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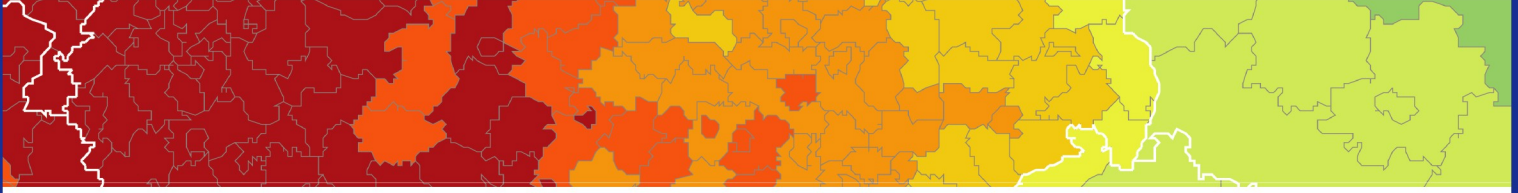
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Inspire policy making by territorial evidence



ESPON 2020 Mapkits Using ESPON Mapkit

Final Report

Version 11/05/2017

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ESPON 2020 Mapkits

Using ESPON Mapkit

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Abbreviations

EBM	EuroBoundaryMap
EC	European Commission
ECL	ESPON Cartographic Language
EFTA	European Free Trade Association
ESPON	European Territorial Observatory Network
EU	European Union
FUA	Functional Urban Areas
FYROM	Former Yugoslav Republic of Macedonia
GADM	Global Administrative Areas
GDB	GeoDataBase
GEOSPECS	Geographical Specificities and Development Potential in Europe
GIS	Geographical Information System
GISCO	Geographical Information System for the Commission
GREAT	Generalised Representation for European Areas and Territories
ITAN	Integrated Territorial Analysis of the Neighbourhood
LAU	Local Administrative Units
LUZ	Large Urban Zone
NUTS	Nomenclature of Territorial Units for Statistics
M4D	Multi Dimensional Database Design and Development
NMCA	National Mapping Cadastral Agencies
OGC	Open Geospatial Consortium
OSGEO	Open Source Geospatial Consortium
PUSH	Potential Urban Strategic Horizons
SNUTS	Similar to NUTS
TeDi	Territorial Diversity
QGIS	Quantum Geographical Information System
UMZ	Urban Morphological Zone
WUTS	World Units Territorial System

Executive summary

This technical report 'Using ESPON Mapkit' aims at describing how projects may deal with mapping in a perfect ESPON way. 3 mains points are developed:

1. Presentation of **map templates and geographical layers** used in the ESPON context and their respective characteristics (colours codes, size of the fonts, border width, etc.)..
2. Description of **how geographical layers may be used** for analytical purposes, and more elaborated maps (discontinuities, smoothed maps, etc.)
3. Rules on how to use **graphic variables** such as colour, value or size.

1 PART 1 – Mapping within ESPON

1.1 The ESPON visual chart, layout elements

A Mapkit can be considered as a **concatenation of geographical layers** (regions, boundaries, capital cities, etc.), displayed in a **adapted layout** which provides the **ESPON Map identity** and implemented for several GIS softwares (QGIS and ArcGIS) and other tools useful to produce thematic maps (such as Philcarto or R).

With regards to the production of thematic maps, several key elements have to be considered to ensure a convenient harmonisation within the map production of the ESPON 2020 Programme ():

- The map template is **adapted for a normal A4 page**: margins of 2 cm on the top, on the left and on the right. Consequently, it is unnecessary to resize the map for incorporating it in standard report.
- ESPON maps must be created using **generalised geometries** adapted for cartographic purpose (GREAT and Voronoi). Precise geometries can be used for analytical purposes and for the Zoom-in¹ Mapkit only (e.g. subregional case studies).
- The ESPON **map projection** for European territories follows the European standards. It corresponds to the **ETRS89 Lambert Azimuthal Equal Area** Coordinate Reference System (EPSG 3034), 52°N as a latitude of origin and 10°E as a longitude of origin. This is the single coordinate reference system for all Europe and it is used for conformal mapping at scales of 1:500 000 and smaller (Spatial Reference, 2017).
- **The textual information** must be harmonised and hierarchised for an optimal understanding of the map content (cf part 1.3 for the styles description).
- The **legend is no predefined design of legend in the ESPON Mapkits**. This is because it is difficult to predict by advance the degree of complexity of the map that will be produced within the ESPON programme. Nevertheless, **it is recommended to incorporate the legend inside the map template**. If the legend includes too many element, it is possible to display it below the map (legend alternatives on Erreur : source de la référence non trouvée)
- **National borders** must be displayed in white with a width of 0.3 mm². **Regional borders may or may not be displayed**, depending of the choice of the map creator. If regional borders are displayed, they must be lighter than national borders.
- By default, **capital cities** are displayed on the ESPON map template. Depending of

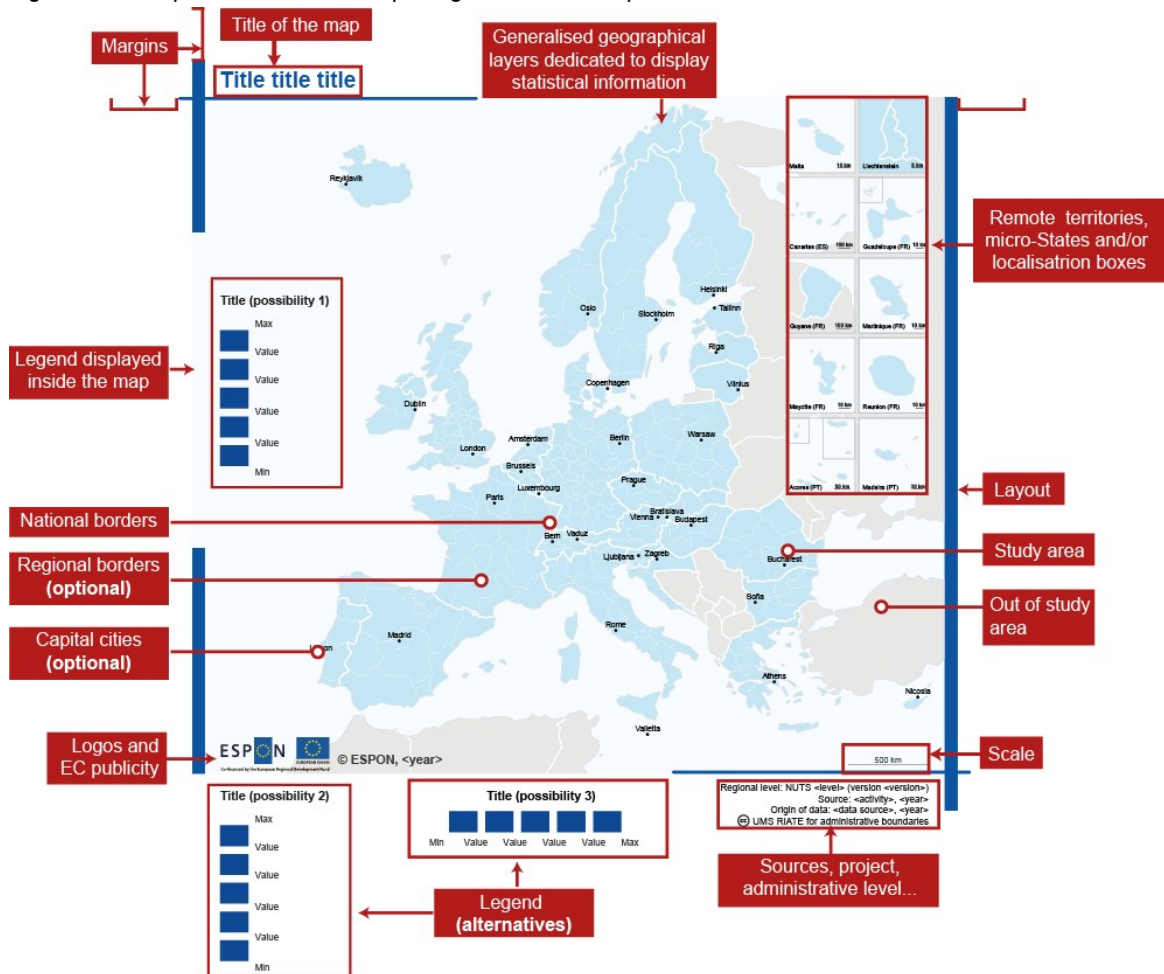
¹ The Zoom-in Mapkit proposed by the ESPON 2020 Mapkit project (Grande Région) use generalised geometries (Voronoi). But ESPON projects can also use their own geometries for these Mapkits.

² Light deviations may occur between .qgs, .mxd and .ai templates due to softwares specificities.
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the choice of the map creator, they can be displayed or hidden in ESPON maps.

- Each map produced within ESPON must systematically include the layout (blue stripes), sources correctly filed, logos and European Commission publicity.
- The alignment of map elements like title, ESPON logo (align to left), ESPON logo (C) ESPON & scale bar (align to bottom), scale bar, “metainfo” on the bottom and map boxes for outermost territories should be aligned right. Furthermore, the alignment on the elements on the right and on the left of the map should be the same distance from the blue bars.

Figure 1-1: Graphical elements composing an ESPON Mapkit



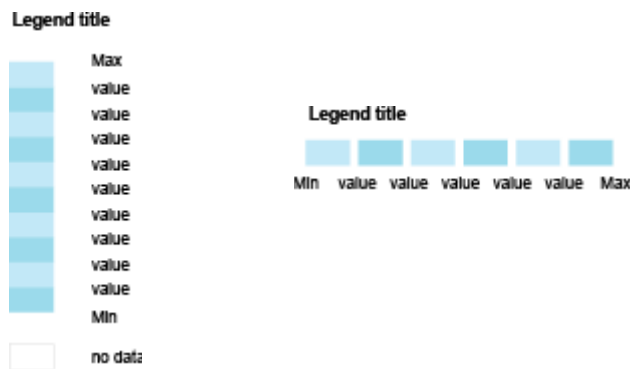
1.2 Legend

The legend is not included in the Mapkit since its representation is very dependant of the “statistical environment” of the map (number of indicators, number of classes, complexity of the indicator, study area, etc.)

Nevertheless, several elements must systematically be considered:

- For numeric indicators, minimum and maximum must be displayed in the legend (min/max).
- The recommended size for the legend box is 35 mm as a height and 65 mm for the width.
- It is recommended to incorporate the legend in the bounding box of the map.
- ESPON projects are free to position the legend vertically or horizontally, depending of the complexity of the legend and the space available in the Mapkit.
- The legend boxes can be linked or not (Figure 1 -2).
- No data must be displayed in white (RGB = 255, 255, 255) in a separate box (cf Figure 1 -2)

Figure 1-2: Style for ESPON legends



1.3 Layers Styles

Due to software implementation and bounding box extent, it is possible that minor differences occur between software implementations. The tables below summarize the styles of all the layers implemented in ESPON Mapkits. These styles (in particular line/dot width) fit with a A4 templated map (with 20 mm margins on the top, on the left and on the right).

1.3.1 Layout (top)

Layer	Background colour (RGB)	Line colour (RGB)	Line/dot width in mm	Line /dot width in pixels
Capital cities (dots)	(53, 53, 53)		1 mm	2,835 pt
Frames (blue stripes)	(3, 78, 162)	None	None	None
Frames (boxes)	None	(187, 189, 192)	0,2 mm	0,567 pt
Scales	None	(76, 80, 81)	0,15 mm	0,425 pt
Coastline	None	(210, 219, 232)	0,3 mm	0,85 pt
North Cyprus	(255, 255, 255)	None	None	None
National Borders	None	(255, 255, 255)	0,3 mm	0,85 pt
Regional Borders (Transnational MapKits)	None	(255, 255, 255)	0,1 mm	0,2835 pt
Disputed Borders	None	(200, 200, 200)	0,2 mm	0,567 pt
Lakes	(247, 252, 254)	None	None	None
Remote areas (non ESPON Space)	(230, 230, 230)	None	None	None

1.3.2 Statistical layers used to create ESPON thematic maps³

Layer	Background colour (RGB)	Line colour (RGB)	Line/dot width in mm	Line/dot width in pixels
LAU2-Voronoi / GREAT Europe GREAT World layers	(194, 232, 247)	Optional – If displayed (255, 255, 255)	Optional – if displayed 0,1 mm	Optional – if displayed 0,2835 pt
FUA polygons (for transnational Mapkits)	(3, 78, 162)	Optional – If displayed (255, 255, 255)	Optional – if displayed 0,1 mm	Optional – if displayed 0,2835 pt

NB : Several additional layers (FUAs, UMZ, NUTS centroids, NUTS boundaries, etc.) are also available in the root folder of each Mapkit.

³ For European Mapkits, urban objects (FUA, UMZ) are available as a point layer, and are not displayed by default in the Mapkits. European Mapkits include also additional layers for NUTS units (borders, centroids). If needed, users can upload them in a GIS (QGIS, ArcGIS) and make thematic maps on these geographical objects.

1.3.3 1c Layout (bottom)

Layer	Background colour (RGB)	Line colour (RGB)	Line/dot width in mm	Line/dot width in pixels
Frames (boxes)	(247, 252, 254)	None	None	None
Countries	(30, 230, 230)	None	None	None
Frames (main / sea)	(247, 252, 254)	None	None	None

1.4 Font parameters

The table below summarizes the font to be used in the ESPON Mapkits. For the readability of the map, elements must be graphically hierarchised.

Name	Font colour (RGB)	Font and size
Title	(3, 78, 162)	Arial, 14, bold
Legend title	(0, 0, 0)	Arial, 8, bold
Legend values	(0, 0, 0)	Arial, 6, normal
ESPON copyright	(53, 53, 53)	Arial, 8, bold
Metadata box	(26, 23, 23)	Arial, 6, normal
Capital cities	(0, 0, 0)	Arial, 5.5, normal
Scale (main)	(76, 80, 81)	Arial, 5.5, normal
Overseas territories + Malta and Liechtenstein names	(0, 0, 0)	Arial, 4, normal
Legend (overseas territories + Malta and Liechtenstein)	(0, 0, 0)	Arial, 3.5, normal

1.5 Managing territories with specific political issues

1.5.1 Representation of Cyprus on ESPON maps⁴

The 1974 ceasefire line should NEVER be represented on ESPON maps as a border or a frontier. There is no cartographic representation of the buffer zone or the 1974 ceasefire line. In addition, the following situations should be considered when representing Cyprus on ESPON maps (Figure 1 -3):

- a) Where no statistical data are involved (for example, when maps indicate EU member states or European islands etc.) the country appears in one colour.
- b) In case where statistical data are not available for areas outside Government control, these areas appear labelled as “No data available” with a correspondent reference in the legend of the map (e.g. Eurostat data).

⁴ Guidance paper delivered by the ESPON EGTC
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- c) When statistical are not available for all areas, the whole country appears labelled as “No data available” without distinction between Government-controlled and occupied areas.
- d) In cases where data exists for the entire Republic of Cyprus (e.g. concerning CLC values, topography, environmental indicators, United Nations, etc.) the country shall appear without differentiation between government controlled and occupied areas.

Figure 1-3: Representation of Cyprus on ESPON maps



Finally, in case of conflict or doubt, the island state of Cyprus should be represented as one entity (covering the whole country). However, where necessary to demonstrate that the acquis does not apply to the areas north of the 1974 ceasefire line, further explanations should be given in the form of footnotes or in the body of the text (in the case of publications).

1.5.2 Disputed areas

The ESPON Area and its neighbourhood include several borders not officially recognized by the European Commission and/or the overall United Nations Community (Western Sahara, Kosovo, Crimea, Transnistria, etc.). In the ESPON Mapkits, a “disputed borders” shapefile is available for displaying these territories with specific political issues on maps. In the layout, these borders must be drawn with a dotted line and a width of 0,3 (same width than national borders).

1.6 Softwares

All the ESPON 2020 Mapkits are available in an **ArcGIS** mxd document, which is an easy way to make harmonized maps and is characterised by an important community of GIS specialists across the World. ArcGIS proposes a significant number of user-friendly functionalities to view and edit data. This software, developed by ESRI, also proposes efficient extensions (such as 3D Analyst or Spatial Analyst) to manage georeferenced files. However, ArcGIS is a strictly licensed program that costs at least around 1500 dollars yearly for the basic desktop version.

This is the reason why the ESPON 2020 Mapkits are available in an open source format: **Quantum GIS** (QGIS) is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License. **QGIS** is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, and Windows and supports numerous vector, raster, and database formats and functionalities. It is possible to download the application on the following URL: <http://www.qgis.org/en.html>. Both QGIS and ArcGIS are well known Geographical Information Systems (GIS), which provide more or less the same functionalities with simple interfaces to make basic maps for the ESPON Area (choropleth maps, typologies, maps with proportional symbols).

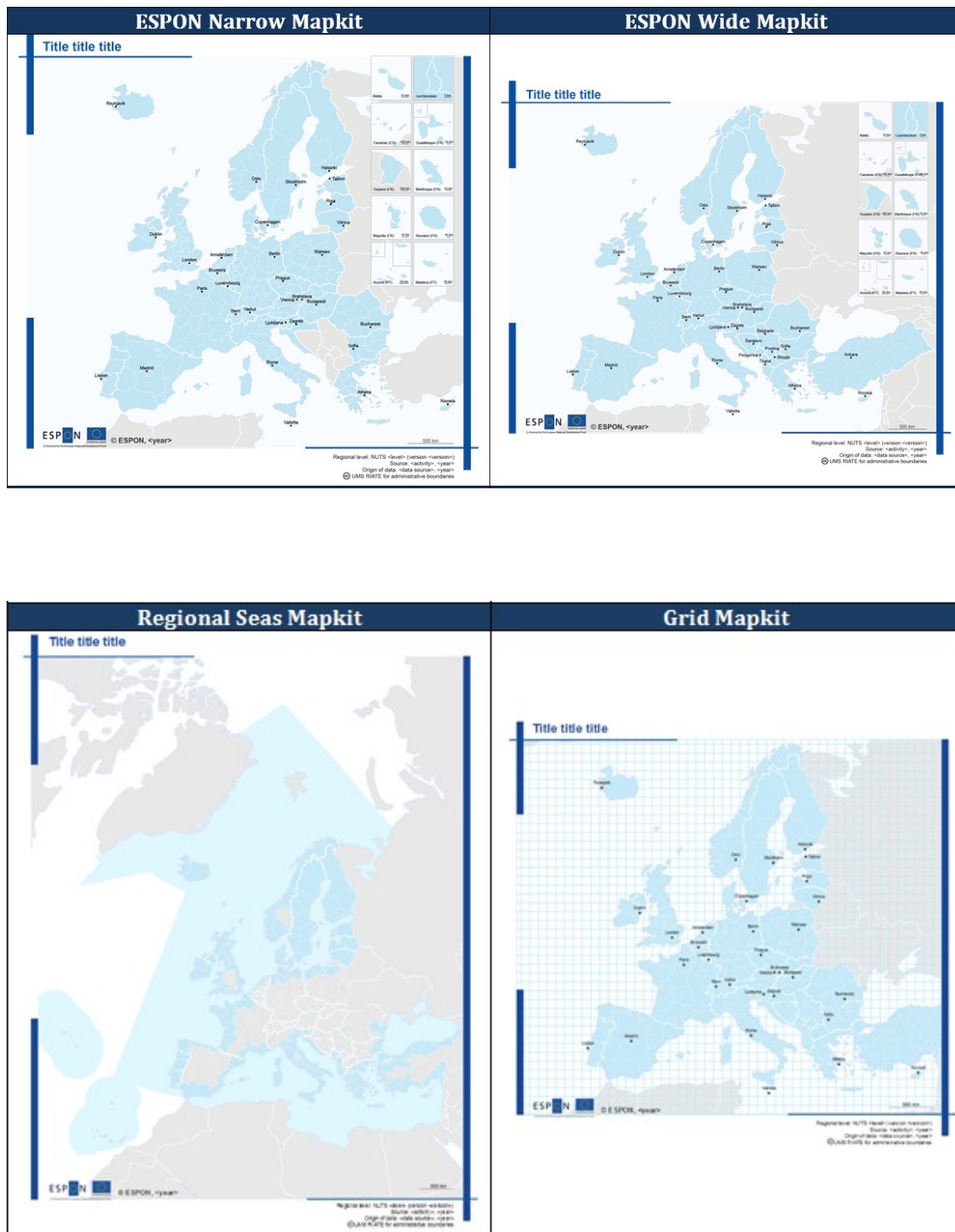
Finally, the Mapkits are available in **Adobe Illustrator** (.ai) format for people used to Computer Assisted Drawing for finalising maps produced in other softwares (R, Philcarto, etc.)

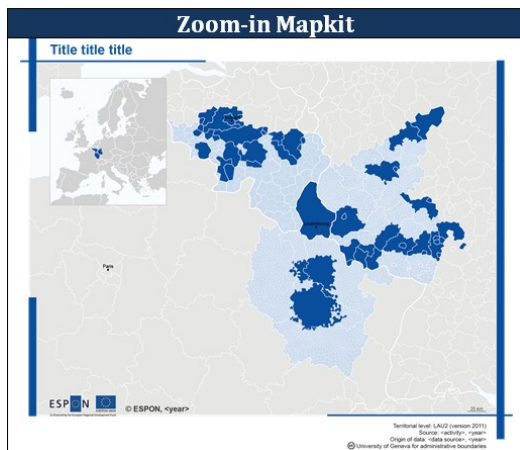
1.7 ESPON Mapkits for the community

The ESPON 2020 Mapkits project has delivered 25 Mapkits to support mapping activities of the ESPON projects. This section describes the overall content of these Mapkits. In all the ESPON Mapkits, the study area dedicated to mapping is displayed in light blue. The codification system of these layers matches with official international databases (UN, Eurostat, OECD, etc.)

1.7.1 European Mapkits

Figure 1-4: Five ESPON European Mapkits





European Mapkits includes generalised geometries for the NUTS divisions (versions 2006, 2010 and 2013; levels 0-1-2-3). It includes also a point layer for cities (FUA nomenclature produced by DG REGIO) with a correspondence table including urban nomenclatures produced within the ESPON SGPTD and CityBench projects. It includes also a point layer correspond to the 4000 Urban Morphological Zones defined within the M4D project. By default, these layers are not displayed in the Mapkits.

The Zoom-in Mapkit stands for the Grande Région (Belgium-Luxembourg-Germany-France) in the example provided. It is built with the Voronoi polygons and the FUA polygon layer is available. It includes also for orientation purpose a European map in a smaller-scale window. It is mandatory to include this window aligned on the left with the title. ESPON Projects are free to adapt this general layout in their activities, for example by using the precise geometries provided by GISCO (cf part 2.4) if needed in their case-study mapping (need to display on the map the official boundaries).

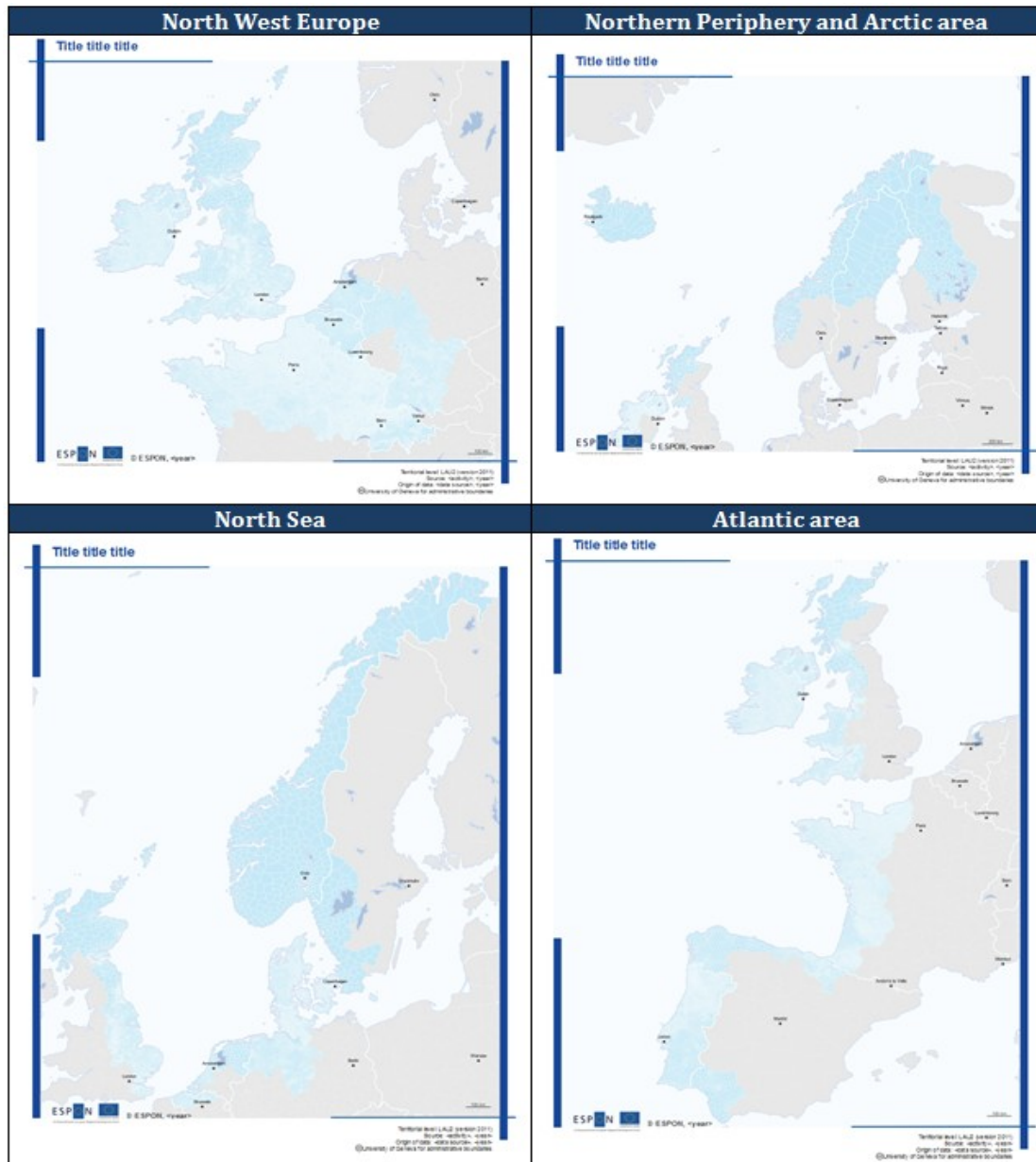
Note that a minor deviation can be observed as compared to official layers provided by Eurostat. The explanation is due to the fact that the GREAT layer has been created in 2005-2006-2007 (and updated at each NUTS revision afterwards). At the time European institutions used a different cartographic projection. The GREAT layer (coasts and territories) was digitalized manually at this moment using the previous projection. However, this is not a problem considering that GREAT geometries are suitable **for thematic cartographic purpose at European scale only**.

1.7.2 Transnational cooperation area Mapkits

12 Transnational cooperation area Mapkits area are available, following the study area covered by the programmes covered by the European Commission. These Mapkits are constituted by LAU2 Voronoi geometries of the study area. The codes of this LAU2 layer fit with the EU 2011 census. Additionally, a polygon city layer is available (not displayed by default in the Mapkit) including Functional Urban Areas created by the DG REGIO. NUTS3 layers (versions 2010 and 2013) are also available in these Mapkits.

Note that LAU2 layer does not cover EU Candidate Countries. LAU2 layer is intersected with lakes above 250 km squares.

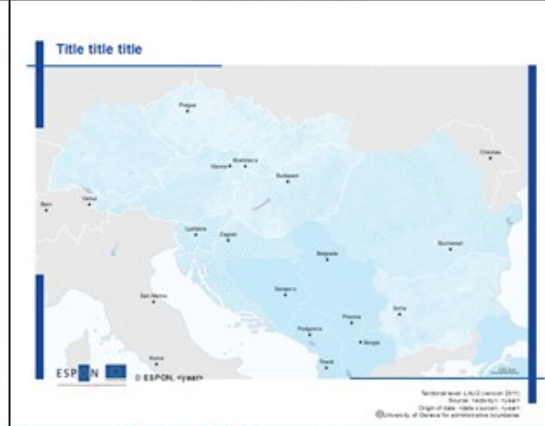
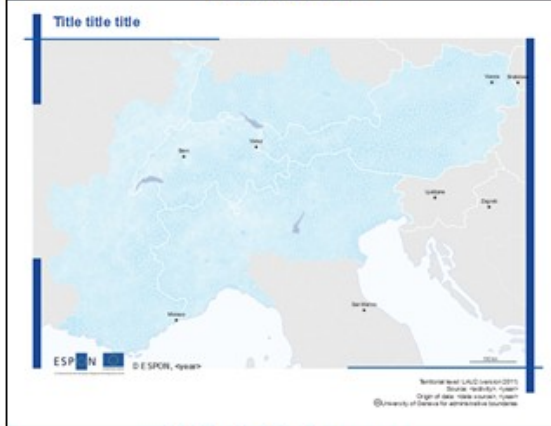
Figure 1-5: Twelve Transnational European Mapkits



Central Europe **Baltic Sea**



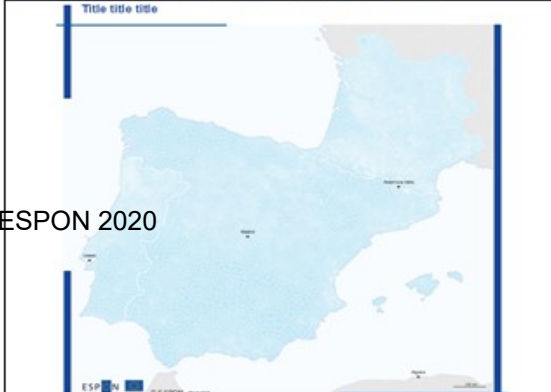
Alpine Space **Danube area**



Adriatic-Ionian area **Balkan-Mediterranean area**



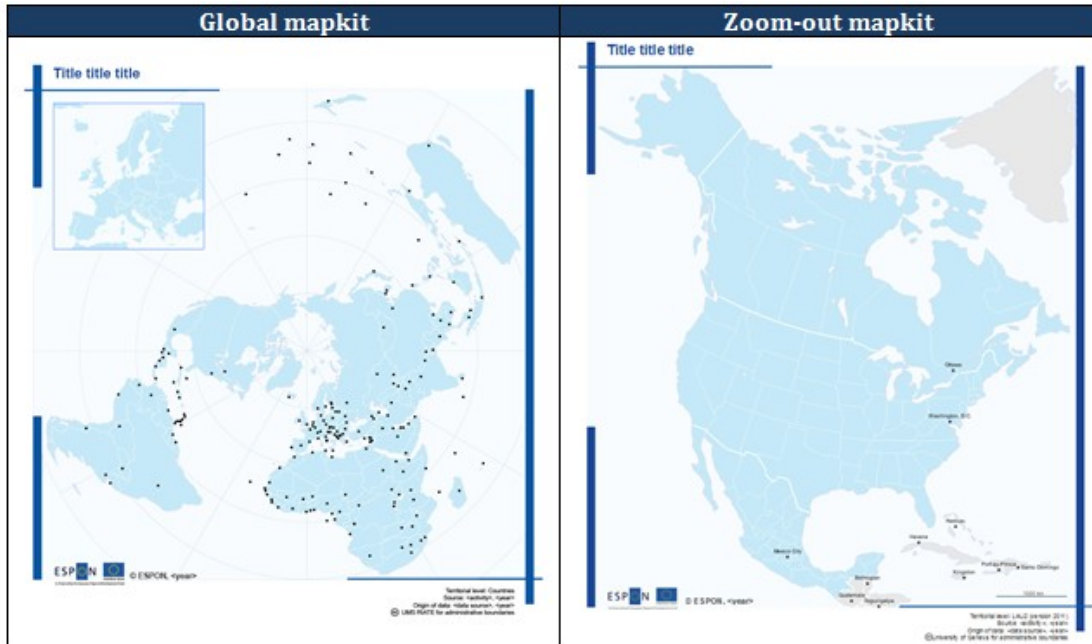
South-Western Europe **Mediterranean area**



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1.7.3 Outside Europe Mapkits

Figure 1-6: Two ESPON Mapkits outside Europe



At World level and for the **Global Mapkit**, there is no common agreement on the definition of countries. The number of countries differs depending on the main data providers at World level (UN, FAO, World Bank, etc). The ESPON 2020 Mapkit project had to make pragmatic choice in order to propose a lower common denominator at this scale for the ESPON Programme. For the Global Mapkit, **209 territorial units** are included in the reference layer (country). The country layer includes all the 193 United Nations members in 2014.

For France, Guyane, Martinique, Guadeloupe and Reunion are aggregated to the French metropolitan territory (one polygon). For Norway, Svalbard and Jan Mayen islands are aggregated to the Norwegian metropolitan territory (one polygon).

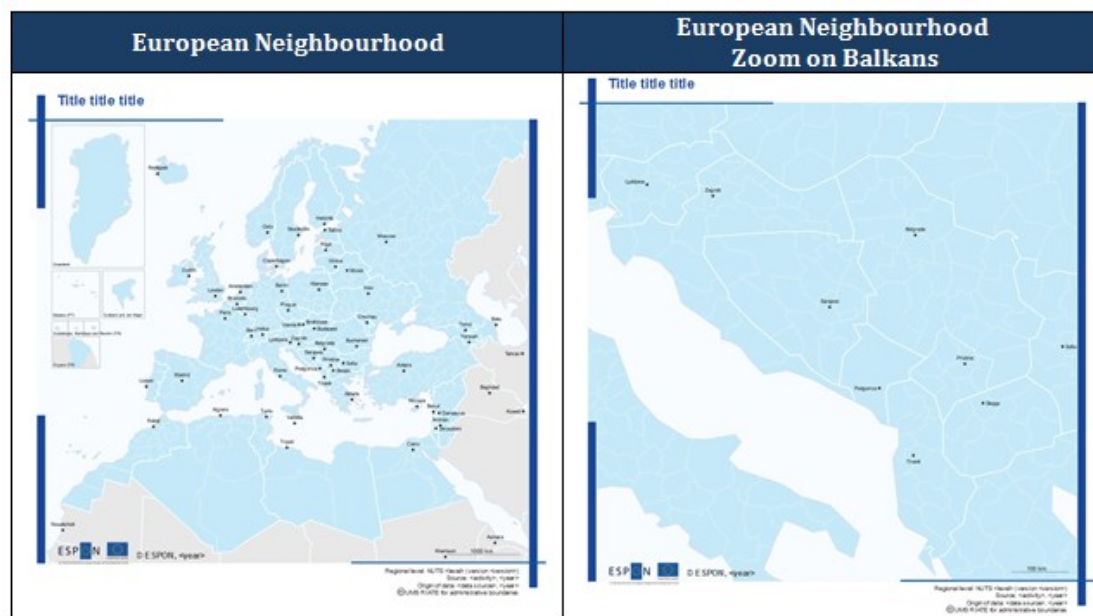
The ESPON World reference layer includes **16 additional territories (out of the UN nomenclature)**, important to be considered regarding their respective size in term of land area and/or population and for geopolitical issues: New Caledonia (FR non-self-governing territory), Antarctica, Western Sahara (Non self-governing territory), Falkland Islands (UK non-self-governing territory), Faroe Islands (DK territory), Guernsey (UK territory), Greenland (DK self-governing territory), Hong-Kong and Macao (CN special administrative region), Isle of Man (UK territory), Puerto Rico (US territory), Palestinian territories (sovereignty unsettled), Taiwan (sovereignty unsettled), State of Vatican city and Kosovo (sovereignty unsettled). Annex 2 provides the listing of territories excluded from the ESPON nomenclature.

The capital layer includes capital cities location for the 193 UN Member States + Vatican city + Western Sahara + Taiwan + Palestinian territories + Kosovo.

The **Zoom-out** Mapkit has been designed taking the example of Canada, United States and Mexico. Geometries have been generalised starting from **Natural Earth**⁵ and **GADM**⁶ layers. The map projection, adapted to this part of the World, as been chosen following the information provided by **Spatial Reference**⁷. Finally, territorial codes have been adapted to follow the territorial nomenclature provided by the **OECD**⁸. ESPON projects are free to adapt this Mapkit to other part of the World, following the organisation of layers proposed in this example. For more local areas (e.g. not covering all a continent) a **world map in a smaller-scale window** must be displayed for orientation purpose, following the principles of the Zoom-in Mapkit.

The **Neighbourhoods** Mapkits provides 6 templates for the ESPON area and its neighbourhoods, as defined by the ESPON ITAN project⁹. It includes namely a territorial nomenclature – “Similar to NUTS” (SNUTS), which has been created in 2011-2012 by the ESPON ITAN and M4D projects to compare European and neighbouring territories without too much MAUP effects.

Figure 1-7: Six ESPON Mapkits for the European Neighbourhood



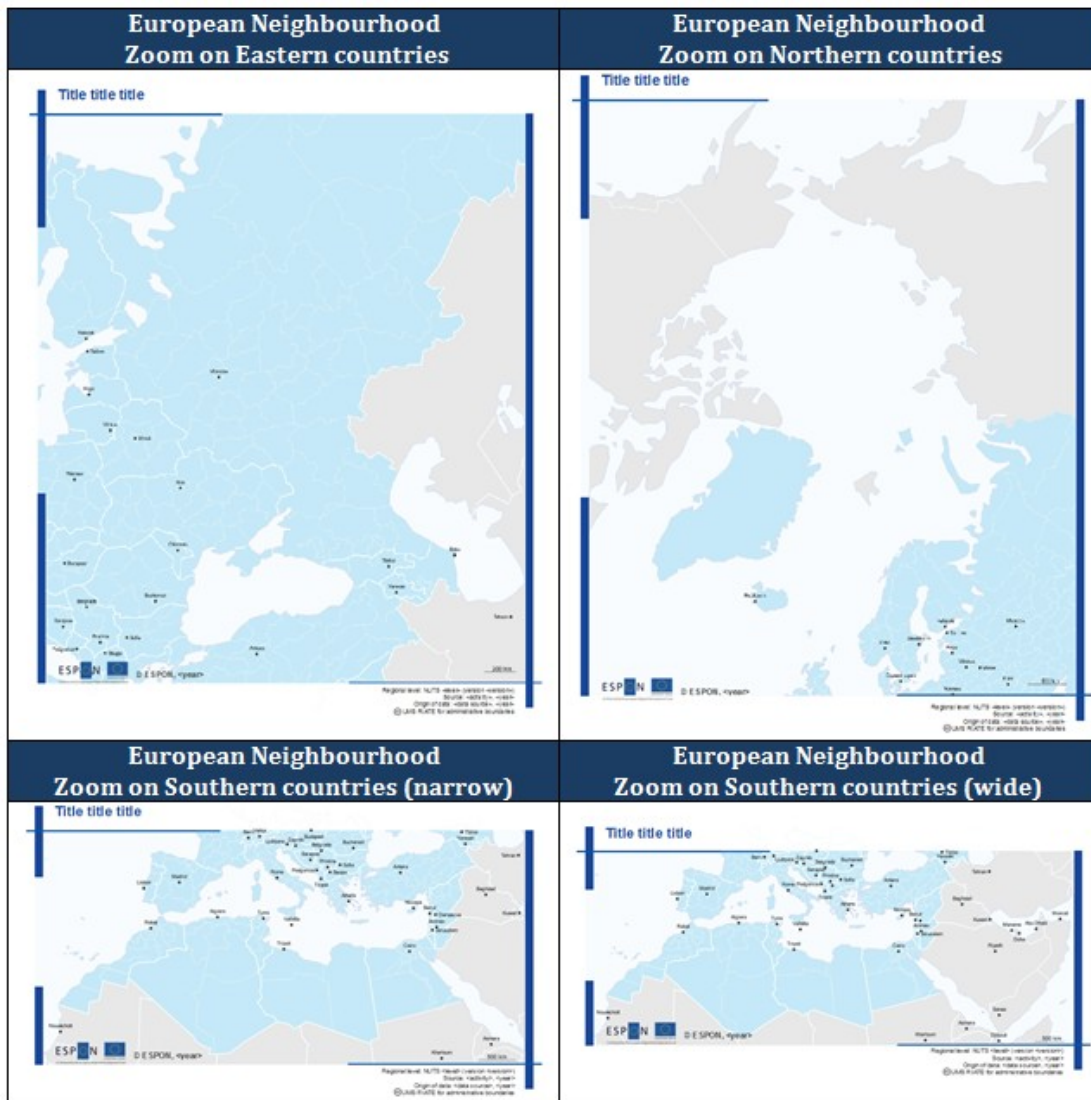
5 <http://www.naturalearthdata.com/>

6 <http://gadm.org/>

7 <http://spatialreference.org/>

8 <https://data.oecd.org/>

9 https://www.espon.eu/main/Menu_Projects/Menu_ESPON2013Projects/Menu_AppliedResearch/itan.html



The study area corresponds to the SNUTS nomenclature defined by the ITAN project. The grey area can be filled depending on the aims of the ESPON project(s) dealing with these specific territories.

1.8 Layers for analytical purposes

The ESPON Mapkits includes also a provision of layers provided by external institutions interesting for analytical purposes (included in the “Layers for analysis” folder of the Mapkit deleverie). These layers are for analytical use only (except for the Zoom-in Mapkit). However, we cannot guarantee that these layers have no topological flaws. Most of them are freely downloadable in the Web, except the GISCO layer. **Users having gained access to the GISCO layer through the ESPON Programme may not use it for other purposes.**

Table 1-1: Listing of available layers for analytical purpose

Name	Object type / description	Spatial coverage	Data provider
Vor2_Census2011_Su	LAU2 Voronoi	ESPON Area	University of Geneva based on GISCO
ESPON LAU2 Census 2011	LAU2 with precision of 1:100 000	ESPON Area	GISCO and Eurogeographics, adapted by Spatial Foresight and University of Geneva
ITAN_GADM_levels23	SNUTS2-3	European Neighbourhood. Seamless with NUTS2006 geometries (Eurogeographics)	GADM – ESPON ITAN – ESPON M4D
Grid_ETRS89-LAEA_10K	Grid 10 km resolution – Official European projection	xMin,yMin 0,700000.00 : xMax,yMax 8400000.00,7500000.00	EEA
Grid_LAEA5210_1K_p olygons	Grid 1 km resolution / Intersected with coastline – Official European projection	EU28 + Switerland + Bosnia + Albania + FYROM	EEA
Grid_ETRS89_LAEA_1K-ref_GEOSTAT_POP_2011_V2_0_1	Population grid 1 km resolution / empty cells are deleted from the grid / Official European projection	EU28 + Iceland + Switzerland + Norway + Liechtenstein + Balkan countries	Eurostat
NUTS_2013_01M_SH	NUTS division 2013 with precision of 1:1 000 000	ESPON Area + Candidate Countries	Eurostat
NUTS_2010_03M_SH	NUTS division 2010 with precision of 1:3 000 000	ESPON Area + Candidate Countries	Eurostat
NUTS_2006_03M_SH	NUTS division 2006 with precision of 1:3 000 000	ESPON Area + Candidate Countries	Eurostat

1.9 Mapkits organisation (shapefiles, templates, documentation)

The classification tree below shows the organisation of the ESPON Mapkit inputs for ESPON Projects.

The “**Mapkits**” folder includes the 25 ESPON Mapkits. The ESPON templates in QGIS, ArcGIS and Adobe Illustrator formats can be found at the root of each Mapkit sub-folder. Each Mapkit is structured in the same way: a graphics folder including the ESPON logos and European Commission publicity in a vector format, and a shp folder including all the layers used in the Mapkits.

Table 1-2: The ESPON Mapkits inputs for ESPON Projects



The folder “**Layers for analysis purpose**” includes all the layers described in section 1.8

The “**nomenclature metadata**” folder includes documentation regarding layers collection, building and nomenclatures creation.

The “prg” folder includes the R programmes used (Figure 1 -8) to create the ESPON Map Template correctly sized (keep the proportionality of blue stripes, etc). This programmes processes information on the bounding box (Xmin, Xmax, Ymin, Ymax) and on the geographical projection system provided by the user and returns a shapefile called “template.shp”. Then and for all MapKits the R programmes (1 programme by MapKit) takes all the input layers and intersect it with the required bounding box.

Figure 1-8: R programme for building a correctly sized ESPON template shapefile

```
#####
# BUILD A ESPON MAP TEMPLATE CORRECTLY SIZED #
# UMS RIATE, FEB. 2017 #
#####

#####
# Install required librairies #
#####

library("rgeos")
library("rgdal")

|

#####
# Function BuildTemplate #
#####

# This function has been designed following a template designed in Adobe Illustrator and provided by ESPON EGTC
# It takes in entry the geographical coordinates (xmin, xmax, ymin, ymax) of the bounding box required and the cartographic projection system

buildTemplate <- function(xmin, xmax, ymin, ymax, prj){
# Template parameters
width <- (xmax - xmin) / 60 # Blue stripes width
extralength <- width * 3 # Height of the extra length on the top and on the bottom of the template
lengthtopleft <- (ymax - ymin) / 5 # Height of the stripe exceeding in top left
lengthbottomleft <- (ymax - ymin) / 3 # Height of the strip exceeding in bottom left
linewidth <- (xmax - xmin) / 300 # width of the little horizontal stripes
linesize <- (xmax - xmin) / 2.5 # length of the little horizontale stripes
```

2 PART 2 – Enhancing statistical information on maps

2.1 From data to map

The process leading from data to a map is complex and a wide range of solutions can be chosen. However, a few precise rules need to be followed to avoid going astray.

2.1.1 Geographical data

One fundamental step when producing a map is the collection and selection of the data that it is useful to display in the form of a map. Today, with the development of computing technologies, geographical information has become easily available, and is easy to access and to use. It is very easy for a non-expert to gather data, transfer it to a map and integrate the map into a research report. It is enough to have reasonable command of the cartographic production chain.

However, selecting, collecting and converting geographical information is neither trivial nor insignificant tasks. They imply choices that are often subjective. These choices mainly concern the relevance of sources and the conversion methods implemented (creation of indices, typologies etc.) which enable the complexity of the geographical information to be summed up in the form of a map delivering the desired message. Our task here, without aiming to be exhaustive, is to make the reader aware of the need for a reasoned approach to the data he or she is using and representing in graphic or cartographic form.

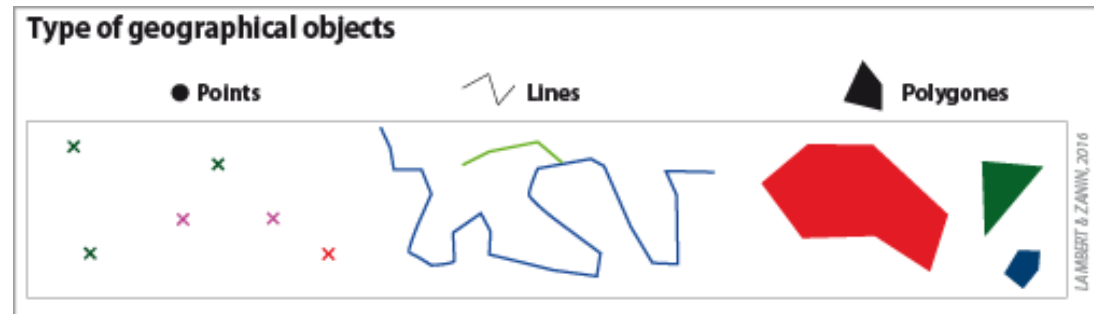
A number of geographical data is used because it is exhaustively available across the space and the theme targeted (for instance, it enables a straightforward question to be answered, such as "can you provide me with the latest trends in unemployment in the European regions?"). In this context it might appear that the methods used to collect and collate the data are of little importance. Yet it is essential to know how to handle the data in order to avoid any error in interpretation or any mistaken conclusion. This necessarily means that prior critical consideration needs to be given to the **intrinsic quality** of the data used (accuracy, credibility, objectivity), to the **setting** in which the data used was produced (survey, census, GIS process, estimates etc.), and to **the extent to which the data are understandable** (complex indicators, typologies etc.). No-one wants to use and interpret data if its reliability and accuracy are not known, or if its finalities or even merely its structure (folders organisation, etc.) are not known.

The choice of the "right" cartographical representation entirely depends on the statistical nature of the data (qualitative, quantitative) (Figure 2 -10) and on the type of geographical object it is to describe (Figure 2 -9). Generally, three types of geographical object are distinguished:

- a point is defined by precise coordinates (localisation of a place by X and Y).

- a line connects two points (a road, flows, between places)
- an area or zone is enclosed by several connected points (a territory).

Figure 2-9: Three types of geographical object



Source: Lambert N., Zanin C., 2016, *Manuel de cartographie. Principes, méthodes, applications*, A. Colin

2.1.2 Qualitative data

Qualitative properties are not measurable; they can be names, acronyms or codes. Qualitative attributes cannot be summed or averaged. There are two families of qualitative-type data:

- **ordinal qualitative characteristics**, which can be classified according to a logical order. This order can result from a given hierarchy (metropolitan regions, peri-urban or rural areas for instance) or from a classification. Their cartographic representation should reflect this notion of ordering and hierarchy. Here visual variables associating colour and colour value or texturing will be preferred to represent differences between the various indicators. For point locations (cities or towns for instance) or lines (roads) it is also possible to use size to differentiate and order the geographical objects.

- **nominal qualitative characteristics** cannot be ordered (official language of European countries for instance). The cartographic representation should in this case give precedence to a differentiation between the various elements making up this type of indicator. Thus the visual variables suited to this type of phenomenon are shape (for point or line locations) or colour. Texturing can also be considered (for zone locations).

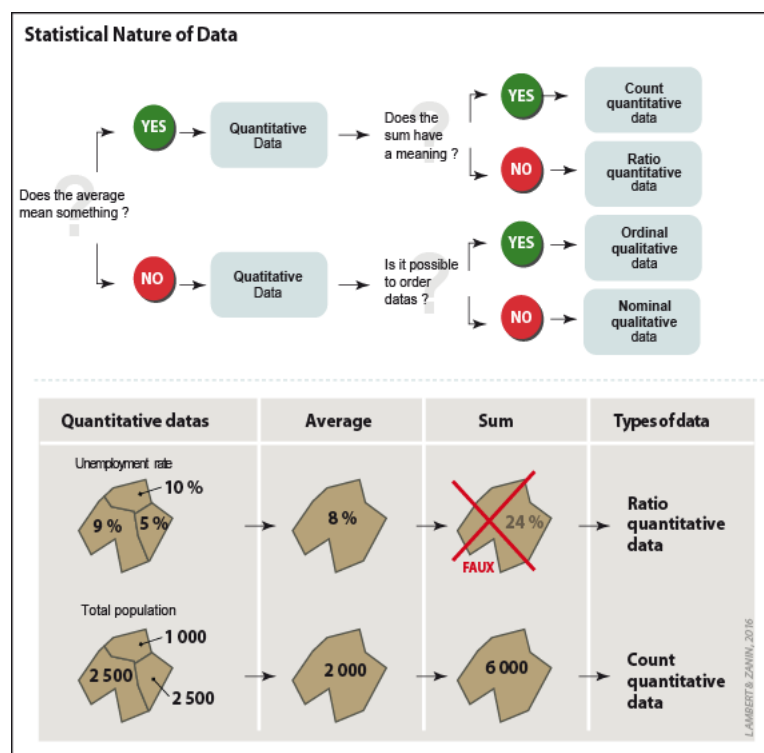
2.1.3 Quantitative data

Data of quantitative nature is always numerical. By definition data of this type is ordered, and averages have meaning. Just as for qualitative data, two families of quantitative data can be distinguished:

- **quantitative characteristics** expressed as "**count data**" – these are concrete quantities and their sum has a meaning (for instance numbers of unemployed, total population). The representation of this type of data should take account adapted styles to design quantities, and differences in proportionality among the different resulting elements. The visual variable suited to this type of data is size. For zone locations point densities can be used (where one point corresponds to a given number of inhabitants).

- **quantitative characteristics** expressed as "**ratio data**" describe a relationship or ratio between two quantities, but their sum has no meaning. By extension, it is possible to associate composite numerical indices with them. This is the type of indicator most often used in ESPON. The cartographic representation should be suited to the ordered progression of the values, from the lowest to the highest. Thus an association of values with colours is the preferred option, whatever the type of localisation. For zone locations, it is also possible to use texturing.

Figure 2-10: Statistical Nature of Data



Source: Lambert N., Zanin C., 2016, *Manuel de cartographie. Principes, méthodes, applications*, A. Colin

2.1.4 Discretisation

This data reduction process is required to render the geographical information intelligible. Numerous discretisation methods can be used. The choice depends on both the properties of the statistical series (magnitude¹⁰, dispersion¹¹, shape¹²) and on the desired cartographic message (single map, comparative maps, audience). The four most commonly used methods are presented here.

- The **natural break method** consists in choosing the natural divisions in the statistical distribution as the class boundaries
- The **equal range method** consists in dividing the statistical series into classes of equal statistical range. To do this the whole statistical series (from minimum to maximum values) can be divided by the number of classes required. It is also possible to use the mean and standard deviation of the statistical series to define the class boundaries.
- The **equal frequency data method**, also known as the *quantiles* method, is based on the division of the total number in the distribution by the number of classes required. The number per class is thus obtained. The class boundaries are then determined by counting the geographical objects in the ordered series.
- The **geometric progression method** consists in multiplying the minimum value in the statistical distribution by the common ratio r^{13} as many times k as there are classes to form to reach the maximum value in the series.

Whatever the method used, several elements need to be taken into account for effective mapping of the statistical series:

- The optimum number of classes depends on the number of geographical objects to be represented (Figure 2-11).
- It is important to remember that discretisation leads to a simplification – and thus a reduction – of the heterogeneity of a statistical series
- The minimum and maximum values in a statistical series should always be referenced in the map legend (always avoid noting "more than" and "less than" in the legend)
- The figures in the legend should be rounded off (1000 rather than 996) so that the reader can more efficiently memorise the anchors of the statistical series.

An example is given with 2-4.

Figure 2-11 - Choices for range of data: an applied example

¹⁰ measured via the central values of the statistical distribution: mode, mean, median

¹¹ measured via the standard deviation, the interquartile interval or the variation coefficient

¹² normal, symmetrical or dissymmetrical distribution

¹³ $\text{Log } r = (\log(\text{max}) - \log(\text{min})) / k$ or $r = 10^{\log r}$

How Many breaks ?

Territorial level (European Union)	Number of territorial units	Huntsberger Method	Brooks-Carruthers Method	Threshold perception of colours*	Number MAXIMUM of classes
NUTS 0 (Country)	28	6	7	8	6/7
NUTS 1 (Landers)	98	8	10	8	8
NUTS2 (Regions)	272	9	12	8	8
NUTS3 (Counties or districts)	1315	11	16	8	8

LAMBERT & ZANIN, 2016

Huntsberger Method

$$k = 1 + 3,3 * \log_{10}(N)$$

Brooks-Carruthers Method

$$k = 5 * \log_{10}(N)$$

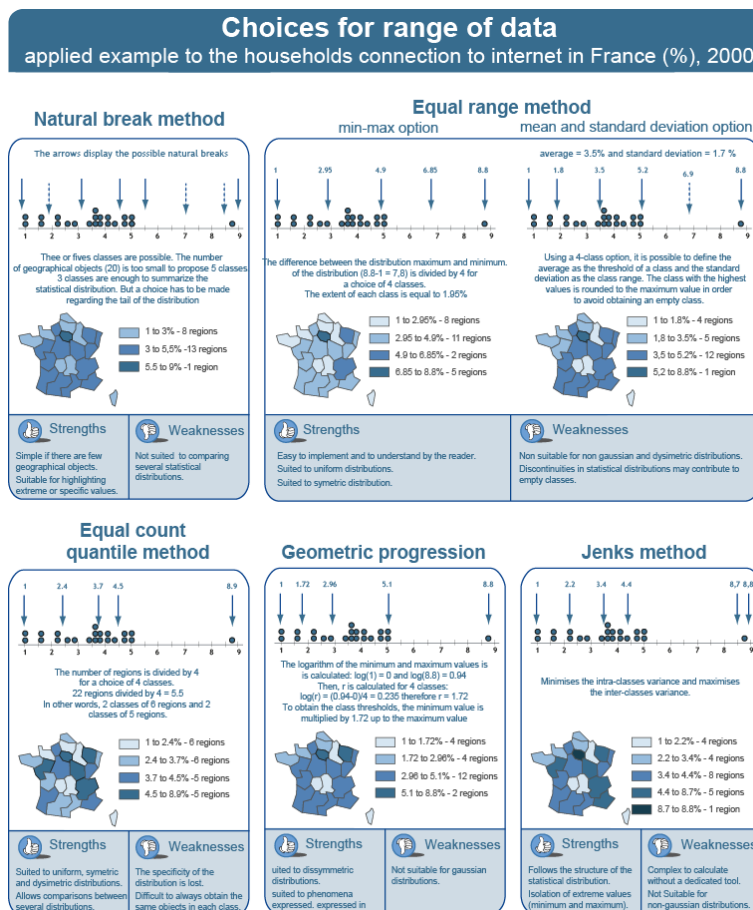
k: number of classes

N: number of territorial units

(*) depends on the spatial organisation

Source: Lambert N., Zanin C., 2016, Manuel de cartographie. Principes, méthodes, applications, A. Colin

Figure 2-12: Choices for range of data: an applied example



Source: ECL Project, 2013

2.2 The graphic language

If geographical information is to be effectively delivered in visual form, certain fairly strict rules need to be applied, and the graphic signs need to be suited to the type of data represented and to the geographical object concerned.

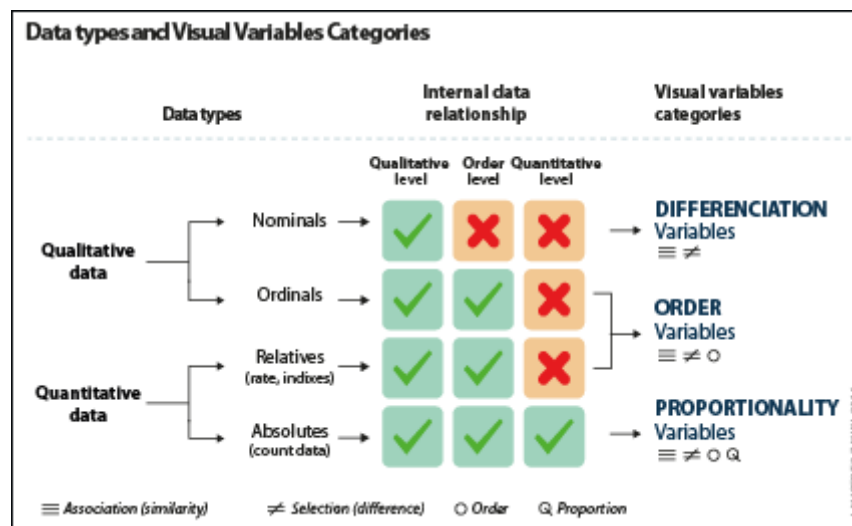
As shown in the previous chapter, data can be classified in four types. These four categories allow the expression of three major internal relations for data: **quality or difference, order and quantity or proportionality** (

Differential level relationships express equivalence and difference relations without any hierarchy. It may be a nomenclature of objects or a typology. The visual variables transcribing these relations must be endowed with an association property (identical data are transcribed by graphical figures perceived as similar) and selection (the different data are transcribed by graphical figures perceived as different).

Ordered relationships (also called ordered typologies) express hierarchy between data (This is before that, this is more than that). This order can be intuitive in the case of a qualitative character (weak, medium, strong) or express a numerical ratio (a density, a rate). This type of relationship is graphically represented by graphic figures that can be visually classified unambiguously.

Quantitative level relationships express the idea that one data count proportionally twice, triple ... as other one. Absolute quantities can be visually transmitted by proportionality.

Figure 2-13: Data types and visual variables

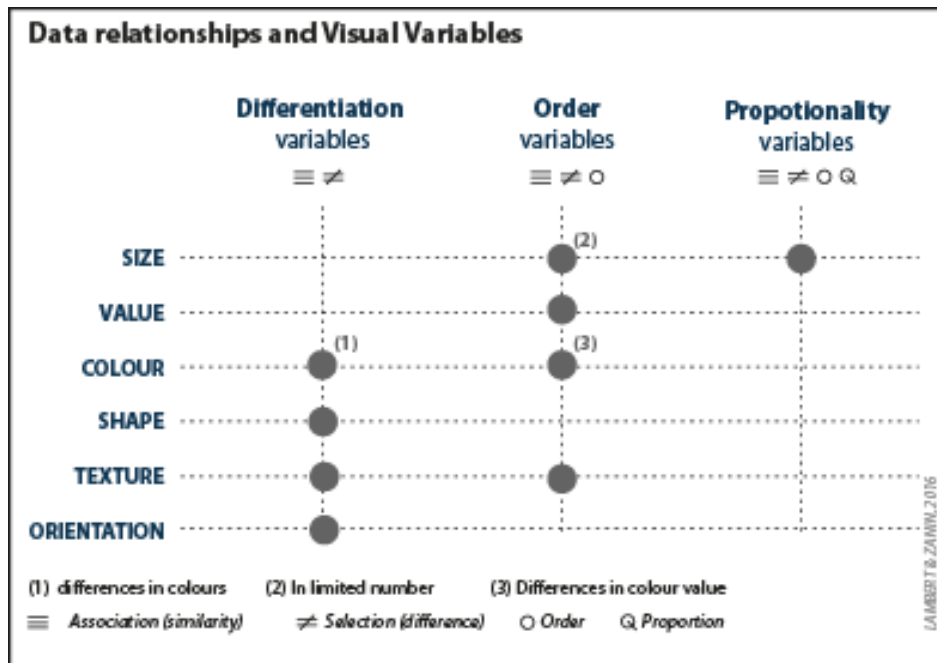


Source: Lambert N., Zanin C., 2016, *Manuel de cartographie. Principes, méthodes, applications*, A. Colin

These rules, enabling the transcription of geographical information in the form of graphic signs, are what is known as the **graphic semiology** (

). When applied to elementary spatial objects (points, lines, polygons), these graphic signs form the cartographic "language". This language is purely visual.

Figure 2-14: Data relationships and visual variables



Source: Lambert N., Zanin C., 2016, *Manuel de cartographie. Principes, méthodes, applications*, A. Colin

2.3 Some proposals for effective colours palette

Since geographical maps are increasingly intended for viewing on a screen, there is no reason to hesitate to use colour. The choice of the "right" colour is however a highly cultural issue. Understanding how colour works enables awareness of the impact of this choice. Here the aim is not to provide precise guidelines on the colours that must be chosen to get things right, it is rather to point out the main aspects of the power of colours in mapping. The dimension, the harmony, and the perception and meaning of colours are major issues.

2.3.1 The dimensions of colour

The human eye possesses three types of cone enabling the perception of the quantities of blue, green and red in white light. The total intensity of the light perceived and the proportions of these three primary colours enable the eye to see the different colours, according to three dimensions (Figure 2 -15), known as HSL - Hue, Saturation and Lightness.

Figure 2-15: The dimensions of colour



Hue (such as red, green, or blue) can be used to categorize features that are qualitatively different, such as a river and a road.

Saturation (or intensity of hue, such as bright red as opposed to a dull, grey red) can be used for qualitative or quantitative data.

Lightness (or value) can be used to represent data quantitatively (either rank-ordered data or numerical values), such as population density. The value is typically light for small numbers (e.g. light green) and dark for large numbers (e.g. dark green).

2.3.2 Colour harmony and perception

In cartography as in matters of dress, not all colours go well together. Also, while some colours are best not combined, for aesthetic reasons, handling colours when designing a map above all requires consideration of the various types of information that the variable is to transcribe graphically. Indeed colours are perceived differently according to context, and they are not easy to use.

The combination of certain colours can also make perception difficult or impossible. In the figure below, the blue square is perfectly visible when on a light green ground, but it is barely visible on a dark green ground. It is however the same blue.

Figure 2-16: Colour perception, some examplesur perception





2.3.3 ColorBrewer: a web tool for selecting colours for maps

ColorBrewer is an online application offering a wide range of colour palettes for map-making that is free of charge (Figure 2-17). This tool¹⁴ is a useful function available to map-makers to choose and test different options. The application enables the user to determine the number of classes on the map (from 3 to 12). The user then chooses among three types of data: sequential, diverging or quantitative. Following these two choices, numerous colour ranges are offered in single or multi-hue (Figure 2-18).

Figure 2-17: ColorBrewer online application

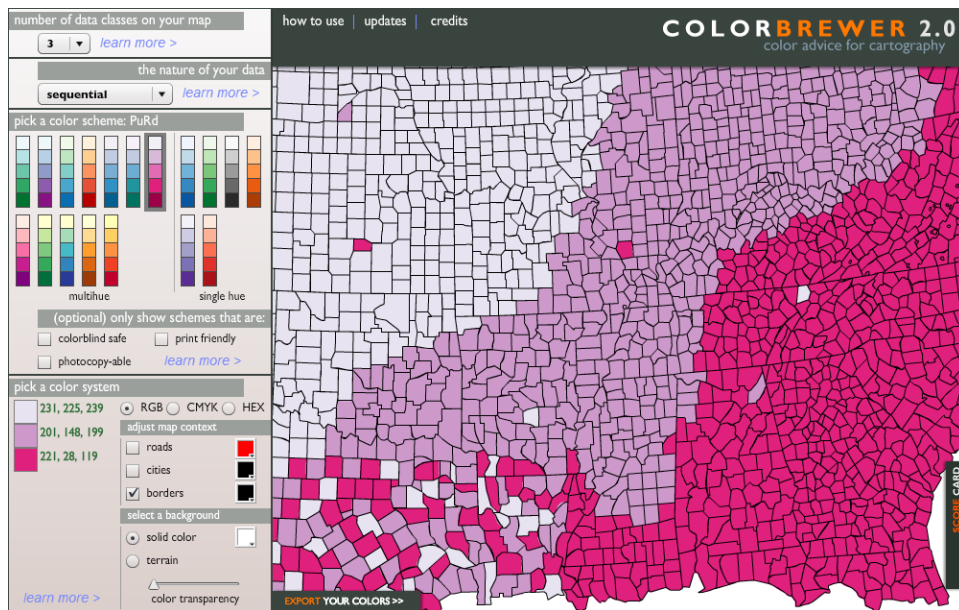
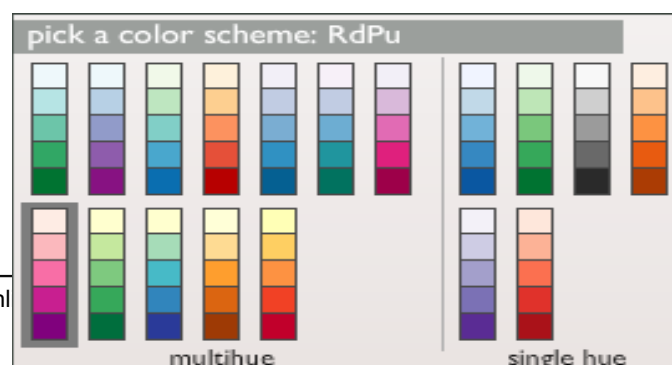


Figure 2-18: ColorBrewer palettes



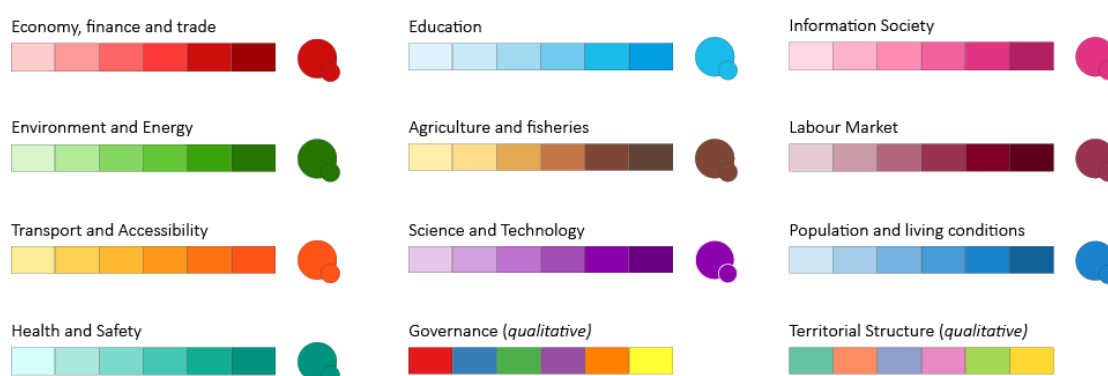
Each of the palettes available can then be assessed according to various criteria: ability to be seen by colour-blind individuals, "printer-friendliness", use on LCD screen etc. Thus the user has at hand the various prerequisites for an efficient implementation of the different palettes according to the base-medium used for the map. The colour palettes are exportable in different formats and easy to use in graphics software. Despite evident qualities, it can be noted that the palettes are often not sufficiently contrasted, which can be detrimental to the clarity of the information shown.

2.3.4 Colours and themes

Numerous paper and online atlases have established links between colour palettes and the subject-matter. This is true for instance of the Interactive Atlas of European Regions (AIRE), which uses 5 different palettes, each corresponding to a topic in the Atlas. This graphic procedure is effective in terms of communication, since it is a further element available to the user to gain rapid understanding of what the map is about. Thus the method can be recommended for synthesis documents in the ESPON programme. However attention should be paid to the fact that not all maps cover just a single theme. Finally, this technique is of course unsuited to TGP reports, often covering a single theme but requiring the use of several colours.

A proposal for colour palettes (Figure 2 -19) for each of the themes in the ESPON database can be made, and adapted to each objective.

Figure 2-19: Proposal of colours schemes for ESPON



Allocating a colour to a theme is nevertheless a delicate operation. Across the world each culture gives specific meanings to different colours. These meanings can be powerful, depending on the environment and the experience of each individual. Connotations are cultural or symbolic, they sometimes echo experience, sometimes emotion. Connotations give

colours meanings that should, as far as possible, be taken into account in mapping procedures.

Beyond the cultural meanings of the different colours, cartography often uses colours for their likeness to those encountered in the natural world. Thus blue is widely used for lakes and oceans, and green for vegetation and natural environments. Brown is used for arable land or mountains, and red for danger (what is red in the natural world is often venomous). White signals absence of information.

In all events, beyond the culturally-bound meanings of colours, if there is one thing to recall for the use of colours in mapping, it is the very strong negative or positive impact that colours can have on perceptions AND understanding of spatial information. Colours enable varying weights to be allocated to the spatial forms shown. When they are well-used they considerably enhance the effectiveness of the map. When they are not, they reduce the effectiveness and even change the meaning.

2.4 The effectiveness of a map

The different visual variables presented above can be combined to simultaneously represent several types of information (for instance a count + ratio data map). Nevertheless it is clear that a map that superimposes numerous different layers of data would in fact be unlikely to deliver a clear message that is comprehensible in less than 10 seconds. Sometimes this is a conscious choice: the aim may be to produce a map that is read, rather than an immediate visual message. Maps that need to be read or deciphered make it possible to convey precise information on a specific area, or to compare different areas. However, they do not readily display a global spatial structure. In other words, the information is not perceived visually, but has to be deciphered point by point.

When faced with complex information, there are several options. First of all there is the option of dividing a complex map into two simpler maps. Positioning one map beside another then enables the reader to understand the phenomenon overall and the relationship between the two phenomena represented on the two maps. It can also sometimes be effective to combine a map and a non-cartographic geographical element (histogram, graph, and diagram). And finally the simplification of complex data does not involve solely the use of effective graphic elements on the map. It can be performed upstream of this stage via statistical processing and classification procedures involving one or several variables. This operation is highly recommended, but falls outside the scope of this manual, which is mainly focused on graphic representation aspects.

In all events, to be effective a map needs to be clear and well-organised, so that the message is understood readily and without risk of misinterpretation. This is the whole aim of the "staging" process in map production. There is one basic rule: the message has priority. It is thus the message that is made prominent, rather than the accompanying elements of the

graphic configuration. The scale for instance is less important than the title, and therefore should be less prominent; its presence should be discreet so as not to hamper the interpretation of the phenomenon represented. Layout and "staging" contribute to this.

2.5 "Staging" the map

When a map is published in a book or a report, or presented on slides at a conference, the layout has to be planned and designed. The layout enables the cartographer to hierarchize the various elements that will turn the cartographic image into a map. Each particular layout is a sort of "staging" (in the theatrical sense) of the information, since each cartographer can choose to emphasise one or other element, so as to foster the perception of a specific spatial organisation. This staging procedure, amounting to moving from the initial cartographic image to the geographical map, is one of the key elements in map development, since it is what makes the map intelligible.

2.5.1 The different elements to make maps appealing

There are several essential elements in a cartographic image.

The **title**, most often positioned at the top, is an important point of entry for the cartographic document. It should be written in sufficiently legible script (but there is no need for underlining, a method that belongs in written text). It should catch the eye quickly and deliver its message. The title of the map is not intended to describe the indicator represented; it should express the message to be delivered by the map, and should therefore be clear and brief.

The **legend**, which should preferably be positioned inside the map rather than besides or below it, is the element that enables the map to be understood in detail. It describes all the visual elements used for representation on the map. Titles of legends can therefore be quite long and technical, and need to be precise. To facilitate reading and comprehension, it must be organised and hierarchized.

The **data source** is another essential element. It should be noted as accurately as possible. It enables precise identification of the data used to develop the map, and means that another person could reproduce the map, possibly altering a few parameters, so that scientific exchange is rendered possible. Nevertheless, as the source is a technical component that does not contribute to the cartographic message, it needs to be presented unobtrusively, generally in small characters and never in bold.

On a theme map, there are three different **dates**, each of which should be present: the date when the map was created (e.g. 2013), the date of the indicator represented (e.g. total population, 2010) and the date of the source (e.g. Eurostat, 2012). Depending on the type of data used, the date can be more or less precise (e.g. on 1st January 2012).

Finally, to provide information on the relationship between surface area on the map and surface area in reality, the **scale** is also essential. It should be unobtrusive, and as far as possible should be in graphic form. A numerical scale (e.g. 1:200 000) would be incorrect if the document is reduced or enlarged, so this type of indication should be avoided. Finally, while the scale is essential in most instances, it sometimes has no meaning if distances at two points on the map are not at all comparable (e.g. polar projection, cartogram).

Other elements can also be used in the layout of the map, but they are optional: orientation (indication of the north), place-names, an inset showing a zoom-in or zoom-out, an inset providing technical data on the design and production of the map, or an outline frame for the map.

Staging the map is an operation that is largely manual, and is performed using graphics software. The aim is to organise the different elements making up the map, and to add elements that help interpretation, so that the map's main message is apprehended in under 10 seconds. This involves naming the important places, and the drafting an explicit, relevant title that does not only describe the indicator represented, but also give keys to interpretation, to guide the reader as soon as possible towards what is important. This operation will differ according to the target audience (stakeholders, citizens, scientists, students etc.) and also according to the type of medium used, so as to enhance readability and effectiveness. To transfer from a paper medium to the screen, for instance for a PowerPoint projection, the organisation of the map needs to be reappraised.

In conclusion, to "stage" a map correctly, the desired interpretation of the phenomenon represented should be visible to the reader. The map is exhibited because it has something to say. The visual effectiveness of a map depends on attention to its clarity and its aesthetics - a map that is pleasant to look at is of course more attractive.

2.6 The rules of the mapping game

The rules set out here enable a number of fundamental points to be highlighted in the design and production of a map. They take the form of 10 simple questions¹⁵ and 10 rules for map "staging".

10 questions to ask before designing a thematic map

- 1- Do I really need a map? Would not a graph or a table be more relevant?
- 2- Do I need one or several maps for my purpose?
- 3- Whom is my map intended for? Who will be looking at it?

15 ECL, 2013.
ESPON 2020

- 4- Will the map be published? If so, where and how? Will it use colours?
- 5- What is the message to be delivered by the map?
- 6- What is the space concerned in the chosen representation?
- 7- Are the data available? Do they require processing?
- 8- What are the semiological rules to suit the data to be represented?
- 9- How can the perception and legibility of the map be enhanced? How important is the aesthetic aspect?
- 10- What can contribute to the legibility of the message?

10 rules to apply when designing a thematic map

- 1- It is not always a map that "meets the bill".
- 2- We need to accept the need to reduce the amount of information, and not to attempt to show everything on the map.
- 3- A map is designed for a specific "audience", and when the audience changes the representation will also change.
- 4- The context in which a map is published influences the way it is perceived. A paper map and a map on a screen are not read in the same manner, and they cannot therefore be designed in the same way.
- 5- A map has a particular message, which should be carefully defined before embarking upon the production process.
- 6- The choice of the base-map delivers a message. The base-map should be precise as to its extent, and unobtrusive (via generalisation).
- 7- The data processing should render the spatial information simple and comprehensible. It needs to be performed with accuracy, and the sources should be properly identified.
- 8- Each piece of data is transcribed using a precise graphic sign enabling the ranking, quality or quantity relationship to be represented. Information should be hierarchized, and non-useful information should be removed.
- 9- The aesthetic aspect should not be underestimated for successful mapping. For instance a black line should never be 100% black, it is better to choose 80% so as to avoid over-sharp contrasts.
- 10- The way a map is "staged" contributes to an effective map.

10 rules to apply for an effective "staging" of the map

- 1- The layout (arrangement) and staging of the map are important factors in the understanding of the spatial phenomena represented on the map.
- 2- Staging is performed in accordance with the shape of the space represented.
- 3- The layout of the different elements should be organised as close as possible around the map without crowding it.
- 4- 4 elements in the layout are essential: the title, the legend, the date, and the data source.
- 5- Further elements can enhance certain representations: scale, orientation, latitude and longitude, place-names, insets (with changes in scale) and publisher's indications.
- 6- The elements making up the map should be hierarchized.
- 7- The title should express what is on the map (and not the fact that it is a map).
- 8- The legend is the "dictionary" of the map. It should present exactly the same symbols as those used on the map. The title "Legend" should not be used
- 9- Text on the map should be legible, and place-names should be easy to localise. Text should never interfere with the data or the layout of the map. Different fonts and colours can be used to establish a clear association between text and the characteristics of the map.
- 10- Visual balance is always an important consideration in the design.

M. A. P. S. = Message + Artistic + Purpose + Scientific

Producing a map is delivering a message by way of an image. The message should be clear, intelligible and as simple as possible so as to facilitate memorisation. Cartographic images need to sum up geographical information in "immediately perceptible" form. To do this, J. Bertin considers that "the effectiveness of the message will be all the greater if the number of images (separate or superimposed) and their complexity are reduced, and the map can be read as a whole". To be attractive and possess high communication potential, a map needs to be aesthetically pleasing, and the finishing touches require considerable attention. Thus the artistic aspect is very important. A good map will be one for which the cartographer is careful to process the various "trappings" of the map, and to use colours wisely. The communication power of the image created in this manner, pleasant to look at and set out in relevant manner, will inevitably be more powerful. A map should be specifically designed for a single purpose, and suited to the target audience. Thus the cartographer needs to know for whom the map is intended, and to adapt the production procedures accordingly. A map intended for scientists should not be designed in the same way as one intended for stake-holders. Similarly, a map with a genuine teaching function will be different from a working document. Finally, we should

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not forget that a map is also and above all the central object of geographical reflection. It is a scientific object developed according to strict, precise rules. Indeed, although a map is subjective and constructed according to a communication objective, and also has a viewpoint, it is nevertheless not possible to completely warp reality. Thus the cartographer has the task of processing data carefully and transcribing it graphically according to strict rules established by the scientific community. Each map should be reproducible, and therefore is open to scientific controversy.

3 PART 3 – Possible uses of available layers

3.1 Local mapping layers: basic use

Three types of mapping layers are available within the ESPON 2020 MAPKIT below NUTS3 level. The first two are primarily planned to process GIS analysis and the last one is dedicated to the production of thematic maps.

- EuroBoundaryMap layer at municipal (LAU2) level: This layer fits the EUROSTAT Census 2011 nomenclature, displaying 117'709 units with a precision of 1:100'000. Primarily based on version 6.2. of the EuroBoundaryMap, the mapping layer has been completed by version 6.0 for EL and version 10.0 for IE and DK.
- Grid layers of various precision: It corresponds to the official layers provided by the European Environmental Agency (1km and 10 km resolution). The delivery includes also the population density grid 2011 (GEOSTAT).
- Voronoi generalized LAU2 layer at municipal (LAU2) level: With 117'709 units fully compatible with EUROSTAT Census 2011 nomenclature, this layer must be understood as the “thematic twin” of the Euroboundary map. It, especially designed for displaying LAU data at macroregional level and higher. Further information on this layer is available in the ESPON Guiding document “Updating Mapkits”

It could be envisaged to use these layers as follow:

- While primarily reserved for GIS calculation, the EuroBoundaryMap could be used to represent statistical local data at subregional scale. Units can be aggregated in order to process analysis of diverse geographical objects such as a mountain range for example. Oppositely they can be disaggregated, which is important when dealing with geographical object such as “islands”. Points and lines can also be extracted from the original surface geometry.
- Apart from processing a vast array of grid calculations there are primarily designed for, grid layers can be used to display information on land cover structure for instance.
- Voronoi generalized LAU layer, including delineation for cities and larger urban zones (compatible with the Urban audit) is intended for thematic mapping only. As a result of its lightness and generalization, many uses can be envisaged besides choroplete mapping (ratio or change) such as the creation of cartograms, the mapping of discontinuities, flows or the extraction of centroids for proportional symbols.

Deliveries are organised in folders. Each folder contains the necessary elements dedicated for each type of analysis. For example, for analysis purpose, you will find Eurogeographics geometries LAU2 in the “Layer for analysis” folder. Data source used for compiling euro

boundaries in maps and some attributes for aggregating LAU2 in other geographical delination (NUTS, FUA, etc.) are available in the “Metadata” folder.

A thematic map, such as those found in an ESPON report, can also be the end result of a complex process of GIS calculations, where several types of mapping layers are required in combination. The next part illustrates a process combining the tree types of layers into a process of map production.

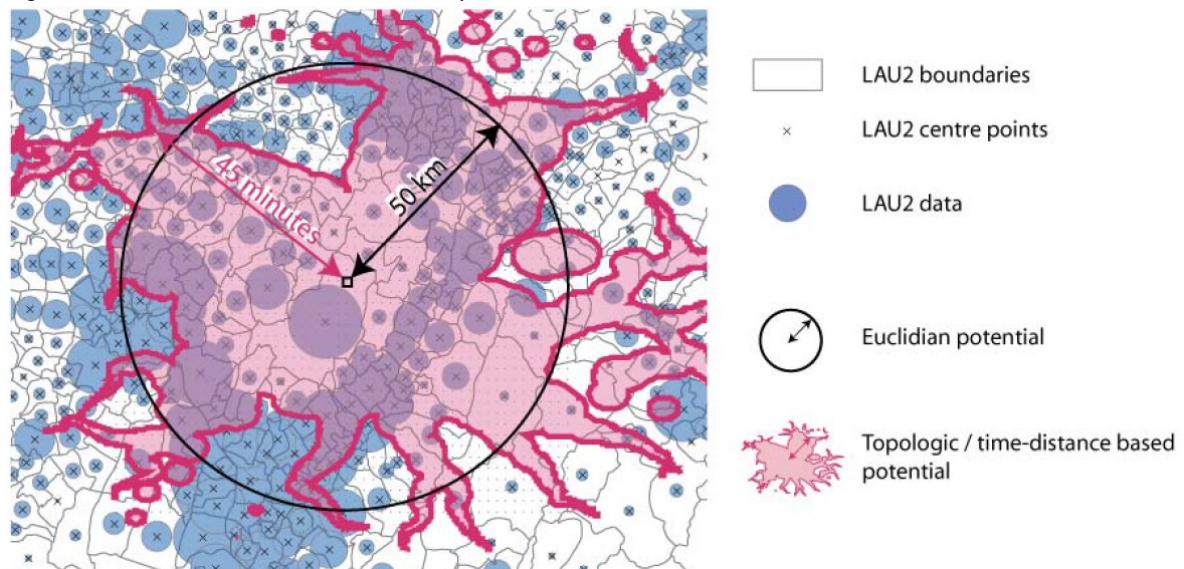
3.2 Example of implementation of multiple layers’ types in combination

Three types of mapping layers are available within the ESPON 2020 MAPKIT. The first two are primarily planned to process GIS analysis¹⁶ and the last one is dedicated to the production of thematic maps:

- EuroBoundaryMap layer, at municipal (LAU2) level, with precision of 1:100'000
- Grid layers of various precision
- Voronoi generalised LAU2 layer

The method of “potentials” - previously applied by the ESPON GEOSPECS project – illustrates how these different types of geographical layers complete one another. In short, the objective of the method is to calculate, for each LAU, the population that can be accessed by road in 45min, as illustrated in Figure 3 -20.

Figure 3-20 - Method for the calculation of potentials



Source: ESPON GEOSPECS, 2012

A thematic map as found in an ESPON report is often the end result of a complex process of various steps of GIS calculation, where several types of mapping layers are required in

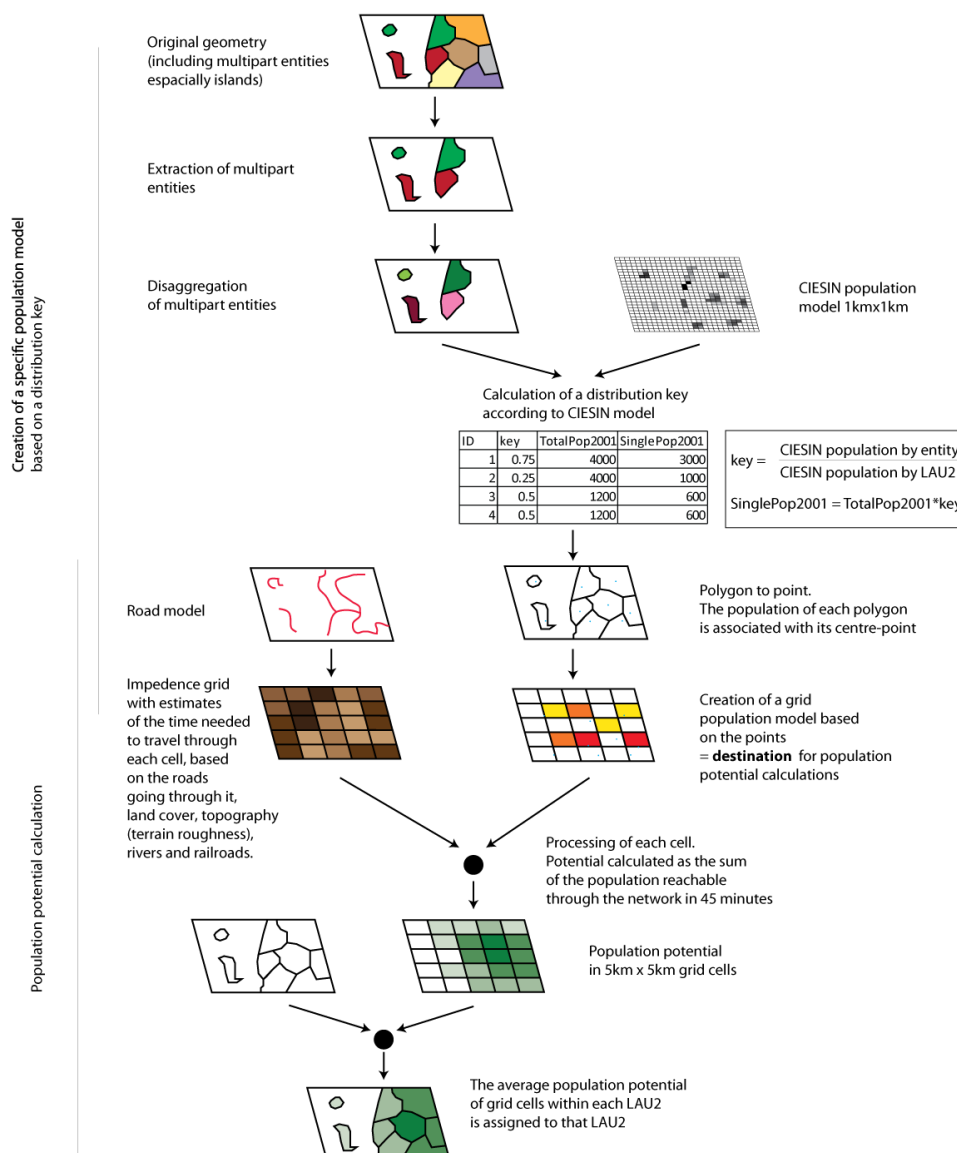
¹⁶ It could be envisaged to use:

- The EuroBoundaryMap to represent statistical LAU information at subregional scale.
- Grid layers to display information on land cover structure for example.

combination. The example of the method for potential (Figure 3 -21) illustrates the necessity to implement multiple layers' types for GIS processing, and therefore justify their relevance into the ESPON 2020 MAPKIT.

1. EuroBoundaryMap layer is used for geo-referencing population data from the census database at municipal level (so-called LAU2). For LAU2 units composed of multiple parts (e.g. coastal LAU2 with islands), it is necessary to estimate the population in each of their components. This involves disaggregating multiple parts LAU2 of the EuroBoundaryMap.

Figure 3-21 - Multiple layers' types for GIS processing



Source: ESPON GEOSPECS, 2012

2. Grid layers are necessary for different types of data processing.
- ESPON 2020

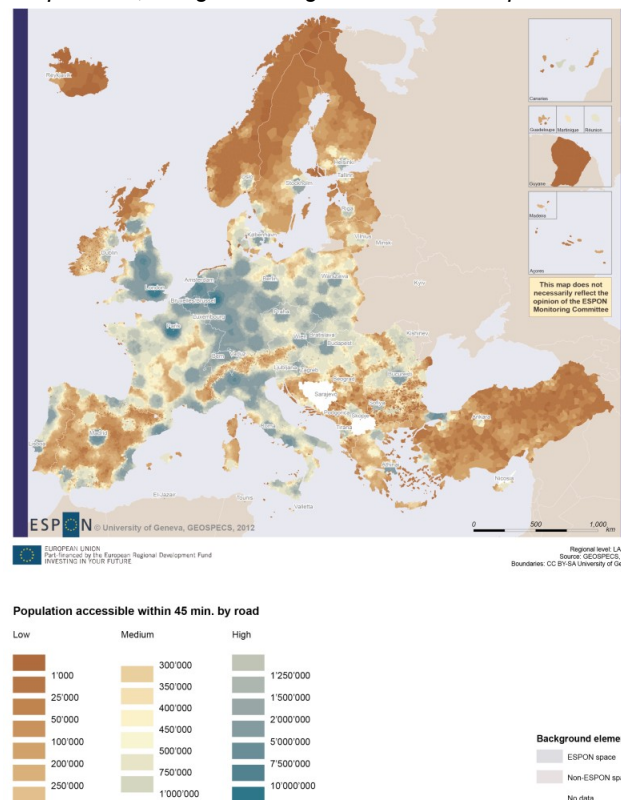
The CIESIN population model (grid resolution 1kmx1km) allows calculating a distribution key that re-allocates census population figures into the different portions of multi-parts LAU2 of the EuroBoundaryMap. Once-redistributed in the EuroBoundaryMap, the population figures are transferred into a 5kmx5km grid layer.

In parallel, a 5km*5km grid layer, called “impedance grid” is generated from a road model to calculate time-distances.

GIS processing on both “impedance grid” and “population grid” provides the population potential, i.e. the population reachable through the network in 45min, in a 5kmx5km grid layer.

3. Results must then be transferred back into the EuroBoundaryMap LAU2 units. The average population potential of grid cells within each LAU2 is assigned to that LAU2.
4. Results are finally represented in a simplified LAU2 layer, i.e.- the generalized Voronoi LAU2 (Figure 3 -22). Indeed, Far from adding accuracy, excessive level of details generates visually counter-productive ‘noise’ to maps above a certain level. In that sense the Voronoi diagram is best appropriate to generate cartographic message due to its “pixelisation effect”.

Figure 3-22: Population potential, using Voronoi geometries at European scale



source: ESPON GEOSPECS, 2012

3.3 Innovative cartography

In the ESPON 2020 Mapkits and as compared to the past, important efforts have been made to propose to ESPON projects a wider possibilities of map creation, namely by (1) extending the possibilities of the input layers, from the local level to the global one; (2) making available a large inventory of Mapkits, with an important variety of geographical extents; (3) using generalised geometries, adapted to communication purposes and (4) by improving the graphics quality of the layout.

Nevertheless, it is also important to remind that the ESPON Cartographic Language study (2013) highlighted that 68 % of the maps produced within the ESPON Programme 2013¹⁷ were realised using choropleth representations, more or less equally divided between maps derived from ratio data (32 %) and typology maps (36 %).

This result reflects the great homogeneity in the general aspect of the maps in the ESPON corpus, and the limited extent to which original representations, such as cartograms, smoothed data or grids, were used. Moreover, a vast majority (79 %) of representations in the ESPON corpus are single maps with a single mode of representation. To improve the dissemination and impact of ESPON results, it is important to propose tools, software and methods that make it possible widen the range of graphic representations used.

When developing innovative maps, several key elements must be taken into account:

- **Software and computing technologies:** a lot of software is currently available for creating more elaborate maps, such as cartograms or 3D-maps. It is consequently to have an overview of existing possibilities, out of the classical map creation possibilities offered by GIS by default.
- **Process of map creation:** from the input data to the final graphical document, each map is integrated in a creation process which requires to be well controlled.
- **Design of maps:** maps are tool of communication to disseminate a message. Several key elements must be taken into consideration to increase the effectiveness of a map.

The ESPON 'Cartographic Language' (ECL) study provided a number of inputs on this issue. However, the cartographic proposals made by the ECL project were not based on the map templates of the ESPON 2020 Programme. The examples described below should be consequently considered as "source of inspiration" for the future map creators involved in the ESPON Programme.

3.3.1 Softwares and computing technologies

As part of the "Options and Recommendations related to further development of an ESPON Cartographic Language¹⁸", a list of available software for producing innovative maps, such as

¹⁷ The corpus included 644 figures produced within the ESPON Programme.

¹⁸ http://www.ums-riate.fr/Webriate/wp-content/uploads/2014/04/Task5_final_dec13.pdf, see pp. 52-54
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anamorphosis cartograms, Dorling cartograms or 3D maps was provided. This document also includes an overview of existing computer technologies to develop online and animated maps.

Since 2013 and the ECL report, new tools helping for map creation have been developed. Magrit is one of them (Figure 3 -23 and Figure 3 -24). **Magrit** is an online and open-source application dedicated thematic cartography (<http://magrit.cnrs.fr/>). This tool developed by UMS RIATE and inaugurated in February 2017 proposes conventional cartographic methods coupled with innovative techniques (proportional symbols, choropleth map, discontinuity map, smoothed map, gridded map, cartogram, etc.). In this tool, users can upload their own geometries and data and export resulting files in vector format (svg, png, GeoJSON).

Figure 3-23: Smoothed map with Magrit (total population 2013)

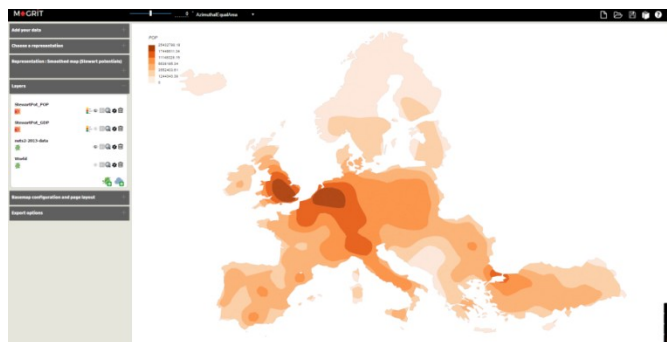
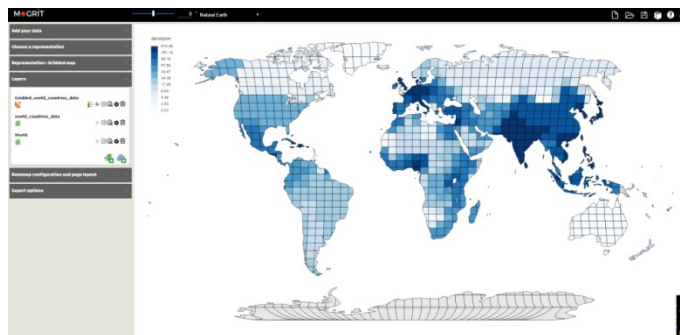


Figure 3-24: Gridded 500 km map with Magrit (total population 2015)



3.3.2 Process of map creation

Section 2 of the mapping guide¹⁹ developed within the ECL project proposes a set of innovative ways to displays socio-economic phenomenon on maps: segmented graduated maps, count and ratio data maps, isopleth maps, 3D isopleth maps, cartograms, discontinuity maps, etc. This report provides methodological explanations of the mode of representation, inputs concerning the design and the construction of the map. It remains also graphically the procedure

¹⁹ http://www.ums-riate.fr/Webriate/wp-content/uploads/2014/04/Task4_final_ECL_MappingGuide_dec13.pdf
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and the organisation of the map development, with details on the types of tools to use.

Adapted to the ESPON production, this report might be useful for ESPON projects interested in understanding the process to follow to build more innovative maps (Figure 3 -25, for example).

Figure 3-25: Process of map creation for producing innovative maps. The example of discontinuity maps (source: ECL, 2013)

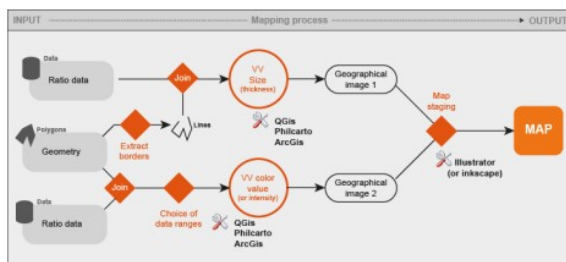
Discontinuity maps

Highlighting breaks in spatial organisation



Discontinuity maps enable the representation of the spatial breaks or discontinuities in socio-economic phenomena, bearing out the notion that geographical space is fundamentally discontinuous. When combined with the choropleth technique (use of colours) this cartographic representation is particularly useful. The discontinuity values are calculated by assessing the relationship (relative discontinuities = $[\max(\text{ratio1}, \text{ratio2}) / \min(\text{ratio1}, \text{ratio2})]$) or the differences (absolute discontinuities = $[\max(\text{ratio1}, \text{ratio2}) - \min(\text{ratio1}, \text{ratio2})]$) between the values attached to the phenomenon on either side of a territorial division. Only the minimum and maximum values are considered. To represent the degree of discontinuity in visual form, the size visual variable is used, whereby the thickness of the boundary varies in proportion to the degree of discontinuity.

This type of representation draws the reader's eye, not to large homogeneous zones, but to the borders where marked disparities in the phenomenon studied are observed on either side.

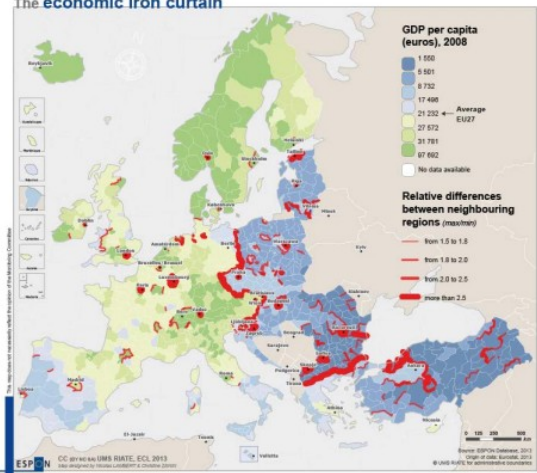


Appropriate data: relative, ratio or index quantitative data, qualitative ordinal data
Map data: Per capita GDP in 2008, NUTS3 and calculation of relative differences



2 2 2

The economic iron curtain



This map shows economic discontinuities from one economic region in Europe to another. The issue is wealth differentials between neighbouring regions - is there a gradual shift from very wealthy regions to very poor regions via a series of intermediate regions? Or are there genuine discontinuities, with very wealthy regions coming into direct contact with very poor areas on the two sides of the border? At national level, there are sharp contrasts between Germany and Poland, Austria and Slovakia, or Greece and Bulgaria. Likewise, between NUTS3 regions the discontinuities underline the differences between long-standing and new members of the EU. But there are also marked discontinuities within certain countries, where the region around the capital city is far more wealthy than the surrounding regions (Paris, London, Bucharest, Prague).

Strengths Weaknesses

The image produced is simple
 Spatial breaks are clearly identified

Calculations can be lengthy
 The discontinuities vary considerably with the territorial divisions used.

Software: ArcGis or QGIS, Philcarto, Illustrator or Inkscape
To go further: Sack R. D., 1983, "Human territoriality: a theory", Annals of the Association of American Geographers, n°73-1 and <http://www.hypergeo.eu/spip.php?article454>

Design of maps

A cartographic language is a graphic method, which uses properties of the visual image to show differences, order and proportionality between geographical data. It allows conveying more pragmatic spatial information from the map, and transmitting geospatial information in a more vividly and accurately way.

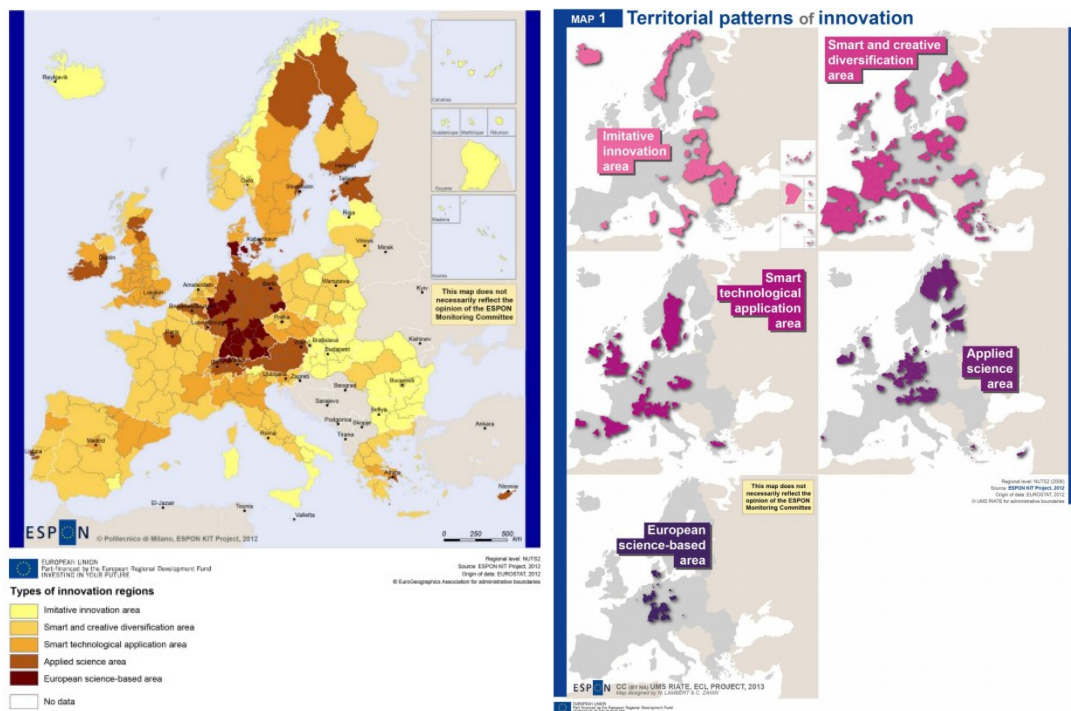
The proposal for a modernised ESPON Cartographic Design (ECL, 2013)²⁰ report provides in that sense some interesting inputs. Even if it is not compatible with the ESPON map template,

20 http://www.ums-riate.fr/Webriate/wp-content/uploads/2014/04/ECL_task6.pdf
 ESPON 2020

it gives some interesting proposals to design efficiency maps produced within ESPON projects, namely:

- Split the results from territorial typologies in several maps to highlight territorial patterns more efficiently.
- Combine maps and plots to better understand territorial dynamics.
- Provide interpretation keys for complex territorial structures.
- Think about colours and border width used in the maps to ease the understanding of the map.
- Adapt the map layout in a communicative way.

Figure 3-26 - Example of proposals made for modernising the ESPON Cartographic language



4 Quality check-list for finalised maps

In order to provide the map creators the possibility to perform an auto-assessment of the maps produced, the project consortium proposes to the ESPON EGTC to implement a **Mapkit checklist**. It would need to be filled in for each map/set of maps that will be published in final reports. It pursues multiple purposes;

- Ensure that the map can be reproduced if needed (i.e. identify the mapping layers and data files used, as well as any modifications that were made to the mapping layer when relevant);
- Check whether the map follows standard ESPON templates, or whether the project had used a modified template;
- Perform basic checks of the graphic semiology used (e.g. if two colours are used, what does the break between colours express? are absolute values represented using proportional symbols?)
- Make it possible to produce statistics on maps produced (e.g. how many maps at NUTS3 level? How many maps cover the entire ESPON space, including CH, IS, NO, LI?)

In order to ensure that the map can be reproduced, there will be some connections between the checklist and the ESPON Database data collection. As part of the checklist, the project will indicate the code of the corresponding indicator(s) delivered to the ESPON Database. When composite indicators are represented, reference will be made to the code of these codes only – information about how the composite indicator is calculated would then need to be found in the ESPON database.

For a map that applied a standard ESPON template, and presuming that the indicator code is known, the check list should take less than 2 minutes to fill in. It would therefore be designed with conditional fields that would only appear if 'non-standard' solutions have been chosen.

The check is accompanied by short explanations to help to fill in the check list (i.e. what are NUTS levels, etc.). The questions to be asked are listed below. It is suggested that these are integrated in an online survey system (e.g. Limesurvey, Surveymonkey) or a fillable PDF document.

[MAP CREATION]

- With which software has the map been produced (default answer: ESRI ArcGIS)?
(other answers : QGIS, Philcarto, Magrit, Other ...)

[LINK to ESPON DB]

- Code(s) of the indicator(s) represented (multiple indicators can be represented in a single map, e.g. total population and population change)

For each indicator:

[GEOGRAPHICAL INFORMATION]

- Has a standard ESPON Mapkit layer been used to represent it?
 - o If yes: select layer from pulldown menu (this also provides information on NUTS/LAU level)
 - o If no: provide information about layer used and deliver the layer to the DB project

[MAP CREATION]

- Type of representation : Ratio, change, stock, typology, flows, discontinuity (radio buttons, multiple options possible):
- If ratio or change:
 - o Represented with values (light/dark)?
 - o Represented using multiple colours?
 - If yes: what does the change of colour correspond to?
 - How were the classes constructed? (Manual, Quantile, Median and standard deviation, etc.)
- If stock:
 - o Represented with proportional symbols?
 - o Represented with different symbols / symbols of different size for different classes?
 - If yes: how were the classes constructed?
- If typology: represented with different colours of same value?
- If flows:
 - o Represented with proportional widths?

- Represented with lines of different width for each class?
 - If yes: how were the classes constructed?
- If discontinuity:
 - Represented with proportional widths?
 - Represented with lines of different width for each class?
 - If yes: how were the classes constructed?
- If other (cartogram/smoothing, etc.,), explain the methodology used and the aim of the map.
- Does the legend of the map follow recommendations of the Map guidance document?

[STAGING THE MAP]

- Has a standard Map template been used as a starting point?
 - If yes: have any changes been made to the template?
 - If yes: has the bounding box been changed?
 - If yes: geographic coordinates of the new bounding box
 - If yes: has the order of layers been changed?
 - If yes: specification of change in order of layers
 - If yes: have additional layers been added to the template?
 - If yes: description of additional layers and where do they come from (source)?
 - If yes: have layers been removed from the template?
 - If yes: list of layers that have been removed
 - If yes: have other graphic elements been removed from the template?
 - If yes: list of graphic elements that have been removed
 - If no: purpose of the alternative template used and source of this template?

[EXPORT QUALITY]

- Has the map been exported to Adobe Illustrator or EPS format?
- Has the map been exported to png format with a resolution of 300 dpi or higher?

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



















































































ESPON reports:

ESPON CARTOGRAPHIC LANGUAGE, Internal CU project, UMS Riate

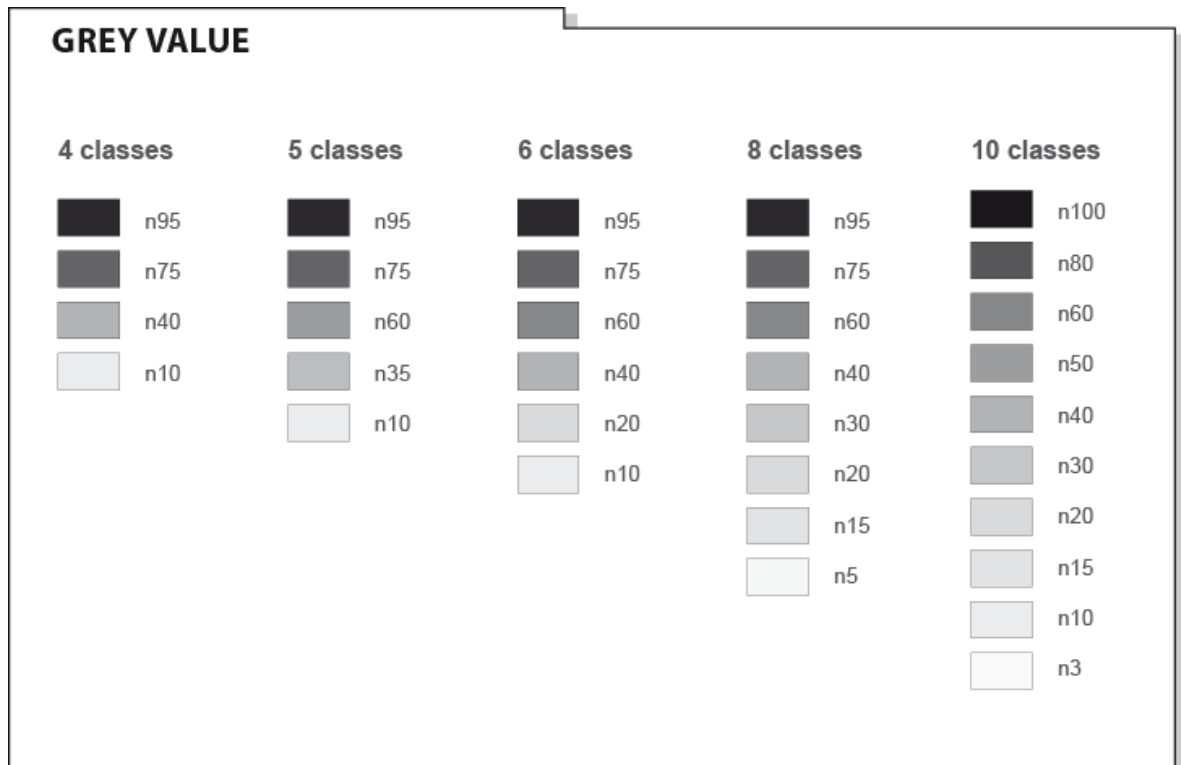
MAPPING GUIDE, 2011, Cartography for ESPON Projects, Technical Report, Espon 2013 DataBase project, UMS Riate

Annex A – Colour references

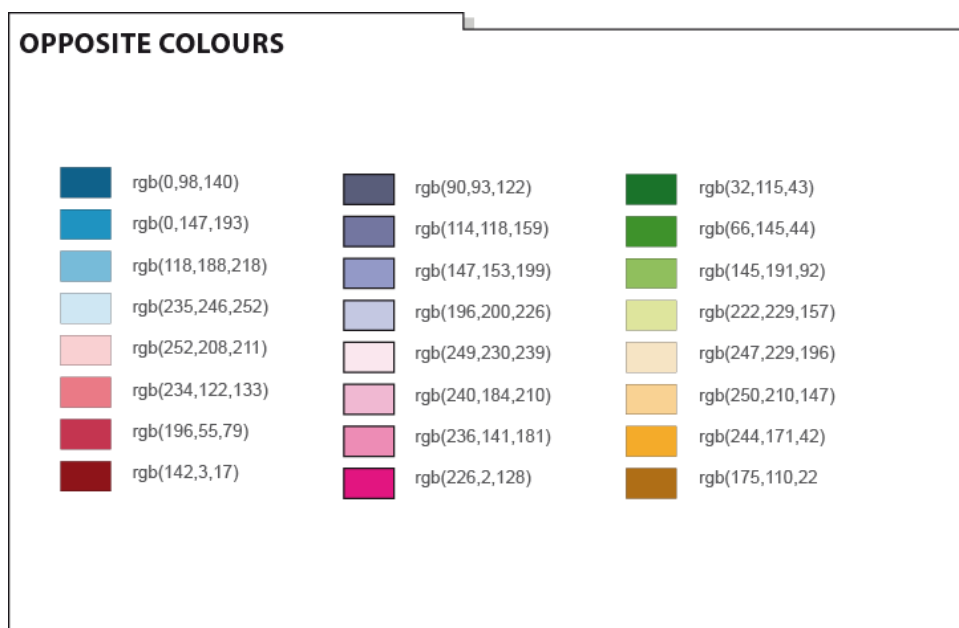
A1 - Differences in value or lightness (colour intensity)

COLOUR INTENSITY			
Blue	Green	Red	Brown
4 classes			
 rgb(0,147,193)	 rgb(31,115,42)	 rgb(235,107,57)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(100,175,64)	 rgb(246,170,65)	 rgb(195,118,70)
 rgb(208,232,244)	 rgb(191,217,159)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(235,246,252)	 rgb(230,239,207)	 rgb(255,249,200)	 rgb(255,237,170)
5 classes			
 rgb(0,147,193)	 rgb(18,94,39)	 rgb(229,53,64)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(60,145,60)	 rgb(235,107,57)	 rgb(195,118,70)
 rgb(167,212,233)	 rgb(129,188,96)	 rgb(246,170,65)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(191,217,159)	 rgb(255,227,125)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(230,239,207)	 rgb(255,249,200)	 rgb(255,237,170)
6 classes			
 rgb(0,124,176)	 rgb(18,94,39)	 rgb(229,53,64)	 rgb(97,68,55)
 rgb(0,147,193)	 rgb(60,145,60)	 rgb(235,107,57)	 rgb(126,70,53)
 rgb(118,188,218)	 rgb(107,178,76)	 rgb(246,170,65)	 rgb(195,118,70)
 rgb(167,212,233)	 rgb(151,197,110)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(200,218,140)	 rgb(255,249,200)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(239,241,199)	 rgb(255,253,238)	 rgb(255,237,170)
8 classes			
 rgb(0,98,140)	 rgb(11,82,34)	 rgb(173,26,34)	 rgb(97,68,55)
 rgb(0,124,176)	 rgb(31,115,42)	 rgb(207,54,65)	 rgb(126,70,53)
 rgb(0,147,193)	 rgb(62,146,44)	 rgb(229,53,64)	 rgb(165,94,57)
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 rgb(118,188,218)	 rgb(145,191,91)	 rgb(246,170,65)	 rgb(219,145,73)
 rgb(167,212,233)	 rgb(180,209,121)	 rgb(255,227,125)	 rgb(229,170,81)
 rgb(208,232,244)	 rgb(200,218,140)	 rgb(255,249,200)	 rgb(255,221,139)
 rgb(235,246,252)	 rgb(239,241,199)	 rgb(255,253,238)	 rgb(255,237,170)

A2 - Differences in value or lightness (grey value)



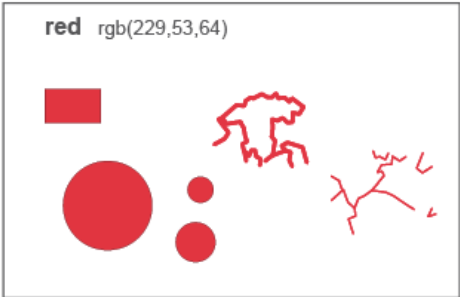
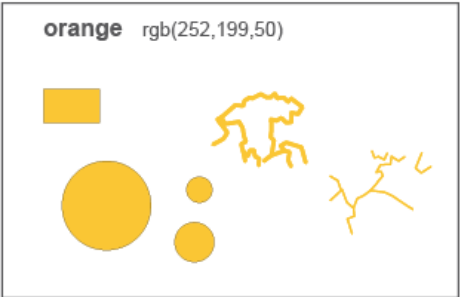
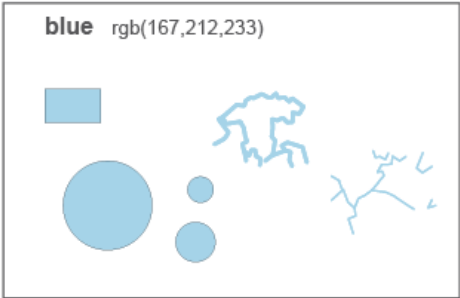
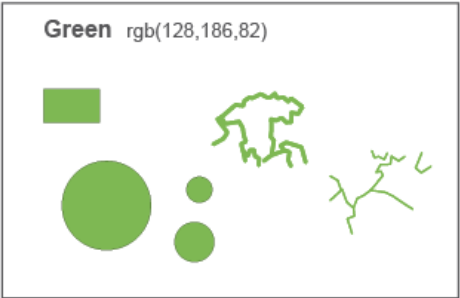
A3 - Differences in value or lightness (opposite colours)



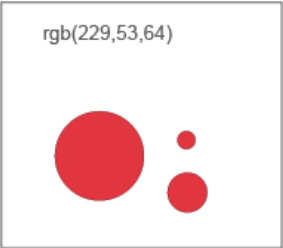
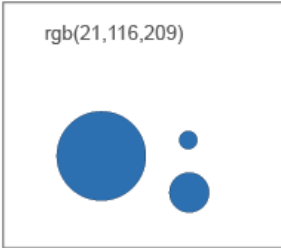
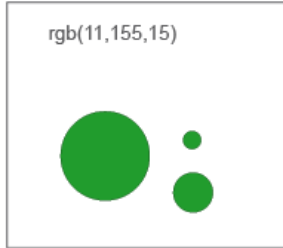
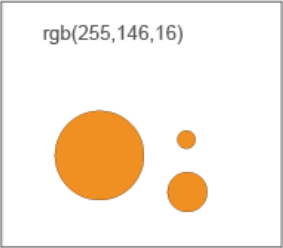
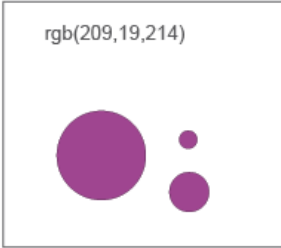
A4 - Colours for differences typology or qualitative value

QUALITATIVE VALUES

(circles and discontinuities)

<p>red rgb(229,53,64)</p> 	<p>orange rgb(252,199,50)</p> 
<p>blue rgb(167,212,233)</p> 	<p>Green rgb(128,186,82)</p> 

(circles)

<p>rgb(229,53,64)</p> 	<p>rgb(21,116,209)</p> 	<p>rgb(11,155,15)</p> 
<p>rgb(255,146,16)</p> 	<p>rgb(209,19,214)</p> 	<p>rgb(100,101,103)</p> 