated by the linear scale) should not change by scrolling. The readability of the atlas can be guaranteed by the changing degree of generalization from zone to zone.

For the publications of *national and regional atlas types*, the applied projection – and the scale as well – is essentially determined by the size of the country and partly the purpose (that is the themes) of the atlas. For the publications of *city atlas type*, aphylactic or equal-area projections may be selected if there is no any special users' request.

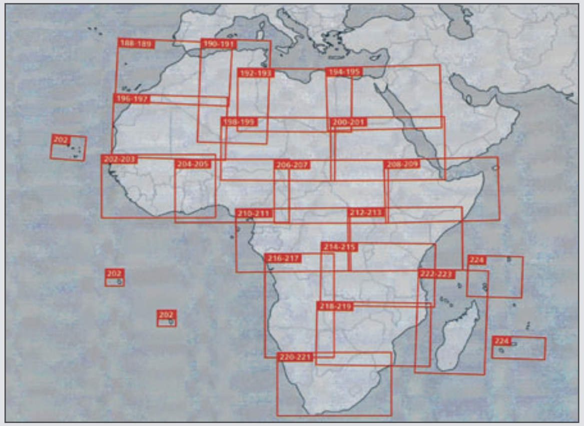
The choice of atlas base maps is determined by the purpose and subject of the atlas. *World atlases* – and occasionally *national and regional atlases* – and general geographical atlases of high quality mostly use base maps that show the relief, which is sometimes combined with hill shading; having an administrative map in the background is a cheaper and widely used solution: the administrative units are tinted and occasionally hill shading is added. The tinting of areas (choropleth maps) in thematic atlases may be disturbing if it does not support the understanding of the subject. Therefore, base maps may only show the geographical grid, hydrography and/or the administrative division; these elements form the skeleton of the map. If the names of settlements, waters, hills or regions are essentially necessary for understanding the theme, they are commonly printed in moderate grey color.

An increasing number of national and regional atlases were printed in the past decades which included supplementary (removable) base maps; these maps were printed on transparent foils showing the administrative division and geographical (mostly settlement) names. The foils superbly complete the thematic maps in the atlas, because when they are placed over the map they support localizing and interpreting the thematic content [Nationalatlas Bundesrepublik Deutschland 2000–2006].

City atlases commonly contain maps with colored surfaces. Generally, colors are applied to distinguish the built-up areas, woods and parks from the undeveloped areas; the built-up areas are divided into residential and industrial zones. Sometimes each district is tinted in different colors, and the residential and industrial areas are differentiated by color gradation. In recent times, processed aerial orthophotos and satellite images serve for background maps for city atlases.

Most recently, worldwide services like Google Maps use series of satellite images with various resolution as background for their map. The displayed picture is generated from a series of image of different resolutions depending on the enlargement. At the same time, relatively simple area-colored maps can be attained and it is possible to get an image of the street to a given address. The user can choose between the versions by a simple click.

FIGURE 4.8
Overview map of the African sheets. Systematic sheet lines of pairs of opposite map pages [The Macmillan World Atlas 1996].



4.3 EXPLANATORY TEXTS COMPLETING THE MAPS

The presentation of a map with texts and pictures on the pages of hard copy atlases became a general method by today. The better understanding of the purpose of atlases is supported by texts explaining the presented themes; tables and graphs complete the information that can be read from the map; photos and illustrations evoke the geographical space. Their proportion can be very different in national atlases. Since the atlas is traditionally a curated collection of maps after all, the proportion of maps, illustrations (tables, diagrams, photos) and explanatory texts should be around 50%, 25% and 25%, respectively [Nationalatlas Bundesrepublik Deutschland 2000–2006, Tschaschel 2007]. However, the limited print format of national or other atlases is a major barrier to the use of these additions.

Digital and web atlases allow for more possibilities (see Chapter 6). The texts, pictures and explanations can be hidden to avoid disturbing reading the map. However, it is easy to make them visible and readable in bubbles or pop-up windows.

As an example, a topologically correct hydrographic map in combination with a good database management system allows us to display various attributes assigned to river sections by moving the mouse over a watercourse (average width of the channel, mean water discharge, dissolved minerals and their amount; landscape at the river section, related geological attractions, graphical sketch of natural exposures, etc.). This example demonstrates that we have almost unlimited opportunities.

In terms of quality, the atlas will be a good publication if the editors always keep an eye on the purpose and the users of the atlas, consciously choose the visualization modes, and ensure the readability of maps. There are limits as well, and crossing the barriers will reduce the value of the atlas. The balance of all components is an essential condition.

FIGURE 4.9

Bar charts. Age distribution of employees [MNA 1989, extract p. 164].

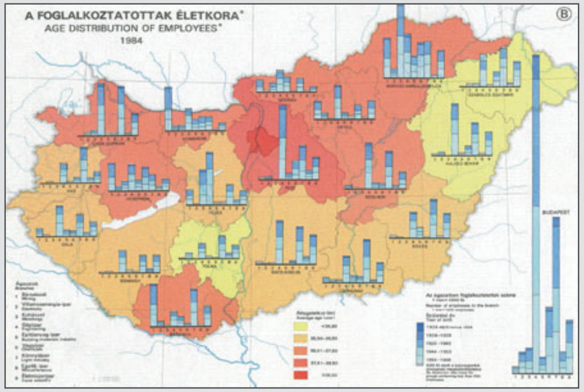
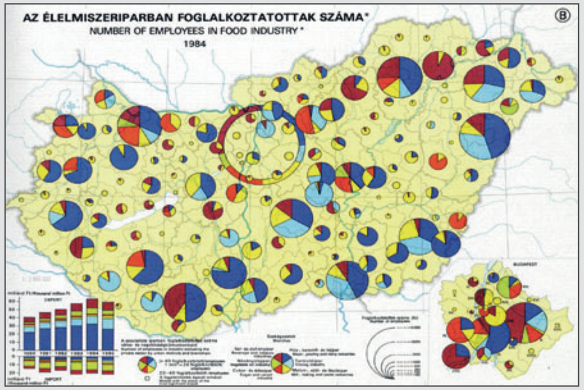


FIGURE 4.10

Pie charts with the inset map for the capital. Number of employees in food industry [MNA 1989, extract p. 193].



4.4 SOME PRACTICAL QUESTIONS OF THEMATIC REPRESENTATION

In classical cartography, the place names referring to bordered areas (e.g., administrative units) and to points (e.g., settlements) are mostly written parallel to the lines of latitude. The map symbols are considered special labels (e.g., the symbol of an anchor is an "abbreviation" of "harbor"), which are placed at right angles to the parallels.

Formerly, some cartographic enterprises handled the diagrams, including bar graphs as symbols, so the base of the bar graphs was parallel to the latitudes. Similarly, as the sectors of pie charts start at "12 hours", they set the direction of 12 hours at right angles to the latitudes, and the pie charts were rotated accordingly.

Today, both the diagrams and pie charts are placed parallel to the map frame (Figure 4.9 and 4.10). The applied computer programs advocate this solution. Accordingly, it is practical to print the graticule in a most moderate color (e.g., in light grey).

When using diagrams, it is worth adding an inset map of the area (e.g., capital city) where the data density is well above the average (Figure 4.10).
If the choropleth map is patterned and not shaded to express the value of the visualized information, the pattern must not be rotated because it may lead to misunderstanding (Figure 4.11).

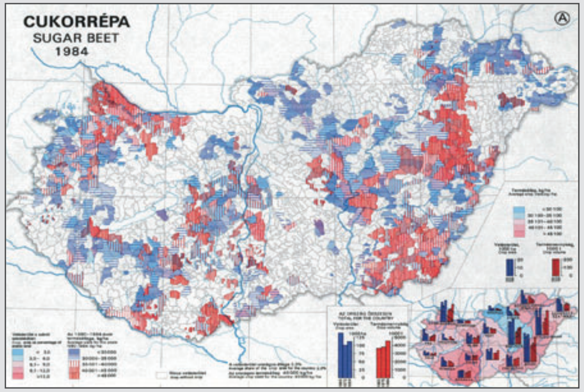
The class boundaries of data sets can be determined by subdividing the values into equal units, arithmetic or geometric progression, and they may contain logarithmic elements. It is convenient if the number of elements is even, because it does not suggest to the reader that the middle element of the legend represents the average.

Dot density maps should not present multiple elements. They can only be used if the distribution of the phenomena does not overlap. Otherwise, such maps should not be used to illustrate the spread of more than two objects.

In general, the thematic representation of natural or nature-related phenomena requires a hydrographic background which might be completed with contour lines. Maps that present social-economic aspects mostly need a base map with administrative divisions and might be completed with hydrography. The coloring of these maps must always be moderate.

FIGURE 4.11

Choropleth with hachure pattern (main map). Sugar beet [MNA 1989, extract p. 225].



4.5 FUNCTIONS AND PRINCIPLES OF GEOGRAPHICAL NAMES

Place names are frequently regarded rather as decorative elements on maps and for this very reason treated by cartographers not always with utmost care. This subchapter will demonstrate that they are essential map elements and should not be neglected.
It will deal with the following questions: What are the basic functions of place names on maps in general and more specifically in atlases? Which are the general principles of place names rendering in atlases? What are the main differences in this respect by kinds or types of atlases?

Basic functions of place names on maps

Place names facilitate map use. If the name to be found on the map (and accordingly the place marked by this name) is not known to the reader, the place name facilitates map use. Identification of a place indicated by a cartographic symbol becomes much easier, when it is in addition explained by a place name. If a reader not acquainted with the topography shown on the map would try to identify an unknown place without a place name, he/she would have to compare the map in use with other maps or cartographic source materials that do have a place name for the place in question or compare the geographical coordinates of the place in question with other sources. Thus, map interpretation would become a complicated and tiresome task.

This results in the recommendation to assign names to an optimum of map elements. If, for graphical reasons, it is impossible to attribute names to each individual feature, at least major and more important features as well as features with exceptional thematic characteristics are to be named. It should be possible to address all significant issues and places of a map by mentioning their names.

Place names enable searching for places. Place names indices are customary components of printed atlases. So are name search functions with interactive electronic atlases. They enable the reader to search for a place on the map via the place name in the index or by inserting a place name into the search function. Without place names this would not be possible.

Place names tell more about the character of a geographical feature. While the cartographic symbol marks just a feature category like mountains, passes, lakes, glaciers, rivers, forests, populated places, etc., the place name may tell more about the specifics of a certain geographical feature – by a transparent generic element of a composed place name like *Coastal Range*, where the generic element *Range* specifies the feature within the wider category of mountains, but also by a transparent specific element such as *new/old, great/little, upper/lower, warm/cold*, also *black/ white* with running waters, adjectives indicating directions *(north/south)*, adjectives derived from country names *(Uherské Hradiště*, where *Uherské* means *'Hungarian'*), region names *(Bohemian Forest [Böhmerwald], Thuringian Forest [Thüringer Wald], Câmpulung Moldovenesc* meaning *'Moldavian'), ethnonyms (Frankfurt am Main, i.e., 'Ford of the Frankonians'; Kroatisch Minihof, Kroatisch* meaning *'Croatian'; Valašské Meziříči, Valašské* meaning *'Valachian'*) and anthroponyms *(Port Elizabeth, Saint Petersburg [Sankt Peterburg]).* Thus, place names hint not only at the language (and herewith culture) of a certain place, they can tell also something about subcategory, function and history of a feature or place.

Principles of place names rendering in atlases

Before highlighting principles, it is necessary to clarify four concepts important in this context: *endonym* and *exonym* as well as *transliteration* and *transcription*.

A distinction of place names into endonyms and exonyms results, if place names are regarded under the aspect of the spatial relation between the (human) community using a name and the geographical feature bearing this name. The name used by locals is the endonym (the name 'from within'). A name used by non-locals and differing from the endonym is an exonym (the name 'from the outside'). Both categories, however, refer to the geographical feature in its entirety. Thus, the German name *Donau* for the Danube is an endonym in the section of the Danube populated by German-speaking communities, while it assumes exonym status along other river sections, but remains a name for the entire course of the river.

While by transliteration every single letter of a donor alphabet is converted into a single letter of a receiver alphabet (including the use of diacritics and special letters) and is language-neutral, by transcription this principle is abandoned in favor of an alphabet corresponding to a certain receiver language. Transliteration results in a lettering that is highly reversible, but allows only experts exact pronunciation, while transcription results in a lettering that is not reversible, but allows the speakers of the receiver language to easily and closely approximate the pronunciation in the donor language.

General principles:

- Principle 1: A certain mode of rendering place names (e.g., only endonyms or a combination with exonyms, transliteration or phonetical transcription) has to be consistently applied within a printed atlas, i.e., throughout all the maps and texts of an atlas. It would be confusing for the reader to find changing modes.
- Principle 2: With electronic atlases for interactive use enabling to switch between languages (of map titles, legends and texts) and to exchange names, the rendering of names has to be adapted to the language chosen for map titles, legends and texts. The linguistic configuration of a screen image is to be consistent in every respect.
- Principle 3: The spelling of standardized endonyms needs to be derived from reliable sources. Especially names of settlements and administrative units have standardized and officially fixed spellings, which are to be respected in every detail. Thus, additions to a name with an official status, such as *Niagara-on-the-Lake*, must not be disregarded; abbreviations (like *S.* for *San, 'Saint'*) should be avoided, since they are not always transparent for speakers of another language. But also endonyms for features of other categories (like water bodies our mountains) have frequently been standardized and are to be spelled accordingly. Reliable sources for settlement names and names of administrative units are official national names gazetteers and data files, for names of other feature categories official topographical maps.
- Principle 4: When the donor language of a name is written in the script of the atlas, endoyms are to reflect all special letters and diacritics of the donor alphabet. A German atlas, e.g., needs to reflect all the diacritics of Polish or Czech (Figure 4.12), when it uses endonyms in these languages like *Łódź* or *České Budějovice*. It is to be respected that, e.g., in Slavonic languages, diacritics can be distinguishing between meanings. A case in point is *sto* and *što* in Croatian, the first meaning *'hundred'*, the second *'what'*.
- Principle 5: Names originally written in other scripts are to be converted into the script of the atlas using approved conversion systems, whenever possible according to systems also widely used by the donor language. This departs from the assumption that not many readers are capable of deciphering foreign scripts. An extremely helpful reference in this respect is the website of the UNGEGN Working Group on Romanization Systems (UNGEGN-WGRS) documenting UN-approved systems as well as providing links to other conversion systems.
- Principle 6: Standardized names in official minority languages are to be represented whenever map scale and space on the map field admit this. Equality in rank of names in majority and minority languages is most suitably indicated by a slash between the names written by letters of the same type and size (Figure 4.13).

FIGURE 4.12

Diacritics of the Polish and Czech alphabets.

Polish:

Ćć, Ęę, Łł, Ńń, Óó, Śś, Źź, Żż

Czech:

Áá, Čč, Ďď, Éé, Ěě, Íí, Ňň, Óó, Řř, Šš, Ťť, Úú, Ůů, Ýý, Žž

FIGURE 4.13

Rendering of features with more than one official name in Gagauzia and other parts of Moldova in an atlas for international use [Jordan and Kocsis et al. 2006/2007, extract].

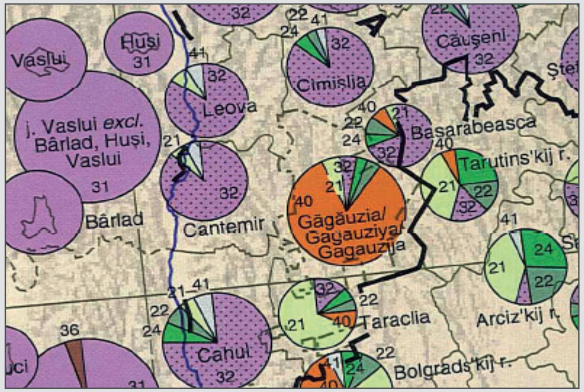


FIGURE 4.14

Rendering of geographical names in an atlas for international use. The various endonyms for the Danube are outlined in Red [Knappe and Ratčina et al. 2004, extract].

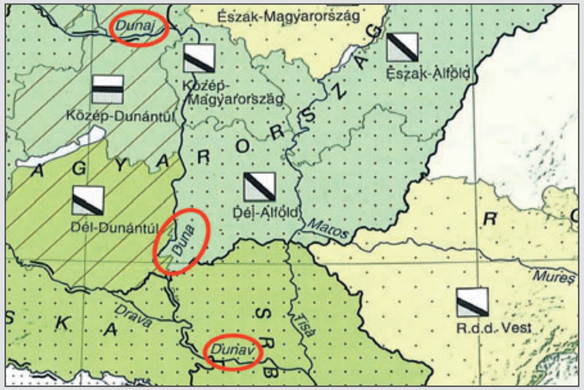


FIGURE 4.15

Endonymic rendering of seas in an atlas for international use – the example of the Black Sea [Jordan and Schappelwein et al. 1999, extract].

The main divide by types of atlases

It is not necessary to differentiate between all the various atlas types (national atlases, thematic atlases, city atlases, school atlases etc.), but sufficient to focus on the main divide, i.e., the divide between scientific atlases and atlases addressing an international, multilingual audience on the one hand and popular atlases and atlases addressing prevailingly a monolingual, domestic audience on the other.

Scientific atlases and atlases addressing an international, multilingual audience are characterized by using two or more editorial languages (in titles, legends and texts) or the single use of a global trade language as a means of reaching a multilingual audience.

- Principle 1: For all kinds of geographical features under a single sovereignty standardized endonyms or English exonyms (as substitutes for exonyms in a multitude of languages) are to be used.
- Principle 2: For features on land exceeding a single sovereignty (e.g., rivers, mountain ranges) three methods are at disposal: (1) to display all endonyms of the communities involved (each placed on the map in its relevant position – e.g., for the *Danube Donau, Dunaj, Duna, Dunav, Dunărea, Dunav, Dunaj* in this sequence, Figure 4.14); (2) to display all names in the editorial languages (e.g., *Danube* and *Donau*, if English and German are the editorial languages used also for map titles and legends); (3) to display the name in the main editorial language (e.g., *Danube*, if English is the editorial language used also for map titles and legends). The first approach has the disadvantage not to represent a common name for the feature. The second and third show this common name, but provide no information on local names. However, with larger map scales this disadvantage can be compensated by adding the endonyms in brackets.
- Principle 3: For maritime features exceeding national sovereignty (like oceans, seas) basically also three methods are available: (1) to display all names used by riparian communities or at least countries shown on the map face; (2) to display all names in the editorial languages; (3) to display the name in the main editorial language. The use of all names applied by riparian communities or in riparian countries is, however, only practicable, if the number of riparian communities shown on the map face is small (four at the maximum). Already with the Baltic Sea or the Black Sea method 1 becomes problematic (Figure 4.15), not to speak of the Mediterranean or the oceans.

- Principle 4: Names written in other scripts are to be transliterated into the script of the atlas, not transcribed phonetically. This is, firstly, to offer a 'neutral' conversion to speakers of different languages – not a conversion that favors only one of the receiver languages –, and secondly, to enable re-conversion – often important for scientists and librarians. The United Nations recommend transliteration systems for many non-Roman alphabets (see UNGEGN-WGRS). Languages using ideographic scripts (like Kanji, the common script of the sinosphere for Chinese, Korean or Japanese), however, offer for the written form of the spoken name and for international use near to English-phonetic transcriptions – the Japanese the so-called Modified Hepburn System, the Chinese the Pinyin conversion system (Figure 4.16). It makes sense to accept these offers, since they are widely used in the public sphere and Latin-script publications of these countries as well as on site (signposts in front of settlements, street names, traffic signage, Figure 4.17). The UN recommends these systems for international use (see UNGEGN-WGRS). Thus, the situation is not that clear-cut and simple. Taking this into account, the UN have abandoned their formerly strictly observed principle to accept and recommend only transliterations also in other cases. In 2012, e.g., they have approved conversions from the Bulgarian and Ukrainian Cyrillic alphabets, which are in fact English-phonetic transcriptions.

Popular atlases and atlases addressing prevailingly a monolingual, domestic audience are characterized by using only one, i.e., the domestic language and perhaps a second language, but second-rank (e.g., in smaller letters) or just for selected elements (e.g., titles, not legends and texts). Typical examples for this category are school atlases (Figure 4.18), world atlases for libraries of educated people (but not for scientists).

- Principle 1: Well-known exonyms in the (main) language of the atlas are to be used for features of major importance, certainly countries, but also country capitals, other major cities, physical-geographical features, especially when they extend beyond a single sovereignty and historical features (in a history atlas) lacking correspondence with a current feature (i.e., having no current endonym). Major arguments for this practice are that exonyms in the domestic language are easy to be pronounced and learned, are easy to be declined and transformed into adjective forms, are part of the cultural and educational heritage of a language and society – closely related to historical knowledge and other educational areas [Back 2002, Jordan 2000]. The practice bears, however, the danger of being misused for political purposes and of outlining historical situations that may be disliked by the donor community. It has always to be

FIGURE 4.16

The UN-approved Pinyin alphabet for Mandarin Chinese with vowel variants for other related languages [UNGEGN-WGRS].

The UN-approved Pinyin alphabet for Mandarin Chinese (used in/for China, Taiwan, Singapore as well as for the minority languages Mongolian, Tibetan and Uighur in China):

b p m f d t n l g k h
j q x zh ch sh r z c s
ā ē ī ō ū ǖ Ā Ē Ī Ō Ū Ǖ
á é í ó ú ǘ Á É Í Ó Ú Ǘ
ǎ ě ǐ ǒ ǔ ǚ Ǎ Ě Ǐ Ǒ Ǔ Ǚ
à è ì ò ù ǜ À È Ì Ò Ù Ǜ
a e i o u ü A E I O U Ü

FIGURE 4.17

Announcement of the next station in two scripts in the Narita Express, Japan [Photo: Peter Jordan 2013].

FIGURE 4.18

Use of exonyms and phonetic transcriptions in a school atlas for a German-speaking audience [Hölzel-Weltatlas für die Oberstufe 1995].

taken into consideration that the use of exonyms is politically sensitive, since exonyms are frequently interpreted as expressions of territorial claims or political nostalgia [Jordan 2000]. For international waters, places on Antarctica or historical features lacking a (modern) endonym as a counterpart, however, the editor has no other choice than to use an exonym. With maps portraying historical situations, names used for this period by historical literature in the editorial language are certainly the most appropriate.

- Principle 2: At least in larger map scales, populated places should additionally be named by the endonym in brackets. It is appropriate to hint users at the existence of another, the local name, with which they may be confronted when travelling or consuming the media.
- Principle 3: With endonyms all the general principles mentioned apply.
- Principle 4: Endonyms originally written in another script must preferably be transcribed phonetically into the orthography of the atlas language. This is to ensure that the domestic reader arrives at a pronunciation at least near to the original, while the correct reading of diacritics may be too demanding.

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5 DATA MANAGEMENT

TIM TRAINOR

Data comprises the basic ingredients for the content and design of an atlas regardless of the form it takes. Any data or information is considered for this chapter. This includes data that is visual as well as data that may be required to create information as part of the content of an atlas. Examples of types of data that are useful to modern atlases include geospatial, text, images, remotely sensed data, and animation.

Most atlases tend to be at medium and small scale. The granularity of the data will change based on the scale of the atlas. It is important to acquire and use appropriate data for the chosen scale. One basic tenet of cartography is that a map is designed for the final output device. In modern cartography, this tenet is a challenge as the final output device is not always known. Decisions made about the data need to support the design of the maps. This chapter details the differences between spatial data types. Then a discussion of attribute data follows. The chapter closes with a detailed account of the importance of metadata when developing an atlas.

5.1 CARTOGRAPHIC DATABASES

Data is often stored in a way that optimizes collection and update activities in a database. When using a database for cartographic production it is beneficial to reorganize and classify the data to make it ready for mapping. To make the mapping process easier, cartographic databases are populated potentially with data from a variety of data sources such as other spatial databases. Once in the cartographic database, the various data types are likely manipulated from their original state.

The cartographic database predominantly stores features such as transportation (roads, railroads) hydrography (oceans, rivers, lakes), physical features (landforms, elevation) and cultural features (urban areas, buildings, airports). This data is generalized through one of several operations such as aggregating or chaining or dissolving. These processes optimize the data for mapping throughput and occur only once in the cartographic database negating the need for redundant processing with each map made. The data manipulations and

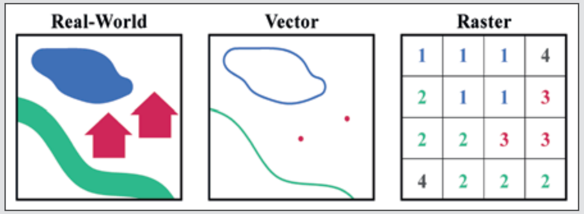
FIGURE 5.1

Data in a spatial database and a cartographic database.

database design differences are used to create very diverse and potentially complex maps. When producing a significant number of maps on a schedule, performance is paramount and a cartographic database supports higher performance than would be experienced in manipulating data from a common spatial database that supports different purposes. Figure 5.1 shows how data is stored in different ways in a spatial database and a cartographic database. In a spatial database the data are stored as a point, line or polygon. In the cartographic database these points, lines, and polygons have been aggregated, chained, or dissolved to make recognizable features.

FIGURE 5.2

Data in the real world, in vector, and in raster format.



5.2 SPATIAL DATA

Spatial data can be classified into two different types of data, vector data and raster data (Figure 5.2). Vector data is stored as series of x,y coordinates. The vector data model is best suited for displaying discrete data that have definable boundaries. These features are represented in three ways: points, lines, and polygons. Points are defined by a set of x,y coordinates, and are often shown as a marker symbol depicting objects such as the centroid of a building. Points are sometimes referred to as nodes. Lines, also known as arcs, segments, or edges, possess a length equal to the distance between their start and end points. An example of a linear feature would be a road that has a defined beginning and end. Polygons are represented as two-dimensional features and have perimeter and area. Polygons also are known as area or faces. Polygons have the same start and end point and their shape is defined by numerous nodes along the perimeter. The shape of a lake is an example of a polygon feature. The use of vector data is ideal when topological relationships must be maintained (more about topology later). Vector data can readily be linked to attribute or non-spatial data (described below).

The raster data model uses a grid or matrix to display values. Each cell, or pixel, in the grid is a uniform size and represents one data value that is stored in a table. The size of the grid corresponds to the level of detail desired for the geographical feature. This model is suitable for displaying continuous data that vary without interruption across a geographical space. Values may be measured directly or derived from nearby locations. Temperature and elevation are examples of continuous phenomena. Satellite and areal imagery, and digital elevation models (DEMs) are common examples of raster data used in digital mapping.

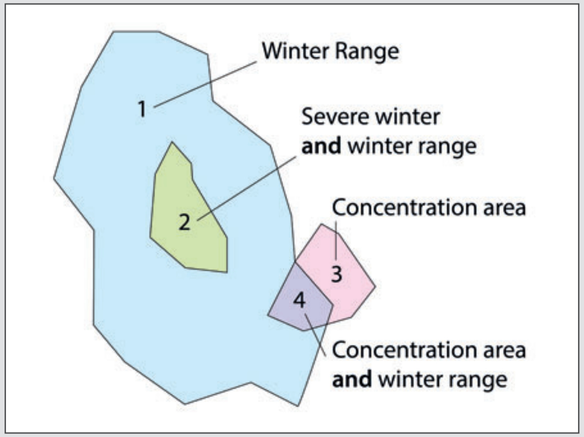
5.3 TOPOLOGY

Topology is a data structure based on shared geometry of points, lines, and polygons. There are many benefits to using a topological data structure over a non-topological structure in map creation. Simply, topology simplifies data storage and assures correct relationship among the various data and data types. Topology is maintained through database rules. Topology uses less storage space since boundaries that are shared between adjacent polygons are stored only once. Also, it helps to prevent and correct digitizing errors such as undershooting and overshooting, and provides more effective analysis of adjacency and connectivity, such as allowing for automated map scaling through which scale is determined by point feature proximity. With this automated scaling, points are aware of their relationships and distances from surrounding points [Theobald 2001].

The advantages of a topological database are numerous, but there are also advantages to non-topological data structures. Chains in a non-topological feature are stored in a sequential manner, whereas with topology this is not a requirement. Therefore, non-topological graphics typically load more quickly. Also, it can be easier to analyze data in a non-topological environment when many attributes exist at the same location. In this situation, there can be many overlapping non-topological layers, each with its own data. Topology is more difficult to manipulate since there is only one layer with multiple attributes for that position. For example, for an unambiguous analysis of different elk ranges in an elk habitat, each range can be displayed as a non-topological, overlapping polygon.

Figure 5.3 shows the attribute tables for (a) non-topological and (b) topological data structures:
(a) The attribute table for non-topological representation of Figure 5.3. Each polygon has one attribute and overlapping relationships are not indicated.
(b) The attribute table for the topological representation of Figure 5.3. Note that because each polygon can have any of the three attributes (winter, severe, concentration area), each polygon has multiple attributes.

FIGURE 5.3
Non-topological and topological data structure [after Theobald 2001].



(a) Attribute table for non-topological data structures.

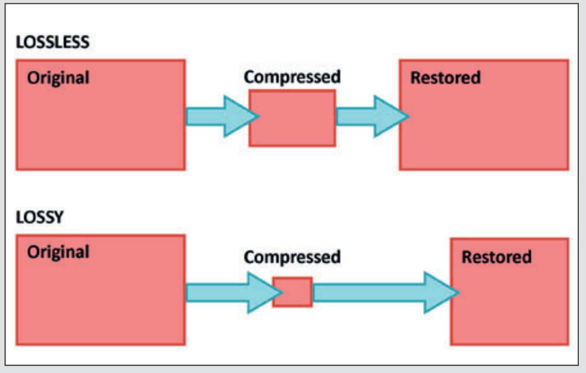
Polygon	Habitat
1	Winter
2	Severe
3	Concentration

(b) Attribute table for topological data structures.

Polygon	Winter	Severe	Concentration
1	yes	no	no
2	yes	yes	no
3	no	no	yes
4	yes	no	no

FIGURE 5.4

Lossy compression reduces the quality of the atlas image [Computer Language Co. Inc. 1998].



5.4 DATA COMPRESSION

Both raster and vector data are appropriate to use in an atlas, but the amount of computer space that they occupy can vary greatly. Raster images are comprised of many grid cells, with each cell having its own associated value. Because of this format, raster, in its native form, occupies more computer space than vector data. Despite their size, raster data processes more quickly than vector data and may be more beneficial to use when dealing with a large number of datasets that necessitates computational speed [Hohl 1997].

Data compression is a method for storing raster data more effectively. Raster data compression reduces redundancy in the data, allowing the file to occupy less computer space. The amount of file size reduction depends on the image type, with bi-level images decreasing to approximately 10 percent of the original file size after standard compression, and pseudo color and grayscale images decreasing to about 30 percent of their initial size. When the choice is made to compress the data (Figure 5.4), it is important to remember that certain types of compression, such as with GIF and JPEG compression, will lessen the quality and appearance of the atlas image [Hohl 1997].

If attributes were assigned to pixels in a raster image just as attributes are assigned to vector data features, then the raster image would increase by more than twice its original size and data compression would be of no benefit. The file size of vector data is not as sensitive to increases in attributed features because vectors require only one attribute record for each line feature. A raster image requires one record per pixel in the line image. For example, for a vector line feature, it would be simple to define the line as a stream and to assign attributes such as stream type and stream name. This is much more efficient than assigning these same attributes to every pixel that makes up the stream [Hohl 1997].

5.5 DATA SOURCES

The availability of geographic data varies greatly from one country to another [Crompvoets and Bregt 2007]. Digital geographic data are sometimes provided via storage mediums such as CD or DVD, but, increasingly, dissemination is provided over the Internet. World Wide Web sites sometimes take the form of geoportals, which are access points to geographic data [Tait 2005]. These portals, or clearinghouses, have been developed by government agencies, universities, private companies, and individuals [Goodchild et al. 2007]. Common datasets available are administrative boundaries, land use/land cover, elevation, geologic data, population/demographics, economic data, populated places, roads/transportation networks, hydrography, and imagery. An important element of geoportals is the capability to search for data based on vintage, location, and thematic attributes [Maguire and Longley 2005]. Searches are made possible by metadata which provide information about geographic data, including what the data are about, when and how the data were compiled, who produced the data, coordinate system information, etc. [Green and Bossomaier 2002].

Academic institutions are popular sources of geographic data in the United States, often specializing in providing data for the state in which they are located. These services are frequently performed by college and university libraries. Commercial companies supply aerial and satellite imagery, navigation software and location-based services, and add value to other private or public geographic data by combining datasets of interest to users [National Research Council 2004].

In the United States, there are several federal government agencies that serve geographic data over the Internet at no cost to users. Some example Web sites include:

- National Atlas of the United States® [https://en.wikipedia.org/wiki/National_Atlas_of_the_United_States],
- USGS Geodata [https://www.usgs.gov/centers/gggsc/science],
- National Transportation Atlas Database [https://www.bts.gov/browse-statistical-products-and-data],
- The National Map [https://nationalmap.gov], U.S. Census Bureau [https://www.census.gov].

Most U.S. State governments have clearinghouses for geographic data, including:

- Minnesota Geographic Data Clearinghouse [https://www.mngeo.state.mn.us/],
- MassGIS–Massachusetts Geographic Information System [http://www.mass.gov/mgis],
- State of Alaska Open Data Geoportal [https://gis.data.alaska.gov/].

At an international level, organizations such as the United Nations are sources of valuable spatial and attribute information. For example, the Second Administrative Level Boundary project continuously collects freely available information about lower levels of geographic areas for each country that contributes which supports global, regional, and national atlas efforts:

- Second Administrative Level Boundaries [https://www.unsalb.org/].

Atlas development will be easier in an electronic atlas application if the data are stored in the fewest number of data formats (vector versus raster) and file types (Shapefile, KML, Oracle database files, etc). Spatial data conversion can take multiple forms: intra-format conversion includes raster to raster and vector to vector, while inter-format conversion includes raster to vector and vector to raster [Adam and Gangopadhyay 1997]. Many commercial off-the-shelf GIS software can perform conversions while other vendors provide tools to convert and reformat data. These conversions may be desirable for the sake of data consistency, they could be necessary to perform certain types of spattial data calculations or manipulations, or an electronic atlas may be designed to only display one format of data (e.g., raster), which would necessitate converting data of the other format (e.g., vector) to the required type.

5.6 DATA QUALITY

Data quality can be determined in terms of accuracy and precision. Accuracy refers to how close a measurement is to the "truth" or some value accepted as true. Precision is the degree to which measurements cluster together, i.e., how repeatable the values are [Maune et al. 2001]. On small and medium scale maps, relative accuracy is of greater concern than positional accuracy. But problems with spatial data can impact an atlas if various source datasets are referenced to different datum, coordinate systems and/or map projections.

Related to, but distinct from, accuracy is the concept of precision. Precision may also refer to the level of detail of measurements, represented in data as the number of significant digits or the number of decimal places [Coates 1998]. In addition, care must be taken when storing, manipulating, and managing data in an electronic environment so that software systems do not introduce spurious precision, which can occur when a higher degree of exactness is indicated than is warranted by the data [McGrew and Monroe 2000]. It is imperative that appropriate data types are used to store numeric data in a database. For example, a y-coordinate with precision to the nearest degree, e.g., 40° N latitude, could be stored as 40.000° N latitude in a database, introducing spurious precision. Also, if a different coordinate system is used for storing the data, then GIS or database software could convert 40° N latitude to 500 001.782 m, for example, erroneously implying a greater level of precision and certainty than the original source of the data. It is important to note that these properties (accuracy and precision) may or may not coincide.

5.7 DATA RESOLUTION

National mapping agencies often compile geographic data at multiple resolutions to produce cartographic products at multiple scales [Brewer and Buttenfield 2010]. In the United States, the U.S. Geological Survey's National Hydrography Dataset (NHD) provides vector data at multiple scales: 1:24 000-scale, called the high-resolution NHD, and 1:100 000-scale, called the medium-resolution NHD [Simley and Carswell 2009]. Many electronic atlases are built on multi-resolution data bases, such as the Atlas of Canada [Kramers 2007] and the Atlas of Switzerland [Sieber and Huber 2007]. The resolution of the data should be appropriate for visualization in the atlas. For a multi-resolution, scale-dependent electronic atlas, such as one in which the data displayed changes at different viewing scales, multiple datasets covering the same area need to be obtained and managed. As an example, the coarse resolution (~1 km) of the North America Shaded Relief image is appropriate for visualizing the terrain at small scales, but higher resolution data, such as the USGS National Elevation Dataset (~30 m), are needed at larger scales (Figure 5.5). For a given area of interest, these multiple sets of data must be managed.

Land use/land cover data are not uncommon in atlases, as they visually depict the natural and developed environment of a region. An area of interest may have numerous datasets of land use/land cover available (for the United States, see https://www.usgs.gov). The data may be available at various spatial resolutions, whether the data were resampled after classification or classified from source imagery having different resolutions. This can be beneficial for an electronic, multi-resolution atlas, but complications can occur if different classification systems or number of classes were used. The land use/land cover data may need to be converted, or cross-walked, from one system or framework to another. The Anderson, or USGS, classification system is commonly used [Anderson et al. 1976], but categories may need to be collapsed or otherwise re-coded if another land use/land cover dataset uses a different system.

5.8 PROJECTIONS AND COORDINATE SYSTEMS

Map projections and coordinate systems are other crucial components of data in an atlas. An appropriate map projection to use in the atlas is an equal-area projection, such as the Albers Equal-Area Conic, so that area is preserved. As Buckley [2003] states, a main objective of atlas mapping is to illustrate "coherent information about selected themes". Thematic maps are prevalent in atlases and their area must be accurately represented so that themes are clearly communicated to the reader [Andrzejewska et al. 1999]. Figure 5.6 shows the differences between two different projections. Coordinate systems can have an influence on the scale of a map. For scale that is shown by the use of a representative fraction, the measurement units on the ground and the units on the map must be the same [Harvey 2008]. Compared to the American system of units, the metric system is often easier to understand. As a rule, U.S. government topographical maps use meters as the standard unit of measurement for the scale bar.

FIGURE 5.5

Different resolutions of shaded relief at different onscreen viewing scales (left: 1:5 000 000; right: 1:300 000).

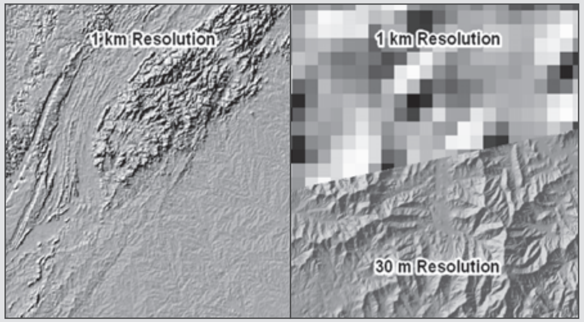


FIGURE 5.6

Albers Equal Area (red) and Lambert Conformal Conic (green) projection in comparison (origin 39N, 96W, standard parallels 33N 45N) [DANA 1999].

5.9 DATA INTEGRATION

Geographic data are often obtained from multiple sources [Coates 1998]. The process of combining these data is data integration [Adam and Gangopadhyay 1997]. Non-spatial attribute data are often collected from printed sources, text files, spreadsheets, or database files. The US Census Bureau integrates spatial data into its TIGER database that originate as digital GIS files, GPS data, or as digitized updates from paper maps [Trainor 2007].

Integrating data into a map from various sources and with heterogeneous coordinate systems can cause data layers to not overlap as expected [Rigaux et al. 2002]. It is important to create a common projection in a map while also being aware that the likelihood of introducing error increases the more times coordinate systems are converted. A common map projection is especially important to create if spatial analysis functions will be employed in the atlas [DeMers 2003].

5.10 NON SPATIAL DATA

Attribute, or tabular, data contain descriptive information about features stored in spatial data models. These data tables contain a key field which can be related or joined to a spatial feature, allowing the user to access information about that entity. For example, if a user has a point file with all of the cities in the United States, those data can be linked to a corresponding attribute file. This can provide various data about each city, such as the name, population, demographics, etc. Geographic entities can then be classified based on their attribute data and grouped to create a thematic layer. These layers can be used to create thematic maps on such topics as population per square mile and median household income. Other non-spatial data types may be used to provide relevant information. Text files, image files, and multimedia formats can be useful for supplementing and further explaining the information provided in the map.

Attributes of geographic data in an atlas could refer to such varied topics as median household income per county, land use/land cover classification, annual precipitation of a region, and so forth. Data should be obtained from trustworthy or authoritative sources. The importance of clearly understanding how data values were derived should not be underestimated. This is necessary for valid comparisons and should be documented. The precision of attributes can be all-too-easily affected in a database, as a statistical mean of 15.42 could be inadvertently rounded to 15 if an integer data type is employed, and this may well have ramifications for data classification.

Spatial and non-spatial data need to be synchronized for temporal accuracy in an atlas. Geographic boundaries, feature locations, and attributes change over time, so the correct vintage of data must be used. When producing the atlas *Mapping Census 2000: The Geography of U.S. Diversity*, data from the 1990 census had to be reaggregated to Census 2000 geography for county boundaries that changed between 1990 and 2000 [Brewer and Suchan 2001]. The date of observation/measurement, the time period over which data are valid, and data revisions are all concerns of temporal accuracy. Temporal precision can be improved by storing exact dates. Significant changes can occur from January to December of a given year, and much meaning of the data will be lost, and fair comparisons made difficult, if data as of January 2010 is stored simply as “2010” in a database or in metadata.

Attribute data are formatted and stored in tables, and are connected to the spatial features that they describe. Attribute data collection should be strategic in order to manage time and resources most effectively. One important tactic is to determine the various specifications for data before capturing the data. If, for example, building entry points need to be collected and documented, it will save processing time to gather these entry points during data capture. Otherwise, building addresses must be geocoded after data capture to symbolize building entry points, requiring extra staffing and processing [Buttenfield and Frye 2007].

The atlas author must also give careful thought to the structure of the attribute data and attribute table field lengths that will be used in the database. Numerical data formats, such as floating-point and integer, are often preferred over data types such as character string because they can be examined and transformed with other numerical data. Also, attribute table fields should not be longer than necessary. An appropriate field length balances the need for saving computer storage space and displaying each attribute in its entirety [Harvey 2008].

Different methods can be employed to input attribute data into a GIS application, such as uploading latitude and longitude coordinates from a GPS, using voice recognition tools, or keyboard entry. Keyboard entry is very prone to human error, and depending on the type of error, an active data dictionary will not identify incorrect data input. When attributes are misplaced a data dictionary will overlook the placement error if the data is still a real and valid value. For example, one may decide to use a GIS coding technique for cumbersome feature names, such as names of plant species for point entities. Numbers could be used in the attribute table to represent the species names, making database queries easier to write. Using numbers makes it more likely that data input is incorrect, though, and a data dictionary would not flag a misplaced code if it defines a real plant species name. The only viable strategy for identifying a data ordering error is to display the mapped data and compare it to the original [DeMers 2003].

FIGURE 5.7

Attribute data are always linked to their spatial features.

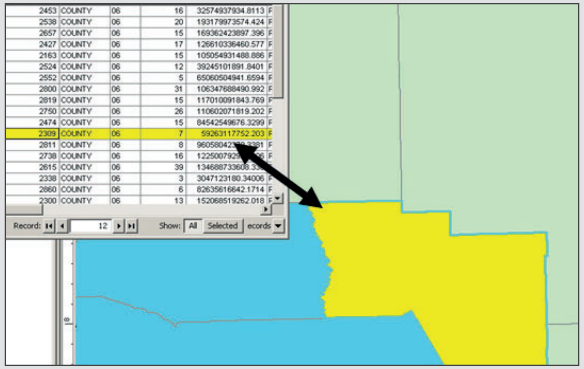


FIGURE 5.8

Many-to-one relationship [ESRI 1999].

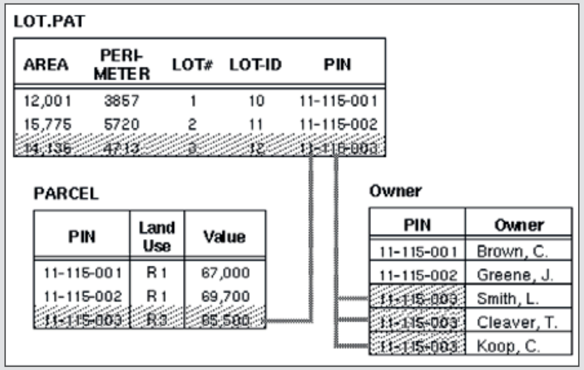
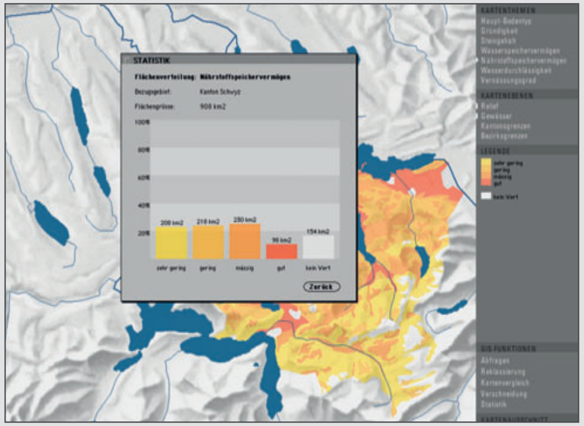


FIGURE 5.9

Display of statistical results in Atlas of Switzerland [SCHNEIDER 2002].



A one-to-one relationship must always exist between a spatial feature and its attribute record. The attribute table data are linked to their spatial features by a key field that contains unique identifiers for each record. Figure 5.7 displays a county polygon layer and its attribute table; the highlighted county is associated to its attribute record colored yellow in the table. The attribute record explains different characteristics of the county, such as its legal area description code and the number of local governments it contains [CGIAR-CSI 2004]. In a similar manner, the process of geocoding links address records stored in a table to latitude and longitude coordinates that can be represented by point features on a map.

Relationships can also be maintained between records of different attribute tables. For example, a many-to-one relationship may be necessary in order to associate many owners to a parcel of land, with each person owning only one lot (Figure 5.8). Caution should be used with many-to-many relationships since they often make it difficult to distinguish artificial attribute record relationships from logical relationships.

5.11 DATA ANALYSIS

Overlay functions, measurement and statistical functions, and database queries are commonly used map database analysis tools. These functions allow the user to perform tasks such as finding specific attributes of objects in a database and viewing them on the computer screen, calculating statistical values such as maximum, minimum, and standard deviation, merging similar and adjacent polygons, and charting the distribution of values. Analytical functions were seen in the first digital national atlas, the Electronic Atlas of Canada produced in the 1980s. Despite this early achievement, further advancement is needed for the GIS analysis capabilities for multimedia atlases (Figure 5.9) [Schneider 2002].

5.12 METADATA

It is critical that metadata accompany geographic data, especially when data are obtained from outside sources. There are numerous considerations for evaluating the quality of data and determining its appropriateness for use. The five parameters of data quality in the Spatial Data Transfer Standard are positional (spatial) accuracy, attribute (thematic) accuracy, logical consistency, lineage, and completeness [Veregin 1999]. Some standards organizations also include semantic accuracy and temporal (vintage) accuracy to describe quality [Devillers et al. 2005]. Some of the major

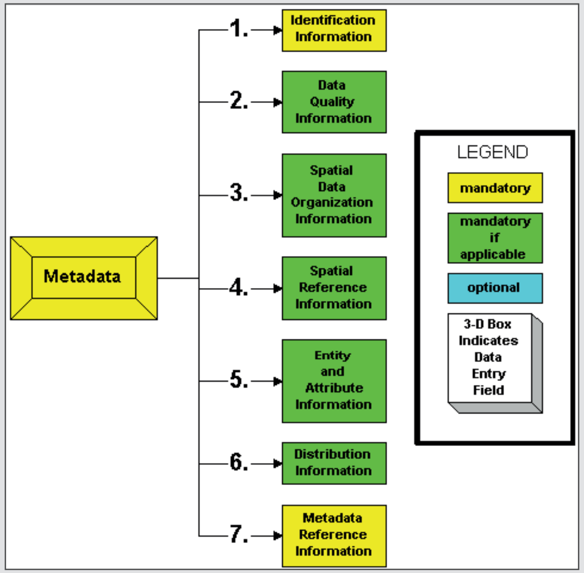
developers of standards include:
- ISO Technical Committee 211 – Geographic information/Geomatics [https://www.isotc211.org],
- International Cartographic Association ICA Commission on SDI and Standards [https://sdistandards.icaci.org/]
- European Committee for Standardization Technical Committee 287 – Geographic Information (CEN/TC 287) [https://www.gistandards.eu],
- U.S. Federal Geographic Data Committee [https://www.fgdc.gov].

It is imperative that metadata in the atlas thoroughly describe the attribute data. More specifically, the metadata should describe the major facets of the content, quality, purpose, source, and accessibility of a geospatial dataset. By creating, displaying, and controlling metadata, the author provides an essential component to the atlas that explains the accountability of data as well as data limitations [Ahonen-Rainio 2005]. Metadata production is most efficient if it is fully integrated into the geospatial data development process to reduce the risks of inaccurate information being recorded and increased costs of searching for information. The point in time that data development actually takes place is the time that metadata can more easily and accurately be collected [Wayne 2005].

In the U.S. Government, spatial data standards are maintained by the Federal Geographic Data Committee. The FGDC has developed a list of seven different aspects of data that metadata should describe (Figure 5.10). This list includes:
- *1-Identification:* Explains the name and developer of the data set, the geographic area covered, and restrictions on data access.
- *2-Data Quality:* Describes how accurate and complete the data are, as well as their adaptability for application and positional accuracy. Positional accuracy involves assessing the horizontal and vertical positional (coordinate) values that were derived from digitizing, surveying techniques, or image processing.
- *3-Spatial Data Organization:* Explains the spatial data model (vector/raster) used, the number of spatial objects, and additional non-coordinate methods of location encoding, such as street addresses.
- *4-Spatial Reference:* Provides the datum, the parameters for coordinate transformations, the projection or grid system, and the latitude, longitude, abscissa and ordinate resolutions. Latitude and longitude resolution values represent the smallest possible difference between coordinate values. Abscissa and ordinate resolution values represent the smallest distance between X and Y values in the planar data set.
- *5-Entity and Attribute Information:* Specifies attributes, attribute values, and code definitions.
- *6-Distribution:* Explains where to obtain the spatial data, the available formats, and cost.

FIGURE 5.10

FGDC Content Standard for Geospatial Metadata [Federal Geographic Data Committee 2000].



- *7-Metadata Reference:* Provides the date the metadata was compiled and the name of the person who compiled it.

Data Quality Information:

Production Rules
Logical_Consistency_Report: not applicable
Completeness_Report: not applicable
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: Unknown
Publication_Date: 1997
Title: Landsat TM
Geospatial_Data_Presentation_Form: remote-sensing image
Type_of_Source_Media: remote sensing image
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19970103
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation: image
Source_Contribution: The Landsat TM satellite image was used as the basis of the vegetation classification and as the background on which to add ground truth data.

Component Elements
Process_Description: Measurements of flow velocity and surface-water slope were made on four different dates on three west-to-east transects across Taylor Slough. Global Positioning System (GPS) coordinates were used to establish the location of sampling points so that measurements could be repeated at the same site as desired. On three of these sampling dates, vegetation, including periphyton, was harvested from 0.5-m 2 quadrats in horizontal layers, either 10 or 20 cm thick, from the bed through the water column to the top of the plants. The plant material was sorted and measured and both plant material and periphyton were oven-dried at 105 deg. C for 12 hours or more to determine biomass of the individual components in grams dry weight per square meter (gdw/m^2). Species composition, density, leaf and(or) culm number and size, leaf area index (LAI), and biomass were determined for each layer.

The metadata example in the blue box on the left hand side is from the United States Geological Survey vegetation database for a portion of South Florida. It displays the production rules and list of component elements sections that are defined by FGDC [DeMers 2009].

With the increase in technological capabilities, atlas readers are now often able to interact with the data set rather than just the map display [Buckley 2003; Aditya and Kraak 2006]. Therefore, it is increasingly important to include metadata for each dataset used in the atlas. More information on the FGDC, including its standards, publications, projects, and list of metadata creation tools, can be found online at www.fgdc.gov.

5.13 CONFIDENTIALITY

With the advancement of technology and data capture techniques confidentiality is a consideration. The level of effort an author needs to devote to this concern is dependent on scale of the data and its representation. A coordinate location refers to a specific location on the globe. For instance, the Latitude: 38.8895563 and Longitude: -77.0352546 refers specifically to the Washington monument. But spatial data also includes administrative areas. When you combine this locational data with statistical data and/or other attribution confidentiality concerns may arise. There are four ways to deal with spatial data confidentiality. The U.S. Congressional Subcommittee on Disclosure-Avoidance Techniques outlined the four ways in the working paper 2: *Report on statistical disclosure and disclosure avoidance techniques* [1978]. These methods include, limiting data distribution, aggregating the data, data suppression, and data swapping. After the disclosure risk is determined, it is up to the author to determine which if any of these techniques is appropriate for the atlas.

5.14 CONCLUSION

The user expectation for an atlas is one of a high quality, interesting, visually appealing collection of maps and other related information. The data characteristics of differing types, forms, and formats of data must be taken into account in the design and production of any good atlas. The volume, complexity, and variety of data serve as challenges to a manageable atlas production operation. The information presented in this chapter offers guidance to atlas developers as they plan and execute an atlas project. While no compendium of all possible examples is possible, the topics offered serve as common experiences in working with today's data.

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6 MULTIMEDIA ELEMENTS

VIT VOZENILEK AND ROSTISLAV NETEK

Multimedia elements have become a characteristic part since modern information technologies came up. They consist of the interaction of various types of computer-based media [Cartwright et al. 2007]. Generally, the term multimedia includes texts, pictures, photographs, animations, maps, charts, graphics, sound, video and other media. Digital media bring a new dimension to the presentation of information that paper maps have not been able to convey so far.

Multimedia elements appear in an atlas in various forms; mostly as a map symbol, as well as a text, picture or photograph situated outside the map field, supplemented with sound, animation or video. All multimedia elements (ranging from simple textual links to virtual reality scenes) significantly improve the information content of a map and make the transfer of information towards the user more efficient. Multimedia maps, maps with an essential role of multimediality, are more attractive, more likely to capture the users attention, and they keep it in mind for a longer period of time [Sutcliffe 1999]. Using multimedia elements to underline the map's content makes it easier to read and understand information on the map. Multimedia can transform an atlas into a powerful interface for other data (other maps, texts, databases, websites, etc.). A special type of multimedia maps is the concept of "story maps". It combines different multimedia elements with the aim to describe a spatial topic by the more attractive way.

One of the biggest assets of multimedia elements in cartography is their "aesthetic value". Nevertheless, the aim and purpose of the map must always be respected and multimedia elements must always remain appropriate, in terms of their number and design, so that the map and the whole atlas are easy and pleasant to read [Vozenilek 2005].

Multimedia elements play several roles in an atlas:
- higher graphical content in a map,
- higher information value of a map,
- simpler and quicker transfer of information from a map,
- higher attractiveness,
- capturing users' attention,
- emphasis on selected content,
- more intensive use of a map,
- interface for further information.

These are the main multimedia elements:
- text,
- pictures,
- sound,
- animations,
- video,
- virtual reality.

6.1 TEXT

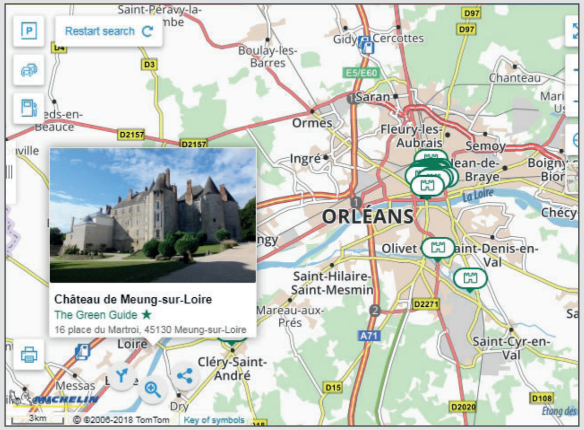
Although text is not a typical multimedia element, it is one of the most frequently used elements in digital atlases. Text can be used to describe various situations in a map, a complex graph or a diagram. It can specify details (that could easily be missed by the user) and basic spatial arrangement

FIGURE 6.1

Text provides descriptions and links to further information [https://jetsettingfools.com/].

FIGURE 6.2

Photographs as a multimedia element [https://www.viamichelin.com/web/Maps].



of the represented phenomena that are challenging to interpret.

Text mostly consists of a hyperlink leading to a map or a specific map symbol [Vozenilek et al. 2013], a page in an atlas, a table, graph or picture, a video or sound recording, etc. Multimedia character of text can also be used for descriptions in the map (see Figure 6.1).

It is not suitable to overuse text in atlases because it can make readers lose their concentration. It is therefore recommended to use short and simple textual information. Sentences should be precise and to the point and a text segment should not be divided into several blocks placed in different parts of the map. Often, it is more suitable to use text in the form of lists or overviews.

Differing color makes it clear that a text is a multimedia text. The color is defined with respect to the color of the background so that the text is easily distinguishable and readable. The reader's attention can be captured by repeated color change, resulting in a flashing text. Font size, type, style, decoration (underline, shadow, halo), transformations (rotation, effects, animations, transparency) and spacing are chosen according to cartographical rules.

Due to the fact that a multimedia atlas can be displayed by a variety of devices (desktop monitor, laptop, tablet, smartphone, etc.) with different specifications (screen size) and technology used (LCD, LED, OLED, TFT) there are no generally applicable recommendations that would ensure that the text in maps will display correctly in all cases.

6.2 PICTURES

Pictures are likely the most widely used multimedia element in atlases. They emphasize and specify details in the map or illustrate particular phenomena. Pictures make interpretation of the information in an atlas faster and easier than textual elements, thus speeding up the process of transfer of information from a map.

Pictures include photographs, drawings, schemes, diagrams and graphs. Multimedia pictures can have the form of a stand-alone map symbol or of an advanced layout element. Both can also perform the function of a link to other multimedia sources.

Photographs (Figure 6.2), both black & white and color, serve as a strong communication tool. They stand closest to reality and significantly increase the atlas attractiveness. Panoramic (360°) photographs are also used (Figure 6.3 and 6.4). Previews, i.e., smaller photos of unified graphics (dimension, size, caption) provide a link to photographs of higher resolution or further information about the locations.

Drawings and *symbols* are usually less realistic than photographs but they can serve as an effective supplement to text or its substitutes. Generally, any drawing or symbol can be used. Apart from conventional cartographic symbols, many specific pictures can be applied, e.g., widely known logos and icons.

Diagrams and *graphs* (Figure 6.5) are used in the case it is not possible to provide information in the form of a text or picture, e.g., figures. They are suitable to compare statistical values or to follow trends or make correlations. The multimedia nature of graphs is often supplemented with interactivity – when moving the cursor over the graph's pie, line or column section, the appropriate statistical data or additional information appears. Graphs often make use of autoscroll.

The format in which a picture is stored (raster or vector) denotes its basic parameters. Quality of raster pictures makes its limitations; the more you zoom in, the worse is the visual quality. On the contrary, zooming in vector pictures keeps their quality. Vector formats (e.g., SVG, JSON, PDF, EPS, CDR, AI) also offer the advantage of low data volume and the same quality during zooming in. Raster formats (e.g., JPG, TIFF, WEBP, BMP, PNG and GIF) make it possible to show more complex originals like photographs.

Picture quality depends on its size (height x width, usually in pixels), image resolution (number of pixels per inch) and color depth. The minimum resolution to be displayed on a PC screen is 72 dpi or 150 dpi. A resolution of 300 dpi and higher is recommended for printing. Color depth, which specifies the range of colors per pixel, influences the number of colors. It is recommended to use 24bit. Apple introduced a Retina display which provides a screen with higher pixel density – the user is not able to recognize pixels at viewing distance.

Symbol size depends on the level of detail in the picture and the readers' ability to discern and interpret the symbols. Symbol animation often appears, usually based on a change in shape, size, transparency, fly-by effects, transition, rotation, coloring and shading. The user finds these effects attractive and if they are used cautiously, they have a positive impact on the legibility of the map.

6.3 SOUND

Sound (speech, music, ambient sound effects) is an effective means to present an important part of the information or to induce emotions or capture the user's attention. When combined with other multimedia elements sound transforms the map into an enhanced tool to present spatial information in an unusual and interactive way. Sound creates a positive atmosphere that leads to optimum perception.

FIGURE 6.3

360° panorama photograph provides higher interactivity [https://mapy.upol.cz/].

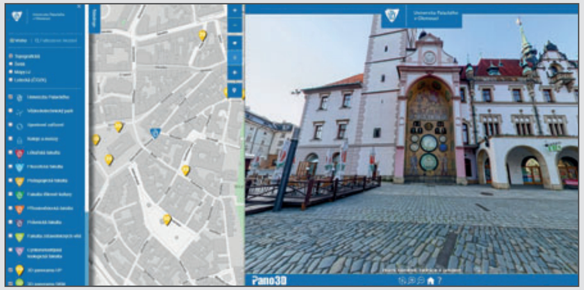


FIGURE 6.4

StreetView combines 360° panorama photographs with augmented reality [Google Maps].

FIGURE 6.5

Visualization of attribute data in a graph [https://d3js.org].

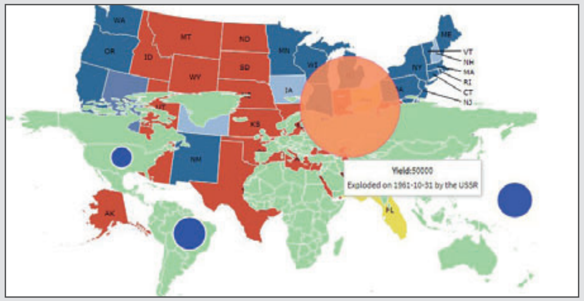
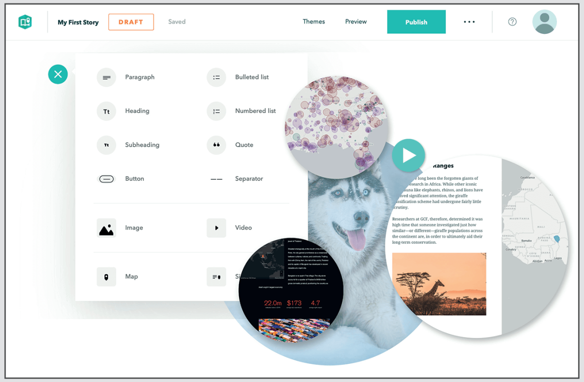


FIGURE 6.6

Atlases usually combine various image elements (graph, photograph) [https://storymaps.arcgis.com].



Sounds play the following role:
- attract attention,
- induce a pleasant atmosphere,
- represent sound attributes,
- support map navigation and orientation.

Sound types:
- music, melody,
- speech,
- ambient sound effects (e.g., noise, hum),
- specific sounds (e.g., bell, blast).

However, there is only a thin line between the right volume and sound choice to induce positive perception and an unpleasant and disturbing sound.

Short sound tracks are used to *capture* the user's *attention* and make them focused on the map, animation or the selected element. They are no longer than a few seconds.

Background sound (often music or ambient sound) creates *a pleasant atmosphere* for map perception. Positive perception of visually transmitted information can also be enhanced by sound effects that have no relation to the theme of the map.

Sound as a multimedia element expresses s*ound attributes* of the phenomena. Sound effects that are activated when selecting a symbol or moving the cursor over can include applause (for theatres), fan cheering (for stadiums), a plane taking off (for airports), ocean wave splash (for beaches), or crowd noise (for marketplaces). Greetings in dialects or national anthems when moving the cursor over the European regions are very popular (Figure 6.6).

The sound might express quantitative attributes, e.g., water level in hydrological maps by water gurgling with a different intensity or earthquake magnitude by a more or less intensive volcano eruption din. In such cases, sound provides redundant information but enhances the knowledge of the phenomena in the map and intensifies the visually transmitted information. Sound can assist the reader to *navigate* when selecting an object in the map. A sound signal indicates the route toward the object (e.g., "move northwards") or indicates the object's location in a territory and provides easier *orienting* in the map (e.g., "Dresden, state of Germany, Land of Saxony, Elbe river").

Using sound in the above-mentioned cases must go hand in hand with enabling the user to set the volume via controls. The standard sound set-up must make the sound easy to hear but not too loud or disturbing so that a contrary, negative reaction is avoided. Low volume limit tends to be 15 dB (background sound), high volume limit is usually 55 db (main topic related sound). The volume of longer sound tracks (background music) tends to be lower and the user is given the possibility to turn the volume up or down as preferred.

When using speech the sound quality must be high enough to make the speech clear and the words easily recognizable on various sound devices. It is because different speakers (especially in cheap laptops and netbooks) can significantly distort the audio output. The length of spoken information should not exceed several sentences (maximum of 45–60 seconds); otherwise, the reader's attention noticeably decreases. It is important to keep in mind that users perceive sound as a secondary source of information, only after visual perception (Figure 6.7).

Quality of sound, which influences whether it can or cannot be used for multimedia maps, is determined by sample rate and sample size (Figure 6.8). Sample rate defines the number of times per second when the sound sample is perceived. A frequency of 44.1 kHz is sufficient for common applications. Sample size defines the number of values in one sample (8 bit for 256 values, 24 bit for 16 million). Both in the case of sample rate and sample size, we can say that the higher the values, the better the sound quality and the larger the file size.

There are few ways to save audio data – Waveform Audio (digital audio), Musical Instrument Digital Interface (MIDI), MP3 or MP4. Waveform Audio saves sound in a data file as a digitalized sound track. The sound is composed of samples taken at regular intervals of the sample rate. Multimedia formats MP4 and MP3 become the most commonly used digital audio formats. MIDI is a standard exchange format originally developed for the music industry. It contains "encrypted" information needed to reproduce the sound (volume, length, frequency, etc.) but not the sound as such. This decreases the resulting size of the file, compared to digital audio files. On the other hand, working with MIDI requires specialized software, a compatible sound card and an additional sound device.

FIGURE 6.7

Map of the most popular songs combines audio alongside map borders [https://pudding.cool/2018/01/music-map/].

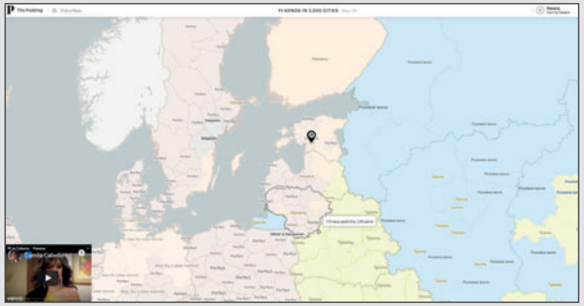


FIGURE 6.8

The interface of the Rezound software that enables to set properties and effects of a soundtrack in a multimedia application [https://rezound.sf.net/].

6.4 ANIMATIONS

Animation means an effective way of representing dynamic phenomena. Animations are used in relation to temporal changes, e.g., appearance of traffic jams, change in a coastal line or seasonal migration of animals [Salam et al. 2013]. Animations can apply to the map as a whole or can only appear after a symbol is selected.

Animated maps have gradually displayed a series of maps representing changes in time [Peterson 2003]. An animation shows a spatial and temporal change during which the map extent changes (zooming in to a certain territory). An animation of layers like in Figure 6.9 leads to a change within one or more layers (change in layer transparency or values). An animation of a scene changes the viewpoint of a given territory (rotation, driving through) and temporal animations express temporal changes in a given period as a sequence of individual maps (e.g., demographical development from 2000 to 2020).

Peterson [2003] classifies animations into temporal animations (that represent a change of a given element over time) and non-temporal animations (that represent phenomena independent of time). *Temporal animations* create generalization animations that express one phenomenon in such a way that its values are first divided into two intervals and then the number of intervals increases linearly.

These are three basic uses of animations in cartography:

- animated maps,
- animated symbols,
- animations as a target after a symbol is selected.

FIGURE 6.9

Animations are widely used primarily for transport-related topics [https://www.flightradar24.com/].

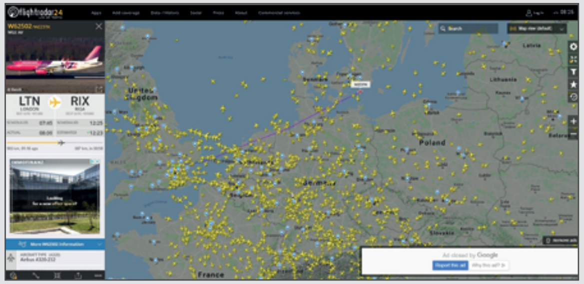
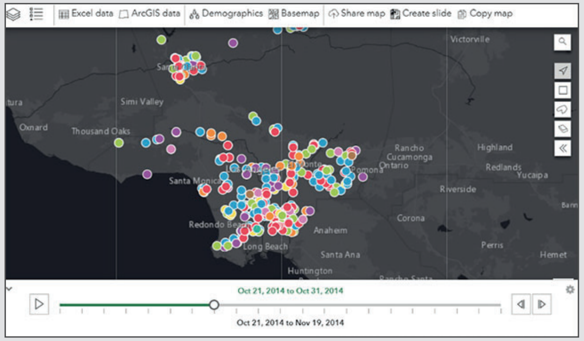


FIGURE 6.10

Animation showing earthquakes over a given period of time [https://esri.com].



Classification animations, on the other hand, do not express the change of a phenomenon over time. The map gradually displays various classifications of the phenomenon in a territory, e.g., classification of data according to various statistical categories. Spatial trend animations are yet another type that follows a trend in the topic of the map. For example, a diagram map can show the percentage distribution of age groups in regions in such a way that data are displayed gradually from the newest to the oldest. Virtual flights over a 2D map or a 3D terrain model make attractive and frequent use of animations.

The user must be able to control each animation (start, pause, stop). Temporal animations should offer the possibility to manually change the time slider, i.e., display the map for a given time interval.

Animated symbols can have the form of a 2D or 3D point, line or area, and can be accompanied by sound effects. Flashing signs are the simplest animated symbols. They only draw the user's attention, for example to attractive objects.

2D animated symbols use a simple movement or a change of a sign, usually using linear techniques. Development programs enable to design an animated symbol using an input and output form of the sign. All that appears between the first and the last image is completed automatically.

Technically more demanding 3D symbols lead to better results. Three-dimensional symbols are created with the use of mathematical models. Each object can be viewed from any angle.

The GIF animations consist of sequences of static images. However, the user can only watch them and cannot control the animation. On the contrary, the MOV or AVI formats can be controlled by the user and thus influence the course of the animation.

Animated symbols can cyclically change their graphic variables (shape, color, size, orientation) without a distinguishing attribute (e.g., a falling house, flashing traffic lights, a growing tree, a rotating windmill, a moving airplane, etc.). The cartographer can use all the graphic variables to express the phenomenon's attributes, e.g., the frequency of a flashing disaster sign can express the degree of its seriousness or the level of transparency of a black cloud can represent the speed with which a smog situation changes (Figure 6.10).

Animated areal symbols offer great possibilities to express the change in land use, an evolution of the economy, changes in political representation and others. If an animated symbol is not suitably designed or located, it can distract the user's attention from the main purpose of the map.

Animations in the map are used as a *target after a symbol is selected*, i.e., as independent elements that are launched in new windows or in areas designated for them. These are mostly animated graphs, diagrams or pictures.

6.5 VIDEO

A video is one of the basic multimedia elements used in digital cartography, even though it can be considered as a special type of animation. Using video in multimedia atlases offers an effective way to present the reality in a short period of time. It has a high potential to represent reality. Thanks to a significant data compression, the user perceives information simultaneously from various sources (image, sound, text, etc.). The content of the video must conform to this fact.

Short *video sequences* are often accompanied by spoken comments or music. Contrary to watching a film from the beginning to the end, video sequences are made for short periods of time (45–60 seconds). This is done in order not to lose the user's attention; after approximately one minute users are not able to process further information in the form of images. Thus, video sequences must be short and to the point and must offer clear information in a relatively short time in a compressed form. They meet these criteria thanks to a combination of video, spoken comments and other types of information (captions, background music, etc.).

Real-time video (which could be compared to "live transmission") is relatively new to maps and atlases (Figure 6.11). Technical image parameters and Internet transmission requirements lead to a high data volume. When compressed, the quality is purposefully decreased so that the transmission is faster and the replay smoother.

The user should always be able to use controls to start and pause the video.

Video use is limited by its quality because to make the information transmission successful it is necessary to maintain a sufficient quality of the transmission. Using low-quality video in low resolution can worsen the quality of the whole map. Video quality is determined by its frame size and color depth, identically to pictures. Frame size means the size of one image (e.g., 640 x 480 pixels); the ratio of the side for monitors and TV's is as standard 4:3, or 16:9. It is common to use 30 frames per second (fps), though 15 fps is still an acceptable value.

Because this is quite demanding in terms of data volume, compression methods have been developed for video, so-called "codecs", which decrease video file size. Lossless compression has no influence on the quality and maintains the same quality of the image in the whole course of replay. Lossy compression omits some image data, thus enabling the smaller size of saved files, to the detriment of image quality. A properly set compression ratio can result in a smaller file size with an almost indiscernible decrease in quality. MPEG (Motion Pictures Expert Group) especially multimedia container MP4, H.265, MOV (QuickTime), and AVI (Video for Windows) are the most frequently used video formats. Sharing video via cloud services such as YouTube or Vimeo become more popular nowadays than to provide it in raw format.

In addition to basic graphic variables [Bertin 2010] animated maps have five further variables:

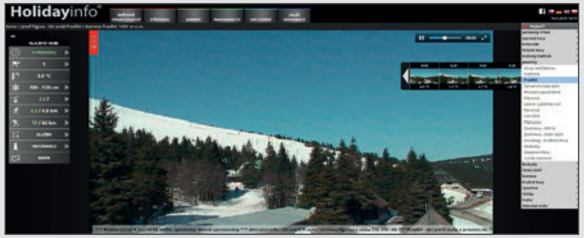
- type of change in the symbol (shape, color, size, orientation, location),
- frequency of change in the symbol,
- sequence of change in the symbol,
- transparency,
- synchronization.

Two types of video are used in digital cartography:

- video sequences,
- real-time video.

FIGURE 6.11

Real-time video displaying a real situation: weather conditions in tourist resorts [https://www.holidayinfo.cz/].



Three parameters determine video quality:
- frame size,
- color depth,
- a number of images per second (frame rate).

FIGURE 6.12

Video as a multimedia element can be used in a wide range of map applications [https://www.dopravniinfo.cz/].

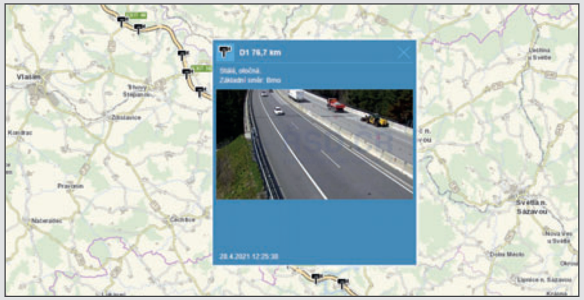
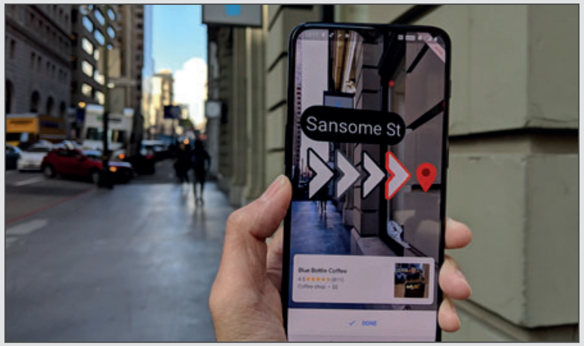


FIGURE 6.13

Use of augmented virtual reality during navigation [https://www.cnet.com/tech/tech-industry/google-begins-testing-ar-walking-navigation-for-maps/].



6.6 VIRTUAL REALITY

The term "virtual reality" can be defined in many ways. In the past, virtual reality referred only to technologies that fully enabled the user to immerse into a computer-generated virtual world, with all senses. Nowadays, virtual reality encompasses a wide range of applications of various technical origin and degree of plausibility. The virtual reality most often refers to a computer simulation that has an impact on human senses in such a way that the perception of the visualized environment is more or less identical to the real world [Sherman and Craig 2003].

Generally, virtual reality represents a fully digitized environment that creates an illusion of the real world, with a certain degree of plausibility. It can be perceived by various senses, controlled and the user can communicate with it. Using an avatar (a virtual character), the user can move, explore or change the virtual environment. The avatar does not have to have a concrete form, what is important is its ability to navigate in the virtual environment.

Virtual reality in atlases can be used in two ways. The map symbols can lead to virtual reality projects that are opened in new windows, or the maps can become part of virtual scenes (Figure 6.12).

Cartography takes advantages of passive, active and interactive virtual reality. *Passive virtual reality* enables the avatar only to view the environment without moving or operating objects (e.g., watching a 3D film). *Active virtual reality* enables the avatar to move freely without being able to change anything (e.g., Google Earth, CesiumJS). *Interactive reality* enables the avatar to move freely, to change the surrounding environment or to react to changes.

Digital maps and atlases most frequently make use of *low-end virtual reality*, where it is sufficient to use the monitor and loudspeakers or headphones to create virtual reality. Control and changes are done via keyboard or mouse (e.g., Google Earth or 3D panoramic photos). *Augmented reality* is a type of virtual reality that combines the real world with a virtual environment. It does not use a complete "immersion" of the user into the virtual world but projects supplementing information and virtual objects into the user's environment.

VRML, X3D, Collada, SKP, KML, 3DS and OpenFlight are the most frequently used virtual reality project formats.

Google Maps (Google Earth) is currently the most well-known virtual reality project in cartography; it is basically a virtual globe. It is a partly active and partly interactive virtual reality because the user can change the content to a certain extent by inserting their own 3D models, by turning layers on or off, or making them transparent.

6.7 CONCLUSIONS

Multimedia elements make digital cartography different from traditional maps and atlases in several ways. Generally, when the user perceives more media simultaneously, their understanding of the transmitted information increases. If two or more multimedia elements are combined, e.g., text, sound and picture, it is important to correctly interconnect all information sources. This means that the icon of loudspeaker that serves to launch the sound track must be placed directly next to the text. This leads to a logical connection between both information sources and the transmission of information to the user is becoming more intensive (Figure 6.13).

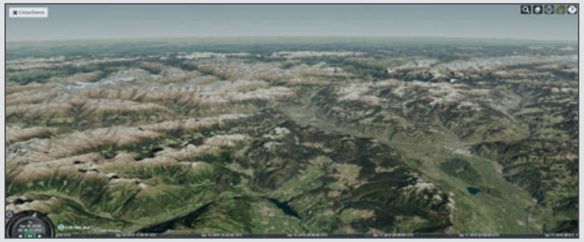
If sound, video and animations are used for the same time period, the corresponding sequences must be synchronized in the map.

For time-dependent variables, the course over time of one element must correspond to the course over time of another element (the image should not display the situation in 2020 and spoken word explain the situation in 1950). If there is a difference between sound and image, the user does not consider the information synchronous and does not perceive it correctly from both sources. This undermines the whole process of map content interpretation (Figure 6.14).

Even though multimedia cartography does not necessarily have to be connected with the Internet environment, we must bear in mind the significance of web applications. Due to the fast development and innovation of new Internet technologies, there is no other medium that would have the same high potential for spreading spatial information. It is multimedia that denotes one of the main driving forces of spreading information via the Internet, not only via maps.

When creating multimedia applications, it is extremely important to repeatedly test their applicability, both during their development and full operation. The application must be 100% operational when first launched. It is not admissible to launch an untested multimedia application. Further monitoring and logging of the application serve as feedback about the technical (in)applicability of the map. It also provides statistical data on user satisfaction or the volume of transmitted data.

FIGURE 6.14
A virtual globe as an attractive 3D model of the Earth (CesiumJS) [https://cesium.com].



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7 ATLAS GUI AND LAYOUT DESIGN

RENÉ SIEBER

The Graphical User Interface (GUI) of an atlas system is the exclusive link between the user and the atlas content. Maps, numerical data, multimedia information (e.g., text, graphics, photos, sound and videos), links, and interactions are only accessible by means of a single flat surface with limited screen space. Commands, data and actions of the computer are graphically represented and can be manipulated by means of tools. Thus, it is of great importance to consider decisions for the atlas GUI from the very beginning of the project, and also to design the atlas GUI very clearly and carefully.

This chapter clarifies the terms, means and concepts, and describes the GUI design process and its elements. Finally, it should be possible for atlas authors to recognize the main design phases, and to extract relevant issues for their own atlas project. Since the general understanding of creating a GUI is based on User Centered Design (UCD; see Chapters 3 and 10), we will focus here more on functional GUI aspects, commonly termed as Interaction Design (IxD).

7.1 WHY TO USE A GUI

A GUI is an essential part of every interactive atlas. In comparison to a Command Line Interface (CLI), a GUI offers several advantages for atlas designers and users. A GUI procures an intuitive approach and a high learning curve by using a well-designed but limited set of options. Novice users get quickly acquainted with the content and the basic functionality of the atlas, while more experienced users can access dedicated, sophisticated functions. Atlas designers have full control over the application, meaning that they can steer and define the general degree of interactivity or even of different parts of it. Thereby, they intend to guide the users unconsciously in order to prevent them from nonsense maps, and additionally offer ways of exploring the atlas and its maps.

From a visual-graphical perspective, the GUI communicates not only the spirit of the brand, but also the *look and feel* of the application, inviting the user to explore the atlas content. Moreover, it serves as a unifying reference frame for the different spatial and thematic issues, thus easing visualization, information retrieval and analysis tasks. When using a GUI, also some disadvantages have to be taken into account. Normally, a GUI needs considerable system resources, and the speed of user operations is limited which might be suboptimal for very experienced users. But the advantages of a flexible, well-designed GUI override these technical limitations by far.

7.2 PLANNING AN ATLAS GUI: GENERAL PRINCIPLES AND CONCEPTS FOR GUI DESIGN

To realize an atlas GUI is a rather sophisticated and challenging task, involving not only atlas authors but also IT and Web specialists, and graphic designers. Therefore, it is highly recommended to follow a focused and well-structured approach. But first of all, we have to know some basic elements of user interaction.

Principles of Interaction Design

When planning and designing an atlas GUI, some general principles of User Centered Design (UCD) and Interaction Design (IxD) should be kept in mind. While UCD is stressing the interaction process between the user and the product interface, IxD is mainly con centrated on the graphical design and implementation of the GUI into an application. These principles, mentioned by almost every famous designer [Tufte 2001, Nielsen 1993, Nielsen 1995, Shneiderman 1998], can be summarized as follows:

- *Knowing your user:* The best-known principle of UCD plays also an important role in IxD. In order to realize a tailor-made product for the target group, the user preferences and behaviors have to be known or assumed. This is an ongoing process; therefore, the atlas system should allow continuous contact to users before, during, and after the project.
- *Matching between system and the real world:* The system should speak the users' language (alerts, etc.). Technical expressions and procedures – except of common one's – should be avoided.
- *Making explicit the system internal state:* The system should always keep users informed about internal processes influencing the external user actions and the system performance, e.g., when calculating a visualization.
- *Preserving consistencies:* Different wording situations, or actions for the same thing should be avoided. Consistencies to be preserved in a GUI are related to: labeling, terminology, graphic conventions, GUI components, and layout.
- *Following standards:* The application should use standards and guidelines for interactions, abbreviations, and terminology. Standards are essential for cross-application consistency and effective implementation. They ensure professional quality and quick recognition while reducing the design effort.

- *Error prevention, detection and recovery:* The system should be tested under different conditions and with different user groups to prevent errors. However, if an error occurs, it should be able to precisely indicate the problem, and constructively suggest a solution.
- *Minimizing the cognitive load on users:* People are able to focus attention for a limited amount of time and information only. Thus, the GUI should provide informative feedback, memory aids, self-explaining icons and other cognitive supports. Recognition suits better than recall: important GUI objects, actions, and options should always be visible.
- *Balancing user control and freedom:* The GUI should give the user as much freedom as needed, and also some guidance. It is important that users can navigate at ease, but they shouldn't get lost in space. Concerning thematic issues, they should be e.g., able to combine different thematic information by selecting from a list of appropriate layers.
- *Ensuring overall flexibility and efficiency of use:* The interface should contain customizable elements. Customization in an atlas GUI can allow users to tailor frequent actions by means of shortcuts or preferences. For people with disabilities, barrier-free flexibility incorporates also to scale up the lettering/labels, or to change misleading color schemata.
  The application should also provide mechanisms to reverse performed actions. This allows users to freely explore the GUI, the functionality and the content, relieving them from the anxiety of being trapped in an unrecoverable mistake. Flexibility consists also in providing different usage modes for different classes of users. Novices could use wizards or other simplified means for an easy interaction, while experienced users can profit of some shortcuts.
- *Optimizing the number of functions:* Functional minimalism is a must for atlases; generally, users are overwhelmed and overcharged with too many functions. Since they use the application occasionally from time to time, they often apply only basic functionality. In every complex, sophisticated application like an atlas, only 20% of the functionality is used 80% of the time.
  Optimization can be achieved by functional layering. Therefore, the most frequently used functions should be placed on the top level of the GUI, while expert functionality can be put on a secondary level.
- *Minimizing mouse tracks and clicks:* It seems to be obvious that the mouse track length should be kept as short as possible. This corresponds to Fitts' law of proximity [Fitts 1954], where the time to click an object is proportional to the distance and inversely proportional to the object size. In addition, the number of clicks should also be kept small in order to provide a barrier-free information access.

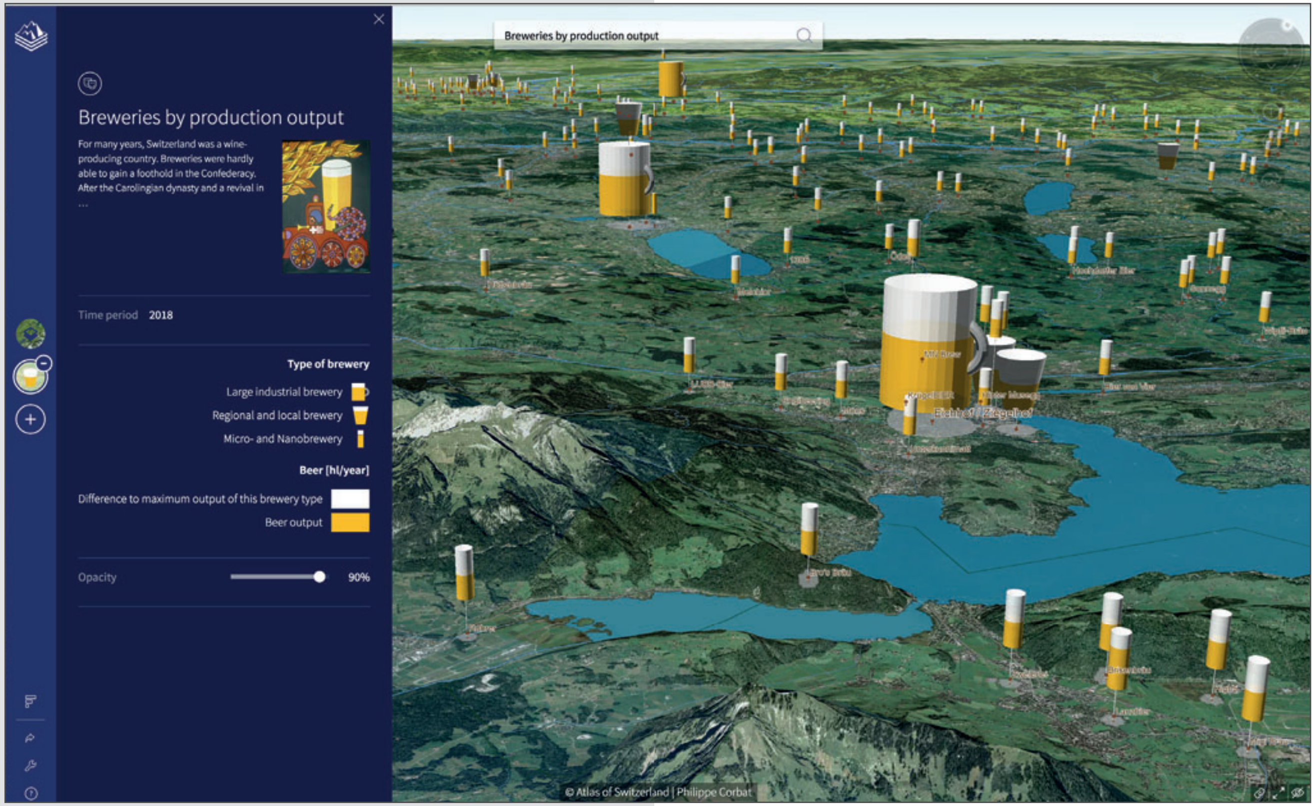
Principles of Interaction Design:
- Knowing your user
- Matching between system and the real world
- Making explicit the system internal state
- Preserving consistencies
- Following standards
- Error prevention, detection and recovery
- Minimizing the cognitive load on users
- Balancing user control and freedom
- Ensuring overall flexibility and efficiency of use
- Optimizing the number of functions
- Minimizing mouse tracks and clicks
- Designing an aesthetic and minimalistic GUI

- *Designing an aesthetic and minimalistic GUI:* Graphical GUI design is most important for a successful application. While from a developer's perspective, functionality and technical design are the two main domains to focus on. But from a user's view, a slim designed GUI avoiding distracting effects is the optimal solution. To reach this goal, a simple advice can be given: Consult and/or engage an (interaction) designer!

These principles address *information access strategies* as well as the *technical and graphical design of an atlas GUI*. Thus, both key strategies and the steps of GUI design are discussed in the following.

FIGURE 7.1

Information accessibility: Beer brewery map serves as a door opener for economic themes [Atlas of Switzerland – online 2019].



Information Access Strategies for Atlases

Before starting the design process, it is very important to reflect the way to get to the relevant and variegated information in the atlas. In fact, there are many ways; thus, the atlas authors should be aware of the different possibilities.

In terms of information accessibility, the information is either

a. directly presented to the user, or
b. the user has to play an active role and search for the information. In our opinion, a mixture of passive and active information access is the best solution.

To start and get acquainted with an atlas, the user will mostly prefer a passive role, where maps are presented immediately. In this context, the incorporation of *Narratives* or *Storytelling* [Caquard and Cartwright 2014] are well suited concepts. We can also make use of Metaphors (book, story, globe, travel, time, toy, workplace), different kinds of *Thematic access* (menu, search, index), and *Spatio-temporal access* (spatial units, coordinates, index, map extent; time stamps or periods). We can also implement a *Contextual access* for map-related information as e.g., Multimedia elements (see Chapter 6).

To actively explore the content of the atlas, the sociological *Serendipity* concept [Merton and Barber 2003] – discovering just by chance unexpected, yet positive facts or events – should be considered. In case of atlas cartography, this means to offer different levels of information for laymen and experts. A simple map, e.g., of beer breweries (Figure 7.1), can work as a door opener for more sophisticated economic map themes. And randomly sorted maps can seduce the user to explore a totally unknown thematic field, only by means of an attractive presentation. Another possibility is the *Gaming* access, using e.g., quizzes, puzzles, or adventure environments, leading to new topographic or thematic discoveries.

Screen Layout Design Strategies

In terms of GUI Screen Layout design strategies, atlas authors should take care of the arrangement of the GUI features and the segmentation of the screen, as well as the density of the layout. In addition, the type of application – desktop, tablet or mixed – and the corresponding screen sizes have to be considered (Responsive design).

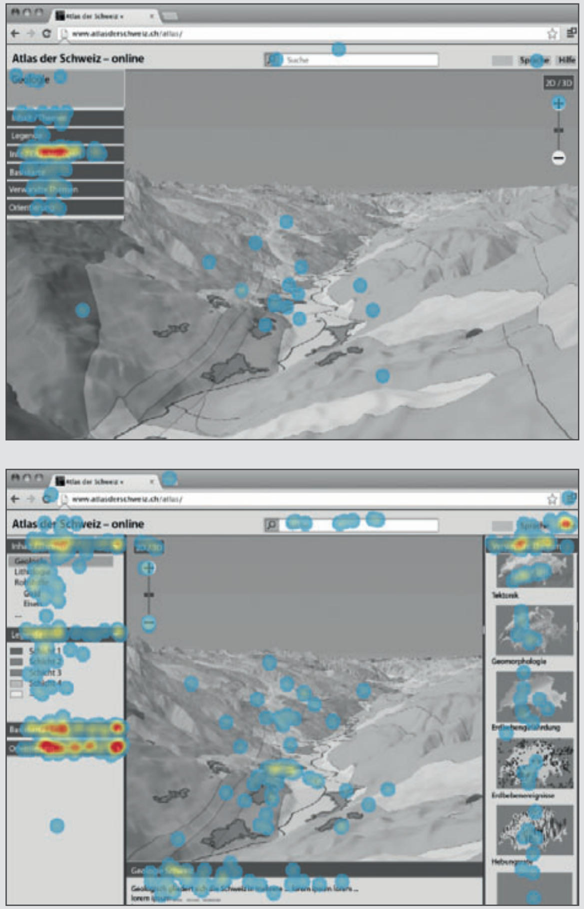
The arrangement of the GUI features can be chosen between the two poles of a clearly structured and a freely arranged layout. The advantage of a structured layout is apparently the fact that users can find the same GUI elements always at the same place. It acts as a reliable atlas framework or even gets a characteristic recognition value. In contrary, a more unstructured layout may be more adapted to the map content, using only space for those elements that are really needed for the map currently displayed.

The density of the layout deals with the question of information depth and hierarchy. Do we need a hierarchical structure of the GUI because of the different importance or of the number of the elements? Which of the atlas GUI elements have to be located on the screen? The most important ones, the most used ones, or only the general/basic elements? How many elements are necessary to be presented on the first level? These questions are best solved with the help of user surveys. In a usability study on task efficiency and GUI layout arrangement for a desktop atlas [Schnürer et al. 2015], users were most efficient and successful in solving basic tasks on layouts with medium density (Figure 7.2, above). Besides, they rated these layouts also as the most pleasing ones.

Thus, the access of relevant information in an atlas depends on a well-balanced combination of active and passive presentation means, and on a layout and tools adapted to the scope of the atlas. But what kind of GUI tools and elements are offered and are relevant for atlas authors? What kind of basic components can we use to create an atlas GUI?

FIGURE 7.2

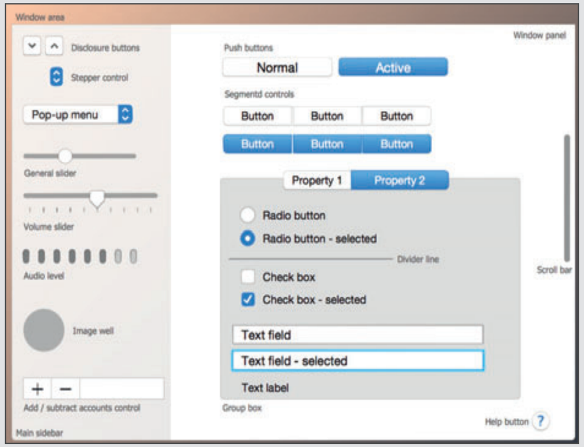
Layout arrangement of an atlas GUI and its effects on efficiency [Schnürer et al. 2015]. Students were asked to select additional information for the map topic (blue dots: 1 click, yellow: 2 clicks, red: > 2 clicks). The resulting surface density maps show clustered (above) or scattered click patterns (below) for the same task.



Most Important GUI Components for Atlas Usage:
- Window or Container
- Menus
- Tabs
- Icons
- GUI Controls or Widgets
- Map Controls

FIGURE 7.3

Example of general Mac-OS GUI interface controls: window panel, menus, buttons, sliders, boxes, text fields, and more [https://www.conceptdraw.com/].



7.3 BASIC GUI COMPONENTS AND ELEMENTS

Generally, the means for users to interact with a digital atlas are rather limited. There are four different types of means, which have to be taken into account:

- *Devices:* Print devices: Paper, coated paper, plastic sheet; Digital devices: Desktop computer: handling with mouse (cursor) / Mobile computer: single-touch, multi-touch, pen
- *Screens:* different types of screens for desktop and mobile applications; most relevant are screen size and resolution, together with the reading distance
- *Multimedia elements:* Visual (map, text, picture, photo) and audible feedback (sound), but seldom tactile/haptic (touch) or odor (smell, taste)
- *GUI components:* Window (container), Menus (command list), Tabs (view pane), Icons (object representation), Controls or Widgets (input/output fields, selection/action elements, navigation controls, informational widgets).

In this chapter, we are focusing on the latter group – the GUI components –, in order to offer a consistent visual language to the user. A list of over 100 structural and interaction GUI components can be found on the Internet [Inspiredart 2007]; we select and group the most important ones for atlas usage. Atlas authors should be aware of the possibilities and limitations of the tools available [www.usability.gov]. In addition, it helps a lot to speak the same language as GUI developers do.

A *window or a container* is an area on the screen that displays information, with its contents being independently displayed from the rest of the screen. In an atlas, the visualization of maps usually runs in such a container; thus, communication between the different GUI elements has to be assured. The window can temporarily be superposed with menus or widgets.

Menus allow the user to execute commands by selecting from a list of choices (see GUI controls). Menus are most convenient because they show all the commands available within an application mode. In an atlas, they are used e.g., to select a map from a hierarchically organized theme list.

A *tab* is a flagged box that usually contains a text label or graphical icon associated with a view pane. When the view pane is activated, widgets associated with that tab are displayed. Fighting often with limited display space, atlases make use of tabs to quickly switch from one toolbox (e.g., legend) to another (e.g., basemap options).

An *icon* is a minimized picture that represents objects such as a command or an application. In an atlas, they are used to symbolize groups of elements like map categories, to represent actions (split screen, print), or to quickly change modus (2D – 3D; day – night).

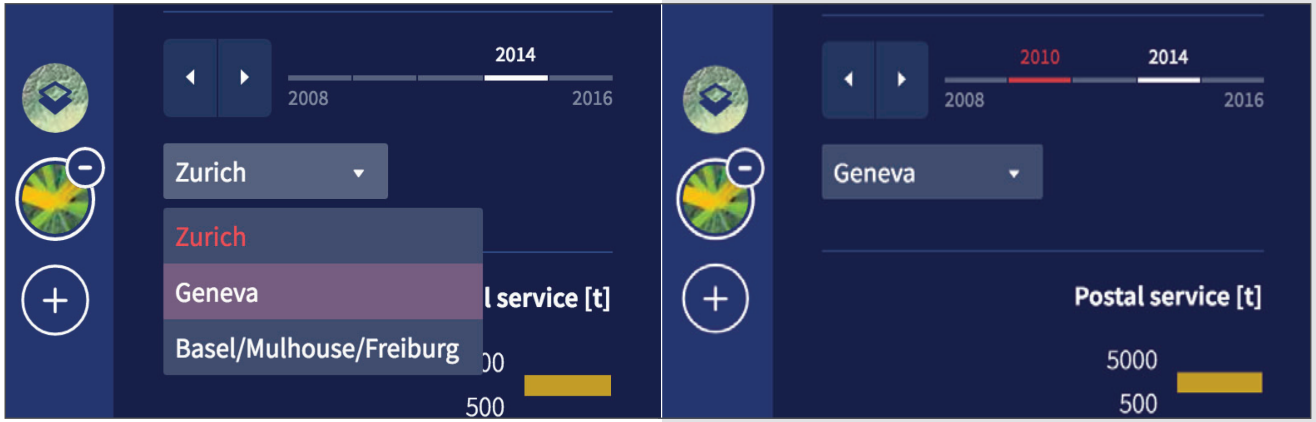
Controls or widgets are the basic components of a GUI; they allow a user to interact with an application (Figure 7.3). Thereby, each widget enables and facilitates a specific user-computer interaction through direct manipulation or display of information. Basically, they can be grouped as *input and output fields* (text field/area), *selection and action elements* (pull-down and pop-up menu, list box, check button/box, radio button, slider, spinner), *navigation controls* (links, tabs and scrollbars), and *informational widgets* (labels, icons, progress bar, tooltip). Widget combinations are also widely used (combo box).

Map controls or widgets are specialized GUI components that enable the user to manipulate the map display and content (Figure 7.4). They often consist of widget combinations. Examples are: widgets for spatial navigation and orientation like zoom, pan, rotate, reference map, pins, compass, and widgets for temporal navigation as e.g., linear or circular time sliders. There exist also information widgets like tooltips, or legend and map display widgets (color picker/slider, transparency slider).

In any case, the general GUI controls and the specific atlas map controls should not be treated separately. Moreover, they have to be considered as an integral framework and as a showcase of the atlas content!

Knowing the elements and the options that define the GUI of an application, we now have a construction kit available to build an atlas GUI. But like in a cookbook, the ingredients have to be combined in the right amount and sequence a to get a tasty, good-looking meal. Thus, the design process is crucial for the acceptance and the success of the whole atlas application.

FIGURE 7.4
Example of specific map controls: time slider and focus switch (cargo flights from Zurich / from Geneva) [Atlas of Switzerland – online 2019].



7.4 TWO APPROACHES OF GUI DESIGN AND IMPLEMENTATION

Designing a GUI is a difficult task, because the GUI should incorporate all the expectations of the developers and the users. Therefore, it is recommended to call a designer person or team to transcribe the all the expectations into graphics and interactions. Designers have a different view on the topic, and on procedures: If they don't understand the meaning of a tool or a process, the atlas user certainly won't too. Designers have to be introduced into the history, the state-of-the-art and also the future plans of the project in order to plan and design the GUI.

Basically, there exist two approaches to design the GUI, both of them human-centered. The first one is based on User Centered Design (UCD) and incorporates mere graphics work, which is tested on usability by means of mockups. The second one, Interaction Design (IxD), combines UCD with technical implementation. While UCD focuses on the interaction process between the user and the product interface, IxD mainly concentrates on planning and designing the general functionality of the GUI, the properties and behavior of the GUI elements, and the graphical design of the atlas and the incorporated maps [Sieber et al. 2015].

UCD Approach:
Five Stages of graphical GUI Design

The UCD approach is subdivided in five progressive stages of GUI design, as Garrett [2002] generally described for website design and implementation procedures. It is similar to the current ISO standard 9241-210, "Human Centered Design Processes for Interactive Systems". However, as Tsou and Curran [2008] stated, Garrett's framework is more specific to the GUI design of web applications and indicates that each development stage can be overlapping if necessary. The following five stages [Garrett 2002] can be considered also as general GUI design procedure guideline for atlases:

1. *Strategy plane:* atlas objective and user needs
   What do we want to get out of the site? What do our users want?
2. *Scope plane:* functional specification, interactivity levels
   Transformation of strategy into requirements: What features will the site need to include?
3. *Structure plane:* formalized function list (functions for map display, spatial identify, query, download, help, etc.)
   Giving shape to scope: How will the pieces of the site fit together and integrate?
4. *Skeleton plane:* grouping functions, layout segmentation
   Making structure concrete: What components will enable people to use the site?
5. *Surface plane:* arrangement, graphic design
   Bringing everything together visually: What will the finished product look like?

This approach follows the two major components of atlas design: *content design* (internal information architecture of data and maps) and (external) *user interface design.* The Strategy plane focuses mainly on the UCD concept by clarifying the goal of the atlas, but also the usability and usefulness of the GUI. It serves as a basic framework for the following four stages. Remarkably: the "real" graphical design takes place only at stages 4 and 5, the Skeleton plane and the Surface plane.

IxD Approach: Six Stages of GUI Design and Implementation

The IxD approach concentrates not only on designing the UI, but also on implementing the general functionality of the GUI. Thus, it considers the properties and behavior of the GUI elements, as well as the implementation process of the graphical design of the atlas.

A more detailed description of the IxD process is given by different authors [e.g., Moggridge 2007, Herczeg 2006, Saffer 2006, Spies 2012]. In short, they point out six successive stages:

1. *Investigation:* Search for similar products and novel technical approaches; use survey techniques (observation, questionnaire, etc.) to find out user profile and user needs; check economic aspects.
2. *Analysis and conception:* Analyze the user requirements; build concepts by means of creativity techniques (brainstorming, semantic intuition, brainwriting, etc.); define personas (user profiles), scenarios, and use cases to create interaction procedures as mock-ups and animations; set a vision statement to define the goals of the project.
3. *Creation of design versions and evaluation:* Design screen-flows to support the general concept and ideas; evaluate and improve the design versions iteratively.
4. *Prototyping and usefulness tests:* Apply three techniques (task and function, look and feel, feasibility) for prototyping, create horizontal and vertical (functions, depth of the application) prototypes; test the usefulness, measure the qualities of utility (features provided) and usability (ease-of-use).
5. *Implementation and realization:* Monitor the implementation process; ensure co-operation between graphic designers and software engineers.
6. *Final tests:* Test usability and correct bugs.

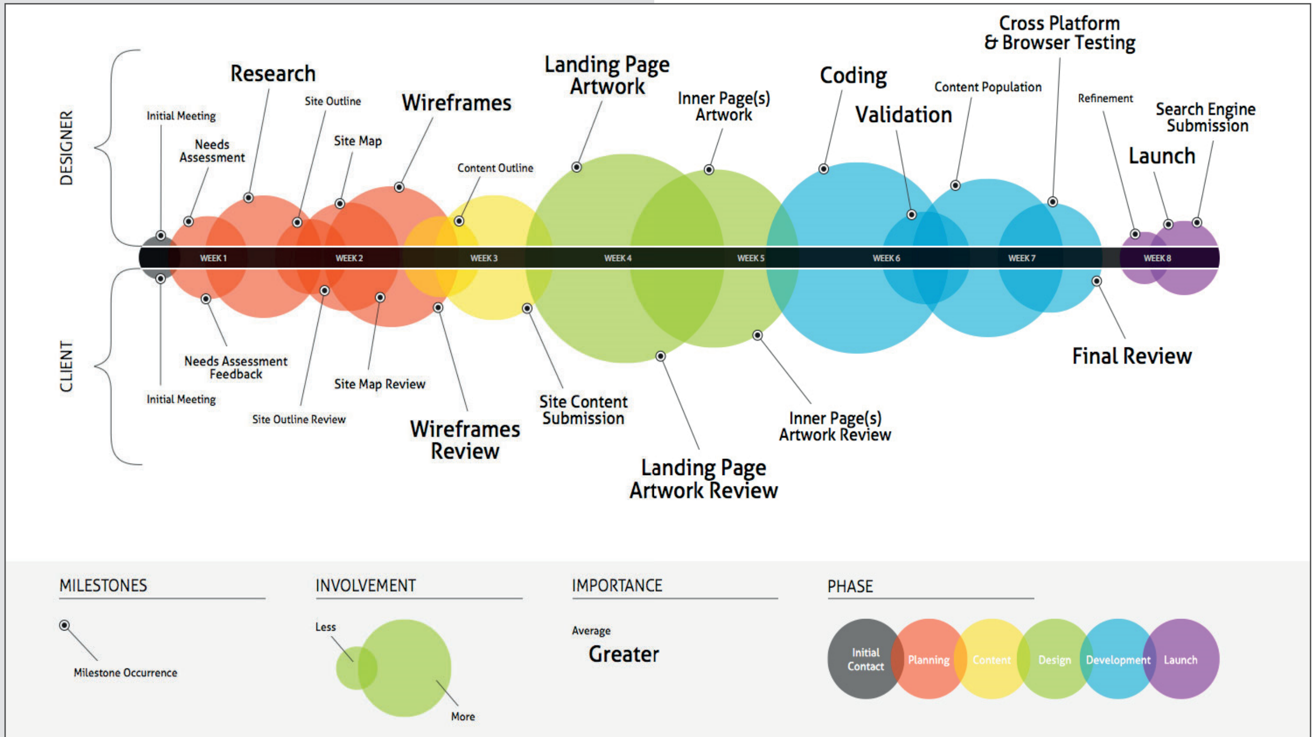
Although these goal-oriented UCD and IxD processes differ slightly both in general and within every specific GUI project, they share several important principles [Sieber et al. 2015]:

- The GUI design has to be strongly user centered;
- The GUI design process has to start from the very beginning of the project;
- The development has to be iterative-incremental, meaning that the GUI is improved in several cycles:
- Prototype testing is a must in different process phases, not only at the end of the project.

These general principles and processes serve as a profound background helping to design an atlas GUI. In general, UCD and IxD approaches are regarded as being suitable for online products in general (Figure 7.5) and for digital atlases as well.

FIGURE 7.5

Overall conceptual model of an IxD approach [Armen 2014].



7.5 THE PROCESS OF ATLAS GUI DESIGN

In order to create an atlas GUI, we prefer to rely on the more holistic IxD approach, which in turn has to be slightly adapted to meet the atlas needs [Sieber et al. 2015]. Basically, the GUI design process is structured in four main phases:

1. Investigation,
2. Rough Design,
3. Detailed Design, and
4. Implementation.

Investigation Phase

As the atlas GUI has to be planned from the very beginning of the project, the investigative phase starts in parallel with general investigations on state-of-the-art in the field of atlases and related fields. It is most important in this first phase, to get an overview of possible GUI solutions and to define use cases (see UCD techniques in Chapter 3). The different steps could be as follows [Sieber et al. 2015]:

- *State-of-the-Art Investigation:* The process of IxD starts with collecting, studying and analyzing competitor products and good GUI design examples (Figure 7.6). Don't hesitate to incorporate as many examples as possible!
  As an outcome, a cross board can be generated which identifies relevant features and evaluates them according to their usefulness for the planned atlas.
- *General Requirements:* Preferably, a reference design is chosen which the atlas layout will rely on. This reference design depends on the purpose and the way the atlas is meant to communicate (e.g., structured design for presenting facts, free layout for exploring). Basic technical issues, like mobile and/or desktop apps or browser-based solutions, compatibility and responsive design of the GUI [Marcotte 2014], have to be discussed. But also more graphical issues, like the question of using vector and/or raster graphics, have to be considered.
  The outcome of this step will be a setup of general affordances.
- *Use cases:* According to the UCD, specific user groups and profiles ("persona"), scenarios and activities have to be defined in order to get some typical use cases.
  As a result of this definition step, characteristic tasks and actions are recognized, leading to a better layout prioritization of the design elements.
- *Interactive Functionality:* To complete the investigation phase, the functionality of the static and dynamic atlas GUI features (icons, tools) has to be elaborated. Atlas authors can choose from a big offer of interactive functions [Cron et al. 2007]. Features belong to well-known groups such as general atlas functions, spatio-temporal navigation, thematic navigation, information and didactics, visualization, and analysis (see Chapter 9). Since the atlas GUI is heavily influenced by the number of functions, their degree of interactivity and hierarchical structure, the general setting of the atlas functionality has to be defined carefully: in most cases, less is more!
  The result is a schematic listing or sketch of all planned atlas UI-elements, showing their interactions, dependencies, and behavior.

FIGURE 7.6a

Examples of mobile atlas GUI: Children World Atlas [Barefoot Books 2014].

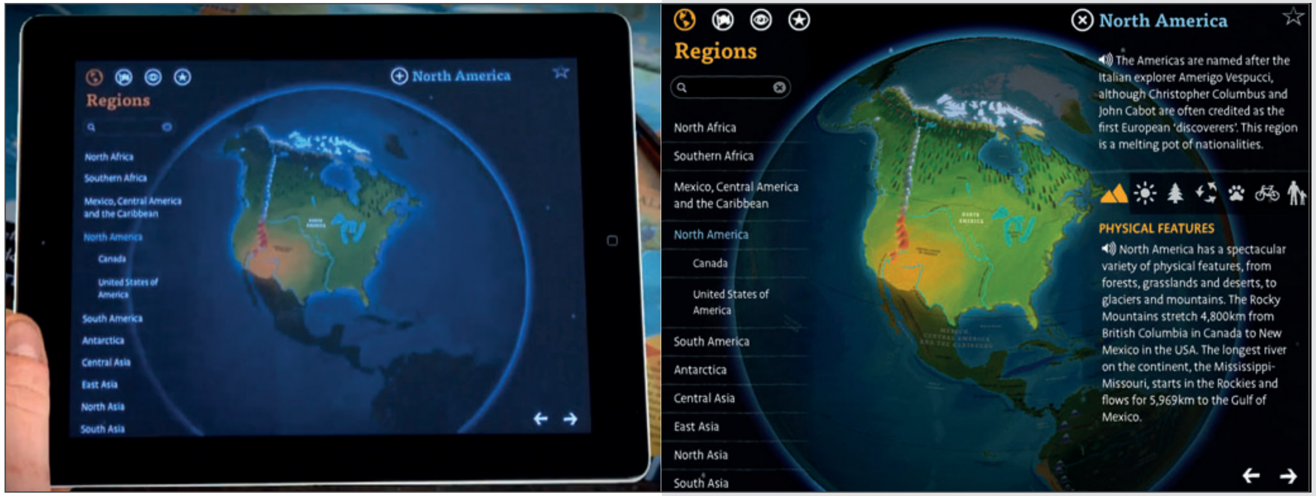
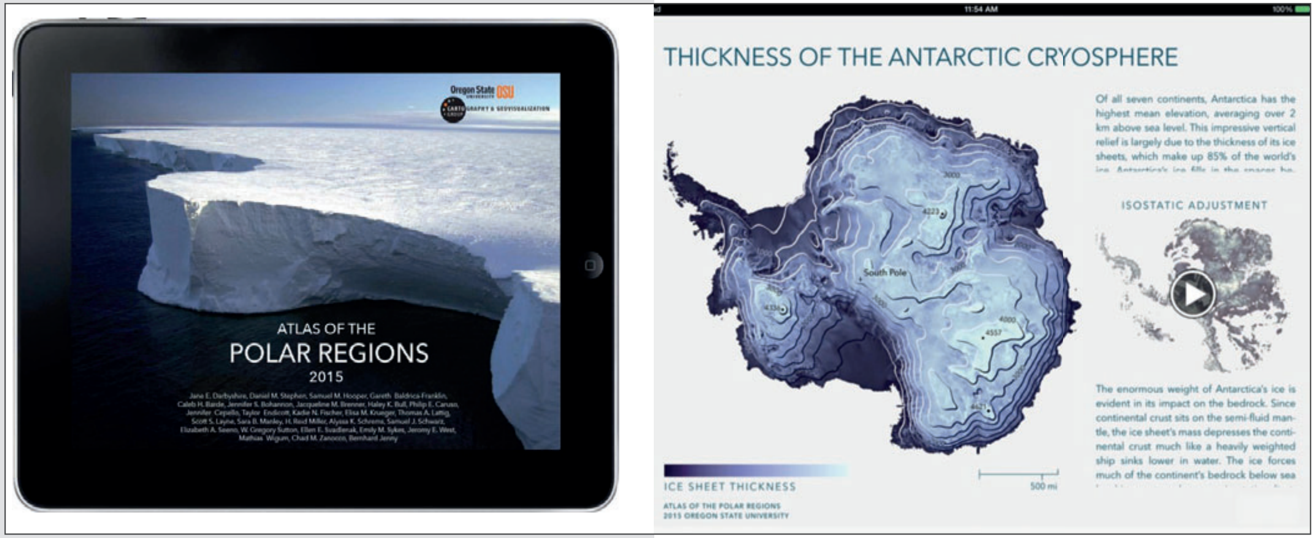


FIGURE 7.6b

Examples of eBook atlas GUI: Atlas of the Polar Regions [Oregon State University 2015].



Rough Design Phase

The rough design phase ranges from the definition of a general framework over an operating workflow sequence to a dedicated GUI specification. Using different prototyping techniques, potential graphical pitfalls, and structural dead-ends can be identified and hopefully avoided. Screen-flows and try-out-versions are produced to get a visual impression, but also to test the interactive behavior of the GUI (Figure 7.7a, 7.7b). The aim of this second design phase is to compose sketches of a coherent, well-working atlas GUI and to agree on a distinct design direction.

- *Wireframes:* Sketching and wireframing techniques are applied to define a storyboard. By means of this storyboard, a run through sequences of actions can be tested easily and improved with low effort. At the same time, the hierarchical structure of the GUI with layout prioritization of the design elements should also be looked at.
  The resulting document will be a storyboard of all relevant actions and statuses occurring in the atlas.
- *Moodboards:* Moodboards – also called artboards – reflect the main design direction of the product. Here, the “Look and Feel” of the atlas is defined. This comprises not only color schemes and styles, but also the arrangement of GUI elements in various showcase layout versions, as well as object animations and actions. It is important to judge these elements in combination with map design.
  The goal of this process phase is to get a vivid impression of possible design styles and to ease the decision on layout and graphics.
- *Overall GUI Design:* During the last step of the rough design phase, a number of main screens is created. Usually, two or three main screen examples are sufficient to cover the most typical GUI elements of an atlas. These exemplary main screens help to demonstrate the responsive concept for flexible multi-use of the atlas on different screen sizes and media. Decisions on general screen layout, typography, leading colors, etc. have to be represented in accom-

accompanying documents. It is also recommended to follow a rapid GUI prototyping approach to test the atlas usage and to clarify roughly the technical feasibility of the proposed atlas GUI.
Results of this phase endorse the general design direction.

> *Design Direction Presentation (DDP):* The DDP summarizes and concludes the rough design phase; it leads to a final decision on graphics and behavior. It has to be approved for release by the customer.

The rough design phase is crucial for the whole atlas project. It is likely that users stay longer on an atlas web site if the overall GUI design is appealing. Thus, an iterative evaluation and improvement of the overall design versions is highly recommended.

FIGURE 7.7a
Start screen design: wireframe (left) and moodboard (right) [Atlas of Switzerland – online].

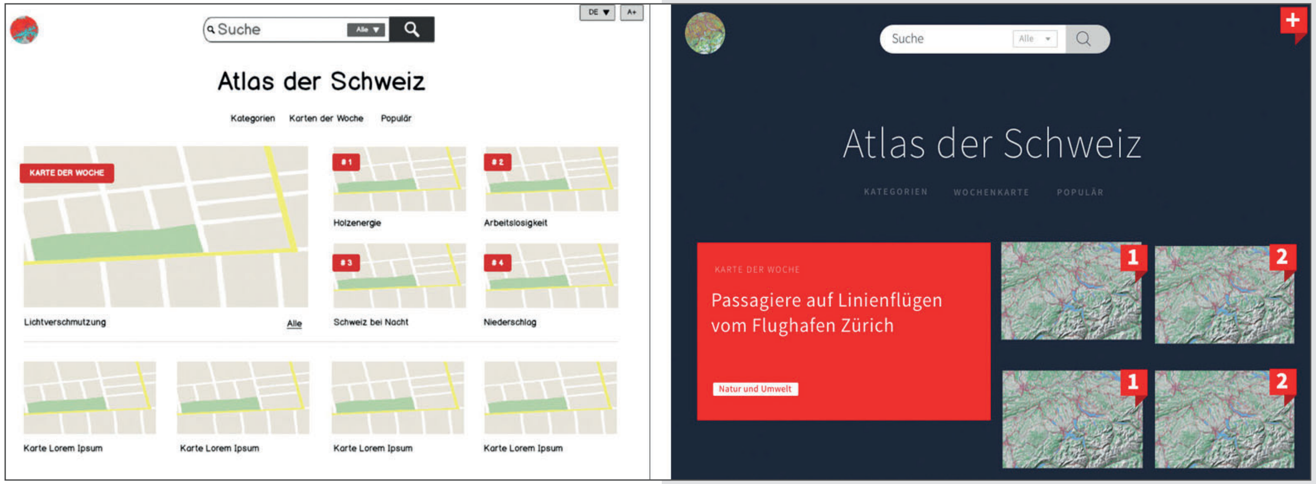
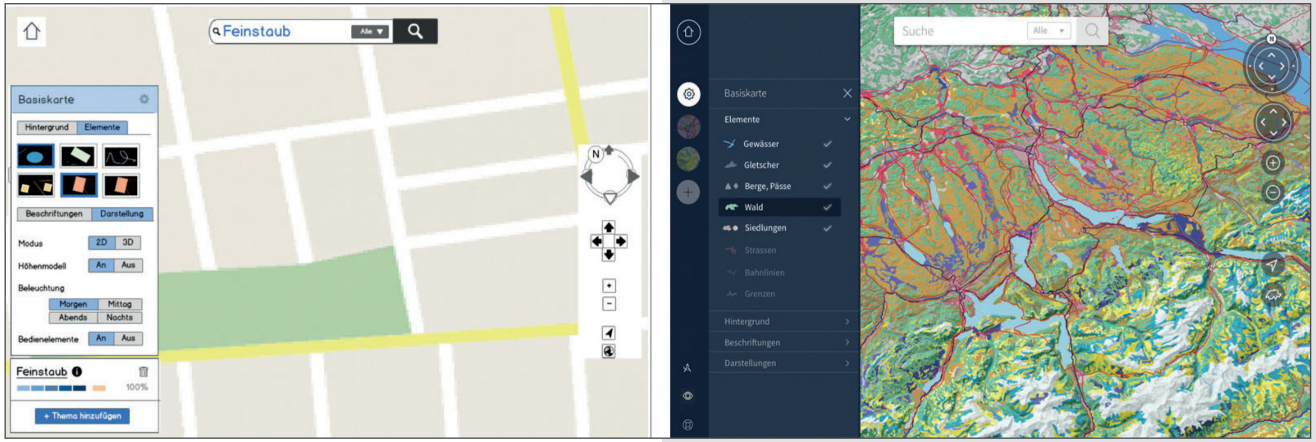


FIGURE 7.7b
Map screen design: wireframe (left) and moodboard (right) [Atlas of Switzerland – online].



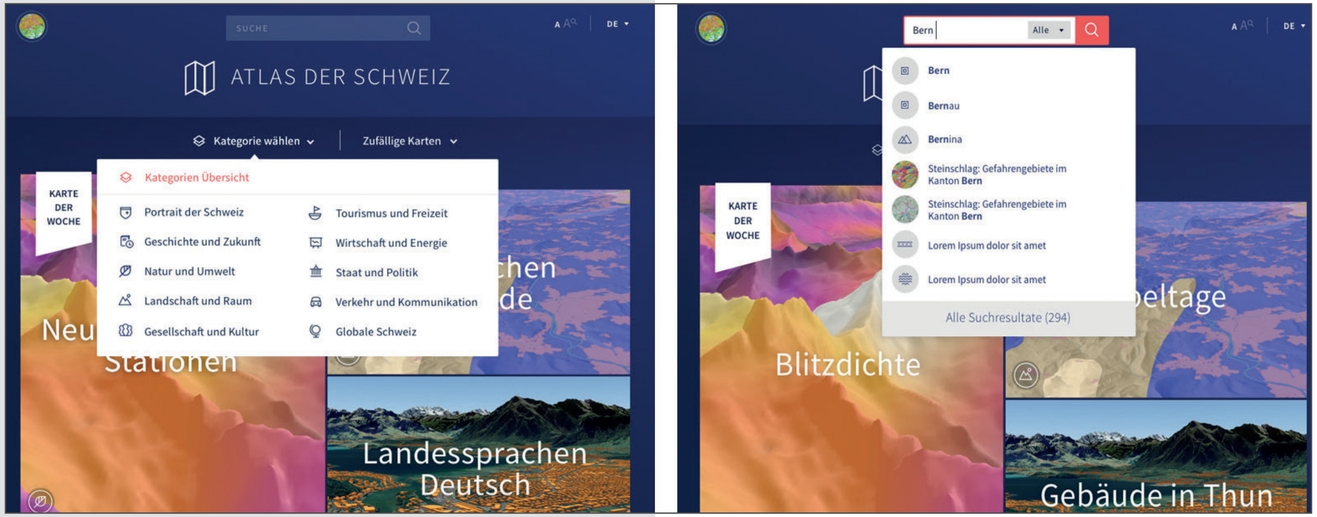
Detailed Design Phase

Once the main direction is approved and accepted by the involved parties, the detailed design can be worked out (Figure 7.8). Only slight changes of GUI design are envisaged during this phase. The intention is to get a clean graphical GUI layout and an interaction plan for further implementation.

- *Detailed Design:* Different screen layouts and single GUI elements have to be drawn or painted. Structural elements of the GUI like windows, icons, controls, as well as GUI interaction elements representing statuses (cursors, buttons), interactions (e.g., clicks), and animations (e.g., slide) are designed. Small corrections of color and element placement are carried out. *The achievement of the detailed design step is the final artwork, which should not be modified anymore.*
- *Design Specifications:* The final artwork has to be prepared for technical implementation: precise dimensioning and definition of all GUI elements and layouts has to be done, following the principle of "atomic design" (from smallest elements to largest ones). Another deliverable is the specification of statuses and interactions.
  The output of this design and specification phase is the Detailed Design Documentation.

\> *Detailed Design Documentation (DDD):* The DDD marks the end of the graphical design process within IxD. It serves as reference document for the implementation phase and contains the dimensions and behavioral description of every GUI element.

FIGURE 7.8a
Detailed design of the Start screen with main categories (left) and quick search (right)
[Atlas of Switzerland – online].



Design Implementation Phase

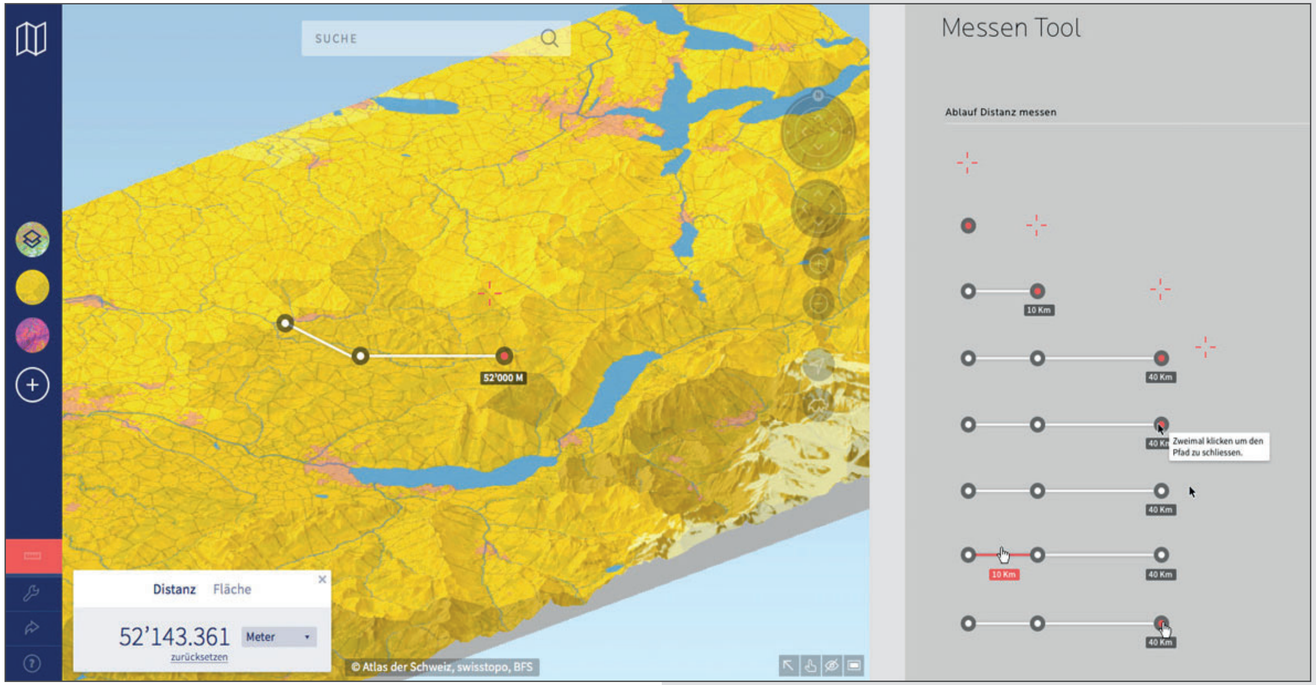
The last phase of the atlas GUI design process covers the technical implementation of the detailed design. In order to ensure a mutual understanding, the GUI designer, and the atlas authors should closely accompany the process. The goal of this phase is to build an operational GUI that could be used by different atlas versions.

- *Implementation of GUI Design Specifications:* The programming of GUI elements and their behavior (statuses, interactions and animations) should be delegated to specialized developers, such as front-end web developers. Requirements of different operation systems, browsers, devices and display environments have to be specified for them.
- *Implementation Testing:* For individual atlas components, intense functional testing has to be conducted. It is desired to fix bugs immediately to have working snapshots of the application available for further development and testing.
- *Usability Testing:* Testing the usefulness and usability of the atlas GUI certainly ameliorates the atlas handling, but has influence on the technical implementation, too. Potential atlas user groups were asked to check the functionality and to "play" with the atlas content. Thus, the integration and smooth usage of functions can be evaluated (see Chapter 3 and Chapter 10).

\> *Operational GUI:* The final result is a technically thin, robust and scalable GUI, working swiftly under different conditions. Ideally, the GUI assists atlas users in performing the tasks without coming to the fore.

FIGURE 7.8b

Detailed design of the Map screen (left) and specifications of the distance measure tool (right) [Atlas of Switzerland – online].



7.6 CONCLUSIONS

GUI design plays a crucial role in atlas production, since the atlas GUI is the all-embracing gateway to maps, attributes, tools and multimedia content. Although the atlas is organized internally in a rather complex structure in terms of thematic content and interactivity, the atlas GUI should provide an easy, seductive access to the maps. The GUI is one of the most important factors for the personal decision whether to use an atlas or not. And even if the person is actually using the atlas, the GUI and its interactivity strongly influences the duration and intensity of use, the pleasure of use, the levels of use, the knowledge gained, and finally the frequency of reuse.

Most important point to keep in mind is to start with the GUI design at the very beginning of the atlas project, or as soon as possible. The steps described in Chapter 7.5 can be applied like a cookbook; yet still it is possible to do it in another sequence, and to replace some ingredients by similar ones. The basic concepts and ideas are valid for interactive as well as for printed atlas products!

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8 VISUALIZATION AND MAP DESIGN

ERNST SPIESS

The visualization of the data, which is reflected in the map design, determines – in addition to the graphical user interface – the appearance and public perception of each atlas and has a strong influence on the recognition effect. Map design is thus one of the most important ingredients in atlas making. In an atlas, there is the advantage of presenting not only one single type of map, but various visualization modes (2D, 3D) and map types. Nevertheless, a well-elaborated visualization concept should be worked out to guide the atlas cooks on their way to a distinctive atlas product.

In this chapter, the broad variety of map modes, map types, and map graphics is shown including many graphic examples and useful hints.

8.1 VISUALIZATION CONCEPTS FOR GEODATA IN ATLASES

Printed atlases have always been a common and ideal medium for the visual presentation of large amounts of geospatial data. The map editor, having in mind a specific segment of map users, selects a series of topics from the abundance of available georeferenced base materials. Within each topic she/he chooses and combines the appropriate map features, analyzes and synthesizes their logic thematic structures and translates them into a map symbol structure that corresponds to that logic. As a result, the map user is presented for each topic with a map that shows a static view. Whether in bound book form or prepared for the display on the monitor, a whole collection of such maps, developed from the selected source data, may be called therefore a *view-only atlas* (see position A in Figure 8.1).

The advent of electronic atlases has opened for the map user entirely new perspectives. The notion of interaction enlarges their potential. It enables a whole range of new functionalities. It has added to the map use a third dimension. This concept has been illustrated first by MacEachren [1994] in the form of the *map use cube* (Figure 8.1). It can help the map atlas editor to position his atlas project by considering the amount of interaction he might allow his users, the degree of synthesis and fixed or open map symbolization he intends to provide.

FIGURE 8.1

Map use cube and interactive atlases [after MacEachren and Kraak 2001, modified].

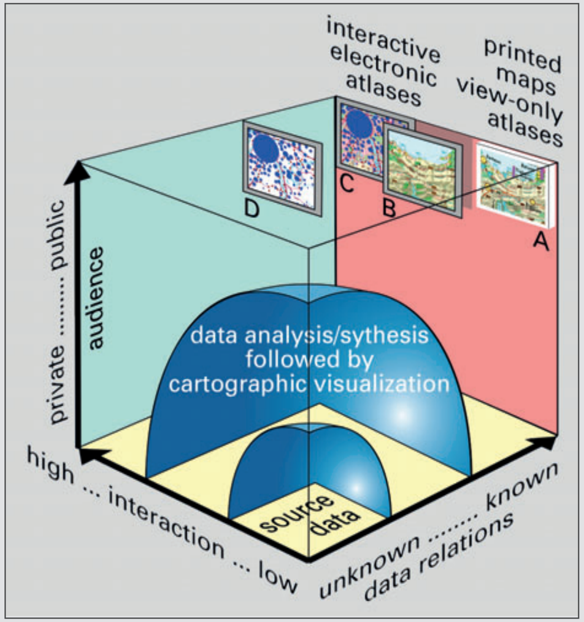


FIGURE 8.2

An interactive online-map with clickable layers, zooming and panning for the presentation of inventories of renewable energy [Renewable Energy Atlas 2012].

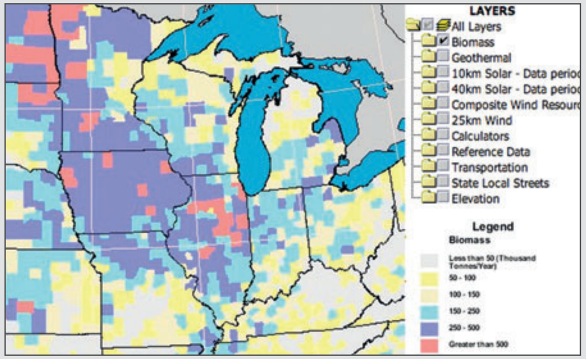
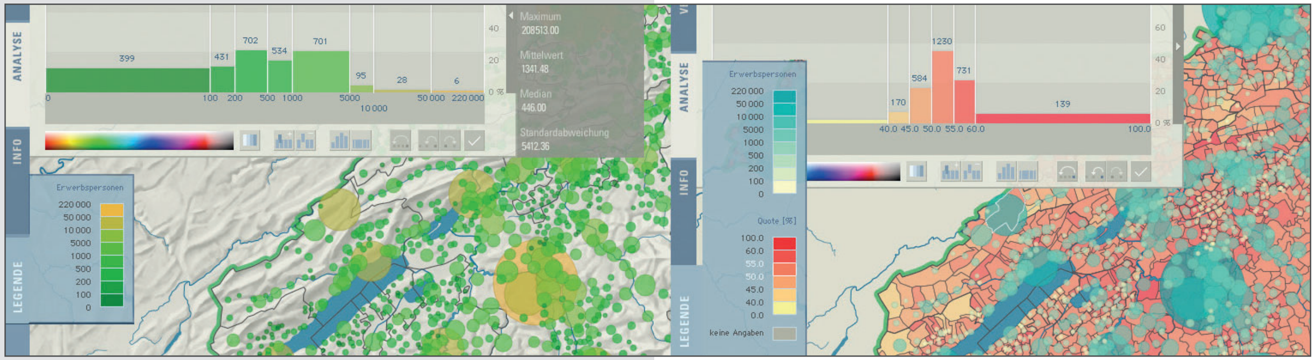


FIGURE 8.3

Two versions of an interactive online-map using different tools for further analysis and modification of the symbolization of statistical data about the active population [Atlas of Switzerland 2.0 2004].



Position B in Figure 8.1 stands e.g., for a *web atlas* that leaves the user with rather restricted means of interaction, like switching on and off different image levels, zooming, panning, etc. Such a concept may be useful for an inexperienced user group.

Position C on the other hand represents an *interactive electronic atlas* with maps that are conceptually structured and designed. But in addition the user has means for further analysis based on original or map data, and a wide range of functionalities for map image manipulations as e.g., change of contrast or transparency, of map symbolization like color and form for the presentation of the data. This atlas type is positioned very near to a geographic information system. It has however the advantage that the data have passed already through a profound analysis, symbolization and design process.

The position of atlas type D – the *analytical atlas* type – in contrast indicates a collection of maps for which the data sets have been more or less provisionally visualized cartographically for further analysis purposes. Possible correlations or interdependencies are known only partly and left open-ended. The profound analysis and interpretation is left to the individual user. The symbolization for such an atlas must remain therefore very flexible. The researchers will want to make full use of all kind of interactive manipulations.

Optimal or Multipurpose Visualization

Depending of the user group the atlas editor has in mind, he will therefore have to decide, if he strives for a meticulously elaborated cartographic design, which will be functionally and efficiently work in almost all cases of user requirements. The main purpose of the interactions to be included is to support and facilitate the interpretation (Figure 8.2). The technique of adaptive map images is part of these efforts for optimization.

The alternative is an open, more or less preliminary design which leaves a number of perspectives for changes to the user group. This approach holds a lot of potential when further analysis and cross-relations are foreseen as the main use of the atlas.

In this case the appropriate functionalities must be available within the atlas, that is tools for free symbol and diagram design, color choice, layer management etc. (Figure 8.3).

Shortcomings of solutions as in Figure 8.3: The placement of tags for the analysis as well as the legends or its parts seem to be steered by the empty space available. They may be often situated far away from the corresponding map element, so that the colors are hard to distinguish or to assign (e.g., in a geology map with hundreds of layer tints).

Cartographic Visualization for 3D Maps

In a 2D map the image plane displays the geospatial 2D coordinates for the location of the map feature, while the symbolized attributes represent a virtual third dimension. The intention to use instead symbols in real 3D shape, is therefore an obvious idea (Figure 8.4). The result is "an artificially produced vision, which is recognized by the visual perception system as being spatial, although there exists no real spatial model" [Buchroithner and Schenkel 2001].
However, in terrain representations such as panoramas, perspective terrestrial or airborne camera views, as well as stereoscopic and holographic imagery, the spatial model is the real earth surface. Some of these representations also play a certain role in 3D mapping.

Advantages of 3D Maps

- Suggestive map image:
  The degree of abstraction of the map symbols can be reduced by presenting a common view on symbol aspect or size (Figure 8.4).

- Correlations with a familiar terrain aspect:
  The influence of terrain forms and height on the map features represented can be made directly visible by overlaying the terrain surface with thematic information as e.g., geology (Figure 8.5).

- Naturalistic approach to terrain profiles:
  The familiar aspects of the horizons or profiles in a landscape can be recognized much easier as the substitute methods of terrain representation.

- Notion of volume:
  The presence of real z-coordinates allows for a rough estimation of volumes of both, terrain forms and 3D symbols.

- New insights in unknown structures:
  The 3D visualization may provide for an easier access into unknown spatial structures or regions.

A 3D map is a perspective representation of geodata which is perceived by the user as three-dimensional.

FIGURE 8.4

Perspective 3D map symbols showing the number of inhabitants per ha. Hidden information can be overcome by rotating the image, but background information (satellite image) is covered [Dickmann and Sohst 2008].

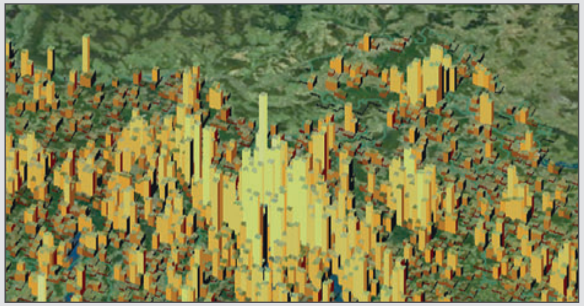
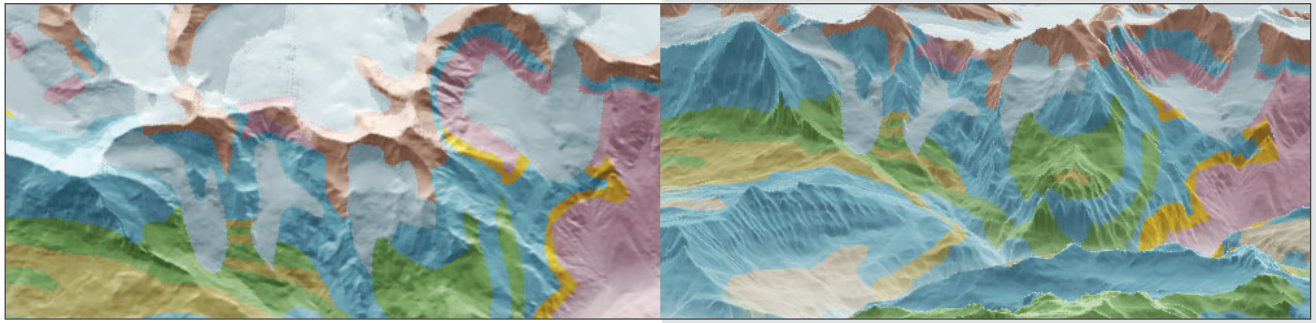


FIGURE 8.5

The 3D version of a terrain map opens entirely new insights, in this case in the geological structure. The interpretation is facilitated because of the familiar scenery of the crest-line [Atlas of Switzerland 2.0 2004].



Disadvantages of 3D Maps

- Loss of easily accessible 2D geometry:
  Relative distances cannot be measured or estimated. The image plain is more or less distorted.

- Considerable parts of the terrain are hidden:
  Due to the elevation of terrain forms in z-direction smaller forms and valleys in the background may be covered by the foreground (Figure 8.5).

- Base map hidden by 3D symbols:
  Due to the 3D effect of the symbols and the inclined position of the projection plain large parts of the base map may be hidden (Figure 8.4).

- Difficulties in the allocation of labels:
  In a 2D map each name is attributed to a visible object or area. In certain 3D maps many of these are hidden behind the foreground ridges or symbols, which causes problems in the correct allocation of the respective names.

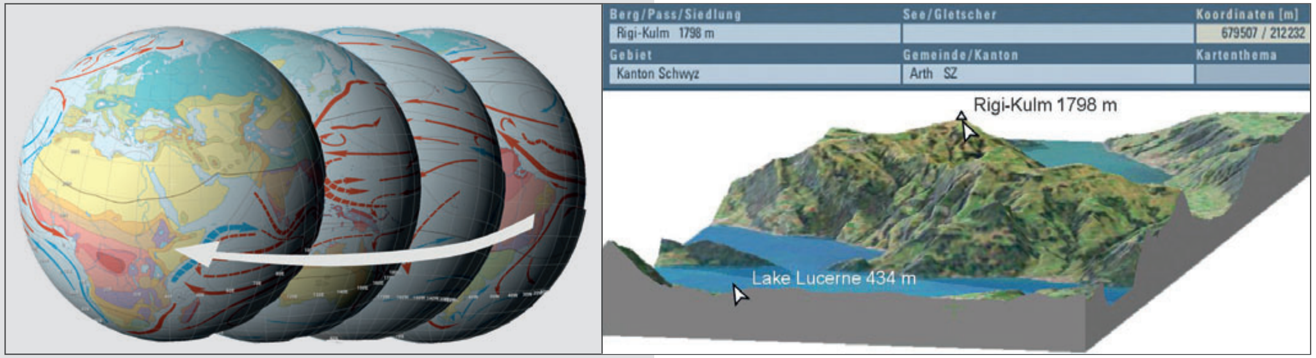
Interactive Functions to Reduce these Deficiencies

- Moving origin and direction of viewing:
  With a dynamic module that allows to vary the projection origin and the direction of viewing the problem of hidden areas and symbols can be minimized (Figure 8.6). But the user can read the map only sequentially and never as a whole.

- Additional alpha-numerical information:
  With a mouse over function each map feature can be addressed. The respective numerical data or elevation can be displayed and in this way replace critical estimations (Figure 8.7).

- Polygon driven labeling:
  Individual map features can be named when the map area is divided in label areas. The name appears with mouse over on the object or in a name box (Figure 8.7).

FIGURE 8.6 (left) and 8.7 (right)
Left: Changing the direction of viewing is an indispensable tool for every 3D map to reach all the hidden areas [Swiss World Atlas interactive 2009].
Right: Interactive labeling and coordinate measuring feature, activated by mouse over in a 3D map, a substitute for labeled and scaled 2D maps [Atlas of Switzerland 2.0 2004].



8.2 BASE MAPS

Rectangular and Insular Map Frames

Rectangular map frames are more or less standard for maps on displays, because the computer windows are rectangular as well (Figure 8.8).

Insular map frames (within a rectangular window) may be useful or necessary if the data to be mapped is restricted to an otherwise delineated area, as e.g., an administrative boundary (Figure 8.9). A problem may arise if there are isolated data also outside that boundary, because the user expects a homogeneous symbolization on both sides, which may not be supported by the available data.

Geocoding the Map Data

An electronic atlas has the great advantage that the data can be geocoded. Whenever necessary the coordinates of any point in the map are displayed in a little box or window (Figure 8.7). Geocoding of the map data is highly recommended.

This does not mean that we can dispense with base map elements. They provide for a quick orientation which is often just enough.

Map Projection and Map Graticule

In general, the map data will be displayed in a projection according to specific needs. For the map grid or graticule a separate level should be provided that can be switched off if not needed. Labeling the graticule poses some problems. If the map is rotated the labels should always hold a horizontal position and show up within the map frame (Figure 8.10).

Strategies for the Selection of Base Map Layers

The advantage of the electronic atlas is that there is no need to conceive a carefully balanced base map for all purposes of map use. With a series of clickable base map layers all needs can be met without overloading the map image. A certain minimum should however be present all the time for orientation.

Criteria for the Selection of Base Map Features

- Mind map of the potential map users:
  Map features with elements the map user is familiar with, as e.g., names of important towns, prominent lakes, bays, mountains are important. Such landmarks allow for positioning the other map features in the user's mental background.

- Allowing approximate geographic location:
  The user must be able to localize each map element relatively to base map elements which are known to him or for which he has means to identify (Figure 8.5).

- Interdependencies between the topic and the base map elements:
  Base map features, which have a close relation to specific thematic layers of the map, are especially important to support the search for correlations in map analysis.

FIGURE 8.8

Three open windows with rectangular frames, two maps represented only with a small section of the map. [Swiss World Atlas interactive 2009].

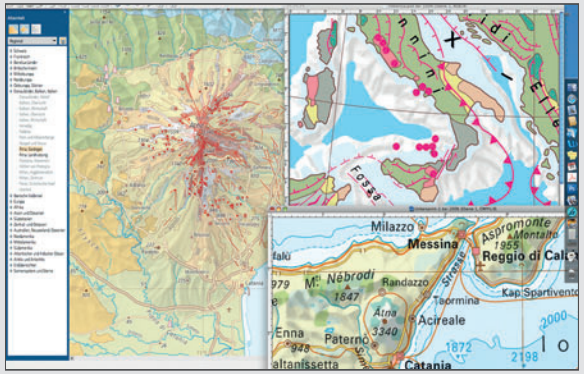


FIGURE 8.9

Insular map [Umweltatlas Berlin 2004].

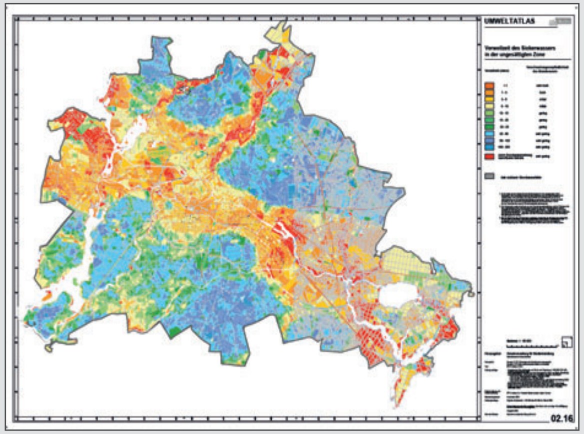


FIGURE 8.10

Labeled map graticule with text keeping always the horizontal position [Swiss World Atlas interactive 2009].

- Base map layers which do not interfere graphically with the other map layers:
  The selection of the base map features must take care of the graphic structure of the different map layers. Superposition of equal structures is to be avoided or must be handled very carefully, e.g., contour lines as base for a topic shown by isorithms.

Typical Base Map Components

- Hydrography:
  Sea shore, rivers, lakes, canals
- Administrative boundaries:
  National, provincial, regional boundaries
- Geonames:
  Names of countries, towns, rivers, etc.
- Topographic features:
  Mountains, valleys, plains, relief
- Traffic networks:
  Highways, main roads, railways, airports
- Map grid or map graticule:
  Labeled grid lines, north direction, scale bar.

Adaptive Base Maps

Considering the fact that zooming is probably one of the most used functionalities in an electronic atlas, the question arises for what map scale the base map is to be conceived. In order to meet the need for a base map that is well balanced for the chosen map scale, the concept of *adaptive zooming* has been developed [Cecconi & Galanda 2002]. It means that several versions of the base map are made available, each of which adapts ideally to a certain scale range.

In other words, the base maps have to be generalized to maintain their functions as geographical localizer and as a resource for map analysis when the map is zoomed in and out.

For the tectonic map in Figure 8.12, zooming is available in four fixed scales. For each of them one to four classes of rivers are selected for the base map (Figure 8.11). To each of these combinations specific line widths are attributed automatically.

FIGURE 8.11

Splitting the hydrography network in four classes [Atlas of Switzerland 2.0 2004].

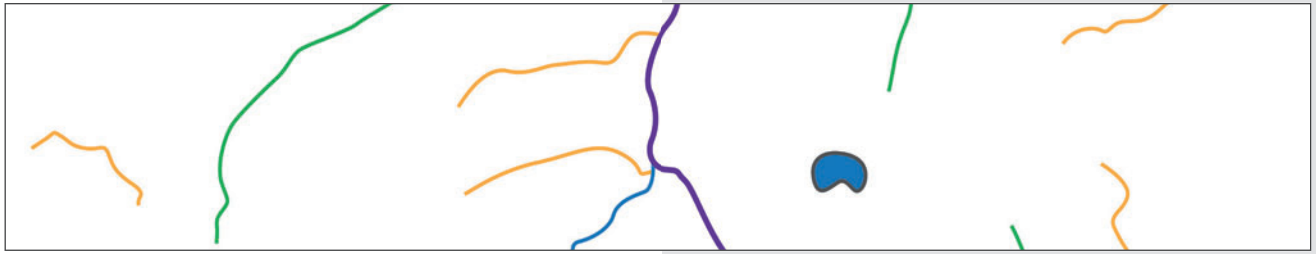


FIGURE 8.12

Depending on the zoom range on the display, the hydrography component of the base map is adapted to the map scale [Atlas of Switzerland 2.0 2004].

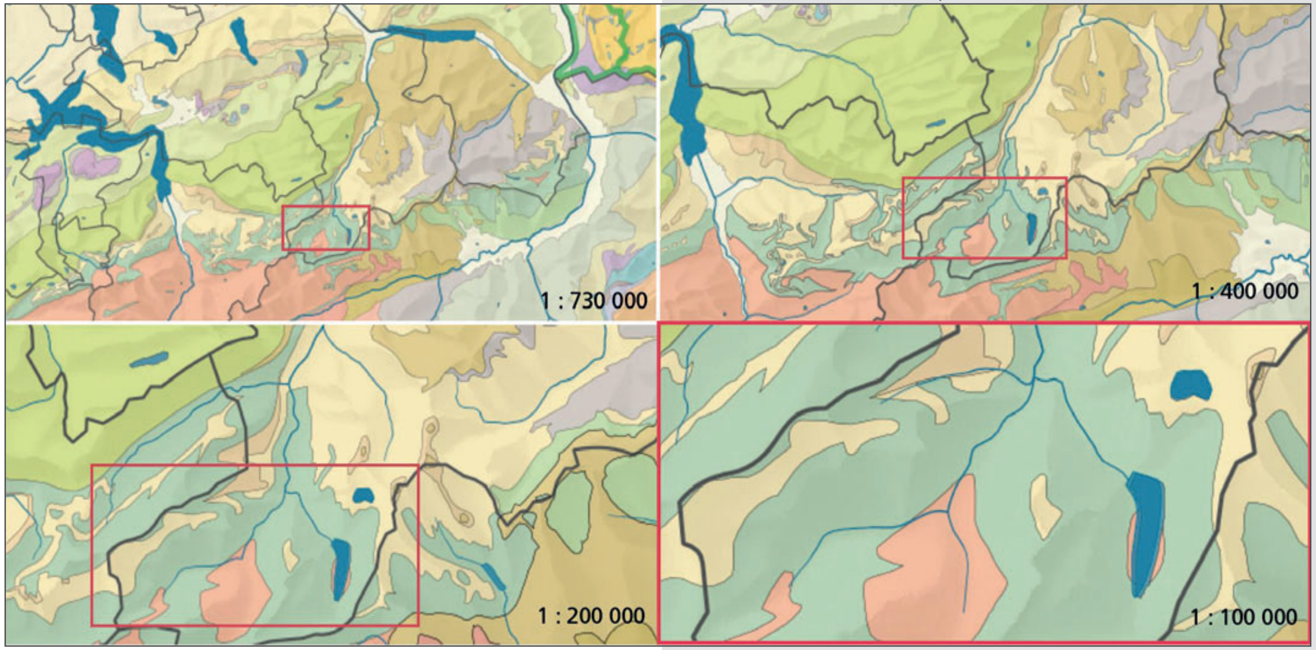
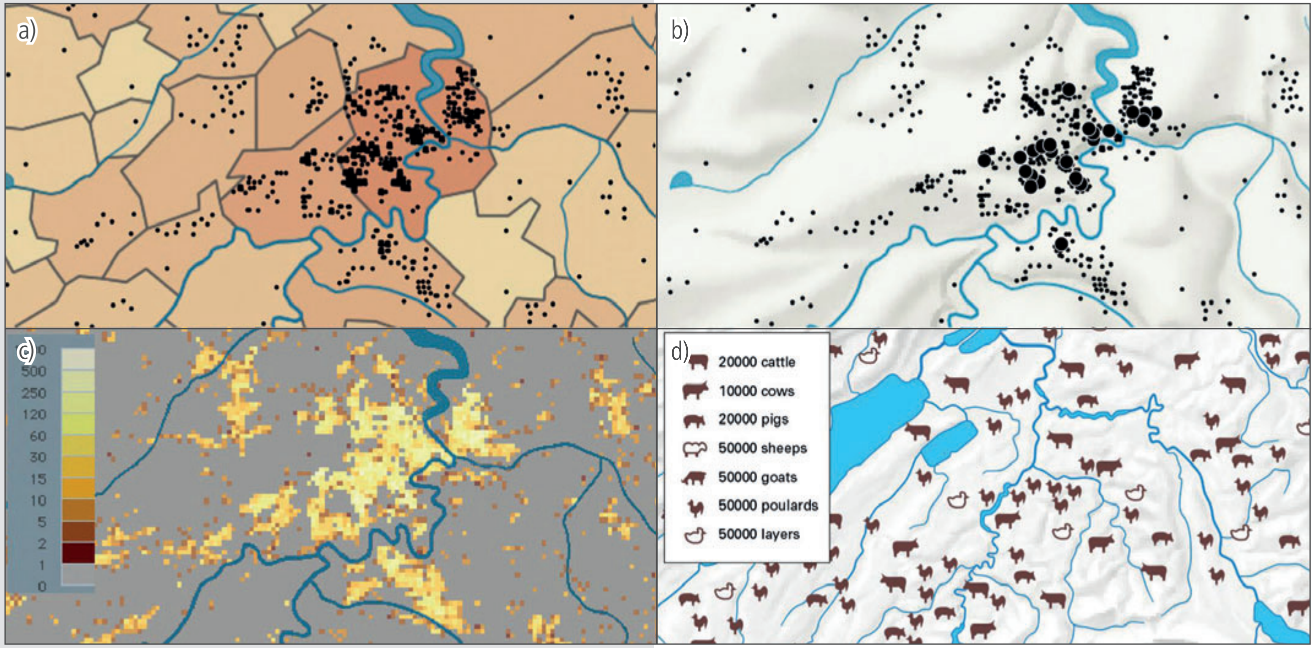


FIGURE 8.13a-d

a) Dot density layer over choropleth layer
b) Dot density layer with two unit sizes
(100 and 1 000 inhabitants)
c) Square grid map showing population distribution
d) Qualitative distribution map, differentiated by
symbol form
[Atlas of Switzerland 2.0 2007].



8.3 MAP TYPES FROM A GRAPHICAL POINT OF VIEW

Considerations about Choosing Map Types

In the analysis of the geodata to be mapped it is important to consider whether the objects of a feature refer geographically to a point, to a line or to an area. This allocation may be different for the same map feature depending on the map scale.

The point of departure in symbolizing these data is to represent this geometry with the corresponding map symbol category, point symbols, line symbols or area symbols. These symbols are not geometric elements in their true sense, but their appearance and context within the map image give the map reader the impression that they refer to a well-defined point, line or area.

Another important aspect of the analysis of the data before map symbolization is the nature of the features to be represented. The information contained may be:

- numerical or quantitative:
  e.g., number of persons, tons, dollars, ratios, proportions, percentages, numerical densities, etc., together with their range
- sequential or ordered:
  e.g., intervals of sizes or numbers (Figure 8.13c), classes of importance, road classes, hierarchy of boundaries, temporal series, etc.
- qualitative or of different kind:
  e.g., different animals (Figure 8.13d), different soil, religion, language, land use, mining products, etc.

The number of classes needs to be considered while choosing an appropriate symbolization.

Dot Density Map
This map type presents the data with one standardized unit optimally positioned (be it a quantity, an object of one kind, etc.). For all these units there is one and the same symbol, e.g., a dot. The size and value of the dot or symbol needs careful consideration to avoid clumping or large unit values (Figure 8.13a).

Dot Density Map with Several Units
If there is too much overlap in regions of high dot concentration, the individual dots cannot be distinguished any more. In this case the method of using more than one unit may be appropriate. In Figure 8.13b each small dot represents 100 inhabitants. The larger dot stands for 1000 and has ten times the area of the smaller one. Dot maps provide for a subtle distribution of the facts.

Square Grid Map
In this map type the information refers to squares of areas of equal size which cover the whole map space. In Figure 8.13c the number of inhabitants per hectare is split up in a sequential range of eleven classes. The color scheme from dark brown to light yellow is difficult to tell apart. It is reversed to the usual rule “the more, the darker”, simulating here the number of lights at night.

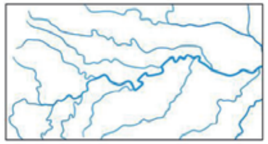
Point Symbol Distribution Map
In contrast to Figure 8.13b the seven object classes in Figure 8.13d represent a qualitative difference, which is rendered by the variable symbol form. Each symbol stands for a fixed number of animals within a fuzzy area around it. If the distribution of each class was to be shown separately, additional color coding would be helpful.

Line Network Structures
When developing a multivariate map with a superposition of several feature layers, the characteristic structures of the linear networks are sensitive (see 8.6 Layer Management).
The graphical structure of the lines should represent the main characteristics of the topic. As an example, smooth, closed non-overlapping lines stand for an isoline structure, revealing an orographic, bathymetric, or even meteorological topography.

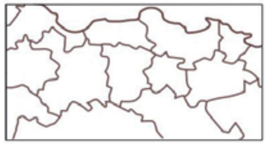
Line networks can be directed (in one or two directions), not directed (free, without specific meaning), or implicitly directed. An implicit direction is met, when a swarm of open-ended lines form a kind of lineament structure, as it is the case with break lines in a geology map.

Isoline structure
Closed lines, no junctions
and crossings

Tree structure
Open-ended polygons
with junctions

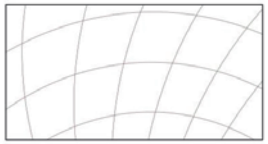


Polygon network
Closed polygons with nodes
and paths



Traffic network
Crossing and joining polygons
with different characteristics

Grid structures
Mathematically defined
straight-forward geometry



Arrow structures
Swarm of curved or straight
arrows in various directions

Lineament structure
Swarm of open-ended
line segments

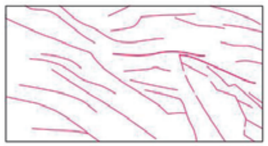
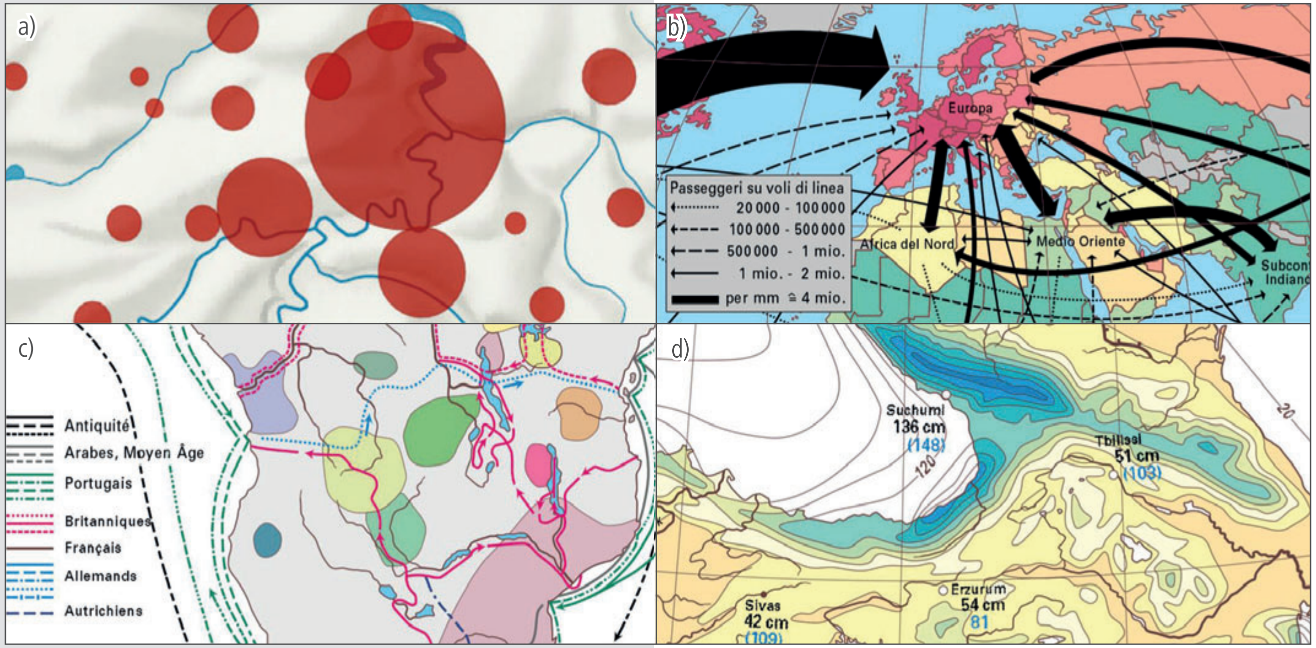


FIGURE 8.14a-d

a) Population per community by area proportional circles [Atlas of Switzerland 2.0 2007].
b) Proportional line width for large numbers of passengers
c) Line map representing different explorers by nationality
d) Isoline map and area mosaic with annual precipitation [Schweizer Weltatlas 2008, mod.].



Proportional Point Map

Quantitative data is represented by area proportional symbols (dots, squares, bars). There is some arguing about the precision of comparisons of the symbol area. A declaration about the area proportional figure scale is therefore recommended (Figure 8.14a).

Proportional Line Map

Quantitative data related to a line is shown by proportional line widths. The possible range of line widths is very restricted. Extreme values on both sides can be broken down in class intervals. In Figure 8.14b numbers between 1.7 and 25 Mio. are represented proportionally. Smaller values are split up in four classes and differentiated with line textures.

Line Map with Qualitative Data

This map shows the main qualitative difference (nationalities) by color, while each subgroup (individual researchers) is symbolized by varying the line texture. The background layer is an area mosaic with the hydrography net work for the base map (Figure 8.14c).

Isoline Map

Each isoline represents a specific quantity. The values of the intermediate points may be interpolated, because the line system is understood as a continuum. In order to enhance the interpretation, the isolines are supported by an area mosaic in the background. The spaces in between the lines are filled with two sequences of colors with the messages “the more blue – the more rain” and “the more brown – the dryer” (Figure 8.14d).

Choropleth Map

In this map type quantitative data is spread over the area it refers to, in Figure 8.15a shown by a diverging color scale. If the data is not computed per area unit (as in Figure 8.13a), the map reader gets visually a wrong impression about the effective numbers (added here for demonstration of the problem).

General Reference Map

This map type shown in Figure 8.15b serves for general orientation. It can be seen as an extended version of a base map, but is not suitable as such. Typical features represented are

- Hydrography
- Relief and spot heights
- Major towns or localities
- Main traffic network
- Geographical names.

Orthophoto Map

The orthophoto map is a mosaic of geo-coded aerial or satellite imagery with switched on additional map features (in Figure 8.15c: roads, railways, rivers and contours). Unlike the classified map features the orthophoto image is left entirely to the interpretation by the map reader. The given scale of the image allows only for a restricted range of zooming.

Panorama

The panorama is a representative of the group of map-like images. It is displayed in central perspective, combining data of the digital terrain model with satellite imagery and other features (Figure 8.15d). Other forms of representations belonging to this group are stereo maps, anaglyph maps, hologram maps and block diagrams.

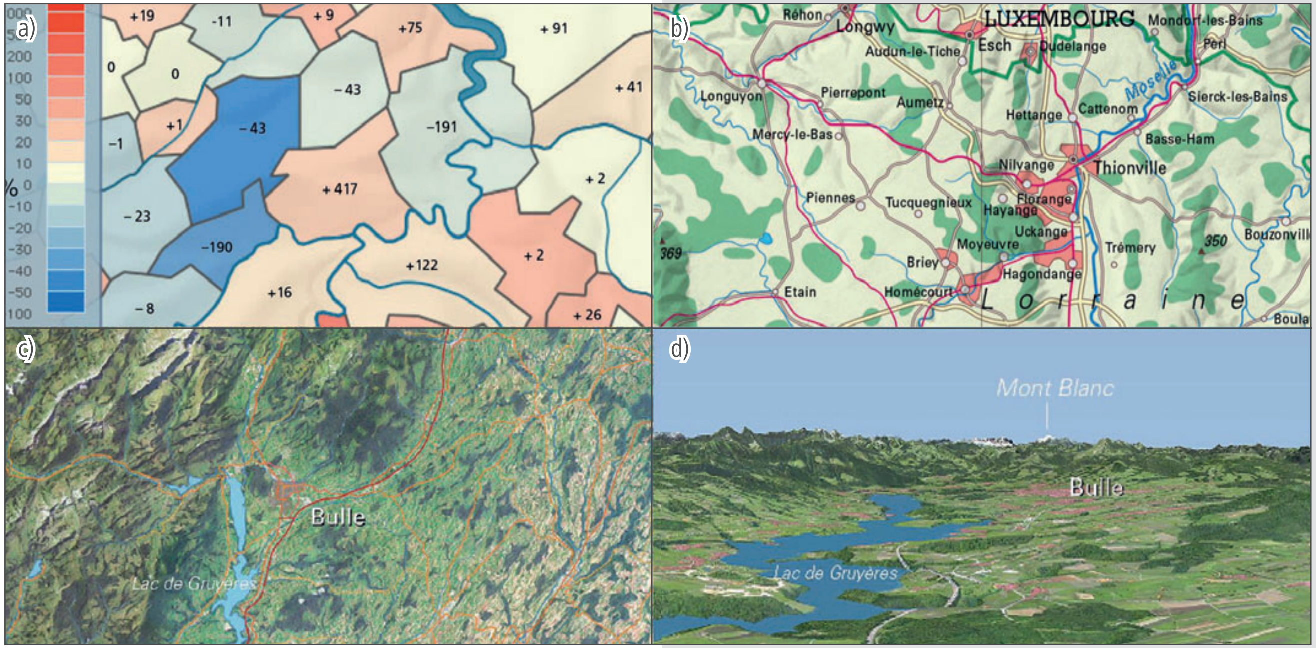


FIGURE 8.15a-d

a) Choropleth map; change of active workers 1998–2003 in percent [Atlas of Switzerland 2.0 2007, mod.].

b) General reference map [Schweizer Weltatlas 2008].

c) Orthophoto map overlaid with traffic information [Atlas of Switzerland 3.0 2011].

d) Geodata-based panorama [Atlas of Switzerland 3.0 2011].

FIGURE 8.16

Suitability of diagram types [Bertin 1967, mod.].

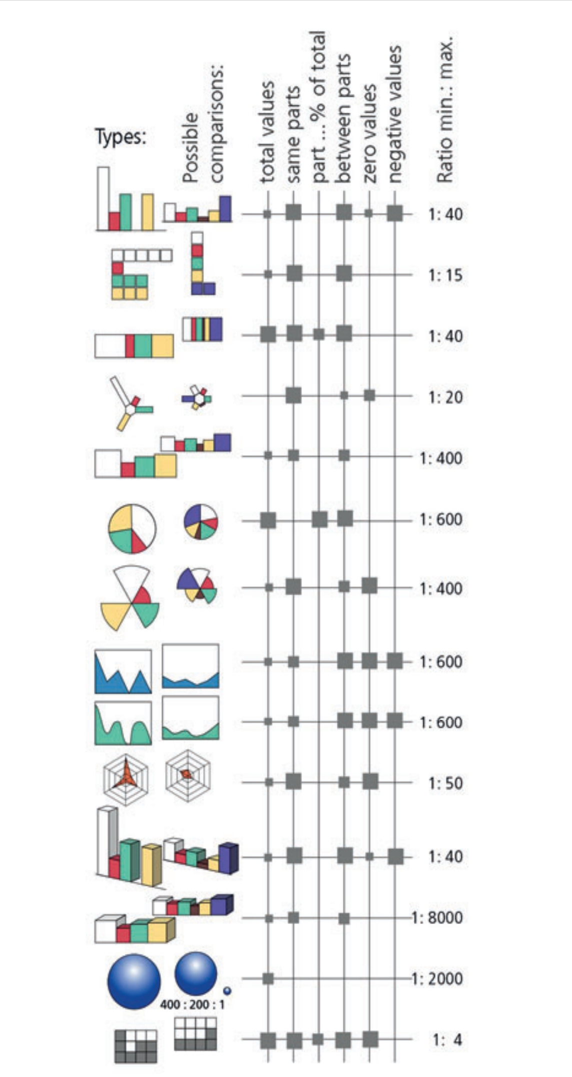


Diagram and Chart Maps

The diagrams or charts in this map type always refer to a certain point, line or area location. The general context of the map explains this allocation.

The datasets to be represented by diagrams may be of quantitative, sequentially ordered or qualitative nature, whereby two or a few more of them are combined. Geometrically these components are laid out usually in an orthogonal, polar or grid mode.

For the map reader each diagram type offers very specific properties. The choice should be made according to the predominant questions, when comparing the different diagrams within the map.

In Figure 8.16 the suitability of some diagram types is assessed under the following three aspects:

1. Comparisons are possible between the
   - added values of each diagram
   - values of parts in all diagrams
   - parts and the total per diagram
   - parts within the diagram
   - zero values and other parts.

2. Ratio of quantitative data
   The map space available for the diagrams is rather limited. Therefore, there are certain restrictions as to the amount of information that can be shown. The restricted size of the diagrams allows only for a limited ratio between the minimum and maximum quantity to be represented.

3. Limited number of intervals or kinds
   Usually, a feature in a diagram can only be divided into a small number of classes.

Grouped Bar Chart

The ratio between the minimal and maximal quantity of tons in this map is 1:120 (Ipswich – Antwerpen/Rotterdam). The empty area of the North Sea allows in this case for a bar of 90 mm (Figure 8.17a). Where there is not enough space, the long bars could be split up and stacked behind each other.

Unit-area Chart

In this map type the quantities are countable. They are rounded to the unit size, which has the advantage that estimation errors are avoided. Where large numbers ask for long ranges, which are difficult to localize, the unit may be stacked 10 by 10 or 5 by 5 (Figure 8.17b).

Wing Diagram Map

This map illustrates the number of active persons in the service sector, divided up in six subsectors. For municipalities with small values, the total number of active persons is indicated by a circle and only sectors above a minimum size are displayed. The estimation and comparison of the area proportional sectors of the different (e.g., yellow) diagrams is rather difficult (Figure 8.17c).

Cube Diagram Map

The export quantities to be represented in this map vary between 100 and 560 000 tons, a case for the use of volume symbols. It is left to the map reader to make reasonable estimations. Here, the gross differences and relative magnitudes are more important than precise quantities. The black bars stand for the respective values in money (Figure 8.17d).

FIGURE 8.17a-d

a) Bar chart with three kinds of unloaded and loaded goods [Schweizer Weltatlas 2008, mod.].

b) Unit-area chart with 5 classes on an area mosaic (proteins) [Schweizer Weltatlas 2008, mod.].

c) Wing diagrams with six subgroups of the service sector [Atlas der Schweiz 1997].

d) Cube diagram map for rather diverging export quantities [Atlas der Schweiz 1981].

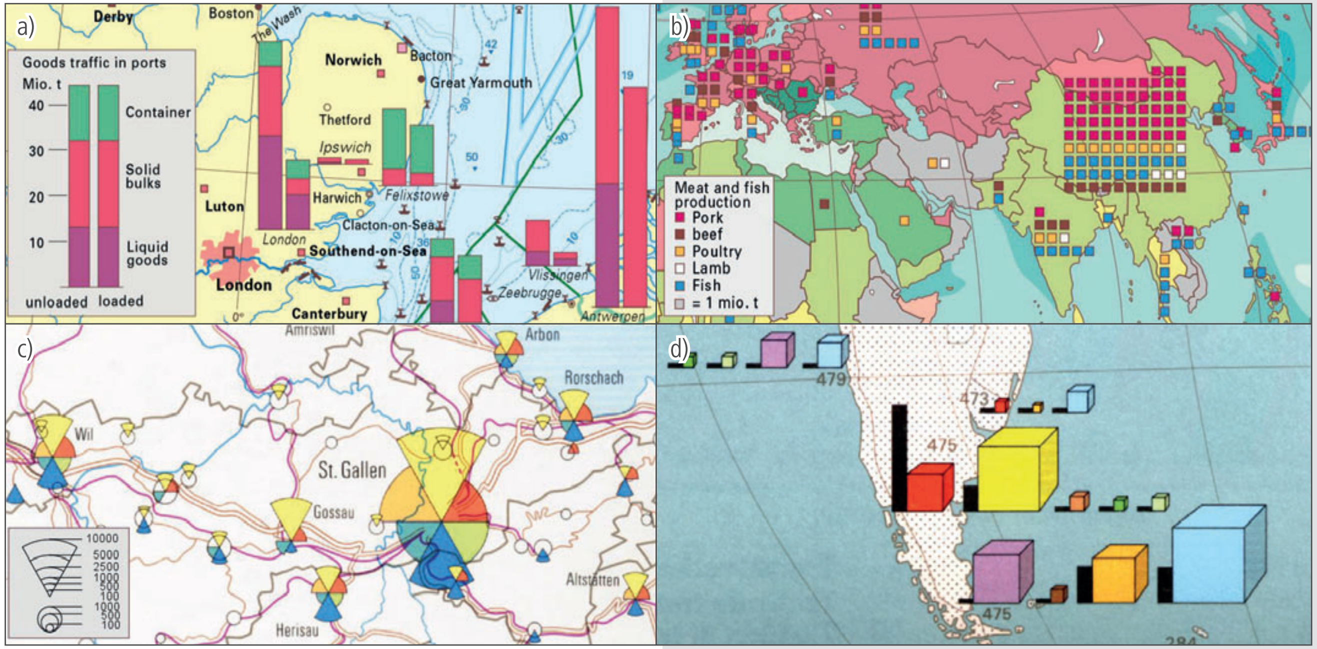
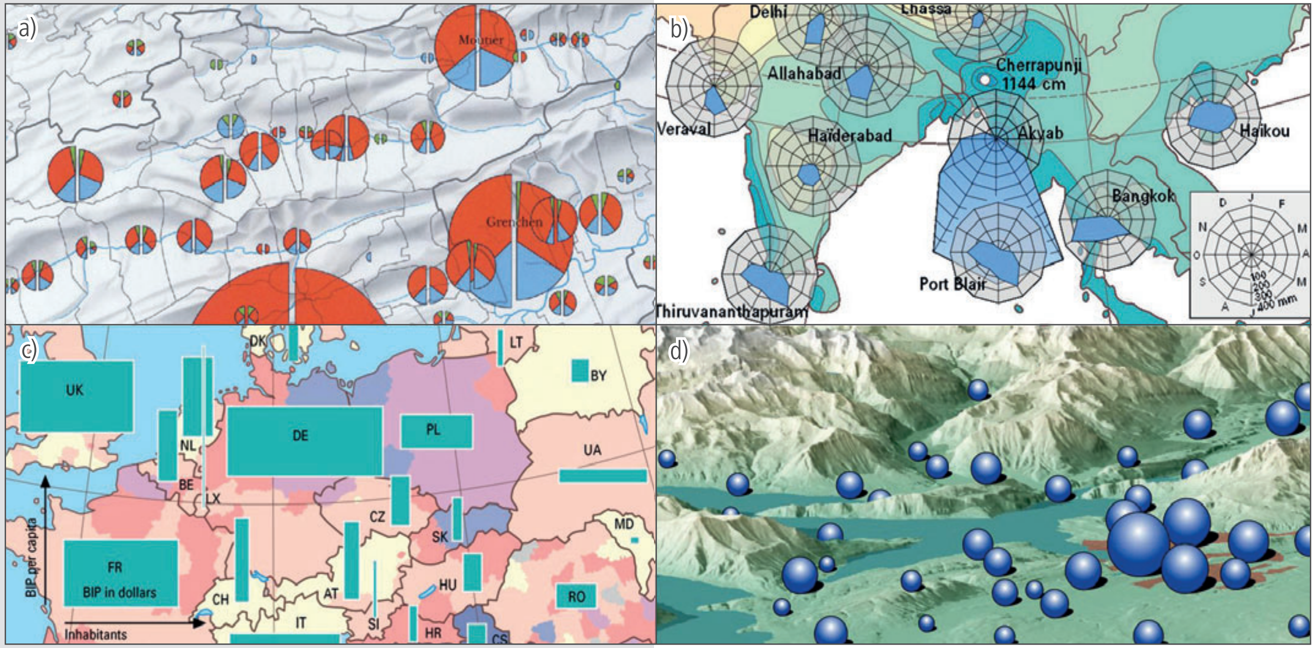


FIGURE 8.18a-d

a) Combined pie diagrams (temporal change of occupation) [Agustoni et al. 1991].
b) Polar line chart (monthly precipitation over annual values) [Schweizer Weltatlas 2008, mod.].
c) Rectangular diagrams, choropleth map in the background [Schweizer Weltatlas 2008, mod.].
d) 3D map with pseudo 3D spheres (population) [Atlas of Switzerland 3.0 2011].



Combined Pie Chart

The differences between each two opposed half circles demonstrate the development in a ten years period. The half circles are divided up in the three main economic sectors, agriculture, industry and services (Figure 8.18a).

Polar Line Chart

The polar chart type is especially suitable for periodical data, as e.g., on precipitation over the twelve months of the year. Extremely large values may cause serious overlap problems. Asymmetry of the areas is an indication for a climate with distinct dry and wet seasons (Figure 8.18b).

Rectangular Diagram

This diagram type allows for the representation of three combined quantities, whereby the area of the rectangle is the product of its two sides. In the sample the value of all the goods produced in a country are the product of the number of inhabitants and the gross domestic product per capita. The choropleth map on the level below shows unemployment by smaller administrative regions gure 8.18c).

3D Spheres

These volume symbols are in correspondence with the other content of 3D maps. The volume proportional spheres can deal with extreme ratios of quantities. The ratio in this map section (57 000 to 1 000) would have allowed also to use volume pillars. The shadow helps to define the respective location at the bottom of the sphere (Figure 8.18d).

Classification of Quantitative Data in Choropleth Maps

Choropleth maps are ideally used for the representation of quantitative densities with relation to area. However, it has become common practice to break down any quantitative data related to areas into a group of sequential classes, this in spite of the visual drawbacks shown in Figure 8.15a.

The procedure of classification leaves the author with a decision out of a number of possibilities, depending on the character and distribution of the data:

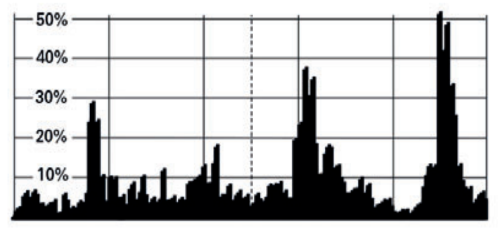
1. Histogram of the data
   In order to get a better overview of the dataset it is recommended to plot a histogram of the random distributed data and sort it as a continuous distribution. This curve is analyzed for its statistical characteristics and serves for the determination of the breaks in the classification (see example on the right).

2. Often used breaks in the data series
   - zero value between negative and positive values
   - statistical mean of all values
   - median, quartiles and quintiles breakpoints of the distribution curve
   - object-based threshold values
   - values needed to make comparisons.

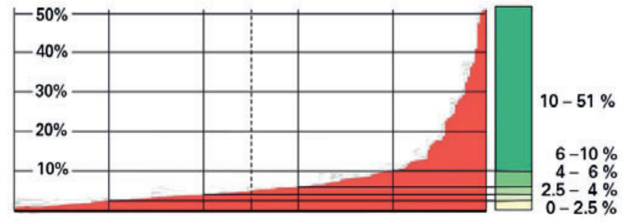
Instead of a breakpoint it can be ideal to select a breakpoint area for one of the classes.

Example:
Histogram of the data for a choropleth map representing the percentage of active labor in agriculture and forestry.

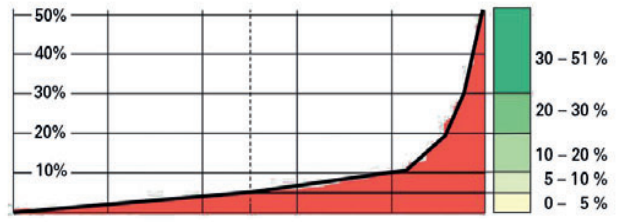
Random distribution by countries and regions.



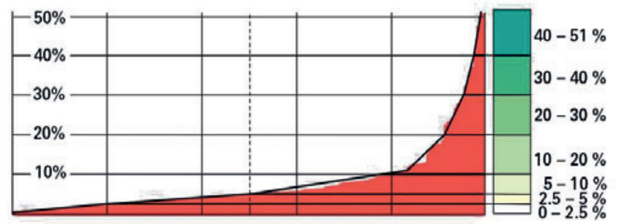
Same data sorted by percentages and classified by quintiles.



Classified by breakpoints of the distribution curve.



Break down in 7 classes for refinement at the upper and lower end of the values.



Choropleth Map Based on a Triangle Diagram

This map type offers a solution, if the data consist of three percentage values which result in 100% when added. The dots in the legend represent the percentage of economically active persons in the three main sectors for the European countries (Figure 8.19a).

Choropleth Maps with Sequential Classes

Equal Number of Regions per Class

The total number of regions is divided in five groups (see example box on the previous page). The breakpoints found are rounded to the next number which is easy to remember. If every region would be of equal size, each of the five colors would cover one fifth of the map. A serious drawback in this case is, that there is no differentiation in the numerical range between 10% and 51% (Figure 8.19b).

Distribution breakpoints

The breakpoints for the classes have been chosen where the gradient of the distribution curve changes. The respective values are moved to the next round value. As we see from the histogram, half of all regions fall into the lowest class and the highest class covers ratios between 30% and 51% (Figure 8.19c).

Seven classes with refinement at both ends of the distribution

The lowest and the highest class in Figure 8.19c have been split into two classes for more differentiation in these sensitive fields. Using this procedure, the "industrial belt" from Milan through Germany and Belgium to London appears distinctly and so do the traditional agricultural areas in the Carpathians (Figure 8.19d).

FIGURE 8.19a-d

a) Choropleth map based on a triangle diagram

b) 5 classes, each one with the same amount of regions

c) 5 classes, divided at prominent distribution breakpoints

d) 7 classes, lower and upper end of the distribution split up [Schweizer Weltatlas 2008, mod.].

8.4 MAP GRAPHICS

Data Analysis and Frequently Asked Questions

With the intention of publishing a geodata set in an atlas map, the properties and characteristics of the data and the components of the respective base map are first analyzed.

Reference of the data?
- to point locations or
- to lines or
- to areas or
- to one of the above as second priority

Level of information?
- quantitative
- sequential or ordered
- qualitative

Range of quantitative data?
- minimum to maximum values
- positive and negative values
- zero values to be included

Number of classes or categories?
- number of steps in a sequence
- number of different kinds

Questions the users might wish to ask?
- highest or lowest values or
- numerical values and names for all locations
- interdependence to other map elements
- and many others.

TABLE 8.1

Example of a design analysis for a glacier map (Figure 8.20).

	Properties	Referring to a point	Referring to a line	Referring to an area	Quantitative	Range of data	Sequential	Number of classes	Qualitative	Number of types	*Symbolization by*	Point symbol, Diagram	Line symbol	Area symbol	Names	Size	Value	Hue	Form, Orientation	Animation
Components	Types of glacier			●			●	2						●			●	●		
	Historic extension		●	●			●	2						●			●	●		
	Annual advances/retreats	●			●	-371...+125 m/a	●	29a	●	2		●				●		●		●
	Glacier hazards	●							●	5		●						●	●	
	Rivers		●				●	3					●				●	●		
	Lakes			●					●	1				●			●	●		
	Boundaries		●						●	1			●				●	●		
	Relief			○										○			○			
	Names	●	●	●			●	3	●	3						●	●		●	

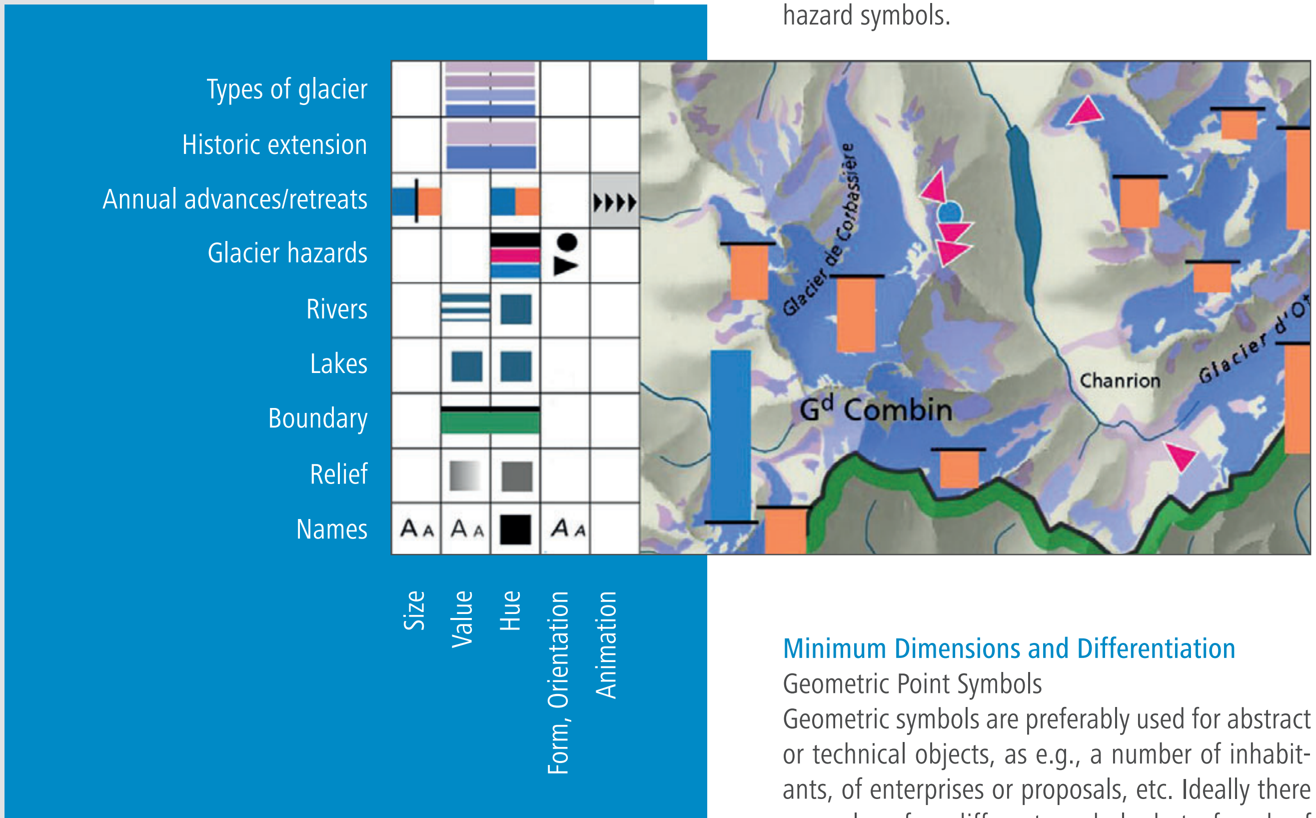
Symbolization on the Basis of the Analysis

As can be seen from Table 8.1 and Figure 8.20, the symbolization follows precisely the data analysis. Possible overlaps within and among the symbol categories had to be carefully evaluated. They present only minor problems in this case. The general rules of representation, like quantity by size, sequential order by value and different kind by hue, have been obeyed.

An optimal symbolization translates the inherent properties of the given geodata by those graphical means which will reflect spontaneously analogue properties.

Incidental symbolization on the other hand requires repeated consultation of the legend and more concentration and time during interpretation.

FIGURE 8.20
Section of a map according to the recipe developed in Table 8.1 [Atlas of Switzerland 2.0 2007].



The solution (Figure 8.20) also makes use of the possibility to combine the graphic variables, so that their effect is increased, e.g., for the hazard symbols.

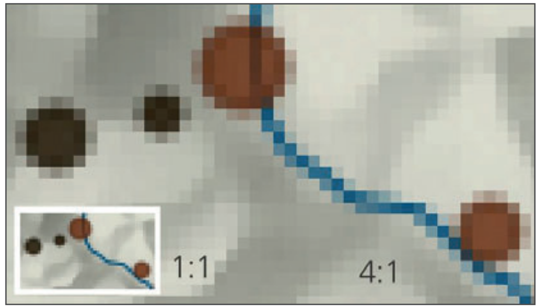
Minimum Dimensions and Differentiation

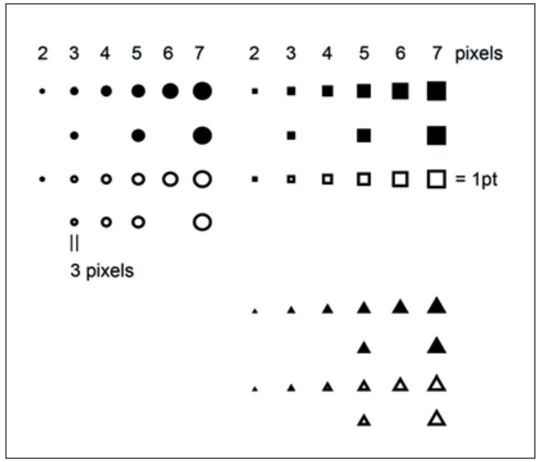
Geometric Point Symbols

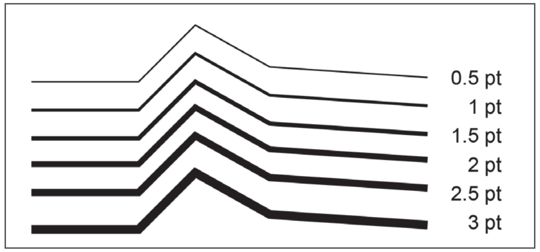
Geometric symbols are preferably used for abstract or technical objects, as e.g., a number of inhabitants, of enterprises or proposals, etc. Ideally there are only a few different symbols, but of each of them many to place.

Minimum Dimensions

For the presentation of electronic atlases on the display, the data is usually rasterized as illustrated in the following. The smallest symbols are composed by just a few pixels in different arrangements for the variation of form. Jagged outlines are smoothened by the antialiasing function.







In the first illustration, a screen copy of the original map is shown after it was zoomed 200%, and the same four times enlarged.
The second illustration on the left gives an overview of the rasterized ranges of symbols at original size on the display. A step of one pixel is used for continuous scales, but a step of two pixels must be used for sequential ranges.
The last illustration shows a series of rasterized lines with antialising effects.

Sequentially Ordered Symbols
Special care has to be taken to sufficiently discriminate the size of adjacent symbols in a sequentially ordered range. In Figure 8.21a and Figure 8.21c showing the rasterized ranges of symbols, one can observe that the pixel images of small symbols vary considerably depending on their place in the raster screen.
Increasing the dimensions by steps of two pixels seems to be efficient (Figure 8.21b). When the result is not satisfying, a combination with another ordered variable such as value can be the solution (Figure 8.21d).

Minimum dimensions for black:	
Round dots or squares	3 pixels
Triangles	5 pixels
Fine lines	1 pixel

Minimum step for small sequential symbols:	
Round dots or squares	2 pixels
Triangles	2 pixels
Fine lines	1 pixel

FIGURE 8.21a-d
a) Four steps (4, 5, 6 and 7 pixels) up to 100; poor discrimination
b) Continuous scale with squares and rectangles (1 pixel = 1 farm)
c) Continuous scale above 5000; minimum dimension 4 pixels
d) Continuous hexagon symbols supported by value steps
[Atlas of Switzerland 3.0 2011].

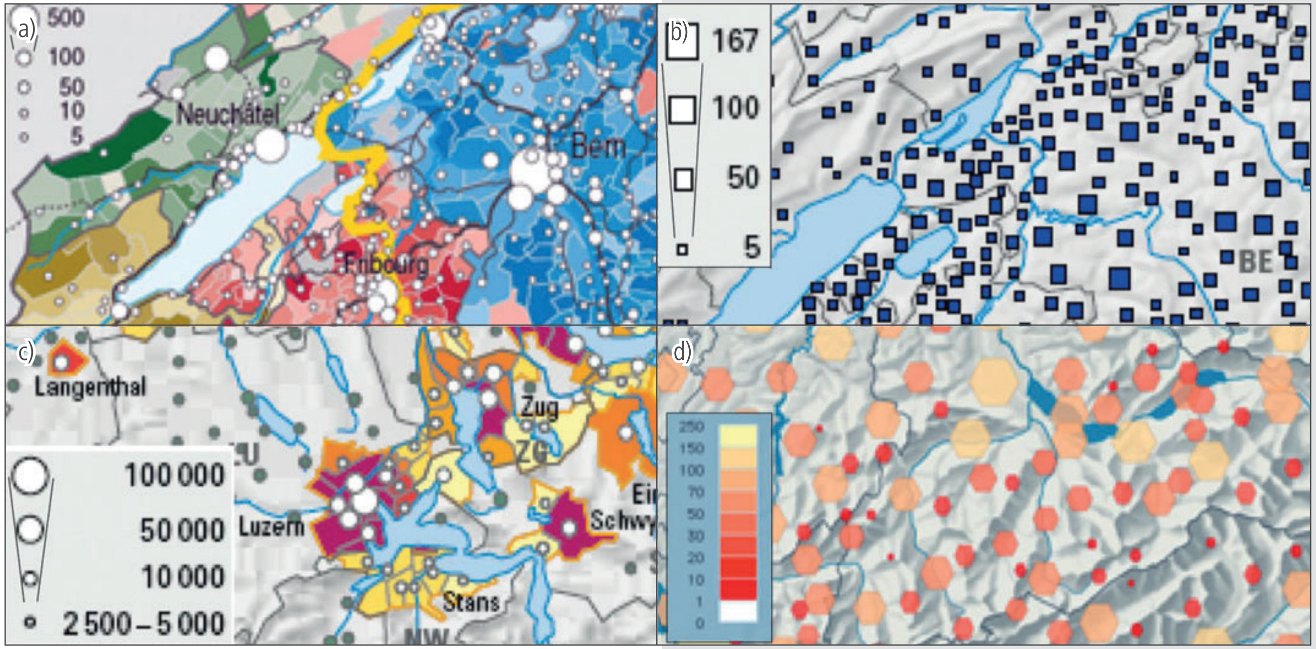


FIGURE 8.22
Fine lines and intricate detail should be avoided for presentation on displays.

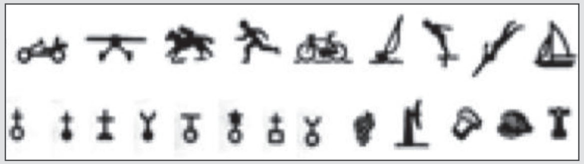


FIGURE 8.23
Geometrical frames for pictorial symbols, an aid for better differentiation.

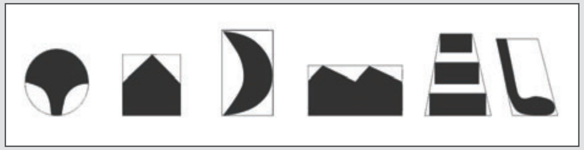
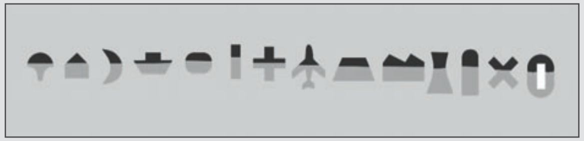


FIGURE 8.24
The upper silhouette of pictorial symbols is essential for its identification.



Geometric symbols are suitable for a small goup of different symbols with a large number of instances in each group.

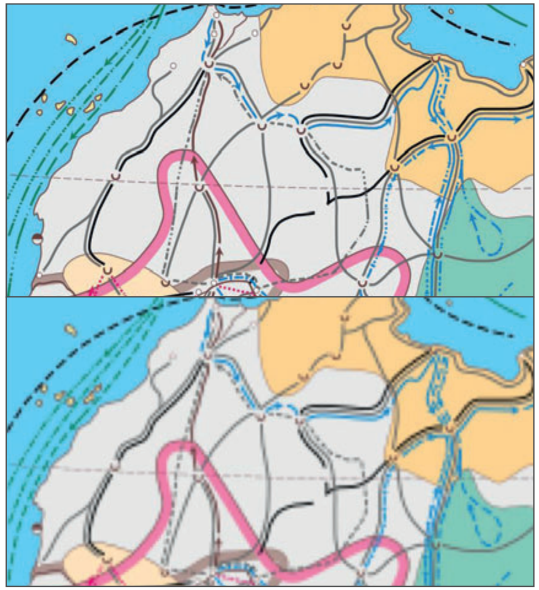
Pictorial symbols are preferred for a large group of different symbols but with rather few instances in each group.

Pictorial Point Symbols
Pictorial symbols are frequently used as a means to illustrate the natural aspect of the objects to be mapped. It gives the map reader a hint as to the signification of the symbol. The need of frequent reference to the legend can thus be minimized.

Graphic design of pictorial symbols
The shape and composition of pictorial symbols in an electronic atlas must be of utmost plainness. Feeble small symbols have no chance on the display (Figure 8.22). To be clearly identified, pictorial symbols need a larger minimum size. It may be useful for clear distinctions to develop the symbol within an elementary outline frame (Figure 8.23).
The perception of symbols starts at the upper part of the silhouette. Therefore it is recommended to treat that part of the symbol with special care (Figure 8.24). The symbols, as small as they are, should not be splitted up in several colors.

Line Symbols
It is common practice in designing electronic atlases to use only full lines in various line width [Atlas of Switzerland 2.0 2007, below], values and colors.

Seldom if ever line textures are applied. Interrupted or dotted lines are scarcely used as well. This is due to the fact that these texture elements are always miniatures and tend to get lost when rasterized (see maps below) [Schweizer Weltatlas 2008].



The first map shows textured lines at original scale with 0.3 mm line widths as constructed in a vector format. The second map is the same map section at the same scale rasterized for the presentation on the screen display. Some of the line patterns cannot be recognized anymore.

As new screens have better resolution (4k), the design of the point and line symbols is approaching the quality of printed maps.

Color Selection and Application

Color is the ideal graphic variable for qualitative discrimination. To be precise we have to speak of hue instead of color. Because, as the color circle in Figure 8.25 (left) shows, the fully saturated pure colors are of different value or lightness, yellow being the brightest, violet the darkest color.

Every hue of the color circle and all the other colors have a certain level of lightness. One should be aware of this fact when selecting a color scheme. For purely qualitative discrimination the colors chosen should include no notion of order or sequence. Therefore, a series of colors with equal value would be the correct solution. However, in practice this aspect is often neglected, and a combination of hue and value is applied.

In electronic atlases a large number of colors is available. In general, the palette used may be somewhat stronger than on a paper map. Some atlas programs include functionalities that allow the user to exchange certain colors according to his needs. They may provide advice that is in accordance with the general rules of color application.

We should not miss to remind that around 10% of all men – women are much less affected – have difficulties to perceive certain colors because of color blindness. They may e.g., see red and green as two nearly equal shades of goldenrod. But it seems impossible to take care of all various deficiencies.

As an illustration to the discussion of color selection and color harmonies we have chosen a non-metric, merely perceptive color system (Figure 8.25, right). Within this double cone every color can be described by its three properties, i.e., hue, value or lightness and saturation.

FIGURE 8.25

Left: Perceptive color system in form of a double cone. Right: Color cone with triangles of equal hue. The axis is the grey-scale, divided up in 8 levels of value. The color samples take increasingly more gray towards the axis.

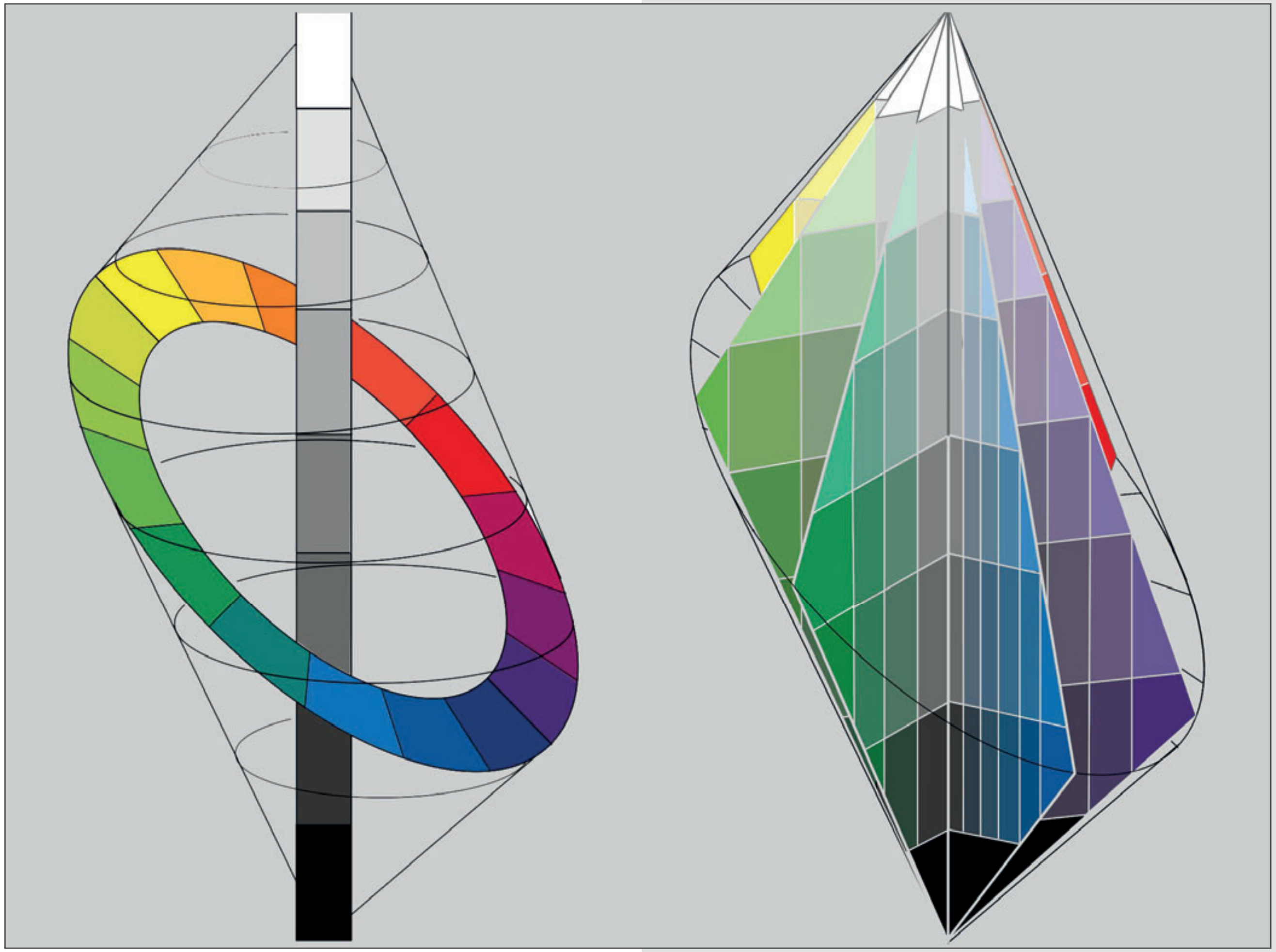
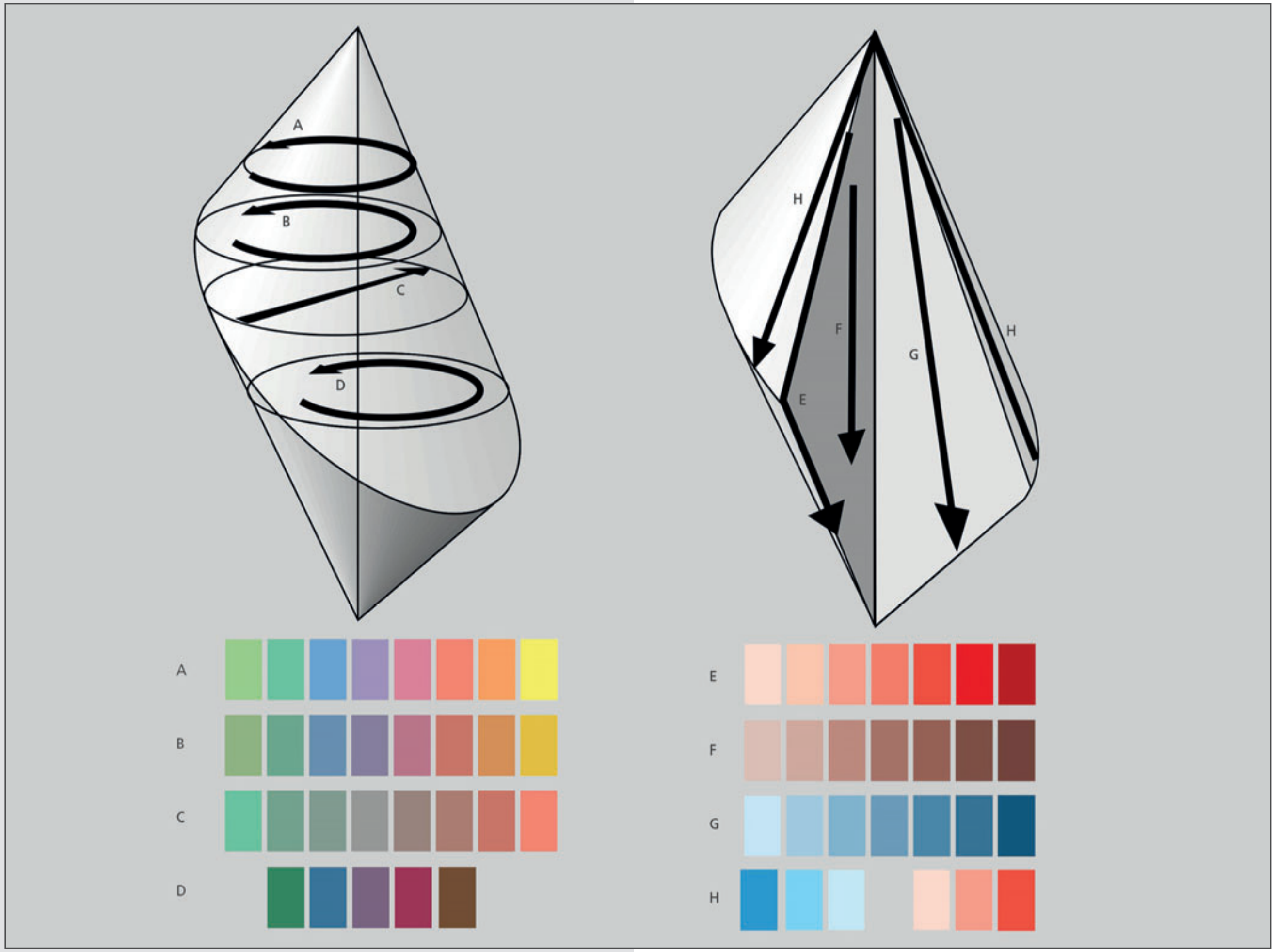


FIGURE 8.26

Left: Places of the individual colors in the double cone for qualitative color schemes.
Right: Places of the individual colors in the double cone for selective color schemes.



Color Schemes for Qualitative Differences

Purely qualitative differences are best represented by different hues. Every notion of order should be excluded. These schemes are therefore found on horizontal layers of equal value in the color cone. (Figure 8.26, left) The four examples of such schemes can be characterized as follows:

A. Series of light and pure hues around the surface of the cone
B. Series of light greyish hues of the same value
C. Series going from a pure color through the grey axis to its complementary color
D. Series of dark greyish hues of the same value, preferably used only for line work

Color Schemes for Selective Differences

Purely selective differences are best represented by different values of one and the same hue. These schemes, called tones and tints are found in the vertical triangles of the cone (Figure 8.26, right).

E. Tints of the same hue along the surface of the cone
F. Tones of the same hue and same amount of greyness parallel to the axis of the cone
G. Tone of the same hue with increasing greyness and value
H. Two diverging selective schemes with a neutral tint between, ideal for positive/negative or increase/decrease opposites.

Harmonious Color Schemes

Usually the map designer strives for harmonious color schemes that will please the eye of the user. There is a lot of arguing about color harmony recipes. The policy followed in this chapter is, that the selection must show at least constancy of one of the three color variables, hue, value or greyness. This rule allows for the following combinations:

- different hues and equal value and greyness (color schemes A, B and D)
- equal hue and value, different greyness (color scheme C)
- equal hue and greyness, different values (color schemes E, F and H)
- equal hue, different values and greyness color schemes G, K and L);
  a combination in which the hues at both ends are complementary colors, is called also "faux-camaïeux" (color schemes J and K in Figure 8.27, right).
- if a few different hues are to be used for a qualitative selection, they should be chosen evenly spread over the whole color circle (color scheme M).

Disharmonious Color Schemes

Problems with color disharmony mainly occur in selections that represent qualitative differences. Considering the above rules, it seems logical that a selection which is missing any constancy or visible principle might cause disharmonious feelings. Disharmony is the result of a chaos, when no visual relationship is sensed between the chosen colors.

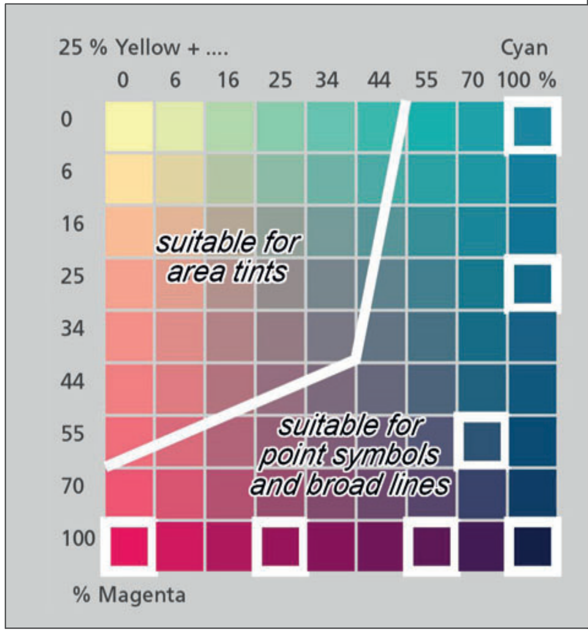
Every hue of the color circle has its natural level of value or lightness (color scheme M). If dark or greyish yellows are combined with light violet or pink and a relatively dark yellowgreen these natural values are violated, what causes an unpleasing effect (as e.g., in color scheme L).

Point and Line Symbols Combined with Area Tints

If point and line symbols are overlaid on area tints, it is important to create enough contrast, so that the small elements remain clearly visible. In these cases dark lines and symbols above rather light area tints are a must (Figure 8.27, left).

FIGURE 8.27

Left: Dark point and line symbols over light area tints.
Right: "Faux camaïeux" color schemes and a sample of color disharmony (color scheme L).



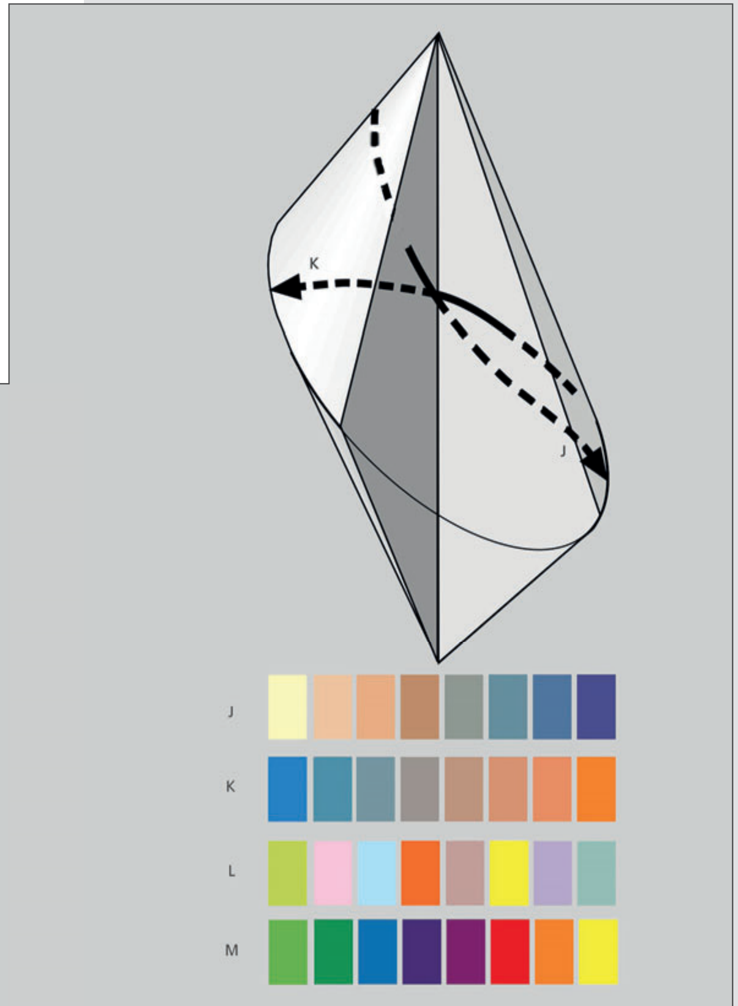


FIGURE 8.28

a) Area patterns in a printed map, rendered here at 100% with the resolution of a display, showing elements with disturbing irregularities
b) Section of the map above, zoomed at 400%, representing these irregular pattern elements more easily distinguishable [Schweizer Weltatlas 2008].

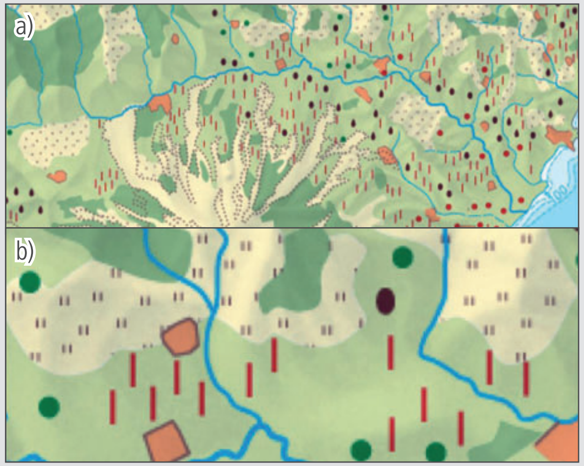
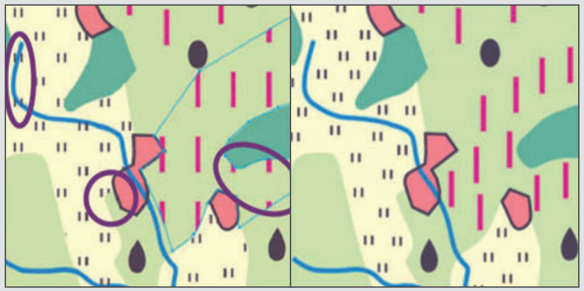


FIGURE 8.29

Left: Regular patterns not adjusted. Right: Patterns adjusted [Schweizer Weltatlas 2008, mod.].



Selection of Area Patterns

The use of area patterns allows for additional visual levels in printed maps. In electronic atlases, however, area patterns instead of area tints are seldom applied. The main reason seems to be the possibility to switch levels with area tints on and off according to needs, thus avoiding the necessity of an overlaid level symbolized with patterns.
Another problem is the variable positioning of these small or tiny elements within the resolution grid, what produces in combination with anti-aliasing disturbing effects, as illustrated by the Figures 8.28 and 8.29. In consequence patterns with thin lines and very small symbols should be avoided, because neighboring elements may look completely different.

Thresholds for Area Patterns

In order to minimize the above effect, the minimum dimensions for points and lines to be used as patterns must be increased, at least doubled. For the spacing a minimum of 3 pixels is to be provided.

Random Distributed Pattern Elements

Naturally grown features can be rendered best with random distributed pattern elements, instead of regular arrangements. This results in a more naturalistic effect (Figure 8.28a).

Avoiding Disturbing Overlaps and Border Effects

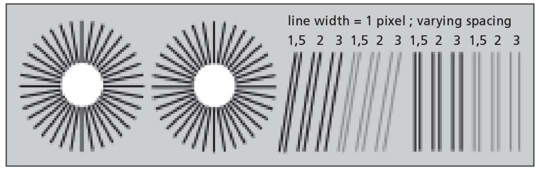
Another unfortunate effect is caused by the overlaps between the pattern arrangement and the borderline of the respective area and other underlying components. With specialized software the symbols can be arranged random distributed and conflict-free within the areas concerned (Figure 8.29).

Selection of Fonts for Labeling

Fonts to be used for labeling maps of electronic atlases are subjected to the specific conditions of the screened image and its relatively low resolution. A number of fonts are designed for the use on displays. In an international atlas special attention deserve fonts that support all languages involved.

Sans Serif Fonts have become the Standard

The fine details of serif fonts disappear or look enlarged by the aliasing effect, as illustrated below. Therefore, sans serif fonts are preferred, especially for small type sizes.



Oblique Fonts: a Problem?

Whether oblique fonts must be avoided, is an open question. The verticals are inclined between 9° and 12°. The illustration above shows a maximum of disturbing effects for the 10° ray. But blurring may occur on vertical lines as well. In order to differentiate between object classes, we should not in every case resign from using oblique fonts (see Figure 8.30).

Threshold for Fonts and Different Type Styles
According to Figure 8.31 the smallest font size for use on the display is approximately 7 point. This minimum size applies to all three font types commonly used. The ratio between the line width and the size or height of a letter varies for the different typestyles between approx. 1:10 (light), 1:7 (normal) and 1:5 (bold fonts). This means that the minimum line width of the light fonts to clearly form the round elements of the letters is 1.75 point. The threshold for bold letters is much more defined by the open spaces within critical letters needed for clear distinction.

Label Placement

For ease of handling there is a tendency to place labels wherever possible on a horizontal path. However, Figure 8.30 shows that labels on a curved path are perfectly legible, if they are carefully placed. Let us remind the rule, that labels for areas should never be arranged on an oblique line, but always on a curve.

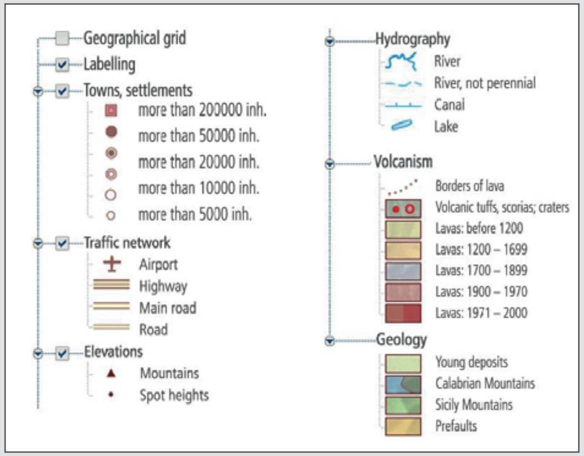
Curved Labels
The object to which the name belongs must always be clearly identified. Therefore, curved names are practically a must for labeling curved objects like rivers, roads, ocean currents, etc. In certain cases, they may also be ideal to better define the area to which the name belongs, if its outlines are not delineated otherwise. If in an interactive atlas the horizontal position of names is retained as a principle, an alternative would be, to highlight the invisible outline of the area by blinking, when the mouse is over its name.

Label Placement and Rotating Maps
Interactive atlases may include a function to rotate the maps. In this case the names belonging to point symbols (e.g., place names) must be able to rotate as well. In Figure 8.31, the reference points for the town names have always the same relative positions to the symbols, which keep their orientation. The labels for rivers and areas just turn around themselves. Similar problems arouse when block diagrams are labeled. But in these cases, additional provision has to be made that names cannot overlap each other.

FIGURE 8.30
Just visible font differences in small labels:
7 pt light oblique (Timor), 8 pt oblique (..Sunda..),
7 pt normal (Bandasee), 8 pt normal (5030),
9 pt normal (Pontianak) and bold fonts (Surabaya)
[Swiss World Atlas interactive 2009].

FIGURE 8.31
This globe map has been rotated, whereby the orientation of the names and symbols has not been changed
[Swiss World Atlas interactive 2009].

FIGURE 8.32
Example of a legend window, allowing the selection of the layers to be represented [Swiss World Atlas interactive 2009].



Text for Legends and Information Windows

In general, the user will strive for as much room as possible for map displays. The legend remains therefore somewhere in the background, as long as it is not needed. When the legend window opens, it will usually appear along the border of the screen, using a minimum of room.

For these reasons legend text sizes are restricted on a minimum. The legend in Figure 8.32 is set in a light condensed 7 point font. This legend combines the concise information about each symbol with the possibility to make a selection among the individual map layers. The area tints can include also the relief component, indicating this way the different shades the color tints may adopt in the map. But if the hill shading is switched off in the map, it should be the same in the legend.

8.5 MAP COMPLEXITY

Analytical Maps

An analytical map shows just one thematic topic together with a base map, which helps for orientation. The advantage consists in an undisturbed perception of all map details, of their value, relative distribution and absolute position. Figure 8.33a is an example of such an analytical map.

Complex Maps

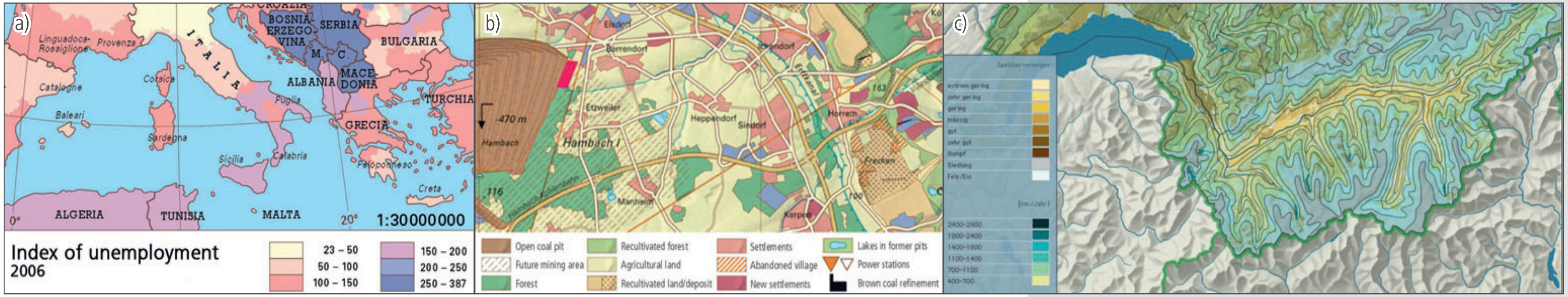
In a complex map, on the other hand, there is always a superposition of several topics or components. The essential element is the possibility to compare details of several features on a local or regional level. The importance lies in the awareness of their interdependencies. In Figure 8.33b a number of features, all of them closely related with brown coal mining in this area, are combined in a complex map.

Strategies in an Interactive Environment

For electronic atlases we have to consider the additional power of interactive tools: Map levels can be clicked on and off. Superposing levels can be dimmed down, making use of transparencies. But only this second function may serve as an alternative to a complex map. However, the lightened image quickly fades away with more transparency, and therefore does not bring a real advantage over the complex image. Figure 8.33c shows an example of an "impossible" overlap of areas in two color schemes. Interpretation of details in restricted regions can profit from changing the transparency.

FIGURE 8.33a-c

a) Analytical map [Schweizer Weltatlas 2008].
b) Complex map [Schweizer Weltatlas 2008].
c) Two topics superposed [Atlas of Switzerland 3.0 2011].



8.6 STRUCTURING MAPS BY LAYER MANAGEMENT

Map Feature Density

The number of layers, each of them containing just one map feature, is rather limited. In electronic atlases, there is a tendency to restrict the number of layers, in view of the ease by which one can switch between layers. Usually not more than three layers may be superimposed, and even only if certain conditions about the map types involved are fulfilled.

Conditions for the Superimposition of Layers

As a maximum, the following map types may be superimposed, if a graphically clear distinction has to be maintained:

- dark point symbols or diagrams above
- medium weight line network above
- light area tints including halftone relief

- dark point symbols or diagrams besides
- medium toned symbols above
- light area tints including halftone relief

- heavy weight line network above
- medium weight line network above
- light area tints including halftone relief

- coarse area pattern above
- medium weight line network above
- light area tints including halftone relief.

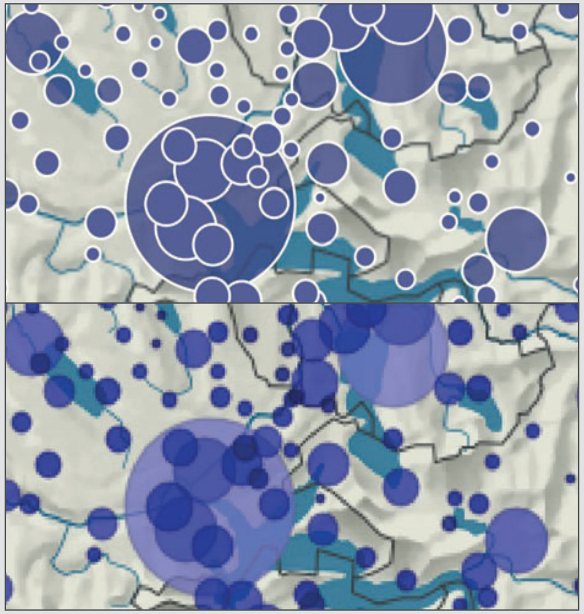
From this point of view, a combination as shown in Figure 8.33c should be avoided, while Figures 8.33a, and 33b are fine.

FIGURE 8.34

Active and hidden layers of the clickable base map for the maps below [Atlas of Switzerland 3.0].

FIGURE 8.35

Symbol overlap situation: Small circles above transparent larger ones (above) and the same section, sizes classified and differenciated by value, fully transparent (below) [Atlas of Switzerland 3.0].



Hidden Layers for Free Combinations

The electronic atlas allows for much more layers than can be presented on the screen simultaneously. Theoretically there is no limit to the number of topics. These ready-made layers are kept in the memory and can be activated for any combination. It is therefore largely up to the users to decide which layers they want to overlay (Figure 8.34). In designing the system, one could (or should) provide for a means to exclude certain layer combinations, which make thematically no sense or are visually impossible.

Transparency and Adjusting Image Contrast

To remain flexible for such variable combinations, extensive use should be made of the functions, which allow transparent images and to adjust image contrast. So e.g., the contrast or value of a layer with line work may be toned down to meet the conditions for superimposition set up above. This procedure can be initiated by a default value, but finally has to be left to the user, as its choices cannot be foreseen.

Map Image Density

The density of map details is often much lower in printed maps. The same amount of detail on the display needs at least twice the space at the lowest possible zoom range, due to the coarser resolution.

Symbol and Type Overlaps, Stacking Strategies

Quite often symbol overlap cannot be avoided. In this case it is important to overlap symbols, using different levels within one layer, so that each element still can be clearly interpreted. The smaller symbols mask the larger ones, when they belong to the same topic, a rule that is especially applied to diagrams (see Figure 8.35). According to circumstances, overlapping symbols are slightly offset, at least if the symbol recognition and the relative position is more important than the absolute one.

Other Strategies for Overlapping Symbols

For better distinction of each symbol, dark or white outlines for symbols or diagrams are recommended. A decent shadow along the outlines of diagrams may give more depth perception between layers. The introduction of a value difference for overlapping graded symbols within one layer, in order to increase the contrast, blurs to some extent the principle message, “the bigger the more” (see the lower map in Figure 8.35).

Masking the Background for Names

Whatever the layer composit is, the main text (especially names) occupies the top position. This aim is reached primarily by dark colors for lettering. However, there may be dark elements underneath as well, as e.g., the outlines of roads as shown in Figure 8.36 (left). The common solution, to assure faultless reading of the names, is to mask them out in the respective elements below. In Figure 8.36 (right) this is realized by thickened names, rendered in a semi-transparent white (halo). If there is enough contrast between the lettering and the underlying features, such a masking procedure can be omitted.

FIGURE 8.36

Overlapping names (left) [Schweizer Weltatlas 2008] and same map where names have been masked [Swiss World Atlas interactive 2009].

8.7 MAP GENERALIZATION

As far as the production of the individual maps is concerned, there is no difference – apart from the coarser thresholds – to the generalization for maps that are printed. The new aspect, brought in by electronic atlases, lies in its potential that maps can be presented in not just one scale, but zoomed in and out. But if the range of zooming should allow for great scale differences, generalization between the different zoom steps can no longer be avoided.

Generalization for Maps in Raster Mode

If the electronic atlas presents all maps in raster mode, the need for generalization can be met only by preparing map sets with different generalization degrees. The pixels are reduced or enlarged only in a small range (e.g., 70% to 170%). When zooming occurs outside this range, another generalized version of the map is presented automatically on the display.

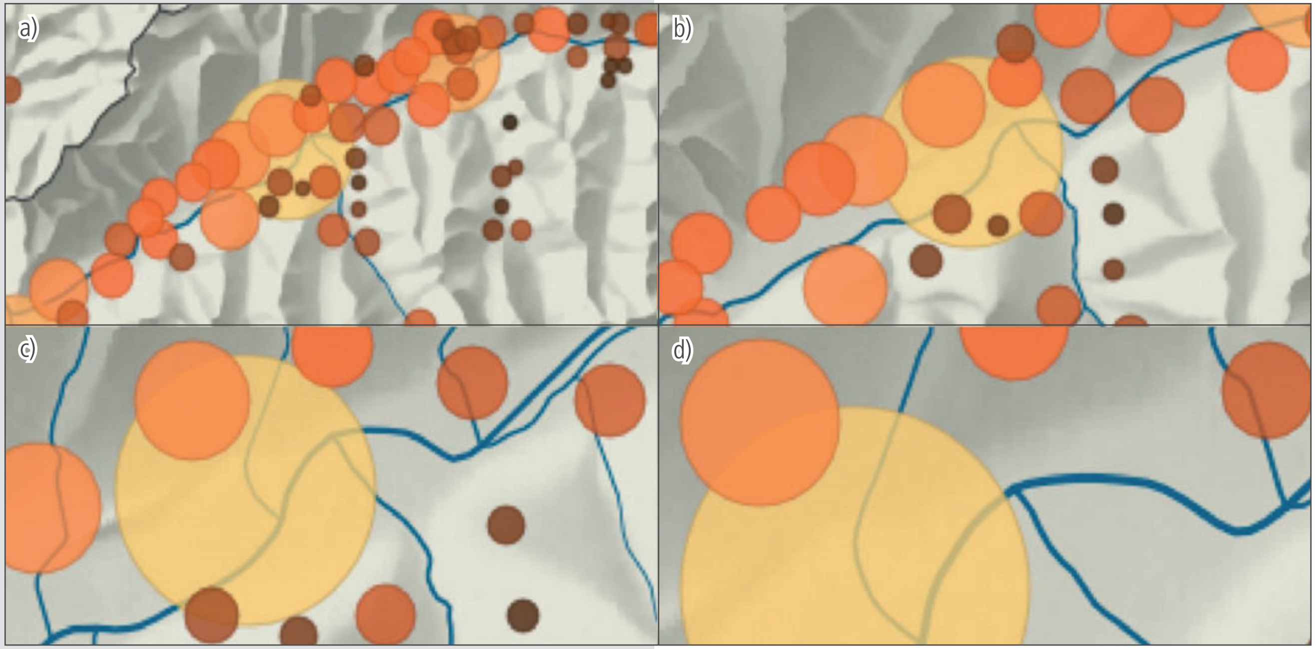
Generalization for Maps in Vector Mode

If the maps are displayed in vector mode, the resolution is not a problem as with raster images. In this case the critical element is the image density. As illustrated in Figures 8.37a to 8.37d, it would not be appropriate to simply enlarge proportionally all elements of the map image in Figure 8.37a. With the increasing space more details of the base map can be shown, and overlaps can be avoided more and more by adapting the figure scale. Thus, this method has been named *adaptive zooming*.

Generalization in an electronic atlas environment includes both, the base map and the thematic components.

FIGURE 8.37a-d

a) Map displayed at the scale 1:800 000
b) Map displayed at the scale 1:400 000
c) Map displayed at the scale 1:200 000
d) Map displayed at the scale 1:100 000; four generalization steps, including the base map and the figure scale of the circles [Atlas of Switzerland 3.0 2011].



Generalization by Object Classification and Selection

Selective map components can be classified in view of their presumable need for generalization. As an example, the rivers of the base map in Figure 8.37 have been divided in three classes. When a displayed image is zoomed out, the classes of minor rivers are successively suppressed and the line widths are adapted to the zooming factor. The number of names may be reduced step by step, if they are classified by importance.

Generalization by Aggregation of the Reference Areas

If the individual areas of a mosaic map become illegible because of scale reduction, an aggregation to larger complexes may be the solution. A common example with statistical data is the change from a lower to a higher class in the administrative hierarchy, e.g., from communities to districts, as illustrated by Figures 8.38a and 8.38b.

In Figure 8.38c the people occupied in industrial branches in various neighboring communities are aggregated in a single diagram for the regional center.

Generalization by Aggregation of the Number of Classes

Another means of aggregation is the reduction of classes in a selective variable, e.g., the number of classes to differentiate the amount of precipitation (see Figure 8.38d).

Generalization by Choosing Larger Units

In dot distribution maps the aggregation is realized by choosing a larger value per dot. This new dot stands for a group of dots with lower values it has replaced.

Replacing a Group of Symbols by a Representative

In symbol distribution maps, a small number of symbols are summarized by one representative, which is placed in the center of gravity of the group of former symbols.

Generalization by Change of Symbolization

For features of a certain aerial extent a representation by an outline with an area fill may be appropriate. However, when considerably scaled down, the area tends to dissolve. In such a situation a principal change of the symbolization may be the solution. A typical example of this type of generalization is for example the settlement areas at larger scales are migrated to town symbols.

Generalization by Graphical Aggregation and Smoothing

The generalization of a mosaic map consists in graphically aggregating tiny area elements and smoothing the area outlines and other intricate line work (Figure 8.38a and Figure 8.38b).

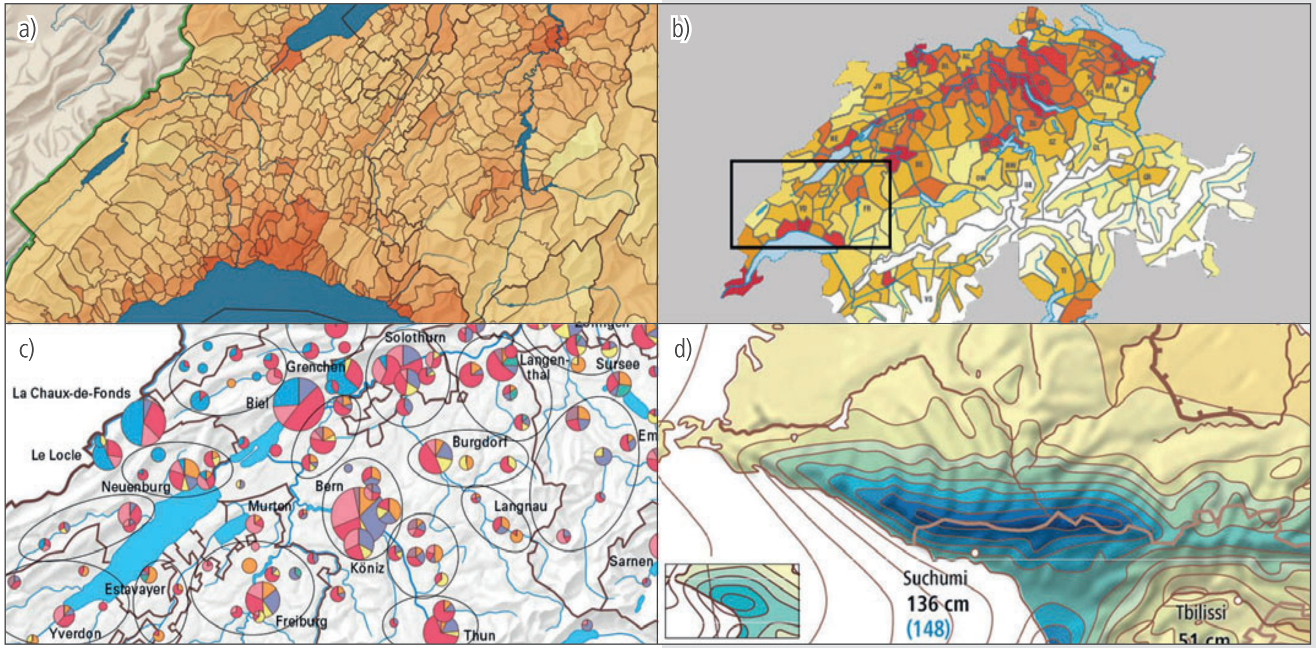
Generalization of Diagrams

Dependent upon the type of diagram various procedures for generalizing may be applied. In diagrams with quantitative components small or zero values are sometimes critical. By the selection of an appropriate diagram they can be shown if needed. When small values tend to visually disappear, as e.g., in pie diagrams, two solutions are possible. All values that are too small are distributed proportionally to the other sectors, or they are aggregated to a category "miscellaneous" or "others".
If there is too much overlap between a large number of diagrams, several neighbors may be aggregated to their regional center, or diagrams of similar characteristics may be shown by its most prominent member (Figure 8.38c).

The expense for the preparation of a whole range of generalized versions is considerable; real needs must be carefully evaluated.

FIGURE 8.38a-d

a) Population density by community [Atlas of Switzerland 3.0 2011].
b) Population density, aggregated by district [BFS 2010].
c) Activities in industry in neighboring communities are aggregated to a regional center [Schweizer Weltatlas 2002].
d) Annual precipitation; the 11 selective classes are reduced to 9, the coastlines and isolines are heavily generalized [Schweizer Weltatlas 2008].



8.8 ANIMATION

Animated versus Static Maps for the Representation of Dynamic Processes

Static maps offer some possibilities for the representation of dynamic or temporal processes:

- value differences, “the darker, the later” or vice versa, for objects with different location
- arrows at the end of a track of a temporal movement (Figure 8.39c)
- succession of front lines (Figure 8.39a)
- comparison of a series of maps with different stages (Figures 8.39b and 8.39d).

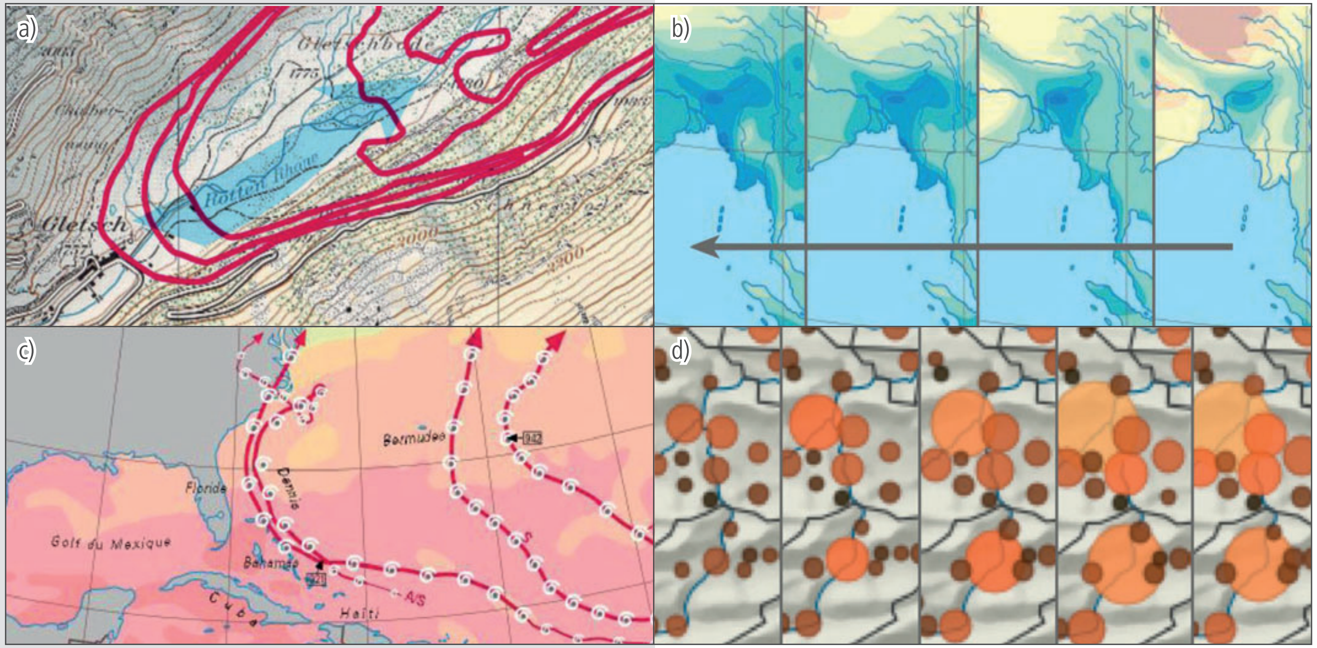
The common problem of these graphical solutions lies in the fact that the inherent time changes are not self-evident. The user is forced to make an intellectual effort to imagine the pace of the motion and to memorize the different stages.

Animated maps on the other hand offer real motion in various forms. The effect of movement is realized by a sequence of images or frames with just minor differences. The dimension of time allows for additional visualization variables:

- moments of display, when map elements appear or disappear
- order, in which the map elements are displayed
- duration of the presentation of a map element
- frequency, by which a map element is shown or enhanced (by blinking).

FIGURE 8.39a-d

a) Spatio-temporal change: Retreat of a glacier
b) Spatio-temporal change: Precipitation during the Monsoon in Bangladesh from April to July
c) Spatio-temporal change: The track of the hurricane is animated by moving the symbol with variable speed and size
d) Temporal change: Population 1850–2000 [Atlas of Switzerland 3.0 2011].



Different Aspects of Map Animation

The sense of motion may be achieved within a static map frame by:

- a spatial change, a change of location of the element within the frame
- a temporal change of the element, without changing its location
- a spatio-temporal change, modifying the aspect of the element as well as its location.

Or:

- by moving the whole map within the window
- by panning
- by continuous zooming
- by rotating, e.g., a globe map
- by changing projections on the fly
- by changing perspectives in 3D maps, e.g., for fly-by's or moving block diagrams.

Problems of Perception and Memorizing with Animated Maps

Static maps may be studied as long as needed and anywhere within the map. On the other hand, objects in animated maps appear and disappear in a set pace. Of course, replay is possible. But in most cases provision has to be made that the movement can be stopped anytime.

Often the map reader does not know where to look to perceive a change. Frame by frame passes by until he realizes, where to focus his attention. To perceive on-going changes everywhere within the map is by theory impossible.

Spatial Changes of Point-related Map Objects

The movement of a single point symbol, e.g., for a hurricane in Figure 8.39c, may be varied in pace and direction. To focus attention on the symbol concerned at the beginning of the change, a blinking arrow referencing the object may help. Memorizing the movement can be supported when leaving a weak trace of the symbol (Figure 8.40c).

Movement within a Linear Object and Spatial Change of Linear Objects

To show the flux within a flow line, e.g., of an ocean current, the linear symbol must be textured, dashed or dotted.

The spatial change of a linear object, like the front line of the glacier in Figure 8.39a, may become in other cases quite a complex perception task, because the form of the line changes as well as its position in a 2D or even a 3D environment. It may also be assisted by keeping some traces of former positions.

Spatial Change of Areal Objects

We can distinguish two cases: The area is moved whereby the outline of the area remains stable, or the area changes position and adapts a new shape. Again, in case of a single area a referring arrow or a blinking effect for the area concerned would be helpful.

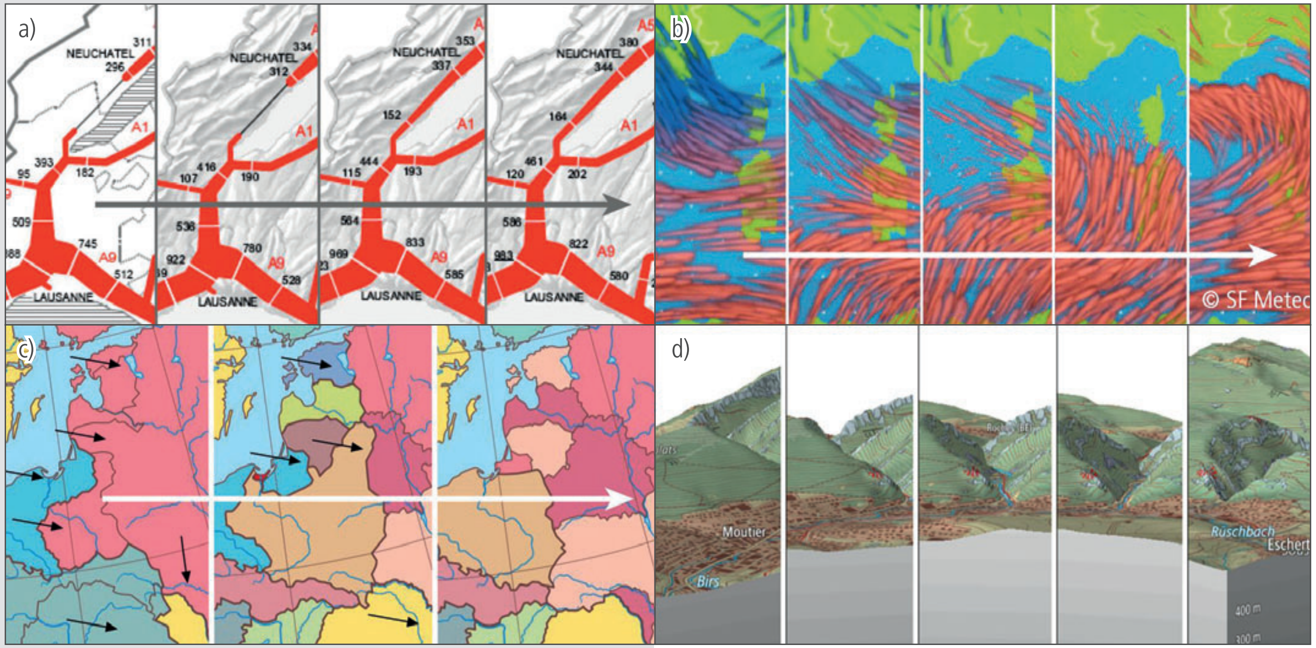
FIGURE 8.40a-d

a) Temporal change: Road traffic frequencies 2002–2008 [FEDRO 2010].

b) Spatio-temporal change: Air currents, including change of temperature [SRF Meteo 2009].

c) Spatio-temporal change: Political territories [Swiss World Atlas interactive 2009].

d) On-the-fly calculation for moving block diagram views [Swiss World Atlas interactive 2009].



If the change is not a continuous one, but consists of just one step from the former to the new situation as in Figure 8.40c, it may surprise the map reader. A means to alleviate this problem is to blend in the new situation continuously via transparency or to highlight all elements that will change in the next step.

Temporal Changes of Point-related Objects

The point symbol does not change its position. The animation concerns only its attributes, as e.g., size in Figure 8.39d. Other graphical variables may be involved in animating the symbol: A change of value is suited for a temporal sequence, color or texture for a qualitative change and orientation for a rotation in reality.

If a large number of symbols within the map frame are subjected to change, it becomes virtually impossible to seize all the inherent information. Figure 8.39d stands for a temporal brush of the number of population over 150 years, but it seems that a thorough comparison of the stages with static maps is preferential to the animated procedure.

Changes of Linear and Areal Objects

Principally the same graphical variables can be used, when animating a line network. The quantitative increase of traffic over time e.g., may be shown by continuously enlarging the line widths (Figure 8.40a), the deteriorating quality of the water of rivers by color and value (Figure 8.40b), the change of population density by different values.

Change of the 3D Images

A major problem of animated 3D images is to calculate all superimpositions on-the-fly and to provide for their elimination. The image of the block diagram in Figure 8.40d can be rotated and tilted and is continuously recalculated.

8.9 CONCLUSIONS

In this chapter, an extensive list of cartographic visualization types was presented. Each atlas is strongly defined, characterized and perceived by the visual impression of carefully selected base maps and map types, as well as by a coherent graphic style.

As an analogy to the selection of menus in a restaurant, chefs/atlas authors must first define the map types and their graphic appearance at a general level. The fine art is then to select and consider from all these possibilities those that perfectly fit the profile of the atlas (customers and data).

For this purpose, it is advisable to first make a list of graphic requirements and create prototype maps, and then determine the most suitable map types and the graphic style of the maps from the variants.

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9 ATLAS FUNCTIONALITY

RENÉ SIEBER AND JULIANE CRON

Basically, atlas functionality is used to answer the four main user's questions: "What?", "Where?", "When?", and "Why?". "What?" refers to the thematic issues and maps of an atlas, "Where?" treats the geographic-topographic context, "When?" sets the temporal frame of the theme, and the question "Why?" is answered by the informative-didactic components of the atlas.
Atlas tools enable the user to manipulate and visualize maps and data. In general, their functionality enables interactions with the geographic and thematic content of an atlas.

When users were asked about tools or functions they would like to find and apply in digital atlases, the request will certainly end up with a full bunch of features. Interestingly, the same effect can be observed with atlas authors: pushed by the (supposed) feature request of the users and also driven by their own ideas, they implement a lot of functionality in their atlas application.

But if we take a closer look at the real utilization of atlas functions we can state that less is more: Users apply only a few functions very often, while most of the functions were rarely or even never used, although they were rated as useful [Pucher 2011].

Why does this gap between wishful thinking, theory and reality exist? Generally, users are "map consumers", not "power users", and most of them are just occasional atlas users. The majority of the atlas users – of any atlas type – use only 20% of all functions available. The user activities mainly focus on looking at maps, exploring them visually, picking some map-related information, and on using some map distribution functions, e.g., *Print and Export*. These findings are documented in several surveys on interactive atlases [Kramers 2007; Pucher 2011; Sieber et al. 2010; Schnürer et al. 2015].

Concerning the occurrence and effective frequency of interactive functions offered in several digital atlases, another remarkable fact is revealing: only a few functions (less than ten!) are available in more than 50% of the atlases [Ortner 2011]. Of course, an atlas has to offer more than ten functions, but they should be carefully selected according to the target audience. Thus, the statement "You have to know your user" [Cooper et al. 2003] is an imperative in order to design atlas functions and tools. In addition, not only the number of functions but also the importance of every function has to be considered to build up a user-focused, tailor-made atlas.

This chapter will give an overview on the atlas functions available, classify them into functionality and interactivity categories, and finally add some advice how they can be best applied as atlas tools.

9.1 CATEGORIZING INTERACTIVE ATLAS FUNCTIONALITY

Interactive functionality is one of the core elements of a digital atlas. To determine the required functionality, an atlas editor firstly needs to understand what functionality means. Functionality can be defined as: "The quality or state of being functional; especially: the set of functions or capabilities associated with computer software or hardware or an electronic device." [https://www.merriam-webster.com/dictionary/functionality]. The definition shows two important functionality aspects: *Quality and State*. *Quality* includes the terms *interactivity and usability* (see Chapter 3), while *State* means the *set of functions* of a digital atlas. Therefore, interactivity and the functional set of an atlas are crucial factors for effective atlas presentation and have to be discussed in more detail.

Levels of Interactivity

Interactivity in atlases allows the user to manipulate geo-related information and maps in order to get tailor-made visualizations and also knowledge gain. From a user-centered perspective, interactivity depends strongly on the tasks and activities users want to achieve. For the use of maps, Van Elzakker [2004] distinguishes between: search activities, selection activities, reading activities, analytical activities, adjustment activities and construction activities (see Chapter 3).

In practice, some of the activities with maps and atlases are used in different contexts and some more often than others. Thus, two levels of functional interactivity are proposed: *Basic* and *Advanced*.

- *Basic interactivity* is dealing with activities like: Looking at maps and compare them visually (time, space), get some information about the topic, move around, search and locate places, export the visualization result.
- *Advanced interactivity* covers more high-level activities as e.g., detect and compare map patterns and processes [Andrienko and Andrienko 2007], import and recalculate data sets.

Based on these two interactivity levels, a dedicated set of atlas functions can be defined and applied to digital atlas tools. As it is outlined in Chapter 7 Atlas GUI Design, the tools were implemented by means of *Input* and *Output Controls, Selection and Action Controls*.

Set of Functions, Functional Groups

To reveal the full capability of digital atlases a set of useful functions must be offered to the user. In the mid-nineties, Van Leeuwen [1996] listed about 40 desirable functions arranged into nine groups: general functions, navigational functions, map functions, database functions, atlas functions, educational functions, cartographic functions, map use and analysis functions, and miscellaneous functions. Subsequently, rather divergent approaches for the classification of functions in interactive atlases were presented, e.g., by Ormeling [1997] and Bär and Sieber [1997]. This might be an indication of the complexity to set up a comprehensive, well-founded classification of the functions.

Considering the structure of modern digital atlases and their functional segmentation of the GUI, an adjusted grouping schema seems appropriate. Based on additional work of Cron [2006a], the functions can be arranged in five functional groups:

- General Atlas Functions
- Navigation Functions
- Cartographic and Visualization Functions
- Analytic Functions
- Information and Didactic Functions.

As a result of an analysis of some of the most popular and comprehensive atlas products currently available, Table 9.1 shows possible functions in interactive atlases. The table gives an overview and can be expanded in the future. There is no strict separation between basic and advanced interactivity level, and it is not recommended to integrate every function labeled as "basic" in an atlas.

In the following subchapters, a characterization for a selection of *representative atlas functions* is provided, always considering the three paragraphs: Description, Implementation/Tools, and Interactivity. To give a graphical impression of the functions, exemplary sketches are added. A full description of all functions can be found in Cron [2006b].

TABLE 9.1
Functions in interactive atlases.

Function Groups	*Function Subgroups*	*Functions* *Basic Level of Interactivity*	*Advanced Level of Interactivity*
General Atlas Functions	System-related Functions	Language Selection; Print; System Status; Help; Imprint; Home; Exit	
	Content-related Functions	Forward/Backward (Map History); Tooltips; Bookmarks	2D/3D Modus Selection; Export/Import: Maps and Data; Hot Spots; Preferences
Navigation Functions	Spatial Navigation	Region Selection; Scale Selection; Zooming; Panning; Reference Map; Location/Georeference; Geographic Index/Gazetteer; Geographic Search	2D Map Rotation; Viewing Direction in a 3D Map; 3D Moving and Flying around; Tracking; Pins, Localizer; Magnifier; Snapping
	Temporal Navigation	Time Point/Period Selection; Temporal Search and Temporal Index	Temporal Animation/Time Change/Time Line
	Thematic Navigation	Theme Selection; Theme Change/Switch; Thematic Index; Thematic Search	
Cartographic Visualization Functions	Map Manipulation	Layer Display/Layer Overlay (on/off); Layer Transparency; Legend Display (on/off)	2D Symbolization/Appearance Modification; 3D Symbolization/Appearance Modification; Projection Change
	Redlining	Labeling: Static	Labeling: Interactive; Additional Map Elements
Analytic Functions	Spatial Queries	Positional Query; Distance and Area Measuring	
	Thematic Queries	Attribute Query	Attribute Selection
	Thematic Analysis	Map Comparison	Classification Modification; Classification (Legend Category) Selection; Map Feature Comparison; Map Feature Selection; Buffering; Intersection; Aggregation
	Terrain Analysis		Hypsography; Slope; Aspect; Visibility; Terrain Profile
Information and Didactic Functions	Commentary Functions	Multimedia: Text, Graphics, Tables, Pictures/Images, Sound, Movies; Preview	Guided Tours; Storytelling
	Self-control Functions		Didactic Tasks; Quizzes; Games

9.2 GENERAL ATLAS FUNCTIONS

The General Atlas Functions are not atlas-specific. They are well-known from other applications, permanently available/applicable and have the same functionality in all programs. Distinctions are made between *System-related Functions* and *Content-related Functions.*

System-related Functions

Language Selection [Basic]

- Description: The function enables the user to choose the preferred language of the user interface.
- Implementation/Tools: Language Selection is realized by means of an *Icon* or a *Push Button*. Either tools containing a symbol of the country's flag or are labeled with the name of the selectable language. A *Drop-Down List* can be used as an alternative if more than 4 languages are selectable or the user interface has not enough space for showing all selectable languages at once.
- Interaction: By clicking on the language *Icon* or *Button* or by selecting the language from a *Drop-Down List*, the user interface and atlas content is translated into the chosen language.

Print [Basic]

- Description: The Print function allows the output of a chosen map or map excerpt on a printer connected to the computer. Settings for printing, such as quality, paper size or format may be made individually before printing.
- Implementation/Tools: Print is usually done by means of an *Icon* with a printer symbol – just as the users know from other programs. As an alternative, the function can be called up from the atlas menu using a *List Box* or a *Drop-Down List*. The assignment of the Print function with a *Function Key (Keyboard Shortcut)* is also very common.
- Interaction: Pressing the *Print Icon* opens the Print setup window, where the user can view and edit the print settings.

System Status [Basic]

- Description: On the one hand, the function can inform the user about the current status of the application, e.g., loading time or running processes. On the other hand, the function can show information that increases the atlas usability, e.g., name and usage of the chosen tool.
- Implementation/Tools: The System Status function is implemented using the *Status Bar* tool for displaying a progress. An animated clock symbol *Icon* is often used as well. Information shown in text form like name and usage of a tool is presented in a *Display Field.*
- Interaction: *Status Bar, Display Field* or animated *Icons* cannot be manipulated by the user directly. As soon as an action of a UI element is triggered on the user interface of the atlas application, the user gets informed about the System Status (Figure 9.1).

FIGURE 9.1

System Status function.

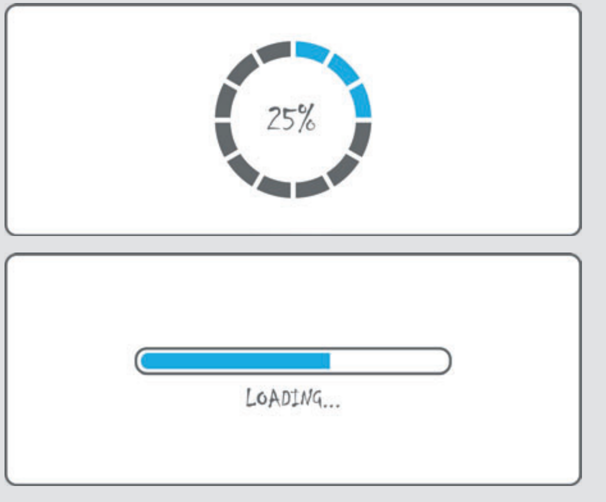


FIGURE 9.2
Help function.

Help [Basic]

- Description: The Help contains information about the atlas content and functionality to improve the usability of the atlas and supports the user in atlas handling.
- Implementation/Tools: The Help function is a combination of *Entry Field, Action Button, Display Field* and *List Box*, arranged in a *Help Panel*. The *Help Panel* can be accessed via an *Icon*, a *Drop-Down List* or an *Action Button* labeled 'Help'.
- Interaction: Within the atlas *Help Panel* the user has either the possibility to choose a help topic from a pre-defined *Selection List* on help topics or to enter a search term into an *Entry Field*. These two possibilities can be integrated in a *Register*. Pushing the *Action Button* starts the search. The answers are shown in a *Display Field* or a *List Box* (Figure 9.2).

Imprint [Basic]

- Description: Information about publisher´s contact data like name, address or e-mail is provided in the Imprint. In addition, the list of source data and the copyright can be shown in the Imprint as well.
- Implementation/Tools: Access to the Imprint can be done via an *Icon*, a *Drop-Down List* or an *Action Button* labeled 'Imprint'. These tools have to be combined with a *Display Field* or an additional *List Box* showing all details.
- Interaction: By clicking on the *Icon*, *Drop-Down List* or *Action Button*, the *Imprint Panel* is called. A new selection list appears if the Imprint consists of sub-categories (e.g., project management, team, editors). Otherwise, the contact details are presented in a *Display Field* without any interaction possibilities (Figure 9.3).

Home [Basic]

- Description: This function returns the atlas user back to the main atlas page (start page) without saving any settings. From the main atlas page the user can directly access all information and functions.
- Implementation/Tools: For the implementation of this function, an Icon or an *Action Button* is used. Integrating the Home function in a *Drop-Down List* – accessible via the atlas menu – is possible, too.
- Interaction: Pressing the Home *Icon* or selecting the option via the *Drop-Down List* leads the user back to the atlas main page.

Exit [Basic]

- Description: The user can quit the atlas and close the application using the Exit function.
- Implementation/Tools: The function should be implemented by default with an *Icon*. The 'x' is a characteristic and well-known *Icon* for quitting any kind of applications. However, an *Action Button* labeled with 'Exit' is less common but also possible. Supplementary, the function can be integrated in a *Drop-Down List* and a *Function Key* can be used.

- Interaction: Pushing the *Exit Button* or selecting the 'Exit' entry from the *Drop-Down List* closes the atlas.

Content-related Functions

Forward/Backward (Map History) [Basic]

- Description: The function allows the user to go one step back or forward. This means the user has the possibility to access atlas maps visited before, or to undo and redo settings.
- Implementation/Tools: The History function is usually done by means of an *Icon*. The combination with a *Drop-Down List* gives the opportunity to move more than one step back or forth. The assignment of *Function Keys (Keyboard Shortcuts)* is widely known. An innovative alternative is the implementation of the function using a *Slider* tool.
- Interaction: The user can move one step back by pressing the *Backward Button*. The *Forward Button* is hidden or inactive as long as there is no option to proceed a step forward. In case of using a *Slider* (instead of *Buttons*), a knob can be moved to the desired position.

Tooltips [Basic]

- Description: The tooltip is a small 'hover box' with information about the item being 'hovered' over.
- Implementation/Tools: The Tooltip itself is realized with a *Display Field*. The possibility to activate and deactivate Tooltips is implemented by means of an *Icon*. *Checkboxes* should be used if the user has more than two choices (e.g., no tooltips, short tooltips, and detailed tooltips).
- Interaction: A Tooltip is used in conjunction with a cursor, usually the mouse pointer. The user 'hovers' the pointer over an item, without clicking it, and a tooltip appears. While pushing the *Action Button* or enabling resp. disabling a *Checkbox*, Tooltips are shown or not.

Bookmarks [Basic]

- Description: Bookmarks in terms of an interactive atlas are used to flag a map as favorite to ensure the easy retrieval of the map via a bookmarks list.
- Implementation/Tools: The function is implemented with an *Icon* or a *Drop-Down List*. An *Entry Field* and an *Action Button* are needed for saving the Bookmark to the bookmarks list.
- Interaction: By clicking the 'Bookmark this map' *Icon* or by selecting the 'Add Bookmark' item in the *Drop-Down List* a dialog box appears. A name for the Bookmark can be defined using the *Entry Field*. Already flagged maps appear in the same *Drop-Down List* and can be opened by selecting its name. In addition, advanced drag and drop functionality can be implemented to add/remove a map to/from the bookmarks list (Figure 9.4).

FIGURE 9.3
Imprint function.

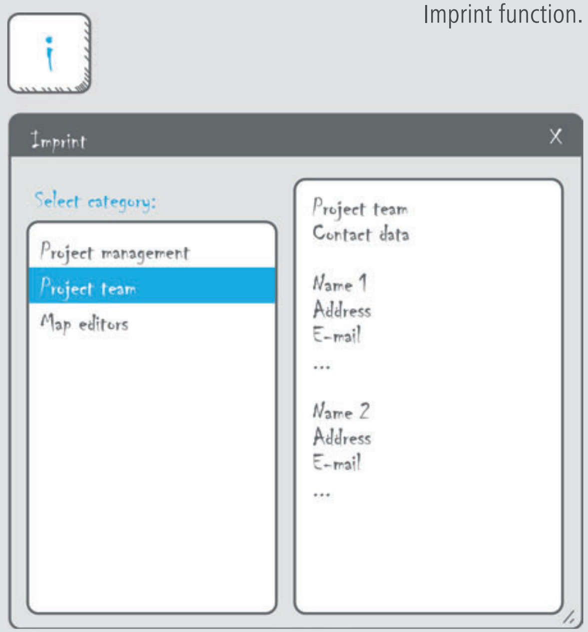


FIGURE 9.4
Bookmarks function.

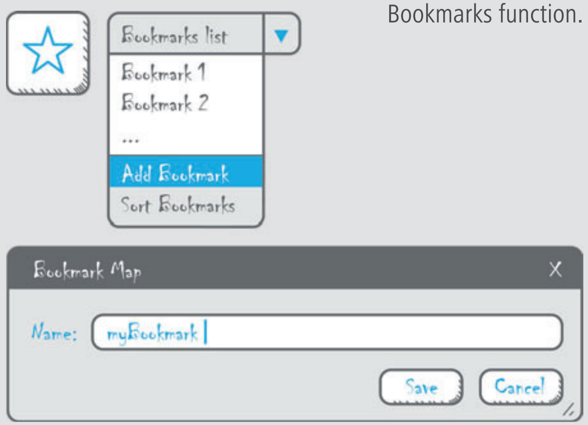


FIGURE 9.5
Export/Import: Maps and Data function.

2D/3D Modus Selection [Advanced]

- Description: Many interactive atlases offer various modules that blend into each other, complement each other and offer valuable expansion opportunities. The Modus Selection enables various presentation and visualization modes.
  Types of atlas modes are: 2D map, 3D map (panoramic view, block diagram), or 3D statistical surface (prism map).
- Implementation/Tools: Any switch between different atlas modes is realized with an *Action Button*, labeled with the name of the atlas module. As an alternative, an *Icon*, a *List Box* or a *Drop-Down List* can be used. The integration of the different atlas modes in tabs is possible, too.
- Interaction: The user switch directly to another atlas mode by selecting and activating the appropriate module.

Export/Import: Maps and Data [Advanced]

- Description: The implementation of this function guarantees the Export and Import of own/user-specific atlas maps and data (myMap, myRemarks) or of maps and data from other applications in a different file format (e.g., Import of GPS tracks, or embed and link maps using Map Services).
- Implementation/Tools: The most frequently used and well known tools for the realization of the Export and Import functions are the *Icon* and the *Drop-Down List.* The allocation with a *Function Key (Keyboard Shortcut)* is recommended. *Icon* as well as *Drop-Down List* are always combined with a separate *Panel* containing an *Entry Field*, a *Drop-Down List* and an *Action Button* for the selection of the Import or Export directories, etc.
- Interaction: By clicking on the Import or Export *Icon*, the corresponding *Panel* appears. In case of an Export, the user can enter a name into the *Entry Field* and select a location for saving via the *Drop-Down List*. The *Drop-Down List* is used in the same way for the Import of a map. The same functionality applies using the *Drop-Down List* instead of an *Icon* for opening the *Import* or *Export Panel* (Figure 9.5).

Hot Spots [Advanced]

- Description: The most common example of a hotspot is a hyperlink. On the one side, a hyperlink is used to display additional information of the map and on the other side a hyperlink is used to jump to a different map or mode.
- Implementation/Tools: A Hotspot is implemented as an *Icon* or an *Action Button*. The combination with a *Drop-Down List* is useful if the Hotspot links to more than one item.
- Interaction: The atlas user is directed to additional information, another map or atlas mode by clicking on the Hotspot.

Preferences [Advanced]

- Description: The function represents all general atlas settings which can be configured individually (e.g., label size, color of the user interface).
- Implementation/Tools: The implementation of the Preferences function requires a complex tool. The complexity depends on the number of settings that can be made. All settings are integrated in a *Settings Panel*, accessible via an *Icon*. *Push Buttons* and *Sliders* are mainly used for changing for example label size, size of the atlas window or compass orientation. An *Action Button* is designed to restore the default settings.
- Interaction: Via mouse click on the *Icon*, the *Preferences Panel* opens. Preferences options can be chosen from a *List*, or selected using *Sliders*. An *Action Button* labeled 'Back to default settings' is useful. By pushing this *Button*, all previous applied settings are reversed.

9.3 NAVIGATION FUNCTIONS

Navigation is a common action in every interactive product. With atlases, navigational functions are even more important, because they concern spatial, temporal, and thematic issues in a geo-referenced, 2D or 3D map environment.

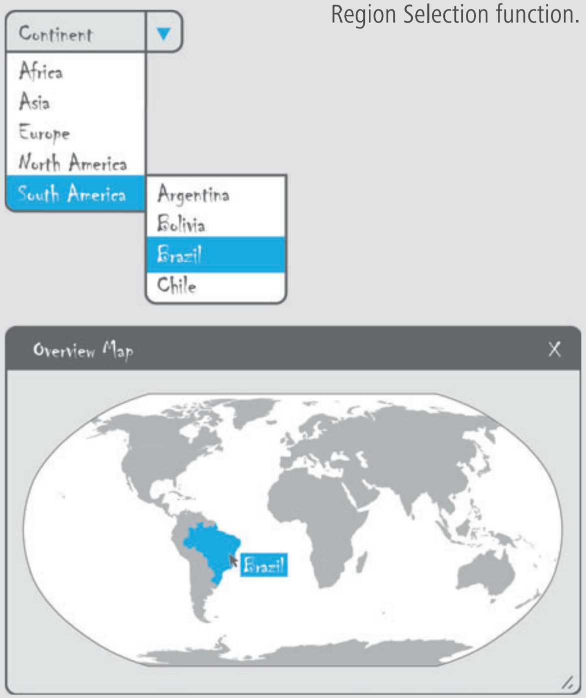
Spatial Navigation

Region Selection [Basic]

- Description: The function serves for the selection of a spatial entity. The entities represent geographic, economic or administrative content, and are often structured in a hierarchical way. Examples of spatial entities are: continent; alpine region; metropolitan region; country; county or community.
- Implementation/Tools: Region selection is usually done by means of a *Drop-Down List*, where all of the spatial entities available are presented. Alternatively or as a supplement to the *Drop-Down List*, different overview maps can be shown as *Geo Icons*, where each map is dedicated to a specific spatial entity.
- Interaction: By clicking on a single name in the entity list or on an element of the *Geo Icon*, the selected region is centered on the map screen (sometimes scale-optimized in region size) (Figure 9.6).

FIGURE 9.6

Region Selection function.



Scale Selection [Basic]

- Description: The Scale selection function is related to the zooming function. Depending on the desired scale, the map is zoomed in or out.
- Implementation/Tools: Selection is done by means of a *Drop-Down List*, or an *Input Field*. A *Slider* can be used as well, where the knobs snap to tick marks when shifted to the predefined next map scale.
- Interaction: Different map scales are organized numerical in a *Drop-Down List* or displayed as marks at the *Slider*. As soon as the atlas user can select the desired scale from the list or moves the slider knobs, the scale of the displayed map changes (zoom in or zoom out). Alternatively, the map user can enter the map scale into an *Input Field*.

Zooming [Basic]

- Description: The function is used to enlarge (zoom in) or scale down (zoom out) the map interactively because of the limited space on screens and for overview purposes. Implicitly, it influences at the same time the map scale and is therefore suited for scale selection.
- Implementation/Tools: Zooming can be implemented in different ways: by means of an *Icon* (magnifier, + / - button), *Slider, Mouse-wheel Action*, or *Function Key*. It is also common to use the rectangle of the Reference Map function for zooming. The application of these tools is not exclusive; zooming is often implemented with different tools in the same atlas. Zooming is defined either in continuous or in pre-defined steps (zooming factors or specific map scales).
- Interaction: Zooming with pre-defined steps is done either by selecting a zooming factor from a *Drop-Down List* or by using the Magnifier *Icon* (change to the cursor modus) and double-clicks in the map. Continuous zooming works with scrolling the mouse-wheel in zoom mode, or with resizing the Reference Maps' rectangle.

Panning [Basic]

- Description: The function is characterized as region selection in a map at fixed scale, where the map extract is scrolled continuously to its new position.
- Implementation/Tools: Panning is done by means of an *Icon (Button)*, a *Scrollbar* on the map border, or a *Moveable Slider* (location rectangle) in a Reference Map.
- Interaction: According to the tools, there are three ways to pan a map: a) by dragging the map with the mouse directly and freely after having activated the Pan Icon; b) by scrolling the map only vertically/horizontally with a *Scrollbar*, c) or by moving the location rectangle (bidirectional). In some applications, the map is panned by drag and drop with the left mouse key pressed.

Reference Map [Basic]

- Description: First of all, the function serves as a generalized overview map of the region treated in the atlas. In addition, it often depicts the visible area (map extract).
- Implementation/Tools: The Reference Map is mostly designed as a static *Icon* of the map representing the atlas region. The map contains only the most important map elements like streams, main cities and country boundaries. The map extract is depicted as a location rectangle, while the viewing point in a 3D view usually consists of a location point combined with a field of view. If the Reference Map contains a moveable and resizable *Location Tool*, the Reference Map serves also as a combined scaling and panning tool.
- Interaction: The Reference Map can be used as a static overview map without any interaction. Interactivity is realized, when zooming of the Reference Map itself for more precise geo-location is possible. Interactivity of the *Location Tool (or Camera Position)* includes repositioning and zooming by moving and resizing the *Location Rectangle* with the mouse. As an alternative to moving the rectangle, moving the Reference Map is also a valuable solution. The Reference Map is usually visible but can be hidden by a click.
  In a 3D Reference Map, altering the position, line of sight, or field of view, is done by dragging the viewing point, moving the line of sight, or by changing the angle of the field of view.

Location/Georeference [Basic]

- Description: The Location function is dealing with the geographical position of the map, or in case of 3D mapping, the position of the camera. The position is usually displayed in (national) coordinates, and thus provides a geo-referenced frame of the map. In case of map rotation, this can also include a north arrow or main directions.
- Implementation/Tools: The function is implemented as a predefined *Panel* with editable *Input Fields*. Thereby, the position can be determined as precisely as possible (e.g., as the atlas application is allowing). It is recommended to add some additional geographical information like the name of the administrative or natural entity of the map center.
  The Location function is often combined with the Reference Map, since they complement each other ideally.
- Interaction: Entering valid numerical coordinates in the *Input Field* results in a change of the map extracts' size and position, as it is done graphically with the *Location Rectangle* in the Reference Map.

Geographic Index/Gazetteer [Basic]

- Description: The Index function contains a name list of all topographic and infrastructural map features (e.g., rivers, lakes, settlements). According to the general aims of the atlas, it can contain labels as endonyms and/or exonyms (see Chapter 4).

FIGURE 9.7
Geographic Index/Gazetteer function.

Together with a Search function, it is an essential component of any atlas.

- Implementation/Tools: The Geographic Index is often indirectly accessible via a *Push Button* or an *Icon*. It is implemented as a *Selection List,* often combined with an *Action Button.* Usually, the Geographic Index is organized in sub-lists of different feature groups, whereas these sub-lists can be freely arranged in user-defined combinations. Items showing up in the current map extent can be emphasized with different color (e.g., items not visible in the extent can be colored in grey).
  The function is often combined with a Geographic Search function or a Thematic Index (e.g., natural reserves, airports, etc.). Only a limited number of index items are visible, the others have to be accessed either by scrolling the list or by using the Search function as well.
- Interaction: Having requested the Index by clicking on the *Icon*, a single geographic name can be selected from a *List*. The selected item is highlighted in the list, but also in the map. Highlighting can be realized by applying different colors, blinking contours, or using cross hairs. Additionally, the map center is repositioned to the item selected (Figure 9.7).

Geographic Search [Basic]

- Description: The function is able to search in a database or file system for topographic and infrastructural map feature entries. It allows to extract and to display multiple entries with the same character string. By first selecting a specific category, the search procedure can be made more efficient.
- Implementation/Tools: The Geographic Search consists of an *Input Field* and an *Action Button* to start the search request. In case that the request applies to more than one item, a *List Box* to select a specific item has to be provided. To meet the different user requirements, it can be helpful to sort the search results in alphabetical, time-dependent or thematic order. As a more advanced function, Geographic Search can be combined with Thematic Search in a multimodal tool.
- Interaction: The user types the search item's name (or part of it) in the *Input Field*. The system responds with a list showing every item name matching the character string. Clicking to the correct label, the map is shifted and re-centered to the item selected.

2D Map Rotation [Advanced]

- Description: The Rotation function is described as re-orientation of a map in well-defined steps or freely by turning about a map center or an arbitrary pivot point. It mainly serves for changing the point of view and thus creating unusual map views. The function can also be used for tracking purposes, where the current direction is more important than the northing.
- Implementation/Tools: In case of using stepwise rotation, the function can be realized by means of an *Icon (Button)* or a *Drop-Down List.*

In case of free rotation, the function is defined as a *Moveable Slider* (in circular shape) showing main directions and degrees, and/or an *Input Field* to determine the geographic direction. Setting the pivot point freely in the map requires a cursor modus change.

- Interaction: Clicking a *Rotation Button* or selecting a rotation angle from a list will cause the map to rotate about a predefined pivot. For free rotation, activating a Rotation Icon changes the cursors' appearance (and mode) to a rotation arrow. The map is then rotated by clicked mouse key around a (pre-) defined axis. The speed of rotation depends on the distance of the cursor to the map rotation center.

Viewing Direction in a 3D Map [Advanced]

- Description: The function serves to set a new viewpoint in a static 3D map. It determines the position, the line of sight and the viewing angle of the camera and is preferably combined with a preview option.
- Implementation/Tools: The determination of the Viewing Direction in a 3D map demands for a modus change. Thus, an *Icon/Button* to evoke the function is required.
- Interaction: Activating the Viewing Direction *Button* turns the cursor into a tool to set a first point (camera position) on the map. A virtual line of sight is then connecting this point with the cursor. By moving the cursor over the map, a possible map image is created on-the-fly and displayed in a preview window. Setting a second point on the 3D map applies the Viewing Direction to the new visualization.

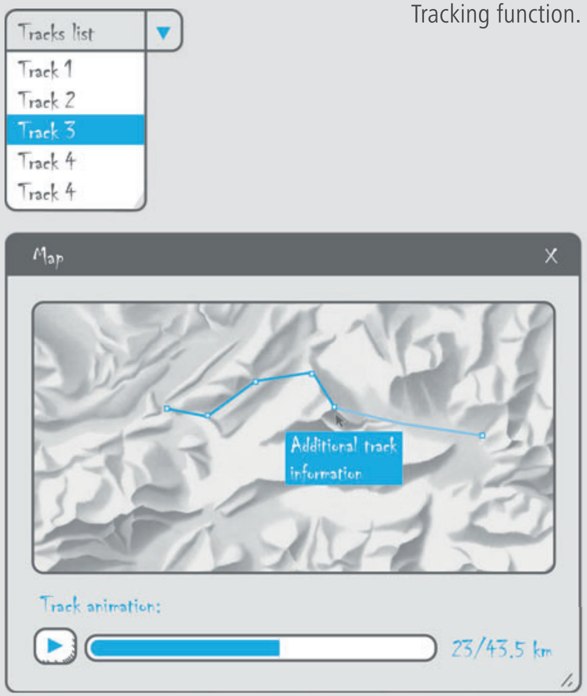
3D Moving and Flying around [Advanced]

- Description: The function is applicable only in a 3D map environment. It allows free navigation in a virtual space, especially over a virtual surface.
- Implementation/Tools: By means of mouse or keyboard input, the function controls the flight speed, the pitch, yaw and roll of the camera. The camera follows the terrain surface in a given or a predefined distance to the ground.
- Interaction: While in the flying mode with mouse down, spatial navigation is done by moving the mouse in any direction. Turning just the mouse wheel zooms the 3D map, while double-clicking brings the camera closer to the point clicked on the 3D map.

Tracking [Advanced]

- Description: Tracking is a procedure to follow spatial positions in a free or predefined sequence. The aim of the function is to extract information on the course and the position of an object. The tracks can originate internally from recorded (flight) paths on an atlas map, or externally from satellite-tracked routes (hiking and biking routes, etc.).
- Implementation/Tools: Track selection is done by means of a *Drop-Down List*, where different tracks are offered. The route selected is displayed in the map window and can be

FIGURE 9.8
Tracking function.



followed in discrete steps (distinct positions) or continuously (movement) with the mouse.

- Interaction: After opening the track list, a single track can be selected directly from the *List*. In case of many available tracks, selection criteria like track length are first applied to the tracks, and one specific track is chosen. The route selected is then displayed in the map window. By clicking anywhere on the track, the whole route can be perambulated, or specific places can be explored directly. Additional track information like coordinates, altitude, or pictures can be displayed in an *Output Field* (as a Tooltip). To follow a track by smooth movement, an Animation has to be started (Figure 9.8).

Pins [Advanced]

- Description: The function is used to mark interesting or important spots on the map. The pinned places can be found immediately and at a first glance.
- Implementation/Tools: A Pin is set in a map using a *Pictogram/Icon*. If different kinds of Pins are available, they should be arranged in a *Drop-Down List*. To label the pins, an *Input Field* is necessary. As any other layer, the Pin layer can be turned visible/invisible using a *Control Field*.
- Interaction: Clicking on an entry in the Pin's list, activates the Pin and it can then be placed anywhere on the map by drag and drop. By dragging the Pin *Icon*, the Pin can be moved to another place or removed from the *List*. Clicking the *Icon* itself opens an *Entry Field*, where the label of the Pin can be set or changed.

Localizer [Advanced]

- Description: The function serves for drawing the user's attention to a special place or typical situations on the map.
- Implementation/Tools: Localizing is implemented as a *Radio Button* and visualized as cross-lines or highlighting, running ants, or intermittent lines. While cross-lines are more suited for localizing point symbols, highlighting can be applied also for line and area symbols. In case of area symbols, the single use of an area contour line as highlighted part is recommended. Otherwise, the areal information (color) of the polygon is hidden and not comparable with others. If the place of interest is not displayed in the visible part of the map, the map can be re-centered to its specific place. The tool can be combined with Indexes or Search functions.
- Interaction: When choosing a thematic or topographic map element from a list, the Localizer function is activated. Localizing can also work bi-directionally; i.e., clicking on a map element will cause the entry in the list to be highlighted and centered.

Magnifier [Advanced]

- Description: The Magnifier function works as a local zoom-in function, thus increasing the map symbols. It also serves for getting detailed information about a small region without loosing the geographical context of the original map and scale.
- Implementation/Tools: The tool is realized as an *Icon*, combined with a *Drop-Down List* for choosing the magnifying factor. The magnified region is usually defined as a circle or square, but could be implemented in other geometric shapes (oval, rectangle), too. The delimitation of the enlarged region is usually drawn as a sharp borderline. A smooth transition is equally applicable.
- Interaction: Clicking with the Magnifier tool in the map will enlarge the map around this center point. The next zoom-in levels can be reached either step-wise by double-clicking the enlarged region (once or several times), or by selecting an appropriate zoom-level from the *Drop-Down List.*

Snapping [Advanced]

- Description: In the context of atlases, Snapping is described as a means of jumping quickly to some specific 'magnetic' point, line or area. The function can be applied in 3D maps to re-locate the viewing point (the camera) to a new position.
- Implementation: The tool is realized as an *Icon*, able to attach itself to some dedicated map features like mountains or lakes. Thus, the tool can be implemented e.g., as a climber for better communicating the basic idea behind it.
- Interaction: By choosing the Snapping tool, the cursor will change its mode and appearance. Clicking on a dedicated map feature afterwards, moves the camera directly to the position requested.

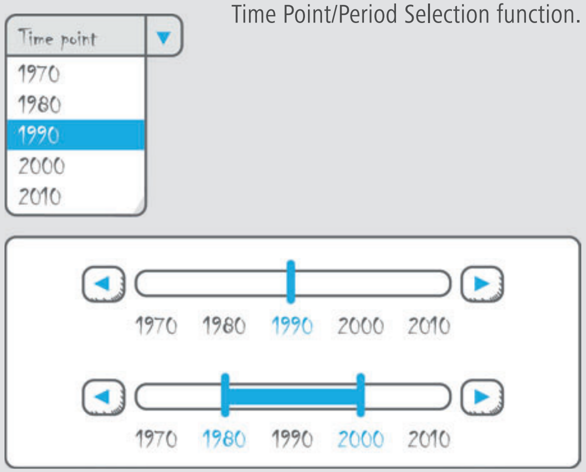
Temporal Navigation

Time Point/Period Selection [Basic]

- Description: Time Selection is described as picking a particular point in time or a time period. Changes in time can be displayed as single maps or as a (animated) series of maps.
- Implementation/Tools: As time information of maps is stored in attribute data, the Time Selection is done by means of a *Drop-Down List* or a *Slider (Timeline)*. In case of Time Point Selection, the *Slider* has only one moveable knob; in case of Time Period Selection, two independent knobs are required. For easier use, the knobs snap to tick marks when shifted to the next time stamp. Some of the time stamps have to be clearly labeled, at least the first and the last one. Using a *Drop-Down List*, the Time Points should be implemented like *Radio Buttons*, so that the user can choose only one option (Figure 9.9).

FIGURE 9.9

Time Point/Period Selection function.



- Interaction: With the Time Slider / Timeline tool, the mark(s) can be moved, or the user can click on a specific time stamp causing the mark to jump to the desired time point. Time Periods can also be moved preserving the range of the period by dragging the time bar instead of the knobs. Using Time List(s), the user clicks on one (or two) time points. To change the Time Period, two new time points have to be chosen.

Temporal Search and Temporal Index [Basic]

- Description: Similar to the functionality of Geographic/Spatial Search and Index, the functions are designated to find maps according to specific Time Points or Time Periods in a database or file system.
- Implementation/Tools: The search process asks for an *Input Field* and an *Action Button* to launch the request. The Temporal Index, accessible via an *Icon*, names all time events of the atlas in a *List* or a *Diagram*, and it may be combined with a *Button* to sort the list in actual or historical order.
- Interaction: To search for a Time Point or Period, the user types the search item's date into the *Input Field*. Subsequently, all map titles containing the time label (or meta information) are listed. By clicking on a title, the map will be displayed; the same procedure is also applied with the *Temporal Index*.

Temporal Animation/Time Change/Time Line [Advanced]

- Description: Animation can be specified as a timed sequence of maps differing in date, where one or more variables of a map layer may change over time. In digital atlases, Temporal Animation is used to visualize spatio-temporal processes dynamically. To make animations useful, there should be either only a slight change from one map to the next, or a significant trend visible.
- Implementation/Tools: Technically, the process is realized as frame-by-frame animation. For smooth transitions between the maps, fading can be used. In the simplest case, Temporal Animation is realized with a single *Button* for time control only (allowing start and stop the animation). More comfortable is a combination with a *Time Slider* (as described for the Time Selection function). Usually, additional time control *Buttons* for pause, forward/backward are also available. Once the animation is running, the date and time of the thematic change is displayed either by the *Time Slider* or on the map itself. Rewinding and looping the Animation represent other comfortable operating elements.
- Interaction: Start and stop of the animation as well as forward and backward are simply activated by a mouse click.

Thematic Navigation

Theme Selection [Basic]

- Description: The function enables the atlas user to individually choose a map theme out of a pre-defined list of atlas topics. Theme Selection offers an easy and structured access to the thematic database of the atlas.
- Implementation/Tools: The function is implemented by means of a *Selection List* – sometimes packed in a theme Icon – in order to save screen space. This list can be arranged as a *Drop-Down List*, or as a hierarchically structured *Drop-Down-Combination Box*.
- Interaction: Clicking on a map title or a theme Icon opens the map layer in the map window. In case of a hierarchical *Theme Menu*, the appropriate theme entry has first to be found and accessed before it can be displayed (Figure 9.10).

Theme Change/Switch [Basic]

- Description: Theme Change causes the replacement of the thematic map layer. This atlas function executes a direct Theme Switch without using Theme Selection or Theme Index. Themes related or complementary to the currently displayed map should be offered to the user.
- Implementation/Tools: Since Theme Change is in close conjunction with Theme Selection, it is also done by means of a *Drop-Down List* or an *Icon*. To invite for further use of the related themes, such *Icons* are often integrated in the atlas GUI as map thumbnails.
- Interaction: The new map theme is selected from the *List (Quick Reference)*, or by clicking at one of the map thumbnails. If the new map theme is not visible, the user has to browse through the *List* e.g., by scrolling the *List* or swiping a thumbnails' carrousel.

Thematic Index [Basic]

- Description: The Thematic Index lists the titles of all available thematic map layers. The map titles are mostly sorted in an alphabetical order, or arranged hierarchically.
- Implementation/Tools: The Index consists of a combination of GUI elements. An *Action Button* is installed to open the *Index Panel* or *Drawer*. The *Panel* or *Drawer* is separated into two parts: A small *Selection List*, where the main themes are presented, and a large scrollable *Selection List*, where the single map themes of every main subject area are visible.
- Interaction: After opening the Thematic Index by clicking on the *Index Button*, the user can either choose a new thematic map layer directly from the *List*, or switch to another main issue before.

Thematic Search [Basic]

- Description: Thematic Search is dedicated to quickly find a map theme by title or keyword.

FIGURE 9.10

Theme Selection function.

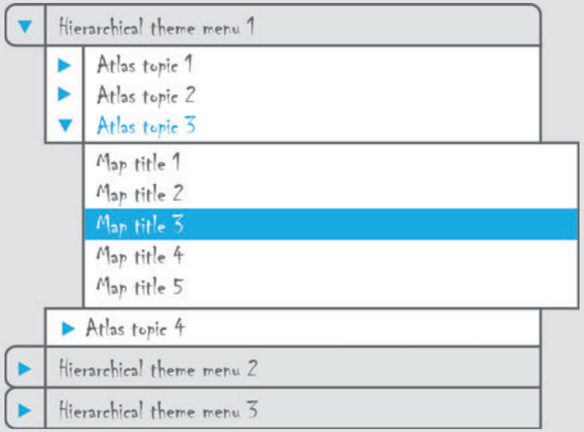
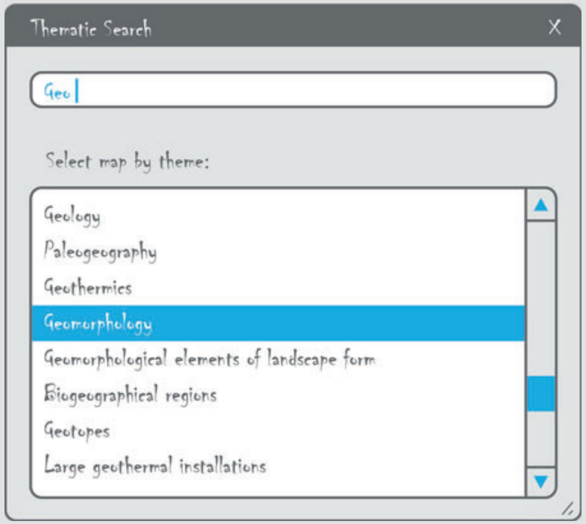


FIGURE 9.11

Thematic Search function.



- Implementation/Tools: The Search tool consists of an *Input Field* to enter the search term. An *Action Button* (or *Return Key*) can be used to start the search process. The Thematic Search function can be combined with a Thematic Index, or as a multi-modal Search Tool with Spatial/Geographic Search.
- Interaction: By typing the title or part of it (string of letters) in the *Input Field* and clicking the *Action Button*, the Search will return a list with all the map themes matching (partly) the request. From the resulting maps' list, the user has to select the map that covers his needs best (Figure 9.11).

9.4 CARTOGRAPHIC VISUALIZATION FUNCTIONS

Cartographic visualization functions are applied for Map Manipulation and Redlining. Users can modify the map graphics for display and publication purposes, or prepare the map for map reading and even visual analysis.

Map Manipulation

Layer Display/Layer Overlay (on/off) [Basic]

- Description: An atlas map consists of a free combination of base map and thematic layers. The function Layer Display is used to turn the different map layers on or off. Map Layers are dedicated either as base map or as thematic layers. The display order of the layers has to be well defined: Usually, vector data is displayed on top of raster data, and polygon data is drawn underneath line and point information.
- Implementation/Tools: For the Layer Display a *Drop-Down List* or a *Panel/Sidebar* is appropriate. The list should be structured according to thematic hierarchy, e.g., the base map layer group 'traffic' is subdivided into 'roads' and railway lines'. By means of a *Control Field* or an *Icon*, the layer can be made visible or not visible. In most atlases, some base map layers are shown by default.
- Interaction: By clicking on a *Control Field* or an *Icon* in the layers' *List*, the layer is turned on or off, and a new map containing the selected layers is drawn. At the same time, the selected layer is automatically displayed in the Legend Display.

Layer Transparency [Basic]

- Description: The Transparency function makes a layer more translucent or more opaque. The function is essential to balance the visual appearance of the map and map layers.
- Implementation/Tools: Layer Transparency manipulation is manly realized by a *Slider* tool with value display, and is often combined with an *Input Field*.
- Interaction: The transparency value of the layer can be assigned by drawing the *Slider* or by typing the numerical value into the

Input Field. Adaptation of the map layer to the transparency value is typically executed and visualized instantly.

Legend Display (on/off) [Basic/Advanced]

- Description: The legend is a basic component of every map. It contains the set of base map and thematic layers displayed in the map. In almost every legend, the legend categories representing the map layers are not only labeled, but also combined with *Icons*. A combination of the Legend Display function with the Layer Display/Selection function is recommended.
- Implementation/Tools: The Map Legend is implemented as a *Sidebar (Drawer)* or *Tab*. Within a static-interactive legend, all map layers are shown and can be turned on and off. In a more advanced dynamic-interactive legend, legend boxes allow changing the color, the opacity, the shape or the size of the map objects (see 2D Symbolization Modification). Such a smart legend may also display only the layers and categories of the visible part of the map. In an additional *Panel*, the user is allowed to highlight specific thematic categories, or even to manipulate the class number using a *Spin Button*, the size and class limits by means of *Input Fields, Action Buttons* or *Sliders* [Wiesmann 2007].
- Interaction: In case of a 'classic' legend, interaction is restricted to open or close the legend, or to click on a layer to turn it on or off.

Using a smart legend, the user can modify specific categories by clicking on their *Icon* (Figure 9.12).

FIGURE 9.12
Legend Display function with
2D Symbolization/Appearance Modification.

2D Symbolization/Appearance Modification [Advanced]

- Description: The function allows to change of the visual representation of the base map and thematic map elements by using cartographic variables (form, size, color, line width, texture). 2D Symbolization Modification is applied to intensify the map's message to the users' needs.
- Implementation/Tools: A combination of tools is needed to fulfill the different modification possibilities. To alter a symbol color, a *Slider*, a selectable *Color Field* or a *Selection List* is appropriate. The symbol size can be modified offering a *Rotation Field* or an *Input Field*. A symbol library realized as a set of *Icons* may serve best for changing the symbol shape. There are even more GUI controls like *Radio or Action Button* that can be used for manipulation purposes. In every case, it's most important to apply the same tools for same or similar interactions.
- Interaction: Interacting with the Modification tools is quite similar to other tools described earlier. For example, a change in symbol color demands first the selection of a map layer, and then picking a color from a *Color Field* or *List*. A more comfortable way is to choose a new color palette, as recommended by the well-known ColorBrewer [Brewer 2003].

3D Symbolization/Appearance Modification [Advanced]

- Description: Symbolization Modification in a 3D view concerns not only the thematic symbols itself. Furthermore, the function is used to change scene effects like lighting, shadows, fog, atmospheric effects, and also elements of the sky (clouds, stars, etc.). These effects contribute to a rather naturalistic 3D view.
- Implementation/Tools: Modification of 3D Map Appearance is achieved mainly by means of *Sliders, Moveable Sliders, Input Fields* and *Action Buttons*, as it is realized in a *Fog Tool*. In case of the lighting tool, the *Moveable Slider* is used to define the position of the light source. This combined tool can enclose different sub-tools, e.g., a time machine (an interactive watch) to set any date and time in order to create a realistic impression.
- Interaction: Moving the *Sliders*, e.g., in the fog tool causes the scenery to look more or less foggy or even shifts fog to a different zone of altitude. The lighting tool is steered by moving the *Moveable Slider* to any (natural) position. In any case, updating the scenery is happening either automatically, or by consciously clicking on an *Action Button*.

Projection Change [Advanced]

- Description: Changing the projection transfers maps from one geo-referenced map grid into another one. It is mainly done due to better presentation or attractiveness of the focus area. Projection Change can be applied to 2D maps and 3D maps, but should not happen unexpectedly. In 2D map mode, a lot of transformation procedures and equal-area or isogonal projection exist. In 3D mode, maps can be displayed as panoramic or globe view.
- Implementation/Tools: Projection Change in atlases is done with an *Action* or *Radio Button* to switch between the different views. As an alternative, a *Drop-Down List* or *Icons* with predefined projections may be available.
- Interaction: The recalculation of another projection is executed by simply pushing the *Action* or *Radio Button*.

Redlining

Labeling: Static [Basic]

- Description: The function enables to display labels of topographic and thematic map features. The labels are available as an arranged static layer, where the labels are designed and placed in a cartographic correct way. Because of the static approach, the placement and size of the labels are scale-dependent.
- Implementation/Tools: The basic version of Labeling is handled in the same way as the function Layer Display. Labels of different map layers can be turned on or off using *Control Fields* or *Icons*.
- Interaction: *A Control Field* or an *Icon* in the label layer list has to be clicked to turn the layer on or off.

Labeling: Interactive [Advanced]

- Description: The function enables to display labels of topographic and thematic map features automatically. The labels are applicable as interactively placed elements.
- Implementation/Tools: Advanced Labeling can be implemented with an *Action Button* to calculate free space for labels and place them automatically. An even more sophisticated way of Labeling is doable, where existing labels can be moved on the map, removed, or added. Furthermore, individual assignment of names and placement of labels can be realized by means of a Text *Icon* combined with an *Input Field*, or by importing a label *List*.
- Interaction: In case of calculated label placement, the user can first define the maximum number of labels (from a given set of labels) to be displayed using *Spin Buttons*, modify text size and text color, and then press the calculate *Button* to place the labels. Changing the position of labels on the map is simply done by drag and drop. Individual placement of labels needs to import the labels or type the names and probably place them afterwards by drag and drop (Figure 9.13).

FIGURE 9.13

Labeling: Interactive function.

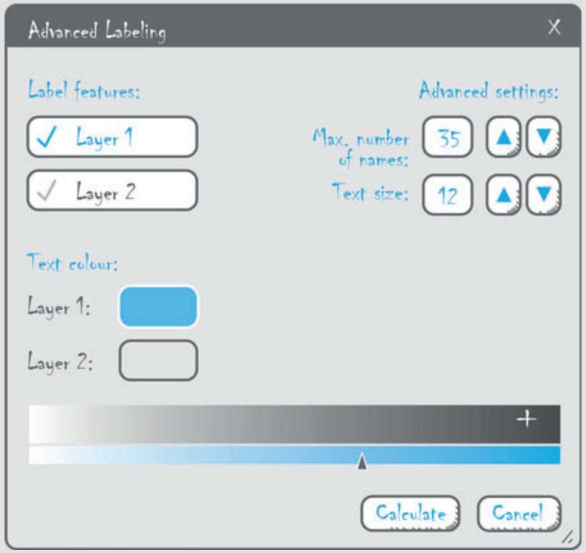


FIGURE 9.14

Distance and Area Measuring function.

Additional Map Elements [Advanced]

- Description: Various map elements like signatures, diagrams, or line and area features can be added to the atlas maps. To add such individual map elements, either a symbol library, or a drawing/digitizing function has to be offered by the atlas system.
- Implementation/Tools: The selection of additional map elements is realized using a *Drop-Down List* that contains the symbol library. All available symbols are presented in grouping order by theme. To draw or digitize user-defined map elements, a drawing mode has to be activated by an *Icon*. In both cases, additional map elements are drawn on a separate layer.
- Interaction: Using the symbol library, the *Drop-Down List* is opened with a click. A single symbol can be selected and placed on the map by drag and drop. To draw points, lines and polylines in a map, the user has to choose the appropriate drawing tool. Subsequently, the cartographic variables (color, size, etc.) of the drawn objects can be altered in a separate *Dialog Box* using the 3D Symbolization/ Appearance Modification function.

9.5 ANALYTIC FUNCTIONS

Analytic functions are adopted from GIS technology; because of their complexity, they are often implemented as combined tools. In atlases, it is intended to design the functions with a user-centered approach. This means that the function works almost like in a GIS, but the usage is more user-friendly and needs no expert knowledge.

Spatial Queries

Positional Query [Basic]

- Description: The query function is dealing with the geographical position of the cursor within the map. The position is usually displayed in (national) coordinates, and can also include altitude information (height a.s.l.).
- Implementation/Tools: A *Display Field* is used to show the position (coordinates) to the user. The realization can also be performed in combination with an *Action Button*.
- Interaction: By moving the cursor over the map, the position of the mouse pointer is displayed in an *Output Field*, similar to a Tooltip (see 9.2).

  In combination with an *Action Button ('Identify Button')*, the button needs to be activated first with a mouse click. Then the mouse pointer changes (e.g., turns into a question mark) and each map object can be identified with a mouse click as well. The object attributes are displayed in an output field again.

Distance and Area Measuring [Basic]

- Description: Distance in a 2D map or a 3D terrain model is measured "as the crow flies" (linear distance), resulting in a circular line or area around the starting point. It would also be reasonable to measure the real distance, following a terrain's surface.
- Implementation/Tools: Access to the function is done by means of an *Icon*. An *Action Button* triggers the measurement of the distance or area. The measurement results are displayed in an *Output Field*.
- Interaction: To measure a distance or an area in interactive atlases, the user draws a measuring line (consisting of individual points) in the map/terrain using the mouse. Measuring points can be adjusted to a new location by clicking on a point and moving the point to the desired location (advanced level of interactivity). By clicking on a specific measurement point, the point can be deleted. New points can be added by clicking on the measuring line. The measurement is completed by pressing the *Action Button* (Figure 9.14).

Thematic Queries

Attribute Query [Basic]

- Description: Attribute Queries are used to select map objects due to their attributes. For example, users can search for cities with a certain number of inhabitants. Nevertheless, Attribute Queries can also be performed without determination of query parameters.
- Implementation/Tools: The query parameters for are listed in a *Drop-Down List* for selection or can be set via a *Spin Button*. An *Entry Field* is used for the individual definition of the selection parameters. The query results/corresponding map objects are displayed in an *Output Field* and can additionally be indicated by flashing or coloring in the map.
- Interaction: The simplest form of an Attribute Query is the display of the query values in an output field during the mouse is hovering over the map objects. To perform a more complex Attribute Query, the selection of the query parameters using a query language (e.g., SQL) or the selection of data that are already collected in a *Drop-Down List* is required. Already indicated numeric values can be increased or decreased by pressing the *Spin Button*.

Attribute Selection [Advanced]

- Description: Statistical data are usually stored in single table files or in a database. The Attribute Selection function allows the query, selection and display of these data out of the file or database system.
- Implementation/Tools: Database access is enabled through an *Icon* or an *Action Button*. The statistical values are visualized in tabular form in a *Display Field*. The *Display Field* itself can be embedded in a *Drawer* or *Tab*. Boolean operators allow for the combination of multiple attributes.

FIGURE 9.15
Attribute Selection function.

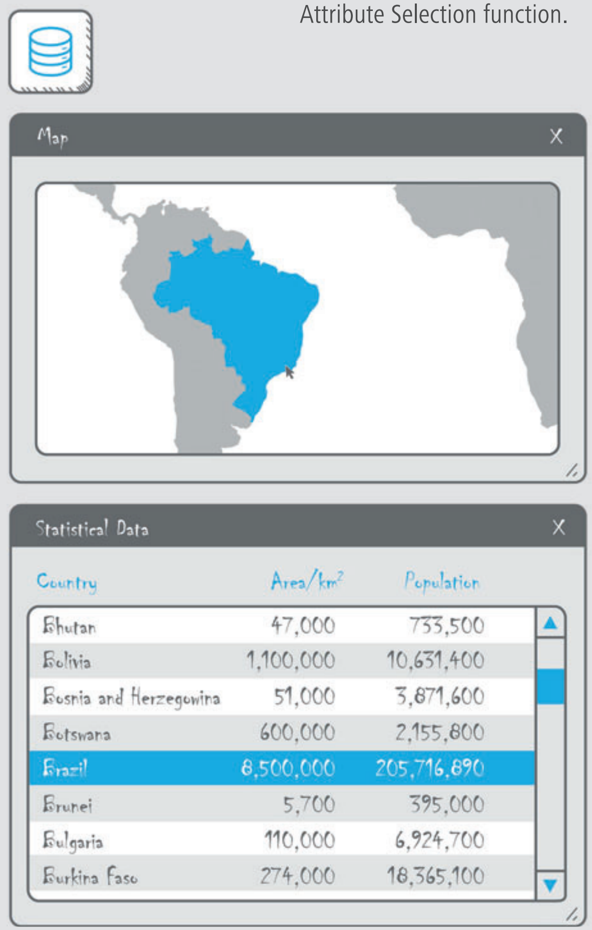


FIGURE 9.16

Map Comparison function.

- Interaction: The statistical data are displayed with a simple mouse click on the *Icon* or the *Action Button*. Likewise, the statistical data is shown after the selection of a map object, e.g., a country, a region or a province via mouse click. If the user hovers the mouse over a value in the table, the corresponding object is highlighted in the map and vice versa (see Figure 9.15).

Thematic Analysis

Map Comparison [Basic]

- Description: Map comparison is a method that facilitates the atlas use concerning identification and evaluation the content of two or more maps. With the help of this function, different map regions, different map topics or different time spans can be compared.
- Implementation/Tools: Map Comparison requires the selection of a second map. In order to do that, a *Drop-Down List* can be used. The implementation of a *Split Screen Button* simplifies the handling of the function (e.g., horizontal or vertical splitting).
- Interaction: Pushing the Split Screen Button divides the screen into two or more sections. After selection of the additional map(s), the user can compare the maps visually. The numeric comparison of different attribute values is possible in combination with the Map Feature Comparison function. The active map should be indicated with a colored frame.

Classification Modification [Advanced]

- Description: Statistical values are combined into classes to achieve a clear, easily read and understandable presentation. The Classification Modification function allows adding or deleting classes and adjusting class boundaries.
- Implementation/Tools: Various tools like *Spin Button, Icon, Radio Button, Drop-Down List, Slider* or *Entry Field* can be implemented to modify the classification of statistical values. *Spin Button, Icon* and *Radio Button* are mainly used to increase or reduce the number of classes. The *Slider* is used to adjust class boundaries and an *Input Field* is used to enter the values for the class limits. Furthermore, an *Action Button* is needed to redraw the map with the modified classification (Figure 9.16).
- Interaction: Class limits can be modified either by dragging the class limitation knobs of a *Slider* or by typing the new class limit values into an *Input Field*. By pressing the *Spin Button*, the number of classes can be increased or reduced by a fixed value. The *Spin Button* can also be combined with a *Drop-Down List* where predetermined values for the number of classes can be selected.

Classification (Legend Category) Selection [Advanced]

- Description: The feature Classification Selection enables the user to select one (or more) specific class or category in the legend. The selected class is highlighted on the corresponding map in order to find and compare thematic information.
- Implementation/Tools: As a prerequisite for this feature, the legend has to be interactive and Classification Modification has to be possible. Every legend class acts like a *Radio Button*, highlighting the selected class and at the same time dimming out the other classes.
- Interaction: Clicking on a legend class turns the color of all the other legend classes into grey. Instantly, the map is colored the same way. Another click on the same legend class brings back the original colors of the legend and the map. A multiple selection of legend categories can be achieved by using the *Shift Key* (Figure 9.17).

Map Feature Comparison [Advanced]

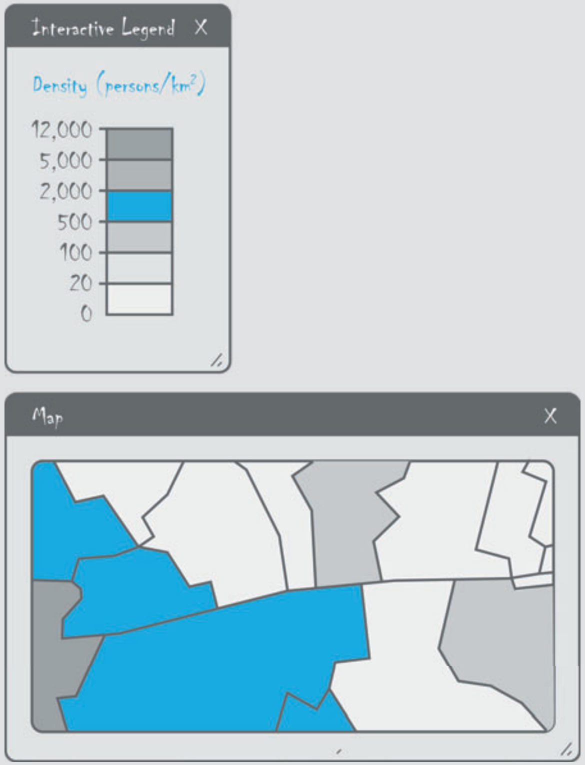
- Description: The Map Feature Comparison function enables the atlas user to analyze and compare map attributes of several specific thematic map symbols or diagrams, e.g. pie charts, from different map regions. The function can also be used to depict temporal variations (e.g., inhabitants of specific cities at different years).
- Implementation/Tools: The attributes of the selected map symbols or diagrams are shown in a *Display Field* as single (stacked) bars. These bars can be ranked by alphabetical order, or by attribute value. It is also possible to integrate an Icon or an *Action Button* to select the map diagrams with the highest or lowest values (e.g., Top Ten Button).
- Interaction: By hovering over the bars in the Comparison Tool, the corresponding diagram in the map is highlighted. Clicking on a bar will highlight the diagram and at the same time re-center the map to the selected diagram.

Buffering, Intersection and Aggregation [Advanced]

- Description: Buffering, Intersection and Aggregation are classic GIS functions. As in most other applications, these three complementary functions are usually implemented together in interactive atlases to achieve the desired result. With the Buffering function, the user creates buffer polygons around input features to a specified distance. The Intersect tool calculates the geometric intersection of any number of map features and creates new features out of the intersected ones. Aggregation in context of an interactive atlas is used to create new maps with a higher level of information density. Therefore, the aggregation function combines or overlays map features.

FIGURE 9.17

Classification (Legend Category) Selection function.



- Implementation/Tools: Access to all functions can be done via a *Drop-Down List*, an *Icon* or an *Action Button*. The Buffer distance and parameters can be entered into an *Input Field* or selected from a *Drop-Down List*. The selection of the Intersection method can be done by means of a *Drop-Down List*. Likewise, map layers and attributes for Aggregation are provided in a *Drop-Down List* for selection. R*adio Button*, *Checkbox or Spin Button* can be used as well.
- Interaction: The map features that should be buffered, intersected or aggregated are selected using the mouse pointer or via a *Selection List*. After defining or selecting all parameters using the above mentioned tools, an *Action Button* executes the GIS operations. The duration of the calculation should be displayed in the System Status bar. The calculated results can be modified in color or transparency using the 2D Symbolization/Appearance Modification function.

Terrain Analysis

Hypsography, Slope and Aspect [Advanced]

- Description: The function Hypsography extracts the altitude of every (grid) point and colors the grid cell according to the altitude value. The function Slope calculates the altitude difference of two points of the terrain model, whereas Aspect determines the cardinal direction of a grid cell in degrees. Again, the resulting values can be colored showing the steepness of slope or the geographic direction.
- Implementation/Tools: For each of the three functions, colors and classes are displayed in an *Output Field*. The colors and class limits can be changed using *Sliders* or *Input Fields*. It is also possible to insert or remove classes with specific *Action Buttons*.
- Interaction: Moving the cursor in the map, Altitude, Slope and Aspect values are calculated in real time and displayed in a numeric *Output Field*. To alter the classification, an *Output Field* has to be opened where the user can shift the class limits. The class color is changed selecting the original color in the legend, and then picking an alternate color from the integrated color *Output Field*.

Visibility [Advanced]

- Description: Terrain Visibility calculates and depicts the area visible from a single viewing point. The user can set this point either directly in the map by clicking on the preferred point or by entering coordinates of the desired point.
- Implementation/Tools: A *Pictogram* evokes the Visibility tool, and by means of an *Action Button* the viewing point can be set in the map. To determine Visibility, the atlas system has to calculate for every point of the terrain whether it is visible or not. That means a virtual ray is sent from the starting position to the end position. If the ray reaches the end point, this point is registered as visible. After

this ray-tracing calculation, a point matrix of visible terrain can be colored. Once more, the color is changed using a *Slider* and an *Output Field*.

- Interaction: To set the viewing point, the user has to alter the cursor mode and click on a specific location in the map. Automatically, the Visibility is calculated by the system and the visible regions are displayed on the 3D map. To change the location/position of the viewing point, it has to be moved by dragging the point on the terrain.

Terrain Profile [Advanced]

- Description: The Terrain Profile denominates the intersecting line of an image plane with the terrain surface. The Profile can be linear from a start point to an end point, or include also curved line segments. Often, the vertical exaggeration of the profile is modifiable.
- Implementation/Tools: A *Pictogram* is activated to start the Terrain Profile function. Using an *Action Button* a line can be drawn on the terrain surface. The distance and altitude of the digitized points are then transferred to an *Output Field* and redrawn in lateral view. As an extension of the function, it is also possible to integrate existing vector lines (e.g., roads), and even to combine data from another layer (e.g., precipitation, topographic labels).
- Interaction: The user selects the Profile tool and draws a profile line by clicking in free sequence onto the terrain surface (and on linear map objects). An existing line can be altered by dragging anchor points to a new position or by adding resp. removing points from the line. To follow the profile line on the map or on the *Profile Panel*, either the cursor on the map or a *Slider* has to be moved. Clearing of the profile line is done by clicking on an additional *Action Button* (Figure 9.18).

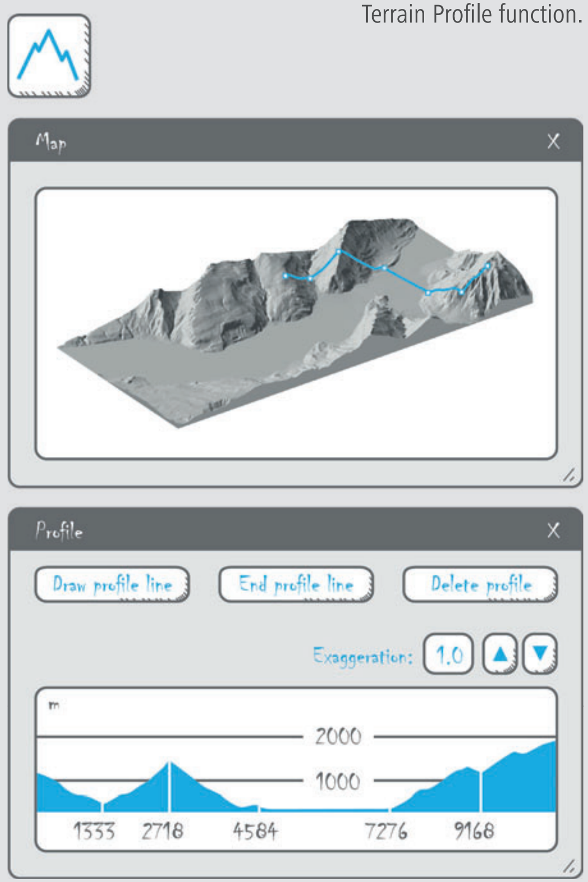
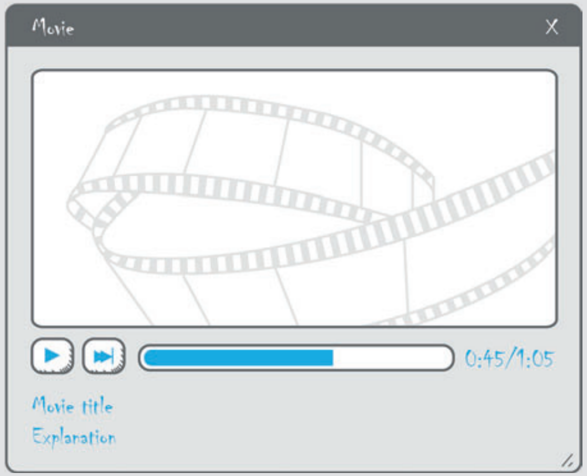


FIGURE 9.18
Terrain Profile function.

FIGURE 9.19

Multimedia: Movie function.



9.6 INFORMATION AND DIDACTIC FUNCTIONS

Information and Didactic Functions should motivate the user to get involved with the map theme. While Commentary functions are mainly suited to create story-telling maps, Self-Control functions address more the gaming component.

Commentary Functions

Multimedia: Text, Graphics, Tables, Pictures/Images, Sound, Movies [Basic]

- Description: The Multimedia function handles different Multimedia elements like text, graphics, tables, pictures, sound, and movies (see Chapter 6). As accompanying elements to the map, they may help and encourage in understanding the characteristics of the map theme, or the help instructions.
- Implementation/Tools: Multimedia elements are placed as *Output Fields* in a separate *Register* or *Drawer*. According to the number and size of the Multimedia elements, the *Output Field* can vary in layout. Multimedia elements can be accessed by means of a *Pictogram/Icon*, an *Action Button ('Info')*, or a *Drop-Down List*.
- Interaction: Clicking on the corresponding *Pictogram/Icon*, *Action Button* or entry in the *Drop-Down List* will open the *Output Field*. Texts, graphics, etc. are displayed in one universal or many different tailor-made *Output Fields*. In some cases – as with sound and movies – additional interactive media functionality (play, stop, rewind, loudness/sound level, etc.) is available (Figure 9.19).

Preview [Basic]

- Description: The function shows a preview of the original map in reduced scale. Furthermore, a Preview serves to quickly display and judge the user-defined map settings, before the map is displayed in the main map window. In particular, this is useful when time-consuming visualization and analysis have to be calculated. The Preview function can also be applied before exporting or printing the map.
- Implementation/Tools: The Preview function is implemented as a kind of thumbnail with an *Icon*, and eventually an *Action Button.*
- Interaction: In atlases with a Preview function, every map view is displayed both in the Preview window and in the main map window. New map settings (e.g., analytic terrain calculations) are first displayed in the Preview. By clicking the *Action Button*, the settings of the Preview were also applied to the main map window.

Guided Tours [Advanced]

- Description: Guided Tours consist of (didactically) arranged instructions of atlas functionality and/or of atlas content. Instructions can be presented by text, commented figures or animations. The aim of Guided Tours is to support the atlas use by explaining functions in the context of a story. Guided Tours should be realized if the atlas is rather complex in terms of content, structure, or functionality.

- Implementation/Tools: Guided Tours can be accessed using a *Pictogram/Icon*. The different media (text, graphics, etc.) and navigation tools (forward/backward, switch tour) are placed in an *Output Field*. While media are used to depict situations and processes, navigation tools allow stepping through a Guided Tour individually. At every stage of the atlas use, it should be possible to enter or leave the Guided Tours.
- Interaction: In general, interaction of Guided Tours is very similar to the interaction of the Multimedia function. However, it differs in aim and content, as it tries to help the user to find and apply the full functionality of the atlas.

Self-Control

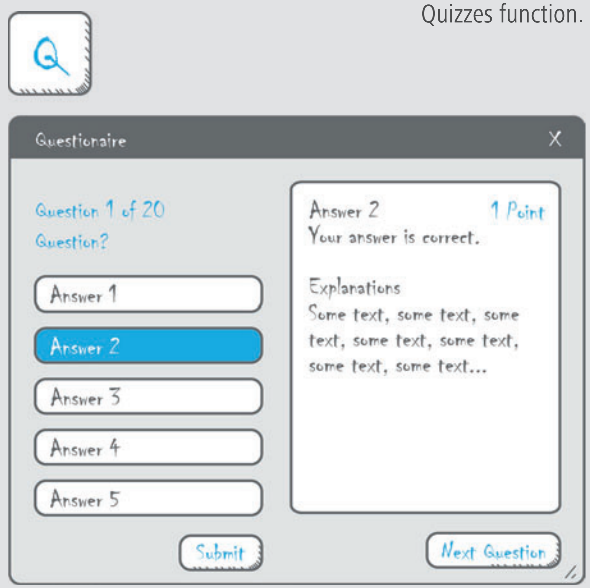
Didactic Tasks [Advanced]

- Description: In order to access the thematic content, Didactic Tasks can be integrated in an atlas. The user has to solve questions or tasks relating to some typical situations or processes of the map theme (e.g., find the highest density or variation of population). Various difficulty levels of Didactic Tasks are applicable for different educational levels.
- Implementation/Tools: Using a *Pictogram/Icon*, Didactic Tasks are invoked in an *Output Field.* A task assistant leads through the steps of task solving. The controlling and verification of successful task solving can be achieved in different ways. One viable option is to offer predefined answers in a multiple-choice test with *Check Boxes.*
- Interaction: A click on the *Pictogram/Icon* opens the task assistant window (*Display Field)* where the questions or tasks are displayed. The tasks have then to be solved by means of the thematic map content and the atlas tools. To proof the result of investigation a *Check Box* or *Radio Button* next to an answer in the task assistant has to be clicked. If the result is positive or negative, a correspondent prompt appears.

Quizzes [Advanced]

- Description: A Quiz is a question and answer game, whereby the user has to solve knowledge tasks or brain games. In contrast to Didactic Tasks, the focus of Quizzes is more on (geographic) knowledge quotation than on solving tasks.
- Implementation/Tools: In most cases, Quiz functions are accessible by a *Pictogram* or an *Action Button*. The Quiz answers are integrated in a *Selection List* (in most cases like *Radio Buttons*) and executed by an *Action Button.* Another possibility to answer the questions is to use an *Input Field*. The answer should always be displayed in an *Output Field*. For correct answers, credit points can be given.

FIGURE 9.20
Quizzes function.



- Interaction: Selecting the Quiz option from a toolbar, the questionnaire is opened. In a *Selection List*, all possible answers are presented. Clicking on an answer will then cause the system to respond in a positive or negative sense. In case of positive response, the user can proceed to the next question or quit the Quiz. In case of negative response, a second chance can be offered (Figure 9.20).

Games [Advanced]

- Description: Multimedia elements like graphics or movies are used to create a gaming environment. Puzzle and memory are two of the most applied games in atlases.
- Implementation/Tools: The integration of a Game function in an interactive atlas is achieved in a similar way as with Quizzes. Games are accessible via a *Selection List* and are often controlled by some *Action Buttons*.
- Interaction: Functionality and interactivity are very much depending on the character of the games. By clicking on an entry in the list, the game is usually started in a separate window. Depending on the type of game, different *Action Buttons* can be activated. When playing a memory, for example, the user can click on two memory pieces, which will turn from reverse side to front side view.

9.7 CONCLUSIONS AND RECOMMENDATIONS

Functionality is one of the most important issues that define user's acceptance and the quality of an atlas. As it is shown in the previous sections, there are more than seventy functions that could be implemented. Thus, atlas authors bear high responsibility to carefully evaluate and select functions and tools in terms of *quantity, type, use and interplay, and design.*

How can authors proceed with this huge amount of functions to find the right ones for their specific atlas product? First of all, they have to take a closer look at the *quantity and type* of atlas functions needed. The results of several studies show clearly, that atlas authors should be very conscious in integrating only a small number of tools in an atlas. Since atlases are not an everyday information medium, too many tools might often disturb the (occasional) user, and they would switch to another web site or to another app and never come back. But how many functions are necessary, and on what interactivity level? To answer this, authors have to investigate in their target user group and conduct specific surveys. In general, it is recommended to start with tools from the two groups *General Atlas* and *Navigation Functions*, most of them from the basic interactivity level. A small number of functions from the other three main groups can be added, depending on the focus of the atlas.

Basically, an atlas should contain at least the following functions:

- General Atlas Functions:
  Language Selection; Print; System Status; Help; Imprint; Home; Exit; Tooltips; Map Export
- Navigation Functions:
  Zooming; Panning; Location/Georeference; Geographic Search; Theme Selection; Theme Change/Switch; Thematic Index; Thematic Search
- Cartographic and Visualization Functions:
  Layer Display/Layer Overlay (on/off); Layer Transparency; Legend Display (on/off);
- Analytic Functions:
  Positional Query; Attribute Query
- Information and Didactic Functions:
  Choice of Multimedia functions, e.g., Text.

The *usability (usage and usefulness) and interplay* of the tools have to be considered in the atlas prototype phase. In most cases, the function groups and subgroups do not include purely self-contained functions. Therefore, the interplay of functions is important as well and has to be proofed [Sieber and Huber 2007].

Finally, the *tool design* marks the last stage of functionality implementation. It concerns the embedding of the functions in the GUI and the graphical tool design. Read more about design guidelines and tool iconicity in Chapter 7.

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10 PROTOTYPING AND EVALUATION

R. ERIC KRAMERS

A prototype is a representation of a product and its purpose is to be used to validate a design model. Prototyping and evaluation are related and sequential steps in a user centred product development process. Prototyping is needed prior to creating, adapting, changing and updating an atlas or any other map product, whether online, other digital or in printed format. This chapter will examine a series of prototyping methods and their evaluation.

Every methodological description and process described in this chapter is written within the context of a User Centred Design (UCD) process. UCD is both a philosophy and a process [Katz-Haas 1998]. As a philosophy, it approaches atlas and map design from the position of the user. UCD is a process because it focuses on understanding what users need and how they think. UCD effectively combines the map-makers business and organizationally mandated needs with those of the atlas user by taking both into consideration and finding the best combination of each. This approach saves effort and cost due to the quality of the end product and the reduction of design errors [Nielsen 1994]. The result will also offer more product effectiveness, user satisfaction and therefore more overall success.

There are many UCD models and methodologies, but many are made up of a variation of common stages (see Figure 10.1) as shown by the methodology used by the Atlas of Canada [Maskery 2002-05]. The first stage is an examination of business requirements, followed by user requirements research in the second stage. The third stage involves the product and systems design, followed by deployment. Various research methods can be used in each stage (Figure 10.1). Prototyping and evaluation occur in the second and third stages. This chapter will focus on various forms of prototyping from simple to complex and the three most valuable methods of evaluation: focus groups, one-on-one interviews and usability testing.

There must always be a target audience or group(s) of users in a UCD approach. It is important, therefore, to define target groups for a new product or determine the user group(s) of an existing one. A common method of doing this is with surveys or questionnaires, either online, by telephone, by mail, or in person. For surveys, the sample size

The value of a user centred development and design process can be summarized as follows:

- reduces the effect of poor and inaccurate assumptions by permitting informed decision making,
- balances business and user requirements,
- separates developers from evaluating their own designs,
- increases user satisfaction and product effectiveness,
- yields the right product, for the right reasons, for the right users.

What do you need to know for effective prototyping and evaluating? UCD answers this question in three parts:

1. Who are the atlas/map users or user groups?
2. What do they need?
3. How will they use the proposed additions, changes etc.?

FIGURE 10.1

User centred design methodology [The Atlas of Canada].

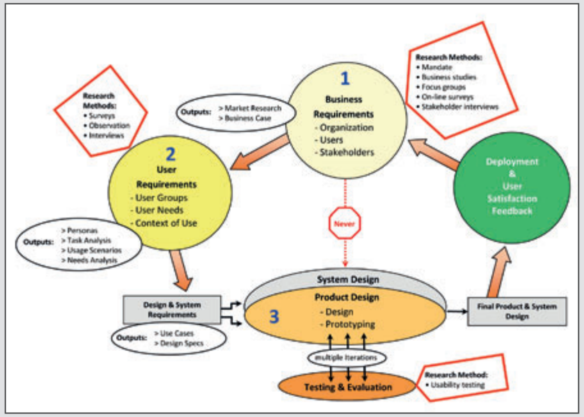
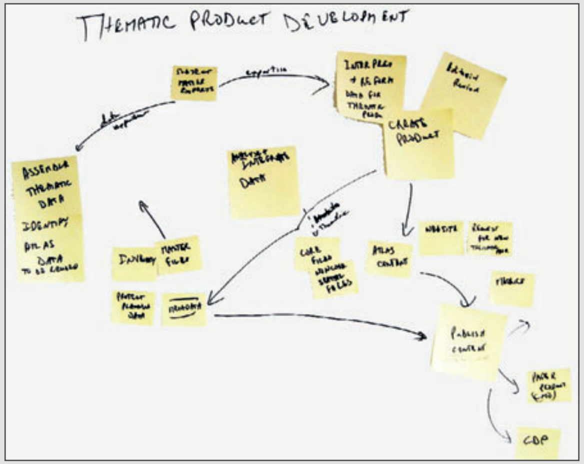


FIGURE 10.2

The result of a card sorting exercise using sticky notes [The Atlas of Canada].



should be large enough for the results to be representative the user group(s) being researched. There are many online sample size calculators that can help to determine this. The primary challenge in effective prototyping is obtaining thorough answers from users, using objective and unbiased questions, to make effective and objective design decisions. Those who make atlases and maps do not have the same perspective as those using them.

10.1 METHODS OF PROTOTYPING

There are many methods of creating good prototypes. Simple approaches can yield effective results and it is not always necessary to build elaborate functional mock-ups or prototypes. Simple prototypes are best in the beginning, gradually building in complexity with user feedback. A UCD principle in design and evaluation is that of iterative testing – start with simple and move to more complex prototypes with each usability testing iteration. One level of prototype leads to the next taking the most suitable ideas forward. This reduces risk by allowing a design team to reject unsuitable choices and make informed decisions. This approach makes the best use of resources and time, resulting in more accurate designs and greater success. This approach works equally well for atlas information architecture models, navigational paradigms, user interface designs, map layout and content designs and map reading evaluations. Not all the methods, described in this chapter need to be used. At the outset, an approach best suited for the product and budget must be determined. Prototypes should not be considered early views of final designs. Putting too much effort in early prototypes should be avoided so they do not become a barrier to design changes [ISO 1999].

Card Sorting

Card sorting is an effective way to determine how map users expect an atlas or map to be organized and structured. This method – done in the early stages of development – will also make obvious what's missing and what does not make sense. The name of each component of your atlas or map is written on a separate card or paper. The number of cards can vary from 10 to 20 or go as high as 25 to 50 or more. The user organizes the cards into what they see as logical groups and flows. If required, they can assign pre-selected group names or choose their own based on group relationships. Each card sorting exercise should be recorded through notes, a photograph or both and be repeated for a series of users. Once completed, the patterns will become evident and a logical user centred organization takes shape. Figure 10.2 shows an example of a completed simple card sorting exercise.

Storyboards

Storyboards are typically used in film and animation creation but are also effective tools for designing atlas and map prototypes. Storyboards show the step-by-step design and flow of information and can be simple or contain considerable detail. In atlas prototyping, they are useful to show the end or various end results of a card sorting activity. They are very effective in summarizing and communicating the structure of an atlas, the relationships between all parts of it and how users navigate within an atlas structure. Creating storyboards is easily done by pencil and paper, or in more detailed ways using illustrations. They are a useful resource in a focus group or one-on-one interview environment to discuss and obtain feedback on an atlas design. The next step could be a more detailed flow chart, wire frame diagram or static prototype showing the results of the storyboard.

Simple Static Prototypes

Simple static, or non-interactive, prototypes are easily made using paper mock-ups or any word processing or presentation software. Creating prototype maps and atlas navigational design models this way is simple and inexpensive. They are a suitable next step after card sorting and storyboards. At this early stage, there are certain to be many possible directions that a design could take, so eliminating unsuitable design directions is the main focus. These models are basic, with no graphic embellishments, and allow atlas and map designers to initially test different map designs and atlas navigational paradigms. The design of these prototypes focuses on outlines for map and atlas page components together with basic text. Figure 10.3 shows an example of atlas web pages using this method. Atlas users can be asked questions as part of simple scenarios to find a map or other content. Many pages like this are suitable to represent the various atlas pages; making selections from one page will lead to others. These prototypes are suitable for a usability test. Since they are so portable, these tests can be done almost anywhere, at any time.

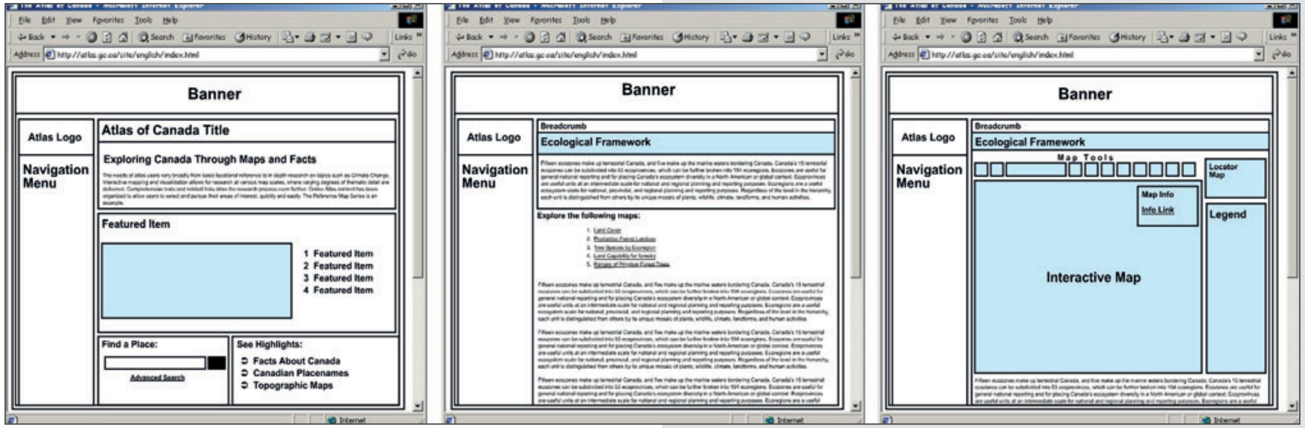


FIGURE 10.3
Simple static prototype using Power Point for an initial site navigation usability test [The Atlas of Canada].

Simple Functional Prototypes

The next level of prototype offers a modest amount of functionality along with more graphical enhancement. The functionality would typically be limited to that which is necessary for a successful testing scenario. For example, a user is asked to find a specific location on an interactive map, find the legend and describe what is there. For this scenario, only the zoom tool and link to the legend would be functional. If the user attempts to use another tool or link, these would not work, and the person would have to retry. This type of prototype may be more suitable for some general user groups, instead of a simple static prototype, as it will cause less distraction from the scenario activity. Figure 10.4 shows an example of this type of prototype where the increased level of detail is easily compared with the simple static prototype in Figure 10.3.

Complex Functional Prototypes

Complex functional prototypes offer full or near full functionality of components of an interactive atlas. These prototypes are typically produced towards the end of the design process after simple static and functional prototypes have been produced, tested and evaluated. Too many unevaluated navigation and design ideas would compromise and clutter the testing results. The design and functions at this level of prototype are more in the nature of fine-tuning than exploring new options. Figure 10.5 shows an example of a complex functional prototype, with its level of detail giving the impression of a finished product.

FIGURE 10.4

Simple functional prototype for site navigation usability test [The Atlas of Canada].

10.2 EVALUATING DESIGNS USING PROTOTYPES

The objective of evaluating prototypes is to validate a design idea or theory. For maps and atlases, this ensures that a particular design contains the right components, at the right size and scale and for interactive maps that there are the right tools and that they are usable. This applies to printed, multimedia and web-based atlases and maps. Designers would want to avoid an atlas where the user cannot find the maps or where the tools to explore the maps are not intuitive. Evaluation permits design ideas to be tested and validated with typical users against the researched user requirements.

FIGURE 10.5

Complex functional prototype for site navigation and map user interface usability testing [The Atlas of Canada].

Research methods fall into one of two groups:

- quantitative and
- qualitative (see Table 10.1).

Quantitative user research is focused on gathering and analysing data using statistical analysis methods. Surveys and questionnaires either online, by telephone, in person or by mail are the most common examples requiring larger numbers of respondents for representative results. Usability testing is also a quantitative method, but conversely uses smaller sample sizes as design issues can be detected with as few as six to eight participants [Szeredi and McLeod 2000]. Qualitative user research is focused on gathering an in-depth understanding of behaviour and the reasons for that behaviour. User observation, interviews and focus groups allow this in-depth research.

Three main research methods for testing or evaluating prototypes are focus groups, one-on-one interviews and usability testing. There are many techniques that can be used with each method. For example, usability tests can be conducted using techniques such as thinking aloud, eye tracking, observation and open or directed tasks. The selection of research method and technique should take into consideration the type of questions to be asked and the type of information required. Interviews and focus groups are used to understand attitudes and motivation (qualitative), while questionnaires and surveys are suitable for answering specific questions with both predefined and

TABLE 10.1

Qualitative and quantitative research methods grid [The Atlas of Canada].

	Qualitative	Quantitative
Attitude/ Motivation	Focus Groups, Interviews	Surveys (online, telephone, mail)
Behavior	User Observation	Usability Test

open-ended answers (quantitative). Care should be taken when bringing together quantitative and qualitative research results. Survey respondents tend to be less critical in their responses and mostly offer the benefit of any doubt to the positive. This can result in moderate scores from surveys but when using more in-depth qualitative research methods, issues, where they exist, will be revealed [Blackie 2001].

The two types of methods are fundamentally different and qualitative results should not be quantified since they are not representative in the same way as quantitative results. For example, if asking users in an online survey to select from a list which tools and functions they needed for an online map, they can easily select many without thinking in detail, why they want or need them. In a one-on-one interview, the use of tools is discussed in a more in-depth probing manner, not focusing on the tools but what the user needs to do. A design team then takes these needs and designs tools with functionality meeting those needs.

TABLE 10.2

Sample usability testing participant screening questionnaire [The Atlas of Canada].

Question	Answer	Action
1. Do you personally use the Internet?	Yes No	Continue Terminate
2. How often do you browse the internet?	Less than once a week Once a week Daily	Terminate Continue Continue
3. On average, how long do you browse the internet each session?	Less than 5 minutes 5 to 30 minutes More than 30 minutes	Terminate Continue Continue
4. Do you now or have you in the past used online maps?	Yes No	Continue Terminate
5. Have you used the online Atlas of Canada?	Yes No	Terminate Continue
6. Have you participated in any market or product research activity in the last12 months?	Yes No	Terminate Continue
7. Would you be interested in attending a one-hour session at our office to give your opinion about an online mapping website?	Yes No	Continue Terminate

Selecting and Screening Participants

Potential participants for any evaluation or testing process must belong to the user group(s) for which the atlas or map(s) is being designed. In order to achieve this, selection criteria need to be established to ensure the right types of participants are selected. These criteria range from very selective and focused to quite general, depending on how specific a user group is defined. Table 10.2 shows a sample recruiting screener for a usability test. The goal, in the example, was to find members of the general public who used the Internet regularly, including online maps, but had not used the online Atlas of Canada and who had not participated in any other similar research in the past twelve months. The restrictions are needed to ensure that biases are not introduced into the results.

Focus Groups

Focus groups are a qualitative research method where individuals, typical or representative of a user group, are brought together. In this setting a group of six to ten typical users spend about one to two hours responding to questions, visual examples and ideas about the maps or atlas that is being designed [Maskery 2002–05]. Focus groups are best used in the early stages of design and conducting one for each user group is best. They offer research information such as:

- expressing their needs for your atlas and maps,
- offering suggestions to improve the design and organization of your atlas,
- providing feedback on existing design and product ideas,
- discussing issues and problems and offer solutions.

A focus group should be led by an experienced moderator who encourages participants to offer answers and keeps the discussion focused and moving. It is also important that the moderator not lead participants to answers. This prevents bias from affecting the participants' answers and discussion. Participants should be aware that there are no right or wrong answers. Two drawbacks of focus groups that affect the quality of the feedback are dominant or vocal participants and the tendency of meeker participants to withhold comments. Both types of participants can offer very good responses, but the moderator needs to be aware of these personalities and ensure they contribute appropriately. There is a limit to the level of detail and depth of feedback that is obtained using this method. Depending on the research objective, focus groups may be sufficient or it may be necessary to go further with one-on-one interviews. Focus groups can be held in many locations but are most commonly held in purpose-built rooms where the session can be taped for later reference. One-way glass in an adjoining room or a video link allows members of the design team to hear and observe.

One-on-one Interviews

A one-on-one interview is a qualitative research method where detailed responses from participants are obtained to find exact user needs and requirements. In this setting, an interviewer will sit with a participant for between one and two hours and follow a prepared series of questions. Between 15 and 20 interviews for each user group are typically needed to gather sufficient feedback [Maskery 2002–05]. Interviews can be conducted in person, telephone or video conference. This method allows the interviewer to go beyond the "surface" responses, to determine what users need, as opposed to what they want. This difference is important because many people will have a long list of "wants", but their actual list of needs is usually shorter. An experienced interviewer will probe a respondent's answers, getting clarification and detail. A respondent may say one thing but actually mean something else or after discussing an answer the weight or need may be less than originally expressed. Sessions are normally recorded for later reference. One-way glass in an adjoining room or a video link allows members of the design team to hear and observe.

Interviews allow a design team to focus on real needs, and then add detail, design and functionality to support those needs. Interviews also allow for more contextual inquiry about each user group. The conditions and characteristics typical of each user group are determined. These include:

- Characteristics of use: how users interact with maps,
- Context of use: where the atlas is used, environmental characteristics, time of day, location, etc.,
- Task analysis: typical tasks performed by each user group.

Usage Scenarios and Personas

Once focus groups and interviews are completed, the researched information can be used to create two outputs: usage scenarios and personas. A usage scenario begins with a description of a typical and specific user need, their context of use, followed by all the tasks required to fulfill that need. They are the source inputs for the product and systems design. Usage scenarios, while focusing on a specific example, are based on the research that is representative of the broader user group.

Personas are a fictional but representative description of a single user group in the form of one typical user. They include and combine more personal information such as representative goals, behaviours, attitudes, motivations and needs. They are also given a face and a name, as this helps the design team to make decisions for a typical user as opposed to just a textual description of one. The usage scenarios are created for the personas. Design decisions are made based on a representative real user completing a typical task, for an actual real-life use. It is not a fictitious user doing an imaginary task in a test situation [Kramers 2007].

Usability Testing

Usability tests assess a participant's response to and performance on predetermined testing scenarios that are based on the usage scenarios. The test scenarios are a series of tasks linked together forming a complete sequence of steps that a typical user would conduct. Success is measured by observation and the ability of the participant to complete the tasks. The product or component is being evaluated, not the participant. He or she helps reveal, through the scenario tasks, what does and does not work and to what degree.

Participants go through the scenarios individually with a moderator who observes and records the results. The session can be observed by the project team, in another room, either through one-way glass or by video link. Tests are often video recorded for later reference. Participants are asked if they consent to the recording and told how they will be used. There are no other people involved in the session and there are no interruptions. Participants typically talk out loud to express what they are thinking as they carry out the tasks. The combination of notes, recording and observation are invaluable to understand whether something works, how well and what issues there may be in preventing a successful result. In addition to uncovering usability issues, the severity of them can be discovered, as this plays an important role in the analysis [Nivala et al. 2008].

Different testing scenarios of the same map function or interface design help refine them. If a task is unsuccessful, analysis of the participant's performance will lead to better design decisions. The results of a usability test are objective. Design is not achieved with a usability test; design decisions are made based on them [Maskery 2002–05]. This environment is also not suitable for subjective, opinion-based feedback. Questions and comments can, however, clarify a usability issue. Usability testing is best done as an iterative process beginning with initial concept prototypes. These need not be complex, such as simple static prototypes (Figure 10.3). The results allow informed decisions to be made for more complex prototypes that are then validated with more usability testing. The number of iterations or cycles depends on many factors including the complexity of the product and time and funds available. Ideally, iterations are repeated until an acceptable level of performance success is achieved. Usability testing requires financial and resource investment, but the results lead unquestionably to a better product [Souza 2001]. Six to eight participants, per iteration, are commonly accepted as sufficient in assessing usability [Nielsen 1994; Szeredi and McLeod 2000]. This ensures that the greatest numbers of design flaws are uncovered. Carefully selecting participants and developing a broad and well-designed series of tasks give the best results [Lindgaard and Chattratichart 2007].

An example of a scenario followed by a series of tasks used in an Atlas of Canada usability test is shown in Table 10.3. Evaluating involves analyzing the testing session results, recording metrics and creating success criteria for the prototypes. An example of this would be the level of success of the tested scenario and how many attempts the participant made to successfully complete it. In longer scenarios, there may be a task that a participant is unable to complete. Assistance may be given to allow the participant to proceed, so that the rest of the tasks are evaluated, and the time is not wasted. The failure of the skipped task would be recorded, and the potential success of the tasks that follow would be valid. The level of success needed should be determined in advance of the testing and is expressed as a whole number or percentage. Determining the resultant

TABLE 10.3
Sample Usability Testing Scenario [The Atlas of Canada].

Scenario:
You have gone to the Atlas of Canada Web site to find some information about a holiday destination in Prince Edward Island called Tignish, a small village, where you have heard there are good hiking trails.

Tasks:
1. How would you find a map showing the village of Tignish?
2. You cannot see enough detail; how would you see more detail around Tignish?
3. You notice a blue symbol close to Tignish that you do not recognize. How would you find out what that symbol means?
4. Can you measure the length of the trail from Tignish through the woods to the beach?
5. What is the distance?
6. How would you print a copy of the map showing the hiking trails?
7. Can you view a satellite image of the area shown in the map?
8. After looking at the image, you think it might be nice to display roads and trails on top of satellite image. How would you do that?
9. Now return to the original map that you started with showing all of Canada

issues and flaws permit informed decisions to be made, which in turn leads to a new product design and either more evaluation or a final solution. The result of the evaluation is to ensure that the mapping product satisfies users' needs and mapping objectives [Tsou and Curran 2008].

10.3 PROTOTYPE AND EVALUATION EXAMPLES

Two examples illustrating prototypes being evaluated are presented. The first involves a printed map and the second, online maps. They each use different prototype and research methods.

Example 1

This example shows how prototyping and evaluation was used for a printed thematic promotional map. In this case an entirely new product needed to be developed. The resultant design model and specifications would be used for a series of maps produced over many years.

FIGURE 10.6

A brochure used as stimulus material (seen here unfolded) for focus group discussion [The Atlas of Canada].

Objective

The Atlas of Canada wanted to develop a new promotional brochure for existing online atlas user groups at public and professional events. The Atlas had, for many years, given away high-quality printed maps as a promotional product and there was always a very strong and positive response to the maps. The increased cost to produce and print them resulted in fewer being published. With the content of the Atlas Web site growing and becoming more diverse, an informational brochure was needed. With a shrinking budget, both maps and brochure could not be produced so a concept idea was developed of combining a brochure and a map. Having never done this before, the Atlas team did not know what format, size, features, combination of information and design style would best resonate with its users. The concept was to combine information about the Atlas of Canada in a fold-out brochure that also contained, on the reverse side, a thematic or reference poster-map when fully opened. This would make the most effective use of resources. The map had to show useful content but at the same time create a desire to see more detailed information and data and lead the map user to the online Atlas of Canada, where they would find it. It should also be attractive enough to be used as a promotional poster. The information about the Atlas would have to be quick to read and easy to digest.

Methodology

The Atlas team decided that focus groups would offer the best option to obtain feedback on the concept. Two focus group session iterations were needed: the first to obtain enough information to design prototypes and the second, to validate findings and the prototypes developed from the first sessions. Participants were recruited for the focus group sessions representing two primary user groups – geography teachers at the grade 7 to 12 levels and the general public. The goal was to identify what type of map, thematic or reference, themes, map style, layout and promotional content were needed. All tests were conducted at a local testing facility with a professional focus group moderator [Maskery 2004].

Prototype and Stimulus Material

A variety of stimulus materials were used to aid discussion. The existing Atlas brochure (Figure 10.6), four wall maps (Figure 10.7) were shown to illustrate different map content, layout, design and supplemental information. These were used in the first focus group sessions. Two concept brochure/poster-map prototypes (Figure 10.8) were developed after the first round of sessions and were used in the second round to validate design and content ideas.

FIGURE 10.7

Maps used as stimulus material for focus group discussion [The Atlas of Canada].

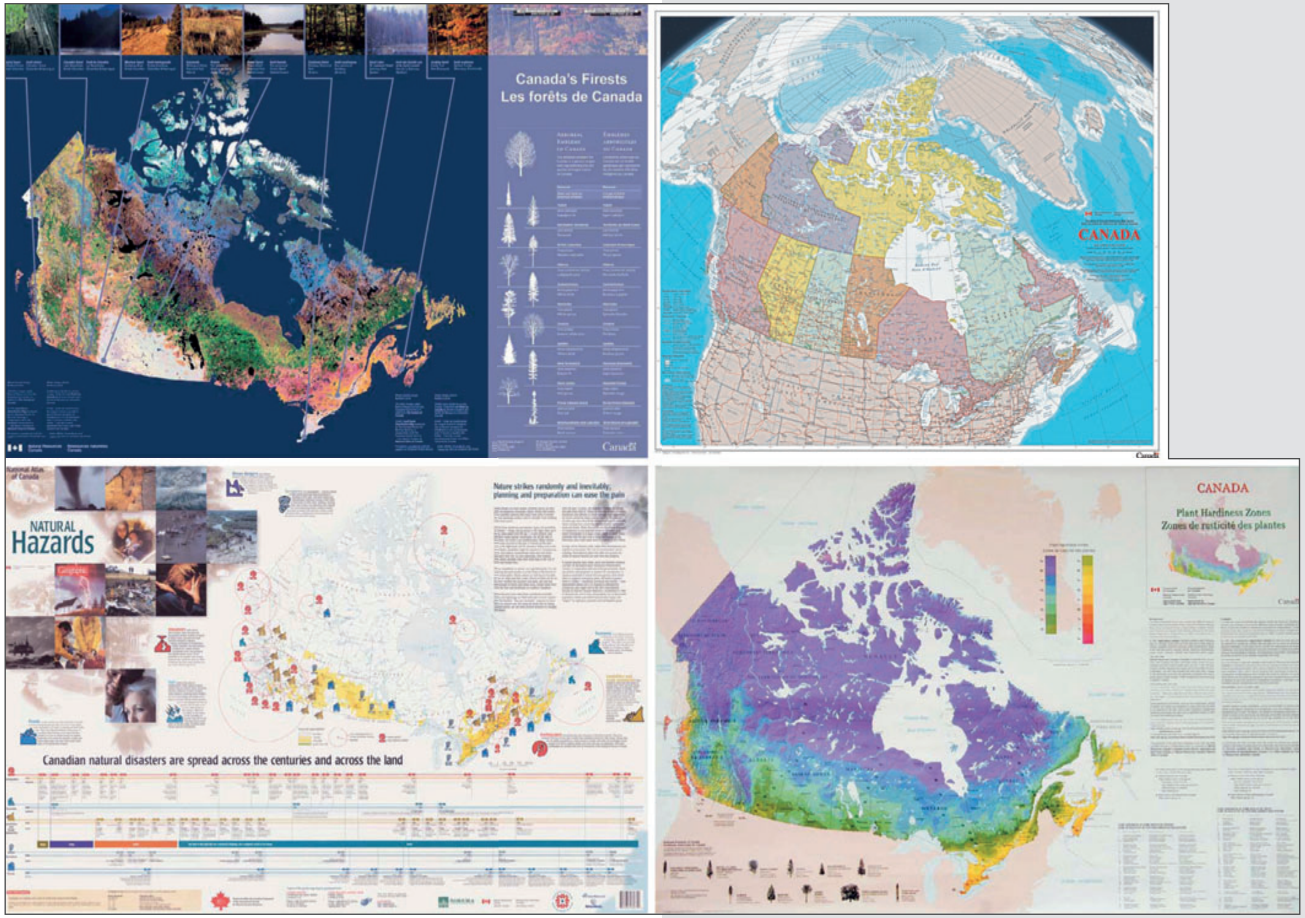
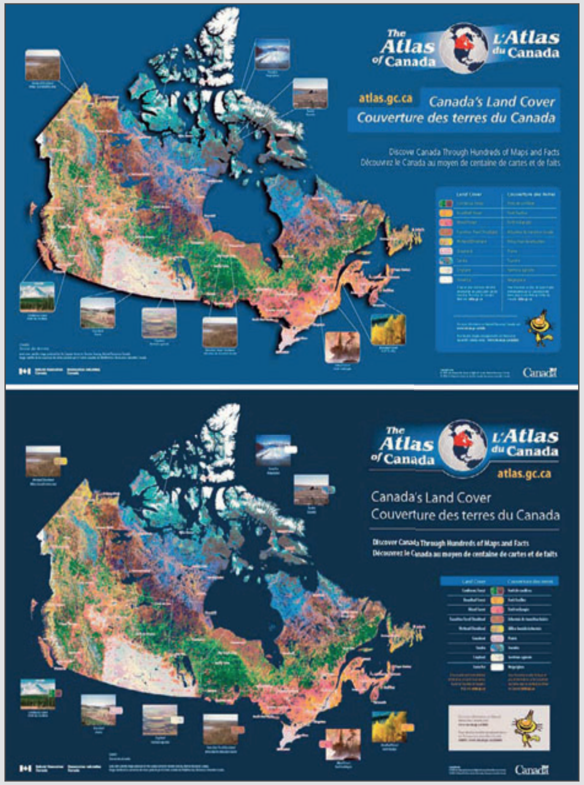


FIGURE 10.8

Poster-map prototypes created based on the results of the first iteration focus group's feedback and later used as stimulus material for the second iteration of focus groups [The Atlas of Canada].



Evaluation: Focus Group Sessions

The coverage of topics in all sessions was the same for both user groups. A complete moderator's guide was developed to manage time and discussion. The topics covered in the sessions included:

1. Finding and using online information and resources
   a. Sources used and uses of information
2. Reaction to stimulus material
   a. Choice of map and reasons for choice
3. Current use of wall maps
   a. Reasons and conditions of use
4. Feedback on brochure content
   a. Initial reaction
   b. Key message
   c. Feedback on text, images, web address
5. Reactions to promotional map concept
   a. Initial reaction
6. Feedback on map elements and characteristics
   a. Folded and unfolded size
   b. Preference for official language
   c. Map style
   d. Base map information
   e. Other supporting information
   f. Use of text and title
   g. Arrangement of map elements
7. Promotional map themes
   a. Identify specific topics for themes
   b. Identify themes with lasting value.

Example 2

This example shows how prototype and evaluation was used for online mapping. Here, a new type of map, archived maps, needed to be added to the existing online atlas. Use is made of previous usability research as a starting point. The existing site design and information architecture were adapted to accommodate the new maps.

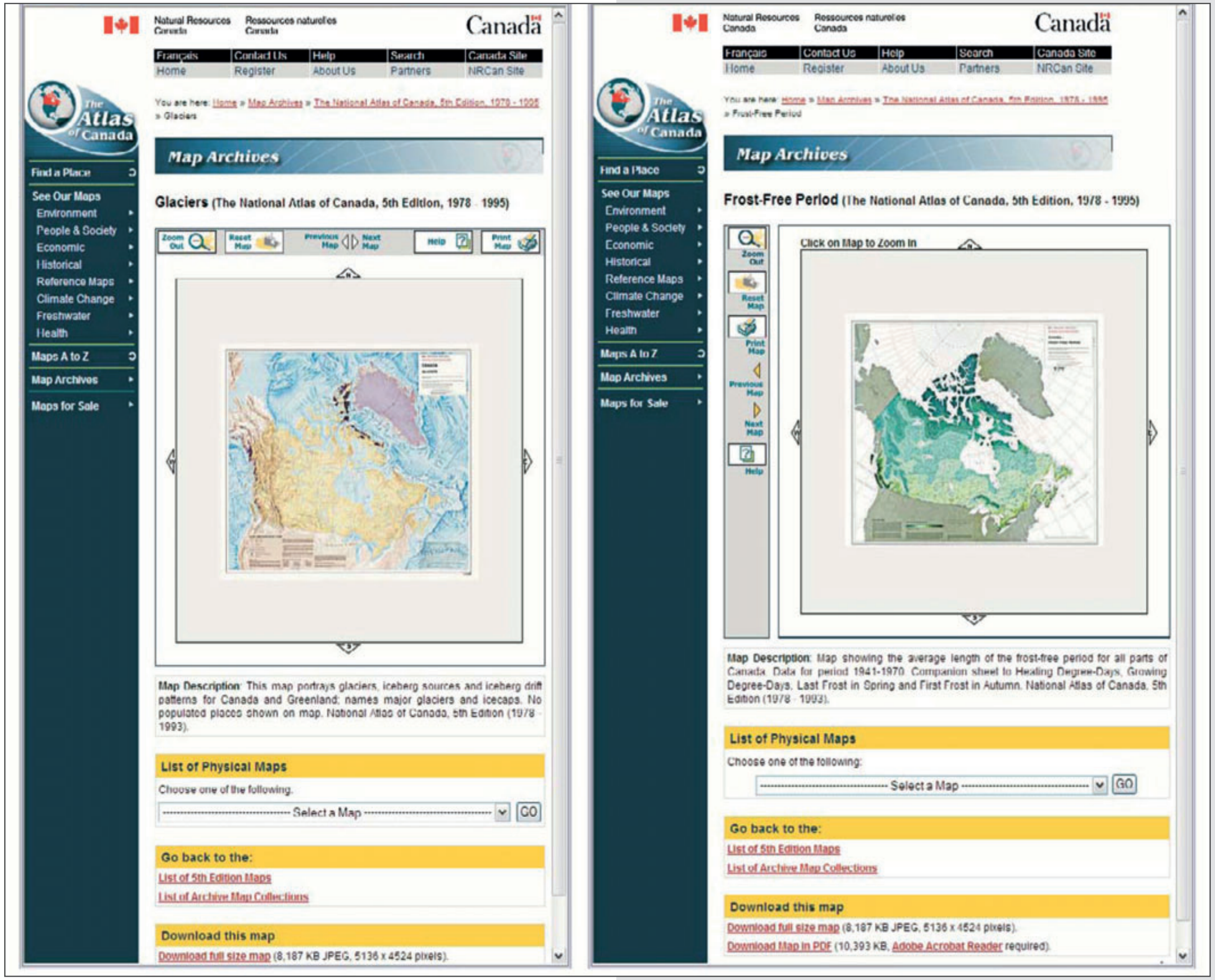
Objective

The Atlas of Canada has many older printed maps of themes that still interest map users. There are over 1100 maps in 19 collections and series and many individual maps of various themes. There was modest but constant demand for scanned/raster versions of these maps but responding to these requests was time consuming. To increase efficiency for the organization and ease of access for the user, it was decided that the best way to make the maps available to the largest number of users was to bring them into the online atlas. There they could be interactively viewed, used and downloaded.

There was a short window of opportunity where staff and other resources were available, so the existing Atlas mapping user interface was adapted for these maps. In addition, the existing information design of the Atlas site was adapted to suit the needs of users and the new maps.

FIGURE 10.9

Map Archives user-interface complex functional prototypes evaluated with usability tests [The Atlas of Canada].



Methodology

The online atlas used a well-developed and researched mapping User Interface (UI) and information architecture. The Atlas maps using the existing UI were very different from the scanned raster maps. Therefore, not all interaction functionality such as attribute queries, zooming to specific regions, would be compatible. In addition, the archived maps originally existed as printed volumes. Accordingly, new browse functionality would be tested to replicate browsing through a book of maps. Besides the adapted UI, additional navigation and downloading information would be added to the UI. Two complex functional prototype user interface pages (Figure 10.9) and navigational schemes were made for evaluation with usability tests. There were only time and resources for a single series of usability tests involving eight participants. All tests were conducted at a local testing facility with a professional usability moderator [Maskery 2003]. The order of prototype presentation was counterbalanced across participants with half having received prototype one first and the second half received prototype two first.

Prototype

Two complex functional prototypes, of the proposed map archives section of the Atlas web site, were developed. The decision to use near full functionality was two-fold. First, due to considerable previous usability testing and development on the existing Atlas mapping UI, they were relatively quick to produce. Second, due to the short time line, more robust scenarios needing all functionality were required.

The two prototypes had the following characteristics:

- All needed interaction functionality would be built into each.
- The tool bar would be horizontal across the top of the map window on one prototype and vertically along the left side of the map window for the other.
- Both prototype pages containing the UIs would use different maps and participants would have to navigate to maps in different parts of the Map Archives section.
- Other links on the UI page would assess finding other maps in the same series or collection and navigating to maps in unrelated collections.
- Scenario questions of both prototypes would vary to permit redundant assessment of usability and navigation.

The prototypes resided on an Atlas of Canada test server and were accessed via a public network connection for the test sessions. Standard network delays for loading pages were part of the test environment.

Evaluation: Usability Testing Session

Since the prototypes used a combination of existing mapping UI tools and features along with new ones, the tasks were designed to assess both. The usability testing was a good opportunity to re-validate existing UI tools, allowing for possible improvements to the existing thematic map UI. The specific evaluation objectives were as follows:

1. Test the usability of the map tools through tasks and ease of use ratings:
   a. Navigation to a map
   b. Pop-out menus (observed behaviour and comments)
   c. Usability of the pull-down menus to select a map
   d. Zooming in/out, including the location of the zoom instruction
   e. Panning
   f. Resetting the map/viewing the original full map
   g. Previous/next map tool
   h. Print map tool and clarity of print map template page (Layout and content)
   i. Find help information
2. Verify user reaction to:
   a. Title of section (Map Archives)
   b. Titles of map collections within section (order of name, edition, year)
   c. Subcategory names being meaningful for maps listed
   d. Pull-down menus to select a specific map
   e. Map tool bar location (top/left)
3. Test the usability of text and links on map page and usefulness ratings:
   a. Map description
   b. Selecting another map from the series
   c. Going back to previous maps
   d. Downloading the map
4. Track the use of “bread crumbs” for navigation:
   a. Tally uses by task
   b. Ask user awareness after tasks.

The two prototypes were evaluated, each with their own tasks. A total of 12 tasks were used to assess the usability of each prototype. The combination of all tasks allowed for redundant evaluation of the prototypes’ functionality and features. Here is a selection of the tasks for one of the prototypes:

1. You have heard that the online Atlas has recently added some maps from previous printed editions and you are interested in maps for the forestry industry. You want to find a map about sawmills. Please show me this map.
2. You notice two large red circles at the top left-hand corner of the map and you want to see what they are. Show me how you would get more detail.
3. You would like to see more detail for Nova Scotia, particularly the Halifax area. Show me how you would do that.
4. You now want to print what you see in the map window for future reference. Show me how you would do that.
5. You also decide to save a copy of the map. Can you show me how you would do that?
6. You would like to view other maps in this map series. Show me where you would go to view those maps.

TABLE 10.4

Selected summary of Archive Maps usability test task success and assist rates [The Atlas of Canada].

Task	Success Rate	Assist Rate	Number of Difficulties
Prototype 1			
1	8/8	0/8	1 each for 2 participants
2	3/8	5/8	0 for 3, but 5 who failed task had 2 to 4
3	8/8	0/8	0 for 7, 3 for 1 participant
Prototype 2			
1	7/8	2/8	1 each for 3 participants
2	4/8	6/8	0 for 1, but 4 who failed task had 2 to 3
3	6/8	4/8	1 for 4, 2 for 3 participants

TABLE 10.5

Selected summary of usability test participant use of interactive map tools [The Atlas of Canada].

Map Tools	Participant 1	2	3	4	5	6	7	8
Zoom In	Y	Y	Y	Y	Y	Y	Y	Y
Zoom Out	Y	Y	Y	N	Y	N	N	Y
Print	Y	N	Y	Y	Y	Y	Y	Y
Previous Map/Next Map	Y	N	Y	Y	Y	Y	Y	Y
Return to Map (on Print Map page)	Y	N	Y	Y	N	N	N	Y

The sessions were video recorded and observed, in an adjoining room with one-way glass, by the design team. Notes were taken by the session moderator and the observing team. Evaluation metrics were also collected during the usability test sessions. These were:

- Success rate, see Table 10.4,
- Assist rate, see Table 10.4,
- Ease of use,
- Use of features, see Table 10.5,
- Navigational routes to find maps.

While metrics are valuable, observing the testing sessions offers much more. The amount of time used for direct activity, thinking and evaluating before acting and any confusion experienced by the participant is easily seen and recorded. For example, observing how six of eight participants had difficulty finding and understanding a tool before successfully using it, offers a more detailed and refined understanding than just the numbers. All the observed and recorded results should be seen together to offer the most complete picture of the usability test. The success or failure of any component can be assessed, and design decisions are made based on all the results.

10.4 CONCLUSION

Creating prototypes and evaluating them are effective methods of validating a new, revised or adapted atlas, map or other geomatics product. There are many methods of creating good prototypes from simple to complex and fully functional. They ensure that a product is developed in an informed manner that will lead to success. As part of a user centred design process, prototypes and their evaluation will lead to well-developed products that meet organizational and users' needs.

A guiding principle in UCD is that of iterative development and testing: start with simple and move to more complex prototypes with usability testing after each is developed. This allows the most suitable ideas to come forward and reduces risk by rejecting unsuitable design choices. This approach works equally well for all geo-information products. Not all methods need to be used every time and simple prototypes can yield very effective results for both new and established products. There are situations, for example, with a fully developed product, when complex functional prototypes are the best option for additions and changes.

Flexibility is important to ensure that the best combination of prototype, evaluation method and number of iterations is selected based on the needs of the product and level of resources available. The goal in any development process is to create the most usable and successful product possible. Effective prototypes and their evaluation will lead to this, every time.

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ESS Contribution number / Numéro de contribution du SST: 20090121

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Location	Leibniz-Institute for Regional Geography, Leipzig, Germany	Organization and Marketing
Best menus offered	National Atlas Inventory (2019–today) National Atlas of Germany: Digital Ed. (1999–2007), Spinoffs (2007–today) Digital Atlas of Geopolitical Imaginaries of Eastern Central Europe (2011–2014)	
Dr. Hartmut Asche	Professor Emeritus	THE COOK OF CHAPTER 2
Location	Institute of Geography, University of Potsdam	Editorial Aspects
Best menus offered	The Atlas Toolbox: Concept and Development of a Rule based Map Component for a GIS-VIS Production Environment (with R. Engemaier). In: Ruas, A. (ed. 2011): Advances in Cartography, Vol. 1, 147–159. The Demographic Atlas of Croatia – A Web-Based Atlas Information System (with A. Toskić, D. Spevec, R. Engemaier). In: Gartner, G., Ortag, F. (2010): Cartography in Central and Eastern Europe: CEE 2009, 345–360. Demographic Atlas of Albania (2003) Diercke Weltraumbild-Atlas (1981/82)	
Dr. Ferjan Ormeling	Professor Emeritus, Member Explokart Research Group	THE COOKS OF CHAPTER 3
Location	University of Amsterdam	Atlas Use
Best menus offered	Atlas van Nederland 2nd Ed. (1986–1990) Atlas van Nederland – supplement 1st Ed. (1977–1980)	
Dr. Corné van Elzakker	Assistant Professor	
Location	University of Twente, Faculty ITC, the Netherlands	
Best menus offered	Understanding Map Uses and Users (with K. Ooms). In: Kent, A.J., Vujakovic, P. (eds., 2018): The Routledge Handbook of Mapping and Cartography. Chapter 4, 55–67. Routledge: Milton Park, Abingdon, Oxfordshire. User studies in cartography: opportunities for empirical research on interactive maps and visualizations (with R.E. Roth, A. Çöltekin, L. Delazari, H. Fonseca Filho, A. Griffin, A. Hall, J. Korpi, I. Lokka, A. Mendoça, K. Ooms) (2017). International Journal of Cartography, 3, Sup 1 – Research Special Issue, 61–89. The Atlas of Experience. In: Geospatial World (2013) 4, 34–36.	

Dr. Károly Kocsis	Project Manager "National Atlas of Hungary", Institute Director
Location	Geographical Institute, Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
Best menus offered	National Atlas of Hungary: Printed version (2018–today), Internet version (2018–today) Belarus in Maps: Printed version (2017) Hungary in Maps: Printed version (2009, 2011) Ukraine in Maps: Printed version (2008) Southeastern Europe in Maps: Printed version (2005, 2007)
Dr. Mátyás Márton	Professor Emeritus
Location	Department of Cartography and Geoinformatics, ELTE Budapest, Hungary
Best menus offered	Virtual Globes Museum (2007–today) Térképeken a világtörténelem (1999) (The Times Atlas of World History – Hungarian Ed.) Atlas of Central Europe (1993)
Dr. Peter Jordan	Honorary and Associate Professor
Locations	Institute of Urban and Regional Research, Austrian Academy of Sciences, Vienna/Austria and Faculty of the Humanities, University of the Free State, Bloemfontein/South Africa
Best menus offered	Book series "Name and Place" (with P. Woodman, Volumes 1–8, 2011–2019) Place Names as an Expression of Human Relations to Space (2016) The Endonym/Exonym Divide from a Cultural-geographical Point of View (2015) Atlas of Eastern and Southeastern Europe (1989–2014) Resources and Environment. World Atlas (1998)

Tim Trainor	Chief Geospatial Scientist (retired)	THE COOK OF CHAPTER 5
Location	United States Census Bureau, Laurel, Maryland	Data Management
Best menus offered	United States Census 2020 Regional Atlases (with D. Bevington-Attardi). In: Monmonier, M. (ed. 2015): The History of Cartography, Vol 6: Cartography in the Twentieth Century. 101–106. A Forward to Electronic Atlases: National and Regional Applications (1995). Cartographic Perspectives (20), 3–4. U.S. Bureau of the Census, Congressional District Atlas (1993)	
Dr. Vit Vozenilek	Professor of Geoinformatics and Head of the Department	THE COOKS OF CHAPTER 6
Location	Department of Geoinformatics, Palacký University Olomouc, Czech Republic	Multimedia Elements
Best menus offered	Atlas of transport accessibility in Czechia (2017) Atlas of Higher Education in Czech Republic (2014) Atlas of Special Education Centres in the Czech Republic (2013) Atlas of phenological conditions in Czechia (2012) Atlas of foreign development cooperation of the Czech Republic (2011) Atlas of Election for Representative of Olomouc Region (2009) Hranicko – Atlas of microregion development (2008) Climate Atlas of Czechia (2007)	
Dr. Rostislav Netek	Lecturer in Web Cartography	
Location	Department of Geoinformatics, Palacký University Olomouc, Czech Republic	
Best menus offered	Atlas of Higher Education in Czech Republic (2014) Atlas of foreign development cooperation of the Czech Republic (2011)	
Dr. René Sieber	Project Manager “Atlas of Switzerland”	THE COOK OF CHAPTER 7 AND CHAPTER 9
Location	Institute of Cartography and Geoinformation, ETH Zurich, Switzerland	Atlas GUI and Layout Design Atlas Functionality
Best menus offered	Atlas of Switzerland, Printed version (1992–1996), Interactive version (1995–today) Swiss World Atlas, Printed version (1991–1993)	

THE COOK OF CHAPTER 8

Map Design and Visualization

Dr. h.c. Ernst Spiess	Professor Emeritus
Location	Institute of Cartography, ETH Zurich, Switzerland
Best menus offered	Swiss World Atlas: Editor in chief printed version (1981–2008) Atlas of Switzerland: Editor in chief printed version (1978–1996)

THE COOK OF CHAPTER 9

Atlas Functionality

Juliane Cron, M.Sc.	Researcher and Lecturer
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Best menus offered	Swiss World Atlas: Printed version (2007–2017) Swiss World Atlas: Interactive version (2006–2013)

THE COOK OF CHAPTER 10

Prototyping and Evaluation

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Best menus offered	The Atlas of Canada: 5th Ed., Printed version (1986–1993), 6th Ed., Interactive version (1995–2015) The Canadian Communities Atlas: Interactive version (1997–2001)

Atlases serve as a spatiotemporal and sociocultural compendium to display, explore, compare, and analyze topographic and thematic information in order to gain novel knowledge.

The intention of **The Atlas Cookbook** is to give advice to atlas authors in a general way:

- to give an overview over the realization stages,
- to show how to start a new atlas project (which is always the most difficult part),
- and how to deal with conceptual, organizational, graphical or publishing issues.

Therefore, we organized **The Atlas Cookbook** in ten chapters, which reflect a feasible and practicable way to conduct an atlas project. The cookbook can be read as a whole, but also only a single chapter can help!

The Atlas Cookbook is written on a management level, not in a technical way. Most of the comments and recommendations are applicable for current and new digital technologies, but many sections are also valid and useful for editing printed atlases.

ISBN 978-3-033-09795-7

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