

[CV-03-007] Visual Hierarchy and Layout

Abstract

Mapmaking, by digital or manual methods, involves taking complex geographic information and building a visual image with many components. Creating effective maps requires an understanding of how to construct the elements of the map into a coherent whole that executes the communicative purpose of the map. Visual hierarchy and layout are the cartographer's tools for organizing the map and completing the map construction. The cartographer layers the mapped geography in an image into a visual hierarchy emphasizing some features and de-emphasizing others in vertical ordering of information. Likewise, the cartographer arranges the components of a map image—title, main map, inset map, north arrow, scale, legend, toolbar, etc.—into a layout that guides the reader's eye around the horizontal plane of the map. The visual hierarchy and layout processes work together to create the structure of the map image.

Keywords: balance, contrast, gestalt, map construction, map design fundamentals, map layout, visual hierarchy

Author & citation

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Explanation

1. [Definitions](#)
2. [Introduction](#)
3. [Manipulating Visual Hierarchy and Layout](#)
4. [Visual Hierarchy](#)
5. [Layout](#)
6. [Unity of Map Construction](#)

1. Definitions

visual hierarchy: graphical implementation of a ranked order of map elements such that the most important elements have the greatest visual prominence

map layout: the ordering of the map elements in the horizontal (X, Y) dimensions of the visual field

map image: the mapped geography and all the other elements that cartographers use in a



map construction: title, frame, inset, legend, toolbars, controls, etc.

mapped geography: the graphic representation of spatial phenomena, often separated between thematic and base information

intellectual hierarchy: the ordering or ranking of all symbols and elements in the map according to their relative importance

contrast: the perceptual comparison of one portion of a visual image to another, the greater the difference, the stronger the contrast

gestalt: a theory of perception that describes the manner in which humans perceive the components of an image and organize them into broader structures or interpretations

figure-ground: the relationship describing the advancing visual prominence of one part of an image against the rest of the image, which serves as a background

compartmentalized: a map layout that places each of the main components of a map page into a separate, often boxed, compartment

fluid: a free-flowing map layout that eschews sharp divisions between map elements

balance: the equipoise of an image, derived from the visual weight and direction of each of the elements of the image

negative space: that portion of the visual field that is not occupied by any graphic elements

2. Introduction

2.1 Visual hierarchy and layout in the map design process

Visual hierarchy and map layout are part of the overall map design process (see Aesthetics and Design). They are collectively referred to as map composition or map construction—the term used here. Cartographers use visual hierarchy to emphasize the more important parts of a map and de-emphasize the less important ones thereby creating a layering of information. They use layout to organize the elements of a map construction into a logical, effective, and coherent whole.

Because a cartographer uses visual hierarchy and layout to move from a map concept and plan to a completed map image, visual hierarchy and layout are at the heart of the mapmaking process. Map construction is one stage in the multistep process of map design, which can be seen as a five-step process (modified from Slocum et al., 2009):

1. Evaluate the subject phenomena
2. Determine the purpose of the map and its audience
3. Collect and process data appropriate for the map
4. Design and construct the map
5. Evaluate use and effectiveness of the map.



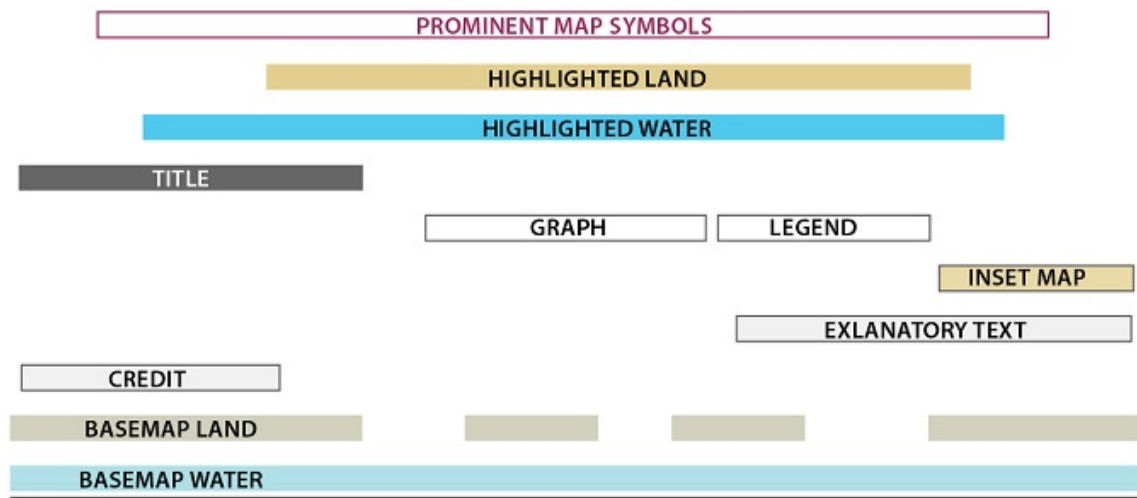
The fourth stage, design and construct, involves the careful use of visual hierarchy and layout to structure the map and create an effective graphic image.

2.2 Vertical and horizontal organization of visual field

The two aspects of map construction, visual hierarchy and map layout, are often considered the vertical and horizontal means for organizing the information contained in a map (Dent et al., 2014; Slocum et al., 2009), see Figure 1. **Visual hierarchy** is the graphical implementation of a ranked order of map elements such that the most important elements have the greatest visual prominence. Visual hierarchy works by bringing specific elements of the map visually closer to the reader (higher in a vertical ordering) and pushing others further away from the reader (lower in a vertical hierarchy). Contrast is the essential factor controlling the prominence of elements in a visual hierarchy.



Visual Hierarchy



Map Layout

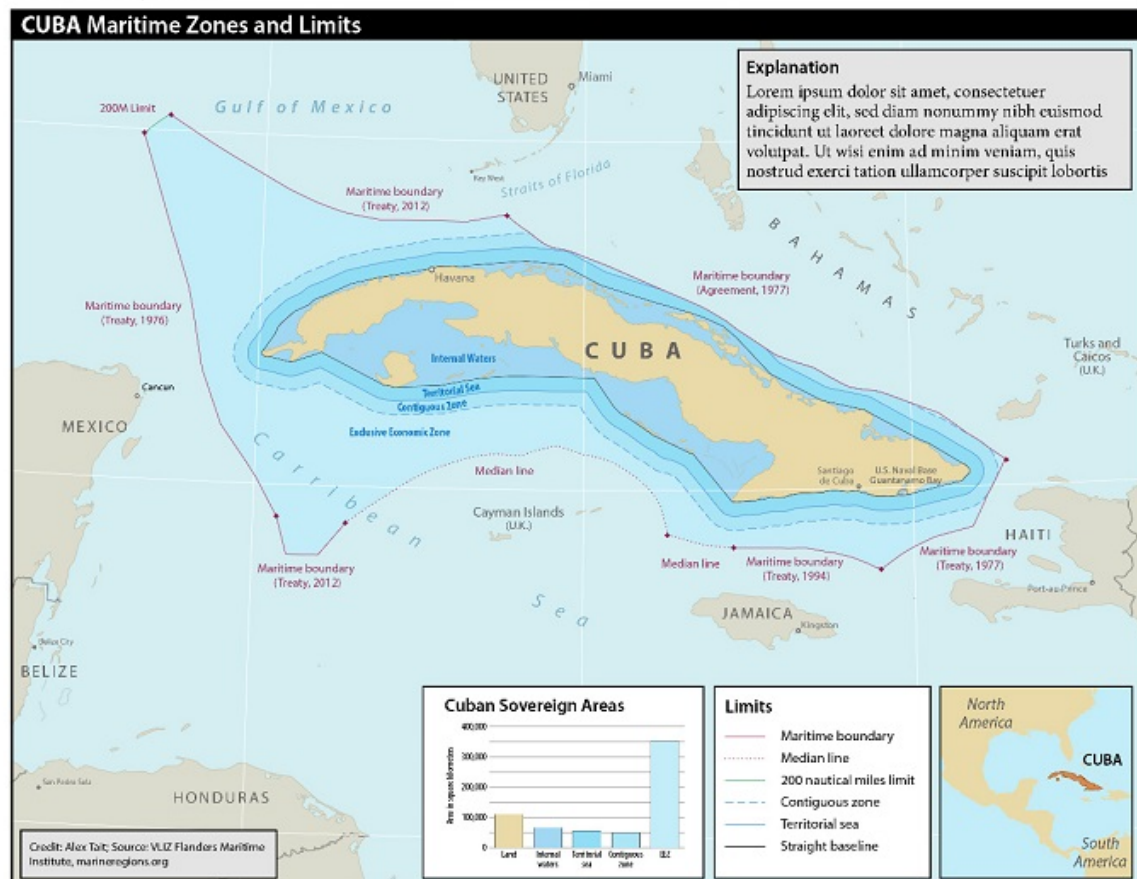


Figure 1. The two components of map construction: visual hierarchy and map layout.

Map layout is the ordering of the map elements in the horizontal (X, Y) dimensions of the map's visual field. Essential factors include contrast, balance, grouping, and ordered



arrangement of objects. Layout and visual hierarchy work separately and together to manipulate the visual attention of the reader (as explained below). The cartographer needs to be aware of competing visual cues between layout and visual hierarchy. For example, in Figure 2 the map title has the highest contrast in the image (white text on black background) which raises it in the visual hierarchy, but its position in the layout at the top edge keeps it below the visual prominence of Cuba in the center.

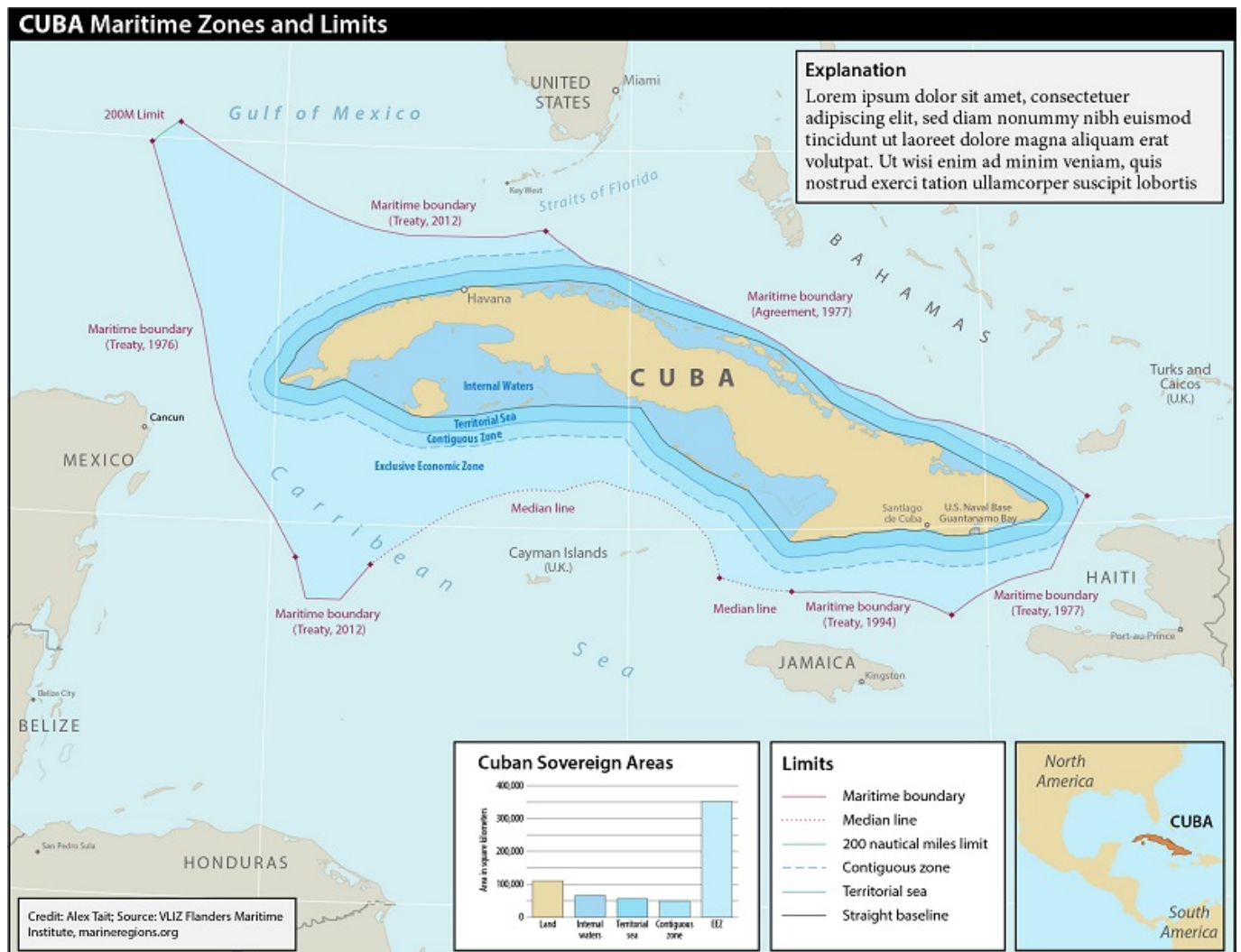


Figure 2. Compartmentalized map layout.

2.3 Map image and mapped geography

Though the elements that constitute a map exist within a single visual or conceptual field, it is helpful to divide the whole map into two related concepts, the **map image** and the **mapped geography**. The map image contains the mapped geography and all the other elements that cartographers use in a map construction: title, frame, inset, legend, toolbars, controls, etc. The mapped geography is the graphic representation of spatial phenomena, often separated between thematic and base information.

This division of the map design process by map image and mapped geography can be seen as the "big picture" of map design, i.e., the structure of the arrangement of the map pieces, and the inner workings of map design, i.e., the structure of a single map piece within the big picture (Krygier & Wood, 2016).



Visual hierarchy and layout are both applicable to the construction of the map image (big picture), though layout is the primary tool. For the mapped geography (inner workings), layout is affected by the choice of projection, map center, and scale, but most of the structure is controlled by the visual hierarchy of the mapped geography.

2.4 Other considerations for the map construction process

Much of the research and writing regarding visual hierarchy and layout has focused on the traditional single static map, originally in a print context. Web and mobile-based interactive maps and animated maps are also composed using visual hierarchies and ordered map layouts (or suffer from the lack thereof!).

The knowledge gained regarding visual hierarchy and layout is useful in the design and composition process for web and mobile maps and animations, with modifications and additions (Meuhlenhaus, 2014). A key difference with web and mobile maps is the ability to hide information behind a button or menu so that it can be revealed on demand. In addition, the issues of screen real estate, pixels per inch, and resolution are all critical for map layout in a digital display world (see Mobile Mapping & Responsive Design).

The need to follow institutional map specifications can be a hindrance to effective map design and construction. A slavish devotion to standard symbolization and conventional map elements can ruin the visual hierarchy of a map by emphasizing unimportant information. For example, if parks must be a bright emerald green, even when not the subject of the map, they will always rise in the hierarchy.

3. Manipulating Visual Hierarchy and Layout

3.1 Maps and human vision

The mechanisms cartographers use for manipulating the visual hierarchy and layout of a map image are tied to the way the human eye sees. Vision is inherently spatial and the processing of visual information by the eye and brain creates the map image (MacEachren, 1995). Effective map design and construction builds on knowledge of how we see the map image and how we mentally process visual information. We perceive differences in our visual field, and a cartographer's manipulation of these differences is critical to effective structuring of a map.

3.2 Contrast: the primary tool for visual hierarchy and layout

Almost every writer discussing map design, from Raisz (1948) and Robinson (1952) to Brewer (2016) and Muehlenhaus (2014), acknowledges the vital role played by visual contrast. It is the key means used to emphasize some parts of the image while de-emphasizing others. Contrast is dependent on the visual variables (see [Symbolization & the Visual Variables](#)), but a listing of the means of creating contrast is not the same as the list of visual variables. Grouping, gestalt and other graphic characteristics are also used to create contrast.

























Contrast is the perceptual comparison of one portion of a visual image to another, the greater the difference, the stronger the contrast and generally the higher in the visual



hierarchy an object or component will rise. Table 1 lists contrasts useful for map images. Some of the elements of contrast are also elements of grouping or gestalt.

Table 1. Types of Contrast



Type	Stronger		vs		Weaker
Size*	Large		vs		Small
Color: Hue	Warm		vs		Cool
Color: Saturation	Intense		vs		Pale
Color: Value‡	Dark/Light		vs		Light/Dark
Focus	Sharp		vs		Blurry
Position	Center		vs		Periphery
Continuity	Edged		vs		Continuous
Grouping*	Isolated		vs		Grouped
Arrangement	Ordered		vs		Random
Distribution	Dense		vs		Sparse
Cropping	Entire		vs		Cropped
Detail*	Intricate		vs		Generalized

*Cartography texts disagree on which is stronger and which weaker.

‡Value's strength depends on the background, dark is stronger on a light background and light on dark one.

3.3 Grouping and gestalt

Grouping organizes a map's visual field by use of similarity. **Gestalt** is a theory of




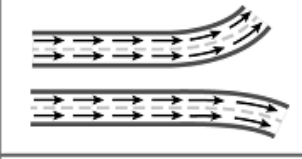
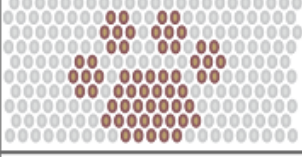
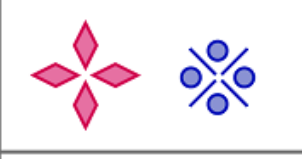
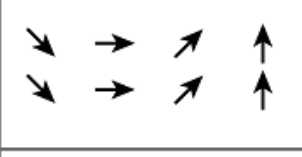






perception that describes the manner in which humans perceive the components of an image and organize them into broader structures or interpretations. It comes from the German for "form" or "whole." Gestalt and grouping are sometimes used interchangeably, but not all aspects of gestalt are grouping. Table 2 lists ways that objects can form new and broader characteristics of grouping and interpretation.

Good map design will take advantage of these characteristics of grouping and gestalt in creating an effective layout and will enhance differentiation in a visual hierarchy. Of course, not all aspects of gestalt or grouping are useful for all map objects. For example, many reference maps that are showing a single point in time will not group into "stages."

Table 2. Types of Grouping and Gestalt



Name		Type	Description
Proximity		Grouping	Objects close to each other group into clusters or other forms
Similarity		Grouping	Objects with similar visual variable characteristics (other than location) form groups.
Direction		Grouping	Objects that flow in similar direction form groups.
Common Fate		Grouping	Objects that share the same movement form groups.
Experience or Familiarity		Grouping	Familiar shapes or arrangements form groups.
Symmetry		Grouping	Objects that are symmetrical about a line or point form a group
Stages		Grouping	Complex series of objects group into steps or stages (primarily for animations).
Simplicity		Interpretation	A group of complex objects will form a single, simpler shape
Figure-Ground		Interpretation	Some objects will group and be promoted as figure above a ground (this is the most important gestalt principal for cartography!).
Closure		Interpretation	The eye will complete an object's form to create a whole.
Good Continuation		Interpretation	The eye will continue the form of an object that is partially hidden or that is interrupted.

3.4 Figure-Ground



The **figure-ground** relationship describes the advancing visual prominence of one part of an image against the rest of the image, which serves as a background. The establishment of figure-ground relationships is a key tool for the construction of maps. It provides an effective visual technique for layering information and for focusing the eye on the most important parts of an image.

There are many ways to establish an object or group of objects as figure against a background and most involve contrast or grouping as described above. One important means is the visual imposition or laying of one object atop another. Differentiation between land and water is a special case of figure-ground and is essential in most maps. Techniques such as breaking networks of lines (e.g., the graticule), vignetting the coastline, and strong hue and value differentiation work to emphasize the land-water boundary.

4. Visual Hierarchy

4.1 Planning a map's hierarchy

Visual hierarchy is the organization of a map image by manipulation of the visual strength of individual components and is most effective when it is tied to the intellectual goals of the cartographer. Asking and answering key questions about the map and its purpose should precede construction of visual hierarchy (see *Visual Critique*, forthcoming). Why are you making the map? What feature or features are most important? What can be pushed to the background?

The process of answering these questions create an **intellectual hierarchy**. The intellectual hierarchy is the ordering or ranking of all symbols and elements in the map according to their relative importance (Dent et al, 2009). This list of components in a map usually includes some or all of the following: thematic symbolization, base map, inset maps (locator, distant location, or zoom detail), title, legend, scale, orientation device, extent indicators, explanatory notes, source notes, credits and copyright, neatline, additional graphics (photos, graphs, etc.). Interactive web and mobile maps will have additional components such as buttons, menus, and toolbars (see [UI/UX Design](#)).

4.2 Matching intellectual hierarchy to visual hierarchy

Establishment of the intellectual hierarchy allows for assignment of the map elements into a matching visual hierarchy. The most important elements will receive the most visual emphasis and will be higher in the hierarchy. It is not critical to sort every individual element, but only to plan for the general prominence of the major elements of the map

Visual hierarchies for a static thematic map (adapted from Dent, 2009) and an interactive web map (adapted from Meuhlenhaus, 2014) are in Table 3. There will be additional layering in the hierarchy within each of the levels shown in the table during map construction.

Table 3. Intellectual and visual for a static print map (left, after Dent et al., 2009) and for an interactive web map (right, after Muehlenhaus, 2014).



Level	Static Print Map Elements	Interactive Web Map Elements
1	Thematic Symbols	Title/splash screen
2	Title/Legend/Map Symbols/Labels	Map symbology, Key reference data, Info windows (opened)
3	Base Map: land areas, political boundaries, physical features	Base Map, Base map labels, Navigation tools
4	Explanatory Materials: sources, credits	Map interactivity, Pan/zoom/selection tools, Print/share features
5	Base Map: water features	Locator maps, Charts/graphs, Multimedia supplements
6	Other Base Map Elements: labels, grids, scales	Supplemental info, Attributions, copyright, Neatlines/grid/graticule, Tool tips

4.3 Construction of a visual hierarchy

The process of constructing the visual hierarchy for your map follows the plan you have created in establishing the intellectual hierarchy, which in turn is based on the communication goals of your map. Use your inventory of contrast, grouping, gestalt, and figure-ground tools to establish the visual hierarchy. The goal will be to use contrast to establish differentiation in the visual prominence of elements of your map. It is important to work both within the mapped geography (the inner workings) and the whole map image (big picture) separately and then look at them together.

The differentiation of appropriate visual variables for points, lines, polygons and type are all important within the mapped geography. Remember that manipulation of the visual hierarchy of graphic elements in your mapped geography is the primary way to emphasize features. As you work with placing emphasis on the important parts of visual field, keep in mind the interplay between the main mapped geography and the other map elements.

5. Layout

5.1 Map elements and layout

Layout is primarily the horizontal organization of elements on the map page (or screen) but it also influences the visual prominence of map elements. In an effective map layout, the cartographer will utilize the mechanisms of contrast, grouping, and gestalt, in addition to horizontal positioning, to create a logical and coherent arrangement. The layout should be intrinsically linked to the map's purpose (Dent et al., 2009; Brewer, 2016).

The list of elements to consider when laying out the map are mostly the same as for visual hierarchy (see above). One major difference is that horizontal positioning has limited flexibility, because mapped information usually moves as a single unit. Some freedom of horizontal positioning is possible through the use of projection, centering, and scale, as well as annotation, highlighting, and labeling atop the map to direct the eye to specific locations within the map image.

5.2 Categories of map layouts



There are many types of layouts in graphic design and many ways to categorize them. In considering map layout, it is useful to look at two general categories of layouts for print and web maps: compartmentalized and fluid (Muehlenhaus, 2014). These two types define a spectrum of map layout design.

The **compartmentalized** map layout places each of the main components of a map page into a separate, often boxed, compartment (Figure 2, above). This layout tends to be rigid, often very rectilinear, and expresses a more institutional look. It allows for easy standardization and can produce precise and polished looking maps, but it often suffers from poor aesthetics and requires the eye to jump across graphic breaks.

The **fluid** or more free-flowing layout eschews sharp divisions between map elements (Figure 3). It often uses a map extended to the edges of the visual field with the other map elements superimposed in areas of the mapped geography that are not important to the map's purpose. Fluid maps generally have better aesthetics and a larger main map scale.

CUBA Maritime Zones and Limits

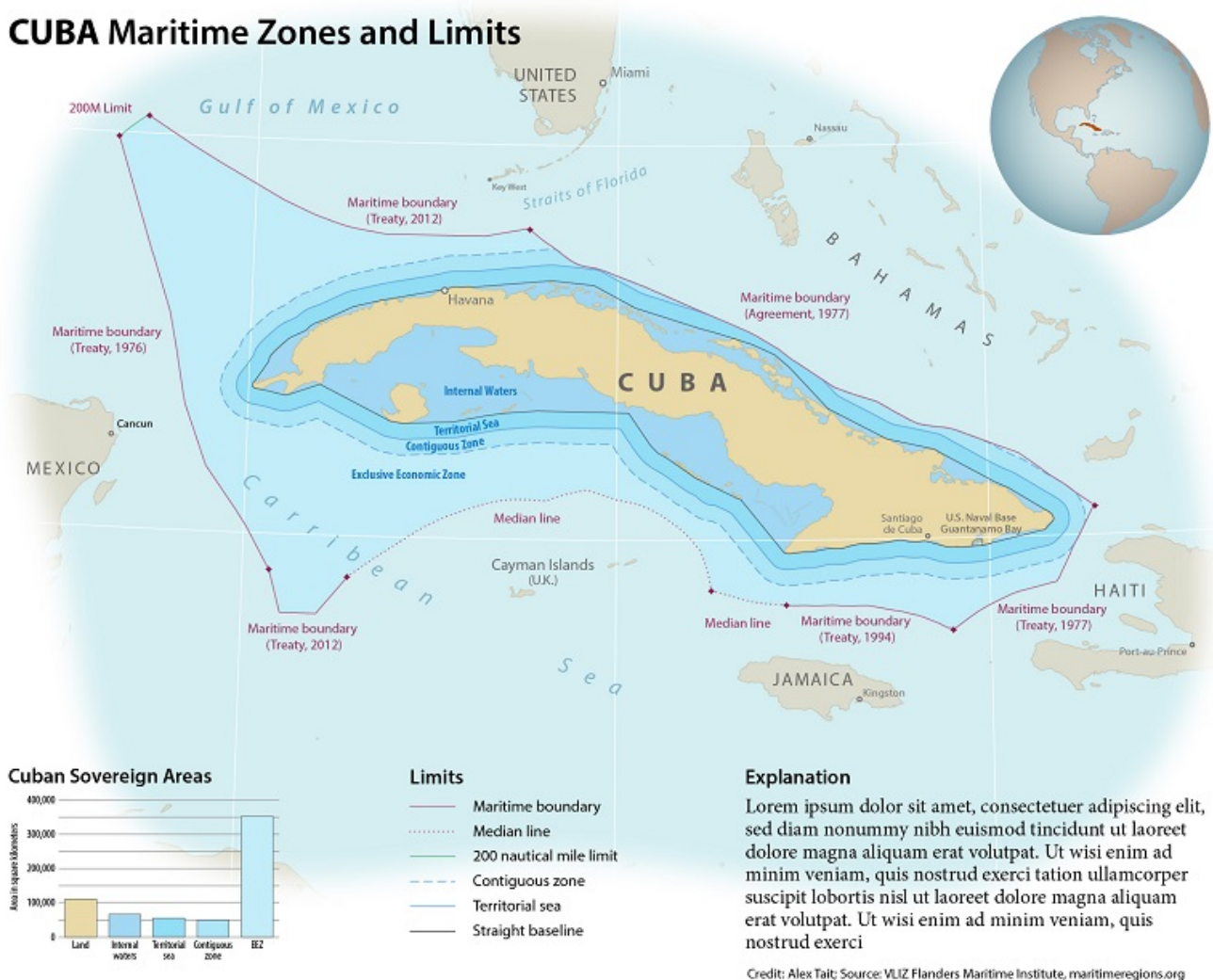


Figure 3. An example of a fluid map layout

5.3 Importance of structure in layout

It is critical to map layout, whether designing a compartmentalized map or a fluid map, to arrange map elements based on a logical grid. Fluid does not mean completely free form.

Maps lacking an underlying grid or similar organization structure tend to look chaotic and hinder the effective reading of information by the user.

Effective map design and construction aims to reduce the number of sight-lines in the image. These are the invisible lines that run through a map layout connecting up the edges of elements or continuing from straight lines within the map. Minimizing the number of sight lines reduces disjointedness and stabilizes the layout (Krygier & Wood, 2016).

The use of responsive design in digital map layouts can provide a means to respond to the screen size and orientation of a device so that map design is effective across desktop and laptop computers and a variety of mobile devices (see Mobile Mapping & Responsive Design). Responsive design practices include simplification of maps for smaller screens, rearrangement of map elements, and providing additional map image for flexibility in orientation and screen width.

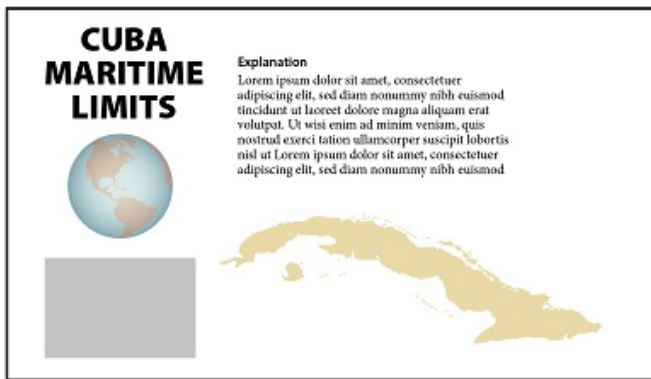
5.4 Balance and negative space

There are additional considerations to take into account while constructing a map layout and organizing the map elements. **Balance** is the equipoise of an image, derived from the visual weight and direction of each of the elements of the image (Dent et al., 2009). In a map, each element has weight due to size, position, color, detail, shape and other characteristics. Simply put, a well-balanced map layout does not appear to tip left or right and it doesn't look bottom or top heavy. As with other aspects of constructing visual hierarchy and layout, the 'squint test' can be very effective in evaluating the balance within a map.

An aspect of layout that is sometimes considered part of balance, and has large importance for design effectiveness overall, is negative space. Also known as white space or empty space, **negative space** is that portion of the visual field that is not occupied by any graphic elements. It is a powerful map design tool that can focus attention on the important parts of a map image. Maps that are overly crammed with data and objects or have boxes around each map element make designing empty spaces difficult (Brewer, 2016). Figure 4 displays the interaction of balance and negative space in map layout. The interplay of each visual element with other elements in the layout also affects the visual hierarchy.



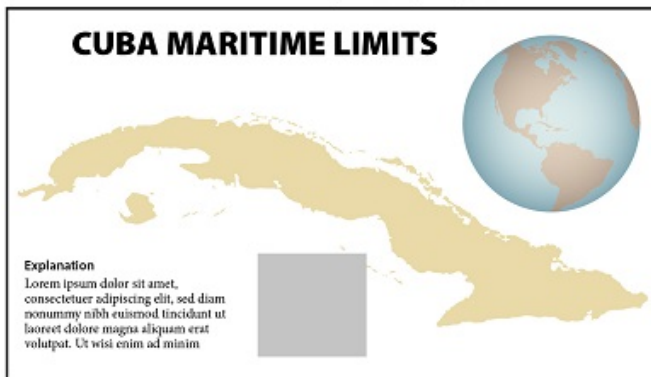
A. Poor balance and white space; tips left, not unified



B. Poor balance and white space; bottom heavy, big hole



C. Better balance and white space; tips right, crowded



D. Much better balance and white space

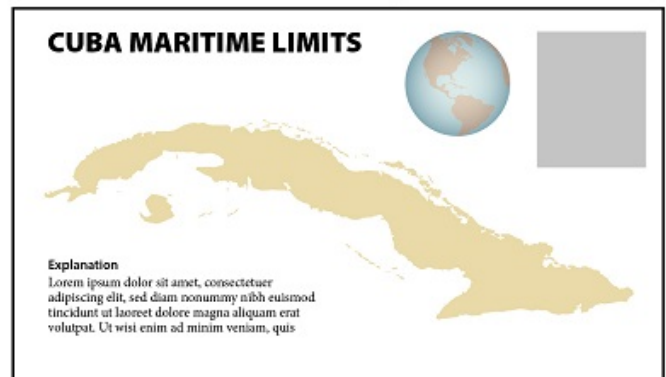


Figure 4. Balance and Negative Space. In Figure 4A, the map layout has poor balance and tips to the left. The map also divides into two pieces because of the elements' position and the gutter of white space; it is not a coherent whole. The layout in Figure 4B is more of a whole but is bottom heavy and leaves an awkward negative space at top center. There is better balance in Figure 4C though it is slightly unbalanced and a bit crowded. Figure 4D has a better balance and comfortable white space around the visual elements, all of which serve to focus the eye on the title and the mapped geography.

6. Unity of Map Construction

Visual hierarchy and map layout work together to create the visual field of a map image. Designed effectively, they provide a logical structure for the map and graphic elements of the image. They organize the map so that it reflects the intellectual organization of the map's purpose (Dent et al., 2009; Slocum et al., 2009; Monmonier, 1993). They use the mechanisms of contrast, grouping, gestalt, and figure-ground to achieve an ordering of visual prominence and arrangement.

For visual hierarchy, the arrangement is primarily vertical and for layout it is primarily horizontal. Together they are the primary components of the map construction process. Using these tools, a cartographer can create a map that is organized, logical, and clear. See Table 4 for some recommended practices.

Table 4. Recommendations for Visual Hierarchy and Layout



Type	Description
Layout	Don't fill all the "corners and voids" (Brewer, 2016)
Layout, visual hierarchy	Place your most important information towards the center of the image (Patterson, 2010)
Layout	Reduce sight lines in a map layout (Krygier & Wood, 2016)
Layout	Use a construction grid to arrange map elements
Visual hierarchy	Color hue, saturation, and value are the easiest means of manipulating contrast and visual hierarchy in your map (Muehlenhaus, 2014)
Visual hierarchy	Eliminate lines to move polygonal graphical objects to the background (Patterson, 2010)
Visual hierarchy	Use a typeface with a wide range of visual weights (Patterson, 2010)
Visual hierarchy	A map's purpose dictates which features are highest in the visual hierarchy (Brewer, 2016)
Layout, visual hierarchy	Do not over emphasize the non-map elements at the expense of the main map symbology

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