Map Compilation Procedures

the operations involved in preparing the compilation and printing originals of maps. Map compilation procedures include editorial and preparatory work, compilation, and the preparation of map originals for publication (map design).

Editorial and preparatory work includes collecting, systematizing, studying, and scientifically collating cartographic source material. Depending on the purpose and nature of the map, a map montage model is made, and the scale, cartographic projection, and cartographic methods of representation and symbols are chosen. The decisions on these questions, together with the technical instructions for the method to be followed in compiling, preparing for publication, and publishing the map, are described in an editing plan, or map program. The editing plan is supplemented either by a series of graphic charts and a section with the color pattern or by the author’s model. Editorial and preparatory work concludes with the computation of the cartographic projection, the construction of geographic and coordinate grids, and the entering of geodetic control points, indications of areas adjoining the map margin, the marginal representation, and the basic cartographic material.

Compilation consists in transferring the cartographic data from the source materials to a prepared base in order to make a compilation original.

The basic process in map compilation is known as cartographic generalization—the selection and simplification of the material that is to be mapped. The data are transferred from the source material to the compilation original by photoreproduction, by photo conversion, by projection through an epidiascope or optical drawing instruments, by photoelectronic conversion, or by mechanical writing methods, such as using the pantograph and perspectograph or graphic procedures (compilation by use of a grid). These methods may be combined. The topographic elements to be shown on the map are entered on the compilation original in a sequence. First, the control points and ground features serving as landmarks are entered, followed by hydro-graphic objects, population centers, road network, relief, vegetation, soils, and boundaries. The specialized data of thematic maps are compiled on a separate copy. Geographic names are entered immediately after depicting the items to which they refer. When nonstandard maps are being compiled, the compilation original is supplemented with a copy of the map’s color pattern indicating the colors that are to be used in printing all tone elements of the map, such as the hypsometric coloring, the colors of bodies of water and vegetation, and special data.

The finished compilation original of a map sheet is edited and corrected. Since it is an author’s original, its graphic qualities do not meet map printing standards and it must be prepared for publication. The publishing original is prepared either by drawing on a paper or plastic base or by scribing on specially coated plastic. An outline obtained from the compilation original is used.

The drawing is done in strict conformity with standard symbols. The drawing may be composite (all hachures entered on one copy), partially separated (one element of the map drawn on one copy and the rest on a second copy), or completely separate (individual publishing originals prepared for each hachure element). Only separate publishing originals are prepared when drawing on plastic.

The lettering is prepared by photocomposition and is usually glued directly onto the drawn originals (contour, hydrography, relief); sometimes the lettering is a separate publishing original. When map originals are being prepared for publication by scribing on plastic, separate engravings are made for each hachure element of the map. The work is done with special scribing tools. From negative engravings, diapositives are obtained onto which the typeset lettering is glued. When publication originals are being prepared either by drawing or by scribing on plastic, special masks of transparent plastic are usually made for the color pattern of the map. The work is checked visually and by preparing a line original on paper or plastic. When composite or partially separate drawings on paper are used, the process of preparing map originals for publication concludes with making separate scanning models and color (lithographic) models. The former serve as guides during retouching, and the latter are used to make the printing plates for the maps’ color pattern.

In analyzing the current trends toward improving map production a number of basic directions may be identified: the development of techniques for compiling and preparing maps for publication; mechanization of photocomposition; introduction of microfilming, electrophotography, and photoluminescence; improvement of photocopying operations; automation of computing and constructing the mathematical base of the map with computers and the automatic coordinatograph; and automation of the preparation of publishing originals and the process of generalization.

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# Cartographic generalization

**Cartographic generalization**, or **map generalization**, includes all changes in a map that are made when one derives a [smaller-scale](https://en.wikipedia.org/wiki/Scale_%28map%29) [map](https://en.wikipedia.org/wiki/Map) from a larger-scale map or map data, or vice versa. It is a core part of [cartographic design](https://en.wikipedia.org/wiki/Cartographic_design). Whether done manually by a [cartographer](https://en.wikipedia.org/wiki/Cartographer) or by a computer or set of [algorithms](https://en.wikipedia.org/wiki/Algorithms), [generalization](https://en.wikipedia.org/wiki/Generalization) seeks to abstract [spatial information](https://en.wikipedia.org/wiki/Geospatial_information) at a high [level of detail](https://en.wikipedia.org/wiki/Level_of_detail) to information that can be rendered on a map at a lower level of detail. For example, we might have the outlines of all of the thousands of buildings in a region, but we wish to make a map of the whole city no more than a few inches wide. Instead of throwing out the building information, or trying to render it all at once, we could generalize the data into some sort of outline of the [urbanized area](https://en.wikipedia.org/wiki/Urban_area) of the region.

The cartographer has license to adjust the content within their maps to create a suitable and useful map that conveys spatial information, while striking the right balance between the map's purpose and the precise detail of the subject being mapped. Well generalized maps are those that emphasize the most important map elements while still representing the world in the most faithful and recognizable way.

## History[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=1)]

During the first half of the 20th century, cartographers began to think seriously about how the features they drew depended on scale. [Eduard Imhof](https://en.wikipedia.org/wiki/Eduard_Imhof), one of the most accomplished academic and professional cartographers at the time, published a study of city plans on maps at a variety of scales in 1937, itemizing several forms of generalization that occurred, including those later termed symbolization, merging, simplification, enhancement, and displacement.[[1]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-imhof1937-1) As analytical approaches to geography arose in the 1950s and 1960s, generalization, especially line simplification and raster smoothing, was a target of study.[[2]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Perkal-2)[[3]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Tobler1966-3)[[4]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-topfer1966-4)

Generalization was probably the most thoroughly studied aspect of cartography from the 1970s to the 1990s. This is probably because it fit within both of the major two research trends of the era: [cartographic communication](https://en.wikipedia.org/wiki/Map_communication_model) (especially signal processing algorithms based on [Information theory](https://en.wikipedia.org/wiki/Information_theory)), and the opportunities afforded by technological advance (because of its potential for automation). Early research focused primarily on algorithms for automating individual generalization operations.[[5]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Li_2007-5) By the late 1980s, academic cartographers were thinking bigger, developing a general theory of generalization, and exploring the use of [expert systems](https://en.wikipedia.org/wiki/Expert_system) and other nascent [Artificial intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence) technologies to automate the entire process, including decisions on which tools to use when.[[6]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-brasselweibel-6)[[7]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-mcmastershea1992-7) These tracks foundered somewhat in the late 1990s, coinciding with a general loss of faith in the promise of AI, and the rise of [post-modern criticisms](https://en.wikipedia.org/wiki/Critical_cartography) of the impacts of the automation of design.

In recent years, the generalization community has seen a resurgence, fueled in part by the renewed opportunities of AI. Another recent trend has been a focus on *multi-scale mapping*, integrating GIS databases developed for several target scales, narrowing the scope of need for generalization to the scale "gaps" between them, a more manageable level for automation.[[8]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-mackaness2007-8)

## Theories of Map detail

Generalization is often defined simply as removing detail, but it is based on the notion, originally adopted from [Information theory](https://en.wikipedia.org/wiki/Information_theory), of the volume of information or detail found on the map, and how that volume is controlled by map scale, map purpose, and intended audience. If there is an optimal amount of information for a given map project, then generalization is the process of taking existing available data, often called (especially in Europe) the *digital landscape model* (DLM), which usually but not always has a larger amount of information than needed, and processing it to create a new data set, often called the *digital cartographic model* (DCM), with the desired amount.[[6]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-brasselweibel-6)

Many general conceptual models have been proposed for understanding this process, often attempting to capture the decision process of the human master cartographer. One of the most popular models, developed by McMaster and Shea in 1988, divides these decisions into three phases: *Philosophical objectives*, the general reasons why generalization is desirable or necessary, and criteria for evaluating its success; *Cartometric evaluation*, the characteristics of a given map (or feature within that map) that demands generalization; and *Spatial and attribute transformations*, the set of generalization operators available to use on a given feature, layer, or map.[[7]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-mcmastershea1992-7) In the first, most conceptual phase, McMaster and Shea show how generalization plays a central role in resolving the often conflicting goals of [Cartographic design](https://en.wikipedia.org/wiki/Cartographic_design) as a whole: functionality vs. aesthetics, information richness vs. clarity, and the desire to do more vs. the limitations of technology and medium. These conflicts can be reduced to a basic conflict between the need for more data on the map, and the need for less, with generalization as the tool for balancing them.

One challenge with the information theory approach to generalization is its basis on measuring the amount of information on the map, before and after generalization procedures.[[9]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Styk2011-9) One could conceive of a map being quantified by its *map information density*, the average number of "bits" of information per unit area on the map (or its corollary, *information resolution*, the average distance between bits), and by its *ground information density* or *resolution*, the same measures per unit area on the Earth. Scale would thus be proportional to the ratio between them, and a change in scale would require the adjustment of one or both of them by means of generalization.

But what counts as a "bit" of map information? In specific cases, that is not difficult, such as counting the total number of features on the map, or the number of vertices in a single line (possibly reduced to the number of *salient* vertices); such straightforwardness explains why these were early targets for generalization research.[[4]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-topfer1966-4) However, it is a challenge for the map in general, in which questions arise such as "how much graphical information is there in a map label: one bit (the entire word), a bit for each character, or bits for each vertex or curve in every character, as if they were each area features?" Each option can be relevant at different times.

This measurement is further complicated by the role of [map symbology](https://en.wikipedia.org/wiki/Map_symbol), which can affect the *apparent information density*. A map with a strong [visual hierarchy](https://en.wikipedia.org/wiki/Visual_hierarchy) (i.e., with less important layers being subdued but still present) carries an aesthetic of being "clear" because it appears at first glance to contain less data than it really does; conversely, a map with no visual hierarchy, in which all layers seem equally important, might be summarized as "cluttered" because one's first impression is that it contains more data than it really does.[[10]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-touya2016-10) Designing a map to achieve the desired gestalt aesthetic is therefore about managing the apparent information density more than the actual information density. In the words of [Edward Tufte](https://en.wikipedia.org/wiki/Edward_Tufte),[[11]](https://en.wikipedia.org/wiki/Cartographic_generalization%22%20%5Cl%20%22cite_note-tufte1990-11)

Confusion and clutter are failures of design, not attributes of information. And so the point is to find design strategies that reveal detail and complexity--rather than to fault the data for an excess of complication.

There is recent work that recognizes the role of map symbols, including the Roth-Brewer typology of generalization operators,[[12]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-roth2011-12) although they clarify that symbology is not a form of generalization, just a partner with generalization in achieving a desired apparent information density.[[13]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-brewer2010-13)

## Operators

There are many cartographic techniques that are used to adjust the amount of geographic data on the map. Over the decades of generalization research, over a dozen unique lists of such *generalization operators* have been published, with significant differences. In fact, there are multiple reviews comparing the lists,[[5]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Li_2007-5)[[12]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-roth2011-12)[[14]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-tyner2010-14) and even they miss a few salient ones, such as that found in John Keates' first textbook (1973) that was apparently ahead of its time.[[15]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-keates1973-15) Some of these operations have been automated by multiple algorithms, with tools available in [Geographic information systems](https://en.wikipedia.org/wiki/Geographic_information_systems) and other software; others have proven much more difficult, with most cartographers still performing them manually.

**Simplify**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=5)]

*Main article:*[*Smoothing*](https://en.wikipedia.org/wiki/Smoothing)



Comparison of several common line generalization algorithms. Gray: original line (394 vertices), orange: 1973 Douglas-Peucker simplification (11 vertices), blue: 2002 PAEK smoothing (483 vertices), red: 2004 Zhou-Jones simplification (31 vertices). All were run with the same tolerance parameters.

Another early focus of generalization research,[[4]](https://en.wikipedia.org/wiki/Cartographic_generalization%22%20%5Cl%20%22cite_note-topfer1966-4)[[15]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-keates1973-15) simplification is the removal of vertices in lines and area boundaries. A variety of algorithms have been developed, but most involve searching through the vertices of the line, removing those that contribute the least to the overall shape of the line. The [Ramer–Douglas–Peucker algorithm](https://en.wikipedia.org/wiki/Ramer%E2%80%93Douglas%E2%80%93Peucker_algorithm) (1972/1973) is one of the earliest and still most common techniques for line simplification.[[16]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Stern2014-16) Most of these algorithms, especially the early ones, placed a higher priority on reducing the size of datasets in the days of limited digital storage, than on quality appearance on maps, and often produce lines that look excessively angular, especially on curves such as rivers.



1:24,000 and 1:100,000 (inset) geological maps of the same area in [Zion National Park](https://en.wikipedia.org/wiki/Zion_National_Park), [Utah](https://en.wikipedia.org/wiki/Utah). Deriving the smaller from the larger would require several generalization operations, including **selection** to eliminate less important features (e.g., minor faults), **smoothing** of area boundaries, **classification** of similar formations into broader categories (e.g., Qmsc + Qmsy > Qms), **merging** of small areas into dissimilar but larger ones (e.g., Qmt), **exaggeration** of very narrow areas (Jms/Jks), and **displacement** of areas adjacent to exaggerated areas. Actually, both maps were compiled independently.

**Smooth**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=6)]

*Main article:*[*Smoothing*](https://en.wikipedia.org/wiki/Smoothing)

For line features (and area boundaries), Smoothing seems similar to simplification, and in the past, was sometimes combined with simplification. The difference is that smoothing is designed to make the overall shape of the line look simpler by removing small details; which may actually require more vertices than the original. Simplification tends to make a curved line look angular, while Smoothing tends to do the opposite.

The smoothing principle is also often used to generalize [raster](https://en.wikipedia.org/wiki/Raster_graphics) representations of [fields](https://en.wikipedia.org/wiki/Field_%28geography%29), often using a [Kernel smoother](https://en.wikipedia.org/wiki/Kernel_smoother) approach. This was actually one of the first published generalization algorithms, by [Waldo Tobler](https://en.wikipedia.org/wiki/Waldo_Tobler) in 1966.[[3]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Tobler1966-3)

**Merge**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=7)]

*Also called dissolve, amalgamation, agglomeration, or combine*

This operation, identified by Imhof in 1937,[[1]](https://en.wikipedia.org/wiki/Cartographic_generalization%22%20%5Cl%20%22cite_note-imhof1937-1) involves combining neighboring features into a single feature of the same type, at scales where the distinction between them is not important. For example, a mountain chain may consist of several isolated ridges in the natural environment, but shown as a continuous chain on a small scale the map. Or, adjacent buildings in a complex could be combined into a single "building." For proper interpretation, the map reader must be aware that because of scale limitations combined elements are not perfect depictions of natural or manmade features.[[17]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-17) Dissolve is a common GIS tool that is used for this generalization operation,[[18]](https://en.wikipedia.org/wiki/Cartographic_generalization%22%20%5Cl%20%22cite_note-18) but additional tools GIS tools have been developed for specific situations, such as finding very small polygons and merging them into neighboring larger polygons. This operator is different from aggregation because there is no change in dimensionality (i.e. lines are dissolved into lines and polygons into polygons), and the original and final objects are of the same conceptual type (e.g., building becomes building).

**Aggregate**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=8)]

*Also called combine or regionalization*

Aggregation is the merger of multiple features into a new composite feature, often of increased [Dimension](https://en.wikipedia.org/wiki/Dimension) (usually points to areas). The new feature is of an ontological type different than the original individuals, because it conceptualizes the group. For example, a multitude of "buildings" can be turned into a single region representing an "urban area" (not a "building"), or a cluster of "trees" into a "forest".[[16]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Stern2014-16) Some [GIS](https://en.wikipedia.org/wiki/Geographic_information_systems) software has aggregation tools that identify clusters of features and combine them.[[19]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Jones1995-19) Aggregation differs from Merging in that it can operate across dimensions, such as aggregating points to lines, points to polygons, lines to polygons, and polygons to polygons, and that there is a conceptual difference between the source and product.

**Typify**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=9)]

*Also called distribution refinement*

Typify is a symbology operator that replaces a large set of similar features with a smaller number of representative symbols, resulting in a sparser, cleaner map.[[20]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-20) For example, an area with dozens of mines might be symbolized with only 3 or 4 mine symbols that do not represent actual mine locations, just the general presence of mines in the area. Unlike the aggregation operator which replaces many related features with a single "group" feature, the symbols used in the typify operator still represent individuals, just "typical" individuals. It reduces the density of features while still maintaining its relative location and design. When using the typify operator, a new set of symbols is created, it does not change the spatial data. This operator can be used on point, line, and polygon features.

**Collapse**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=10)]

*Also called Symbolize*

This operator reduces the [Dimension](https://en.wikipedia.org/wiki/Dimension) of a feature, such as the common practice of representing cities (2-dimensional) as points (0-dimensional), and roads (2-dimensional) as lines (1-dimensional). Frequently, a [Map symbol](https://en.wikipedia.org/wiki/Map_symbol) is applied to the resultant geometry to give a general indication of its original extent, such as point diameter to represent city population or line thickness to represent the number of lanes in a road. Imhof (1937) discusses these particular generalizations at length.[[1]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-imhof1937-1) This operator frequently mimics a similar cognitive generalization practice. For example, unambiguously discussing the distance between two cities implies a point conceptualization of a city, and using phrases like "up the road" or "along the road" or even street addresses implies a line conceptualization of a road.

**Reclassify**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=11)]

*Main article:*[*Categorization*](https://en.wikipedia.org/wiki/Categorization)

This operator primarily simplifies the attributes of the features, although a geometric simplification may also result. While [Categorization](https://en.wikipedia.org/wiki/Categorization) is used for a wide variety of purposes, in this case the task is to take a large range of values that is too complex to represent on the map of a given scale, and reduce it to a few categories that is much simpler to represent, especially if geographic patterns result in large regions of the same category. An example would be to take a land cover layer with 120 categories, and group them into 5 categories (urban, agriculture, forest, water, desert), which would make a spatially simpler map. For [discrete fields](https://en.wikipedia.org/wiki/Field_%28geography%29) (also known as categorical coverages or area-class maps) represented as [vector polygons](https://en.wikipedia.org/wiki/Polygon), such as [land cover](https://en.wikipedia.org/wiki/Land_cover), [climate type](https://en.wikipedia.org/wiki/Climate), [soil type](https://en.wikipedia.org/wiki/Soil_map), [city zoning](https://en.wikipedia.org/wiki/Zoning), or [surface geology](https://en.wikipedia.org/wiki/Geologic_map), reclassification often results in adjacent polygons with the same category, necessitating a subsequent dissolve operation to merge them.

**Exaggerate**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=12)]



In this [OpenStreetMap](https://en.wikipedia.org/wiki/OpenStreetMap) map of [Loveland Pass](https://en.wikipedia.org/wiki/Loveland_Pass), [Colorado](https://en.wikipedia.org/wiki/Colorado), symbol **exaggeration** of the thickness of the roads has made them run together. Geometric **exaggeration** of the hairpin turns and **displacement** of the roads alongside the interstate are needed to clarify the road network.

Exaggeration is the partial adjustment of geometry or [symbology](https://en.wikipedia.org/wiki/Map_symbol) to make some aspect of a feature larger than it really is, in order to make them more visible, recognizable, or higher in the [visual hierarchy](https://en.wikipedia.org/wiki/Visual_hierarchy). For example, a set of tight [switchbacks](https://en.wikipedia.org/wiki/Hairpin_turn) in a road would run together on a small-scale map, so the road is redrawn with the loops larger and further apart than in reality. A symbology example would be drawing highways as thick lines in a small-scale map that would be miles wide if measured according to the scale. Exaggeration often necessitates a subsequent displacement operation because the exaggerated feature overlaps the actual location of nearby features, necessitating their adjustment.[[16]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Stern2014-16)

**Displace**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=13)]

*Also called conflict resolution*

Displacement can be employed when two objects are so close to each other that they would overlap at smaller scales, especially when an exaggerate operator has made the two objects larger than they really are. A common place where this would occur is the cities Brazzaville and Kinshasa on either side of the Congo river in Africa. They are both the capital city of their country and on overview maps they would be displayed with a slightly larger symbol than other cities. Depending on the scale of the map the symbols would overlap. By displacing both of them away from the river (and away from their true location) the symbol overlap can be avoided. Another common case is when a road and a railroad run parallel to each other. Keates (1973) was one of the first to use the modern terms for exaggeration and displacement and discuss their close relationship, but they were recognized as early as Imhof (1937)[[1]](https://en.wikipedia.org/wiki/Cartographic_generalization%22%20%5Cl%20%22cite_note-imhof1937-1)[[15]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-keates1973-15)

**Enhance**[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=14)]

This is the addition of symbols or other details on a smaller scale map to make a particular feature make more sense, especially when such understanding is important the map purpose. A common example is the addition of a bridge symbol to emphasize that a road crossing is not at grade, but an [overpass](https://en.wikipedia.org/wiki/Overpass). At a large scale, such a symbol may not be necessary because of the different symbology and the increased space to show the actual relationship. This addition may seem counter-intuitive if one only thinks of generalization as the removal of detail. This is one of the least commonly listed operators.[[12]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-roth2011-12)

GIS and automated generalization[[edit](https://en.wikipedia.org/w/index.php?title=Cartographic_generalization&action=edit&section=15)]

As [GIS](https://en.wikipedia.org/wiki/Geographic_information_systems) developed from about the late 1960s onward, the need for automatic, algorithmic generalization techniques became clear. Ideally, agencies responsible for collecting and maintaining spatial data should try to keep only one canonical representation of a given feature, at the highest possible level of detail. That way there is only one record to update when that feature changes in the real world.[[5]](https://en.wikipedia.org/wiki/Cartographic_generalization#cite_note-Li_2007-5) From this large-scale data, it should ideally be possible, through automated generalization, to produce maps and other data products at any scale required. The alternative is to maintain separate databases each at the scale required for a given set of mapping projects, each of which requires attention when something changes in the real world.

Several broad approaches to generalization were developed around this time:

* The *representation-oriented* view focuses on the representation of data on different scales, which is related to the field of Multi-Representation [Databases](https://en.wikipedia.org/wiki/Database) (MRDB).[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* The *process-oriented* view focuses on the process of generalization.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* The *ladder-approach* is a stepwise generalization, in which each derived dataset is based on the other database of the next larger scale.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]
* The *star-approach* is the derived data on all scales is based on a single (large-scale) data base.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]