A comparative study of existing multi-scale maps: what content at which scale?

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Abstract

This paper presents a comparative study of existing topographic multi-scale maps, regarding relations between display scale and level of abstraction (LoA) of the map content. The general trends in zoom levels distribution across scales and the original patterns in transitions between LoAs are especially highlighted.

1. Objectives

To provide a mapping application, i.e. a website where users can zoom in or out in a multi-scale map, every cartographic producer has to choose the map scale and content for each available zoom level.

As shown in Figure 1, the difference of content between two consecutive zoom levels can be strong, partly due to the change of scale. Mackaness (2007) explains that the level of abstraction (LoA) of the map content depends on map scale and purpose. This LoA can be defined as a semantic level of detail, as it refers to: which part of the geographic space should be represented? How the geographic objects should be represented and with how much detail?
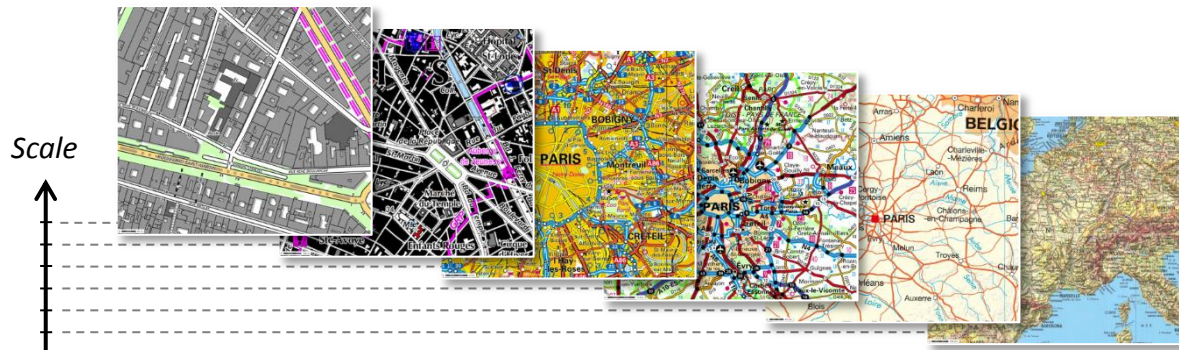
Figure 1. Zoom levels of this multi-scale map present large differences, ©IGN France

Due to these changes across zoom levels, we believe that users may have difficulties to recognize the depicted location or the different representations of a same object at different scales. We need to reduce the gaps between zoom levels and to improve the relations between the map scale and LoA, in order to simplify the multi-scale navigation.

To study the existing specifications, we compare sixteen topographic multi-scale maps, provided by national mapping agencies (NMA), private companies or collaborative communities. In this paper, we highlight the correlation between zoom levels, display scale and LoA, in the general map content (section 2), then focusing on a particular geographic theme: the settlement areas (section 3).

2. How Are Zoom Levels, Display Scale and Map Content Related?

To compare the distribution of zoom levels across scales between multi-scale maps, we first need to define and measure the scale of each zoom level. Besides, most NMA build their

topographic multi-scale map from their paper map series, where each map is designed for a specific printing scale. This map can then be displayed at one or more zoom levels in the mapping application. We call "definition scale" the initial map scale and "display scale(s)" the scale(s) at which the map is displayed.
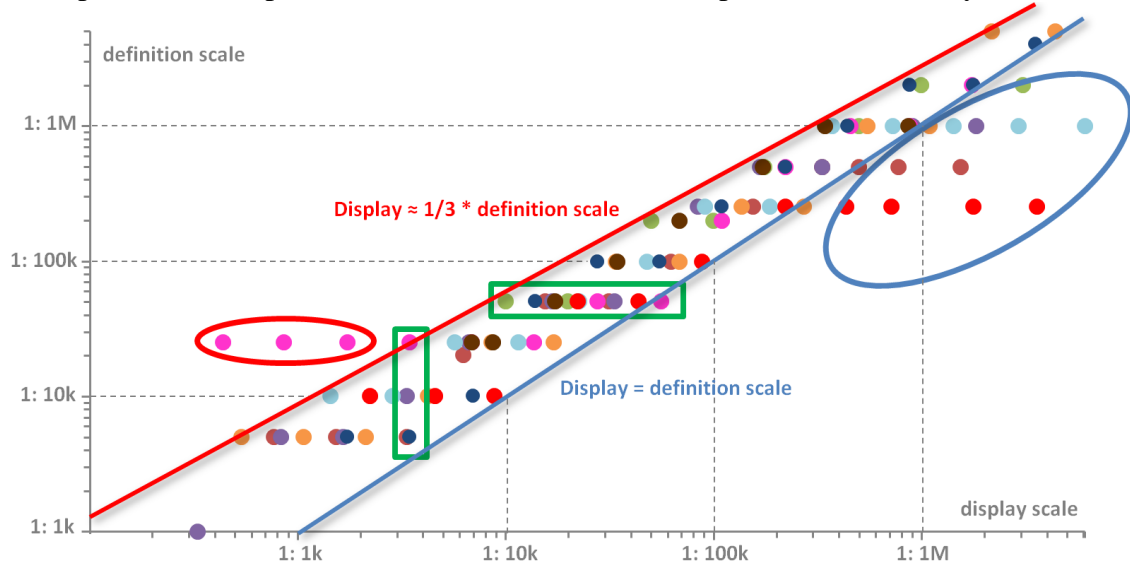
2.1 Display Scale

In the studied mapping applications, the display scale was explicitly given or we measured it on a graphic scale bar. According to our survey, the Web Map Tile Service (WMTS) standard defined by Open Geospatial Consortium Inc. (2010) is generally applied. It specifies a set of scales for mapping applications, composed of twenty-one zoom levels, numbered from 0 for the 1: 100 scale to 20 for the 1: 500M scale.

Nevertheless, for a same zoom level, we found some little variations between applications, due to the changes of map projection and maximal extent, but we consider them negligible for this analysis. For each zoom level, we can thus compare the map content of different multi-scale maps. Besides, it is interesting to note that some applications add one or several intermediate zoom levels compared to the standard, mainly around the 1:1M scale.

2.2 Definition Scale

When the definition scale was not mentioned in the mapping application, we obtained it by comparison with the map series of their producer. However, some multi-scale maps have not been built from map series (e.g. OpenStreetMap) and will not be considered in the following graph. Figure 2 represents the relation between definition and display scale of each zoom level (represented as a point) in considered multi-scale maps (differentiated by colour).

Figure 2. Relations between definition and display scales in considered multi-scale maps

Considering a given display scale (vertical green box) or a given definition scale (horizontal green box), we notice that producers use different relations between definition and display scales. This graph also confirms that many producers use a same map at several zoom levels (same coloured points on the same horizontal line). Multi-scale maps could thus be improved by adding new representations, specifically designed for these display scales.

We then observe that zoom levels are mostly concentrated between the two represented lines. According to the red line, most producers do not display a map until the display scale is equivalent to a third of its definition scale. Considering the blue line, most producers do not display a map at a display scale smaller than its definition scale. As the circled outliers present readability issues, we think that these two rules can be considered relevant.

3. Representation of Settlement Areas across Display Scales

The distribution of definition scales across zoom levels gives information about the variation of LoA across scales. However, map content at a same definition scale may differ between producers. For instance, at the 1: 50K scale, some producers represent the individual buildings, whereas others represent urban areas. To compare the representation of settlement areas between multi-scale maps, we define the following LoAs, illustrated from left to right on Figure 3: individual building, urban block, urban area and city point symbol.
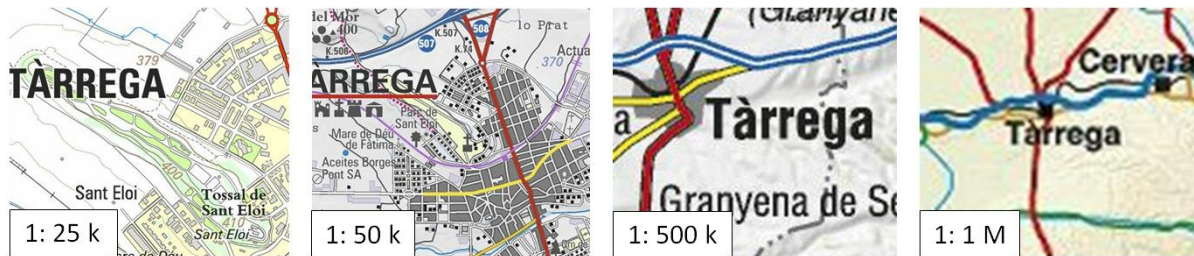

Figure 3. Illustration of the four considered LoAs for settlement areas, ©ICGC

As generalization operators may be used to refine the LoA of settlement areas, we also observed their use in each zoom level. We noticed four of them, which specifically deal with the LoA of map content: selection, simplification, aggregation and typification. Definitions and use cases of these operators can be found in Regnauld and McMaster (2007).

When two LoAs are present in a same zoom level, we also noticed two different patterns: coexistent, i.e. representing different objects in different areas of the map (depending on the spatial context), or superimposed, i.e. simultaneously representing a same object (Figure 4).

Figure 4. Coexistent (left, ©ICGC) and superimposed (right, ©Lantmäteriet) representations
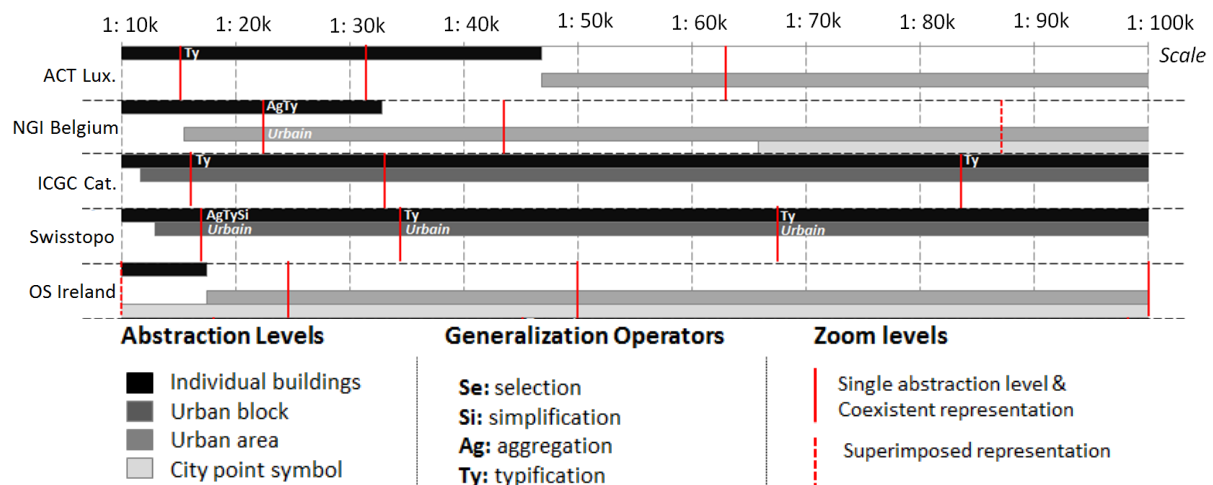

Figure 5. Extract of the representation synthesizing the surveyed information

Figure 5 is an extract of the representation synthesizing the surveyed information, inspired from the ScaleMaster tool (Brewer and Buttenfield 2007). For each multi-scale map, the use of each LoA on a scale range is symbolized by a grey line. The different shades of grey distinguish the different LoAs. We also added on the graph if different LoAs are used in rural or urban contexts. For each zoom level (red line), coexistent or superimposed representations are identified. If generalization operators are used, their relative code is specified next to the resulting zoom level. Figure 5 shows that each map producer applies its own variation of LoA across scales.

We analyzed the percentage of use of LoAs across scales, and found some general trends, which are represented in Figure 6. A scale range of common use (in red) could be observed for individual buildings and urban areas. This figure also confirms the use of coexistent and superimposed representations, but also the existence of different strategies used by map producers concerning the relations between LoAs and scales.
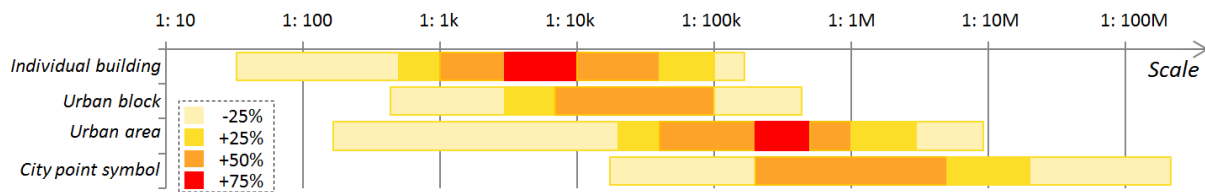
Figure 6. Use percentage of LoAs across scales in studied multi-scale maps

4. Conclusion and Perspectives

This paper describes a survey of existing multi-scale maps, comparing them in terms of display scale, definition scale and map content, with a focus on settlement areas.

We point out the used relations between display and definition scales (Figure 2) and define rules to avoid readability issues. In particular, we stress that producers sometimes use a same map at several zoom levels. Multi-scale maps may thus be improved if we specifically derived representations for these scales, even keeping the existing set of zoom levels.

Then we show the different choices in the relations between display scales and map content for the settlement areas, where each producer applies its own LoA transitions across scales, as the superimposed representations for instance. We assume that these intermediate representations could serve to reduce the gaps between zoom levels and simplify the navigation across scales.

To test this hypothesis, we will now build our own multi-scale maps, with different intermediate representations. We will then conduct an experimentation and measure user task performances, to check which configurations improve the user navigation across scales.

Acknowledgements

References

Brewer C, Buttenfield B, 2007, Framing Guidelines For Multi-Scale Map Design Using Databases At Multiple Resolutions, *Cartography and Geographic Information Science*, 34(1): 3-15

Mackaness WA, 2007, Understanding Geographic Space. In: Mackaness W, Ruas A, Sarjakoski T (eds), *The Generalisation of Geographic Information: Models and Applications*. Elsevier

Open Geospatial Consortium Inc., 2010, OpenGIS® Web Map Tile Service Implementation Standard, OGC 07-057r7, version 1.0

Regnauld N, McMaster R, 2007, A synoptic view of generalisation operators. In: Mackaness W, Ruas A, Sarjakoski T (eds), *The Generalisation of Geographic Information: Models and Applications*. Elsevier