Ordnance Survey's cartographic design principles: An approach to promoting good map design

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Abstract. With the release of open data and a boom in the open source industry, more people than ever before are delving into the world of cartography as maps are widely adopted by technologies and services as a form of data visualisation by people who may not have come from a traditional mapping background. Too often a good idea is let down by poor application of even the most basic cartographic techniques. As a geo-community living in the 'open' era, we must give today's map makers the tools they need to add good cartographic design to their overall user experience.

This paper will introduce our principles with focus on their need, their importance in achieving good map design and examples of their application in our own work.

Keywords: Cartography, cartographic design, map design, principles

1. Introduction

German industrial designer, Dieter Rams, once asked himself a question, 'Is my design good design?' The answer formed the basis for his renowned 'ten principles for good design'.

As cartographers, they offer us useful design advice and guidance. For our work in this paper, we have found that they also lend us a very good framework – perhaps a design in itself – for sharing relatively high-level yet fundamentally important points.

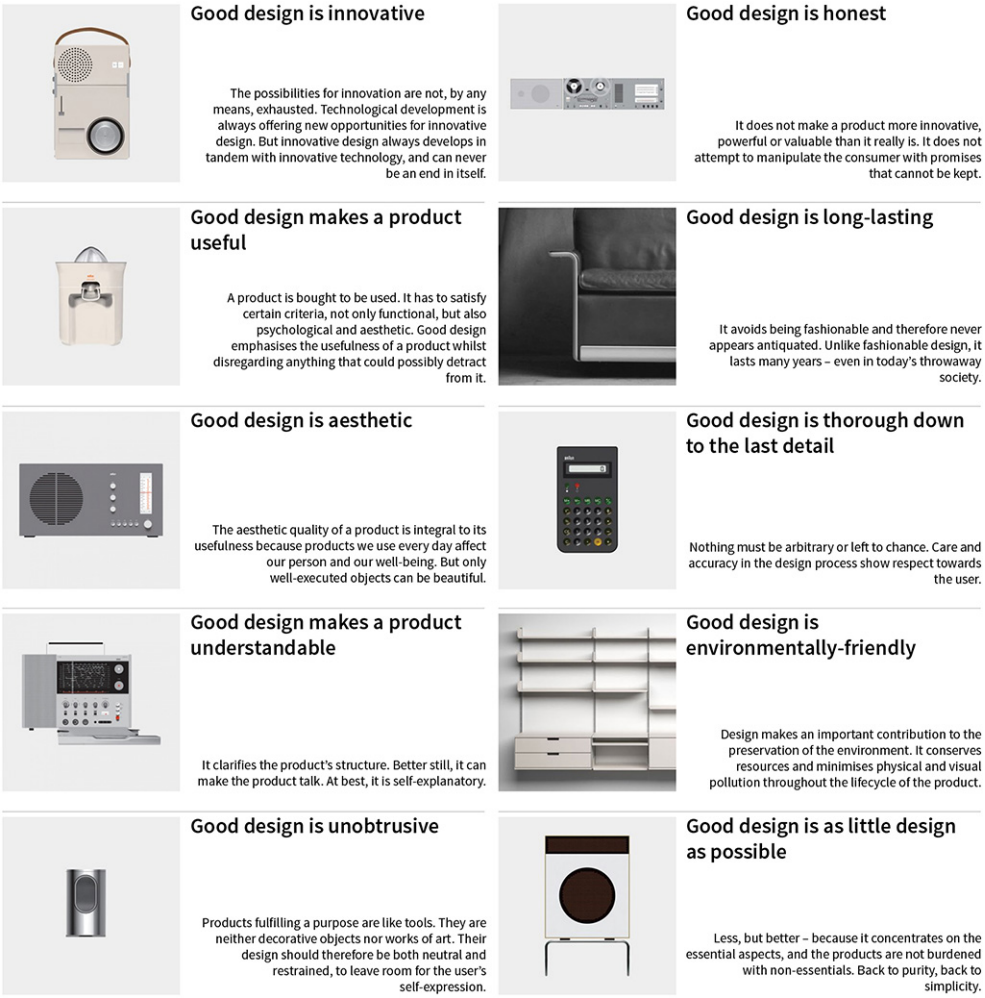

Figure 1: Rams' ten principles for 'good design' (Rams 1980s, images © Vitsœ 2013)

Product design 'represents not only the aesthetic qualities, but what it does, how well a user thinks it's going to do it, and how easily and quickly they can complete a task' (Riley 2013). **Design adds the extra dimension to any product, making it usable, aesthetic and human**.

Increasingly design is being recognised as key to the success of a product or service. This is almost certainly intrinsically linked to the increase in customer demand for a better user experience (UX). When using a product or service a user compares their response with their expectation. If expecta-

tions are managed and met then users will be satisfied, if they are not met then the user will give up or seek alternatives (McMullin 2004).

In order for a product or service to be valuable then it must be all of the other things in the Morville's honeycomb diagram (*Figure 2*).

Figure 2: The UX Honeycomb (Morville 2004, source: Semantic Studios)

Whilst the honeycomb only has seven parts, there is much crossover between these 'must-haves' for a good UX and Rams' principles for good design.

Improved UX results in a 15% average increase in customers including less loss to competitors and greater attraction of new customers (Gualtieri 2009). So, good design is important, or as Rams (1976) himself put it, 'Ladies and gentlemen, design is a popular subject today. No wonder because, in the face of increasing competition, design is often the only product differentiation that is truly discernible to the buyer.'

Whereas cartography is the art and science of mapmaking, cartographic design concerns the map user. It governs the design of a map product or service and is the cartography that ensures the maps intended message is delivered both efficiently and aesthetically.

We are convinced that no matter how trivial an application of cartography might seem, whether it is a revenue-generating product or an internal GIS, any map can be improved through better cartographic design.

Good cartographic design is not always about following a rigid set of rules or adhering to tradition. It is about communicating effectively with the user and if possible being generous with, and even delighting, them (Rosenfeld 2010).

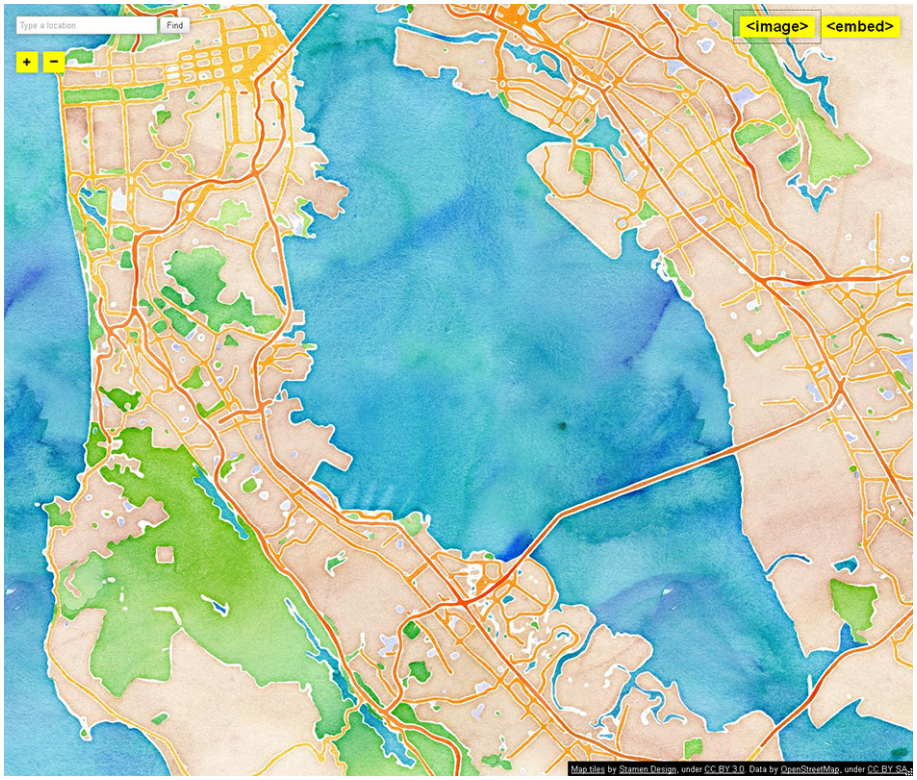

Figure 3: Following principles but breaking all the rules: 'Watercolor' map tiles by Stamen Design (2013). Data by OpenStreetMap

The problem with rules is that they only apply well to specific scenarios and that they can restrict artistic expression, and creative flair and freedom. There are 'musts' in principles but they are confined to a manner of thinking rather than dictating a method of doing. Online guides by Harvard University, ICSM (2012) and the University of Colorado (1999) are relatively high-level, but we would still argue that they take the form of rules that

must be followed rather than principles that allow an objective or common goal to thrive. Unlike rules, principles are specific to a genre rather than an explicit product and offer guidance to the user without telling them how to get there.

1. **Concept before Compilation**
2. **Hierarchy with Harmony**
3. **Simplicity from Sacrifice**
4. **Maximum Information at Minimum Cost**
5. **Engage the Emotion to Engage the Understanding**

BY: GIS CONTRIBUTOR GIS LOUNGE

Figure 4: GIS Contributor's 'five principles of map design' (logo © GIS Lounge

The map principles on GIS Lounge (GIS Contributor 1999) are very philosophical. The principles on the ESRI blog (Buckley 2011) are very well explained and well presented but we still believed that we could offer a valuable alternative resource.

2. Need

At Ordnance Survey (OS) we use these principles instinctively through our experience. However there is increasing need for us to share this 'know-how' with others which has come about due to a combination of events:

Business now recognises the value of geospatial. National mapping agencies and cartographic publishers are no longer the sole users of geospatial services which in the US alone now generate US$1.6 trillion of revenue and save an estimated $1.4 trillion in costs annually (Potere 2012).

Meanwhile, open source software such as QGIS and GeoServer is bringing geospatial technology to anyone with a computer.

Open data has led to a wider audience exploiting the value of location-based information. Government initiatives such as data.gov.uk (*Section 4.1.1*) have promoted this.

Smartphones have brought GPS and mapping to the masses: IDC predicts one billion smartphones to be sold in 2013 (Reardon 2013).

When you combine all of the above you have a worldwide network of both corporate and hobbyist neocartographers. To begin with the emphasis was mainly on data, e.g. crowdsourcing projects such as OpenStreetMap. Maybe this previous generation should have been termed 'neosurveyers'. However now more than ever before we see people playing with cartography. There are now over 90,000 different styles available on CloudMade. Users are clearly wanting to choose their own content but also wanting to apply their own styles, their own designs.

Even those who do not currently consider cartographic design, perhaps a local council viewing data in a GIS, could extract more from the data and more efficiently if they did.

It is to all of these people that we would like to offer our principles. This is one of the key drivers in developing and publishing them – to help those who make maps but are not necessarily from a cartographic or design-oriented background. Help is not about telling people how badly amateur cartographers can go wrong, it is about adding tools and resources to their armoury in order to help them create better maps. Even for cartographic professionals, it does no harm to reflect over the principles either. We believe that we all share the same common goal: beautiful mapping that people love to use.

3. Method

3.1. Creating our principles

Firstly, we need to realise that principles alone cannot ensure excellence. They help things, in this case cartographic design, to be good and they can promote the right conditions in order for things to strive. They are giving a racing driver the fastest car and the knowledge of how to drive it, but it is the racing driver alone who must drive the race.

Motivated by Dieter Rams and other principles discussed, we have analysed our own designs and sought the principles that are common to all of our preferred works.

Using a white board technique we allowed our list of principles to grow until we were satisfied that everything of an overriding importance had been covered. Inevitably, many of these were repetition of the same concept, so these were grouped. We then discarded anything that was deemed to be not of a high-level, many of which were rules not principles anyhow.

The next step was to detach explanations from titles. We were keen for the principles (our titles) to be self-explanatory but they also needed to be con-

cise. We felt that even single words were acceptable so long as they best explained the ‘way of thinking’ that was at the heart of the principle.

Once the principles were suitably shortened to titles, the next stage was to ensure consistency between them. Not just grammatically but moreover that they all sat on the same informational plane. ‘High-level’ covers a range of perspectives from which a system or process is viewed. It was imperative for us that all of our principles should be from the same perspective, i.e. they should all be systematic to a similar level of classification and they should all be as abstract as one other.

3.2. Choosing the right format

From the very outset of this project, we knew how important it was to be able to both present and share our principles with others in the right way.

We knew we wanted a principle of short length in plain English supported by an explanation, comparable to what Rams had written. In addition, we had the idea of supporting each principle with a real exemplar based on our own work.

Here in this paper, we are explaining every aspect of our work on cartographic design principles. When we release the principles by themselves, we will do so in a somewhat different format as outlined below.

Figure 5: Our idea of how one of our principles might look; created by an amalgamation of the work of Vitsœ, Government Digital Service (GDS) and Smashing Magazine (Hinman 2012, image © Smashing Magazine 2013)

We are keen for the presentation of the principles to be befitting of the ideologies of the principles themselves. So we are working with our web developers on putting our work into webpages which we hope will be aesthetic as well as achieving all of the other traits previously discussed, i.e. understandable, accessible, valuable, and useful and so on.

4. Our Cartographic Design Principles

Through the application of cartography, a well-designed map communicates its message clearly and provides a pleasing user experience. We believe that the following eight principles are fundamental to successful map design:

- **Understanding of user requirements**
- **Consideration of display format**
- **A clear visual hierarchy**
- **Simplicity**
- **Legibility**
- **Consistency**
- **Accessibility**
- **Good composition**

4.1. Understanding of user requirements

An effectively designed map is one in which the intended message is clearly communicated to the map user. This is only possible by fully understanding what that message is and how the map is intended to be used.

The design process must start by identifying and fully understanding real user needs. What information does the map user require? How will they be using the map? It is important that all design decisions along the way consider the answers to these questions in order to create the map that the user really wants.

Focussing on needs allows the map design to concentrate on the elements that deliver the most value to the user, hence the greater chance of making the map a success; similarly it will lead to the avoidance of including unnecessary information that will only result in distraction or cause confusion.

4.1.1. Example 1: Mapping for data.gov.uk

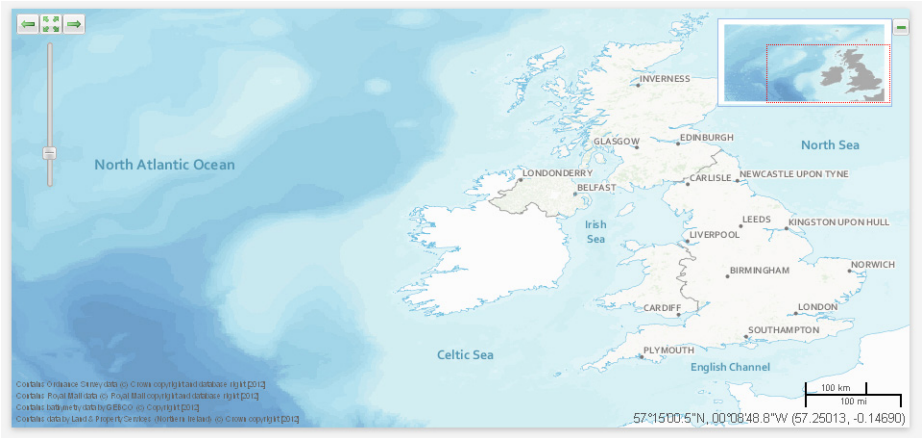

Figure 6: Map widget for data.gov.uk

To help in the discovery of geographical data at data.gov.uk, we worked with the UK Location Programme (UKLP), the Cabinet Office and Ordnance Survey of Northern Ireland (OSNI) to provide a map based search tool capable of providing a richer, more advanced way of searching for records of datasets and services that are referenced by geographical coordinates. This is done by allowing the user to indicate their area of interest on a map and then to submit that as a search against the bounding boxes of the datasets. In order to support this we needed to create base mapping of the UK and its territorial waters.

The mapping is there to provide geographical context to the searching function but the same mapping is also used to allow a preview of the datasets within data.gov.uk. These previews are overlaid above the base map so the colour palette was chosen with this in mind. The base map must add value without cluttering or confusing. Desaturated colours have been used so that any overlying data will stand out well and instantly become the main focus. However names need to be clear enough and the map's location recognisable enough to facilitate the initial searching.

The final agreed cartographic requirement was for a backdrop-style map stack, viewable at twelve levels from a scale of 1:15 million to 1:1,000 (six levels to 1:75,000 in search) within a fixed extent (from approximately 48°33'N to 59°28'N and 20°40'W to 2°51'E).

There was also a requirement for the user to be able to display the mapping in various projections to ensure interoperability between datasets. This led to the decision to use vector data instead of raster for three main reasons: By using vector data we could allow GeoServer to apply transformations to

reproject the data on-the-fly. Cartographic styling could also be applied dynamically, on-the-fly, which is particularly beneficial to the appearance of text. It also means that only one set of data needs to be stored.

4.2. Consideration of display format

To achieve maximum clarity a map should be designed from the outset with its final display medium in mind.

Things to consider are the map's scale and resolution, colour mode (generally RGB for screen and CMYK for print), the size of paper or screen, the type of paper or screen; and interactivity and functionality options.

These considerations may lead to known constraints, for example the minimum point size that can be applied to the map's text in order to still be legible, or the lightest shade of a particular colour that can be perceived on a particular device. When setting such rules one may consider the optimal display or if the user base is varied then a lowest commonly used denominator may be preferred.

4.2.1. Example 2: OS OnDemand

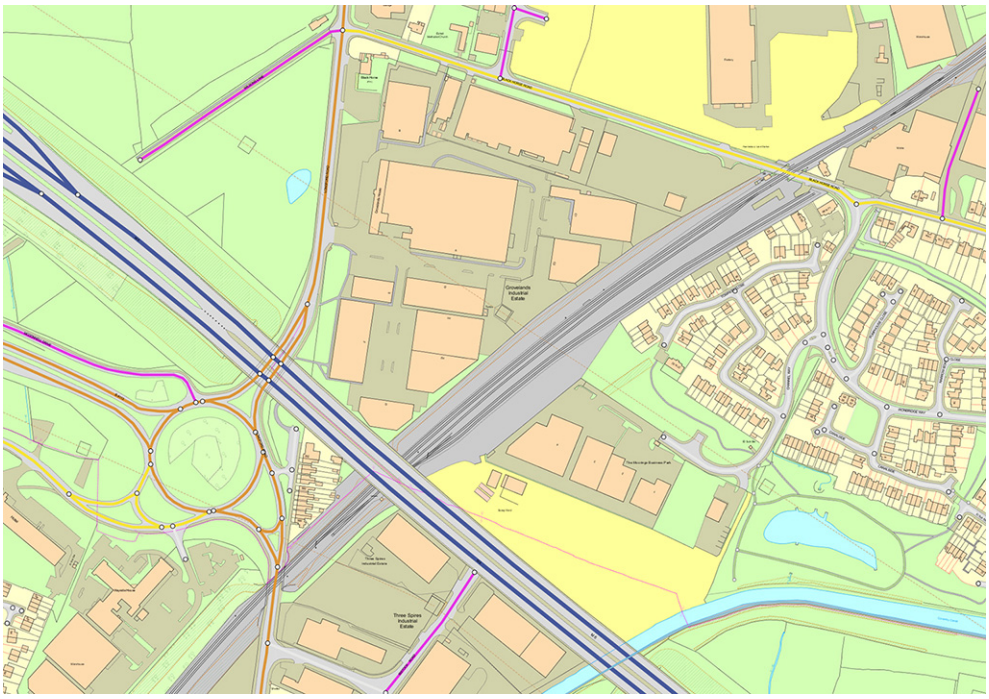

Figure 7: OS MasterMap® within OS OnDemand

OS OnDemand is a web map service (WMS) that allows customers to view their licenced products directly over the web. As well as directly serving up data to customers, the WMS allows us to attach styles to that data too.

Much of this data is map data and since it is viewed on-screen we style it using the RGB colour space and carefully select fonts that are designed to be read on-screen.

OS OnDemand contains lots of products, all viewable at various scale ranges. This means selecting line weights and font and symbol sizes so that they are legible at any given scale within the set viewable range.

Multiple products can be displayed at any one time so we also have to consider those products which will overlap each other. An example of this is where the user can display OS MasterMap® Integrated Transport Network Layer on top of OS MasterMap® Topography Layer (*Figure 7*).

OS OnDemand can be viewed in either a web browser or in a GIS. With this in mind the styles we chose for each product were tested thoroughly in various software packages and on different screen sizes.

4.3. A clear visual hierarchy

The aim here is to draw attention to certain elements of the map and push those of less importance further down the visual plane - although certain features are less important they may still be required, if not then they should be removed. This helps the user differentiate between map features and helps them comprehend the maps message effectively.

The concept of figure-ground is important as it helps the user to distinguish between the main focus of the map (figure) and that which is background or contextual information (ground). The required contrast can be achieved through differentials in:

- colour - hue, saturation, brightness, temperature
- shape
- size
- orientation
- texture or pattern
- proximity - how far away map features are from one another
- graphical effects - such as drop shadow and outer glow
- text - font, weight, style

Maps are a little more complex than foreground and background. Each feature can be assigned a level in a hierarchy primarily based upon its importance to the map use.

	A	B	E	F	G	H	I	J	K	L	M	N
1	**Feature**	**Luma**	**sRGB colour values**			**Hex value**	**HSB (HSV)**			**LAB**		
2		Y'	R	G	B	#	H	S	B	L	A	B
3	Black Text	0	0	0	0	000000	0	0	0	0	0	0
4	Airport symbol	88	73	81	199	4951C7	236	63	78	39	26	-64
5	Red Station points	107	255	60	140	FF3C8C	335	76	100	59	76	4
6	Spot height text	118	157	113	51	9D7133	35	68	62	51	13	41
7	Spot height dots	118	157	113	51	9D7133	35	68	62	51	13	41
8	Woodland text	120	63	143	54	3F8F36	114	62	56	53	-39	38
9	Water Text	125	0	154	207	009ACF	195	100	81	59	-20	-37
10	Motorway	142	6	177	202	06B1CA	188	97	79	66	-32	-24
11	Primary Road	158	55	195	91	37C35B	135	72	76	70	-55	41
12	A Road	162	255	135	158	FF879E	348	47	100	71	48	10
13	Green Vegetation	166	107	190	102	6BBE66	117	46	75	70	-40	36
14	B Road	200	255	192	115	FFC073	33	55	100	82	17	48
15	Building fill	227	251	224	191	FBE0BF	33	24	98	91	6	20
16	Woodland Fill	231	209	240	206	D1F0CE	115	14	94	92	-15	13
17	Foreshore	233	230	235	228	E6EBE4	103	3	92	93	-3	3
18	Water Fill	238	213	244	248	D5F4F8	187	14	97	94	-10	-6

Figure 8: A sample of hierarchy used in OS VectorMap & our common styling (style © Ordnance Survey, 2013)

4.3.1. Example 3: GB Overview

The purpose of this map is to provide an overview of Great Britain (GB) in context to the surrounding countries with the major cities highlighted and it was designed to be used in our web map services.

Figure 9: A scaled down view of the full extent of our two GB Overview maps

Figure 10: An extract of one of our two GB Overview maps

A variety of techniques have been applied to this map to ensure good contrast between features. An outer glow has been used to make GB stand out more than the other land masses. The use of hillshading covering GB also adds a texture that draws attention where it is required. A hierarchy within the text has been achieved by applying different sizes, weights and colour saturations. The topographic features, including the major road network, are not the main focus of the map but are included to add context so they have been pushed down the visual hierarchy.

4.4. Simplicity

Cartography aims to portray spatial information in an appropriate way in order to transform information into knowledge. The inclusion of unnecessary information makes this process less effective and one should always assess that information's value to the user against map clutter and confusion.

Simplicity should be a key goal and unnecessary complexity should be avoided. Quite often the decision to leave things out can have a greater impact on the overall design than what is left in. Tufte (2001) advises to 'avoid content-free decoration'.

'Less is more', Mies van der Rohe

'It seems that perfection is reached not when there is nothing left to add, but when there is nothing left to take away', Antoine de Saint-Exupéry (1939)

Focussing on needs allows the map design to concentrate on the elements that deliver the most value to the user, hence the greater chance of making the map a success; similarly it will lead to the avoidance of including unnecessary information that will only result in distraction or cause confusion.

4.4.1. Example 4: National definitions

A map comparison between GB and the United Kingdom (UK) – this map was created to complement a blog post (OS 2011).

Figure 11: The land mass of GB versus that of the UK

Only the necessary map elements have been retained and no unnecessary graphical effects have been used so there is nothing to distract the user's eye. The message therefore is very clear and communicated simply.

4.5. Legibility

All map elements need to be readable, understandable and recognisable.

Legibility of most map features depends on colour and size which ultimately make them noticeable and recognisable. All need to be large enough and clear enough relative to the viewing scale and the media on which the final map will be displayed. Symbols need to be simple enough to recognise and offer good contrast against the background. Text can be made more legible with a good choice of font, good colour contrast against the background, suitable font size, character spacing and the use of masks or halos. Like any other map feature, text can also be made more recognisable by choosing a representative colour, for example, blue text is immediately recognised as being related to water.

The proximity of map elements to one another is also important. Overlapping symbols and text should be avoided in order to make the information clear to the user.

To achieve legibility a process of cartographic generalisation is often required - this can take many forms; from simplification to amalgamation and will be dependant on scale.

4.5.1. Example 5: OS VectorMap® District

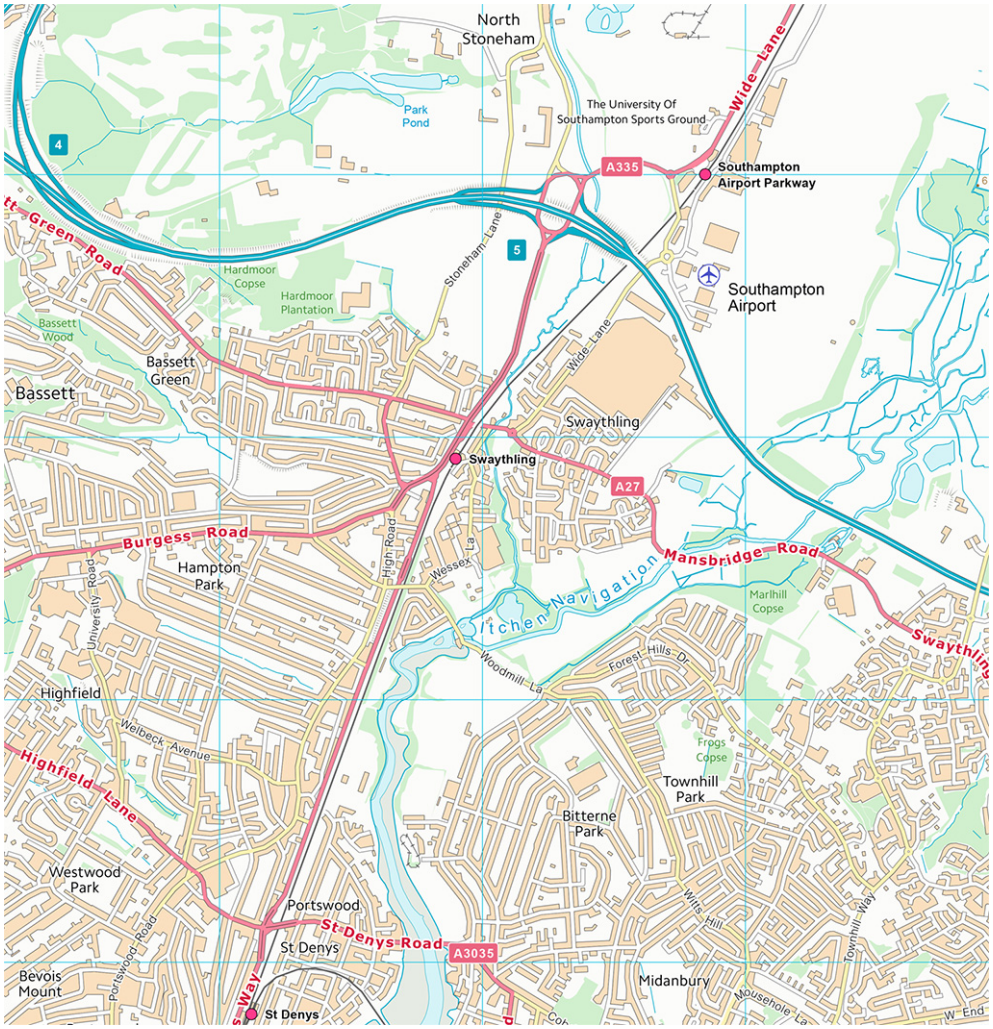

Figure 12: OS VectorMap® District – Full colour raster

OS VectorMap® District uses OS' multi-resolution database allowing it to consume scale-relevant data that has already been generalised (Regnauld et al. 2013). The map features have been generalised to ensure that they are legible at the recommended scales. Buildings, for example, have been amalgamated, simplified and those under a certain size have been omitted from built-up areas (to declutter) or enlarged if isolated (to retain landmarks). Having the right level of generalisation makes the map easy to view and allows us to have confidence in the consistency of the display of line widths and having suitable attribution allows us to better filter and place both text and symbols.

We have chosen all of our fonts based upon their on-screen legibility and ensured that the various fonts work in harmony yet are still distinguishable from one another. Camphor Pro has been chosen as our main font due to its light crispness and readability at all sizes. Arial is used for water as it works well for curved text. Verdana is used for road names because it is heavy enough to stand out above road fill yet complements the other fonts.

Various text sizes and colours have been used to represent different groups of features logically, for example, all water text is blue, spot height label colour matches that of the corresponding point feature and so on. Halos have been applied to text and symbols so that they are clear and legible amongst the surrounding detail. The colour palette also promotes the legibility of and between features (*Section 4.3*).

4.6. Consistency

Consistency provides a map with balance. It enables features to be perceived as being organised into groups and it allows maps themselves to belong to a family of products through a shared identity.

For a family of products or for a web map stack - a suite of styled maps to cover a set scale range - consistency in feature styling allows the user to maintain a sense of location awareness and scale. As well as being aesthetically preferential, a consistent approach can put the user at ease.

Consistency also leads to effective communication through the concept of familiarity. If the same symbol is used repeatedly to depict the same feature, then once the user understands what that symbol represents they can recognise it immediately thereafter. Familiarity breeds confidence.

Conversely, inconsistency can lead to confusion and poor communication of the maps intended message.

4.6.1. Example 6: Common styling

Figure 13: Thumbnail images of OS' traditional styles from paper maps

Figure 14: Thumbnail images of OS' consistent backdrop style

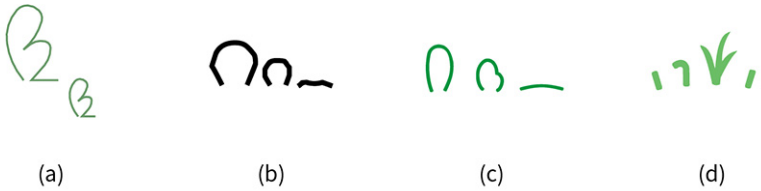

Figure 15: Scrub symbol depiction on 'traditional' paper map products and improved common style (a: OS MasterMap® Topography Layer, b: OS Landplan® and 1:10 000 Scale Raster, c: OS Explorer Map and 1:25 000 Scale Colour Raster, d: common full colour style)

OS' portfolio of topographic map products has grown over a long period of time, during which cartographic trends have evolved leading to many inconsistencies in their styling (*Figures 13 & 15*).

Users want to use multiple products together or as a 'zoom stack'. Common styling aims to provide a consistent look and feel across a range of products and services as required. The result of our work can be seen in the latest OS VectorMap, Meridian™ 2 and Strategi® products and is increasingly being rolled out across our web services. A consistent colour palette is the most immediately noticeable commonality but symbols and font families are also consistent across the portfolio. The idea is that users not only become fa-

miliar with the various representations of features but are also able to recognise an OS map at a glance.

To ensure it could become a common style, we tested our on existing products across the scale range from detailed-level OS MasterMap Topographic Layer right through to the national-level MiniScale® product. For some features, e.g. buildings or urban areas, the colour values caused us problems due the density of the feature across the scale range. Smaller scales show urban areas as large single polygons which are visually more dominant than the smaller polygons of individual buildings at large-scale. To overcome this we either had to reach a compromise, treat buildings and urban areas as two separate feature types, or to make the colours of such features subtly more muted at certain scales. We considered this case-by-case, one feature at a time but checked that all values stayed within the required hierarchical structure (*Section 4.3*).

4.7. Accessibility

Making maps, geographic data and accompanying stylesheets easily obtainable and usable is imperative to their success. Accessibility factors to consider in the design process include distribution formats, user disabilities, cost and intuitiveness in use.

File formats are often vendor-specific which can limit audience based on their software, browser, operating system, etc. Even for paper mapping, there needs to be consideration of points of sale, folding model, etc.

User proficiency is another consideration. A map should be intuitive to use and not rely upon a good knowledge of cartography or any other technical understanding. Furthermore a good design will try to be as inclusive as possible. For example, colour vision deficiency is likely to be prevalent amongst users as it affects an estimated 8% of males and 0.5% of females in the civilised world (ColorLite). It is possible to design with this in mind by choosing more CVD-friendly shades of colour and ensuring suitable colour contrast. Likewise, the sizing of text and feature legibility places expectation on the eyesight of the user.

Accessibility is also affected by the control mechanisms placed on the map, for example licensing and copyright restrictions. Open data – the idea of making certain datasets freely available and open to all – is one way of increasing accessibility in this instance.

4.7.1. Example 7: OS OpenData™

OS OpenData™ comprises a set of OS' digital maps that are free to download and use in both personal and commercial applications.

Figure 16: OS OpenData™ logo

The mapping can be used with other open datasets, for example those available on data.gov.uk, to enhance data you already have or to create new innovative applications.

One of the OS OpenData sets is Strategi which is a small-scale vector product available in three different formats; ESRI Shapefile, MapInfo TAB and AutoCAD DXF. It is ideal to get a regional overview across GB and it contains a wealth of features including roads, railways, airports, ferries, water features, cities, towns, villages, woods, tourist attractions and geographic names. It is also supplied with a gazetteer and cartographic styling guides and stylesheets to help users visualise the data.

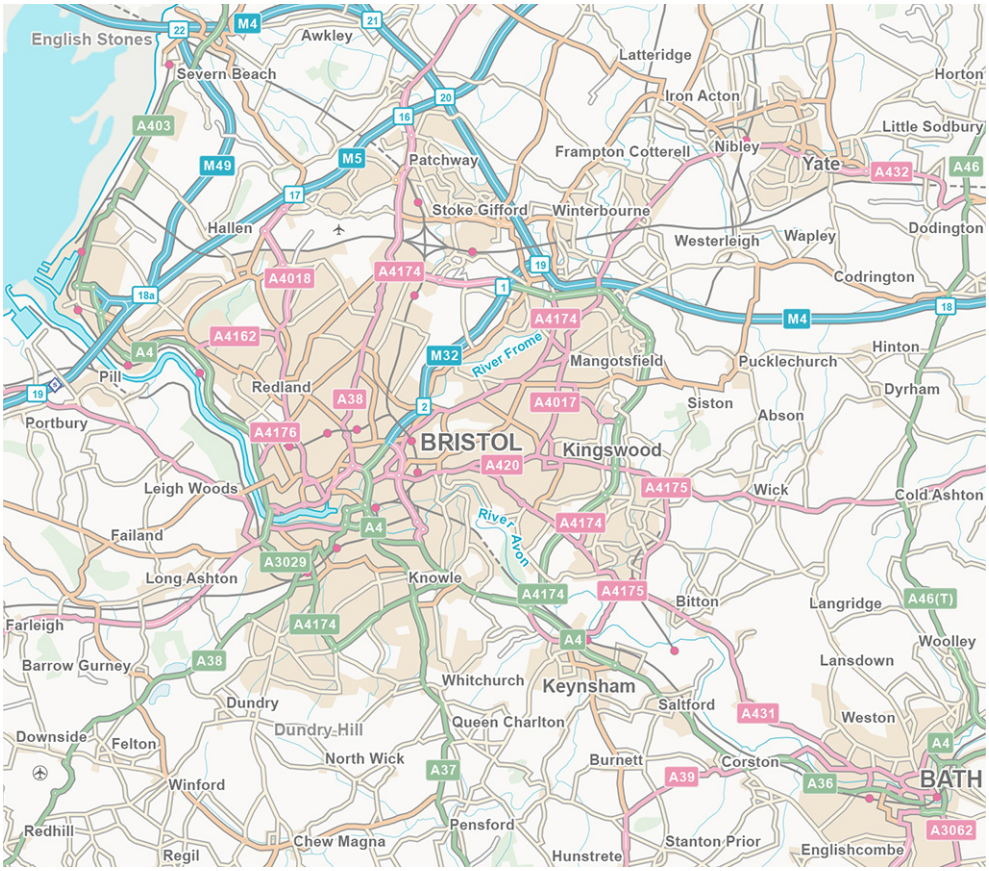

Figure 17: Strategi® (with stylesheet applied)

4.8. Good composition

Composition concerns the arrangement of all the different visual elements, from the map's title to the scale bar (if required). It is both how the map is structured and positioned, and how the map works alongside any additional information. All elements of the map should work together to provide a clear and complete understanding to the user. Their style should be harmonious or complementary.

This is a really important stage in the design process as failure to get the composition right can undermine all effort that has gone before it and result in an unsuccessful map.

The aim here is to achieve balance but the 'visual path' that you want to take the user on should also be considered. The elements that they view first can be influenced by mimicking traditional reading patterns. It is worth noting

here that the 'visual centre' is slightly above the actual centre and it is here that you may want to focus your user's attention. These considerations can have a considerable effect on the overall user experience.

'Elements are arranged with consideration of several factors into a harmonious whole which works together to produce the desired statement – a phenomenon commonly referred to as unity' (Wikipedia).

4.8.1. Example 8: Queen Elizabeth Olympic Park 2030

In partnership with the Institute of Civil Engineers (ICE), we produced a custom map of the Queen Elizabeth Olympic Park, as it will be in 2030.

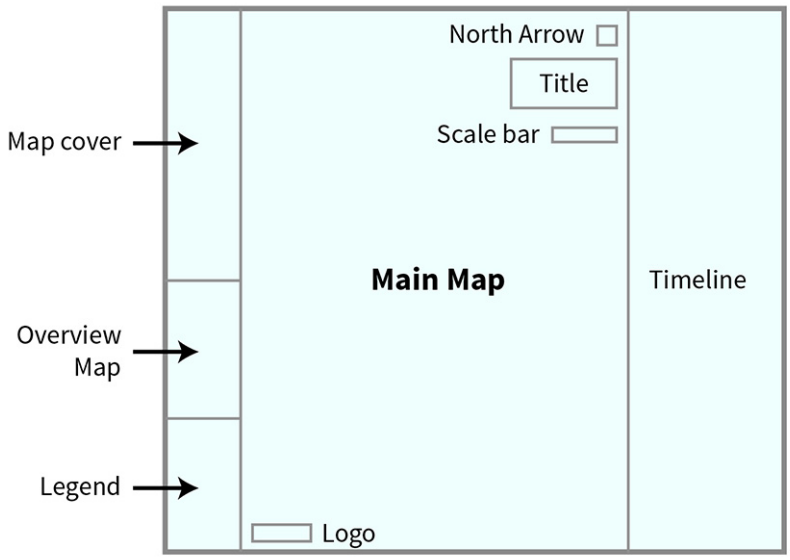

Figure 18: The layout or composition of the Queen Elizabeth Olympic Park 2030 map

This was designed as a folded paper map and demonstrates the work of civil engineers and OS' role in providing geographical information to inform design plans. Being a folded map it was designed from the start with the fold lines in mind - for example, the overview map and legend occupy one panel each. The map of the park itself is the main focus so takes up most of the space and is placed centrally. The maps title, north arrow and logo have been placed on the main map but in the open space where they don't clutter or distract. As we read from left to right the legend has been placed on the left hand side of the map whilst the additional information on the timeline

is placed on the right. Borders are used to separate the different map elements but the overall impression is one of balance and harmony which we enhanced by allowing the map to 'bleed' into the other panels.

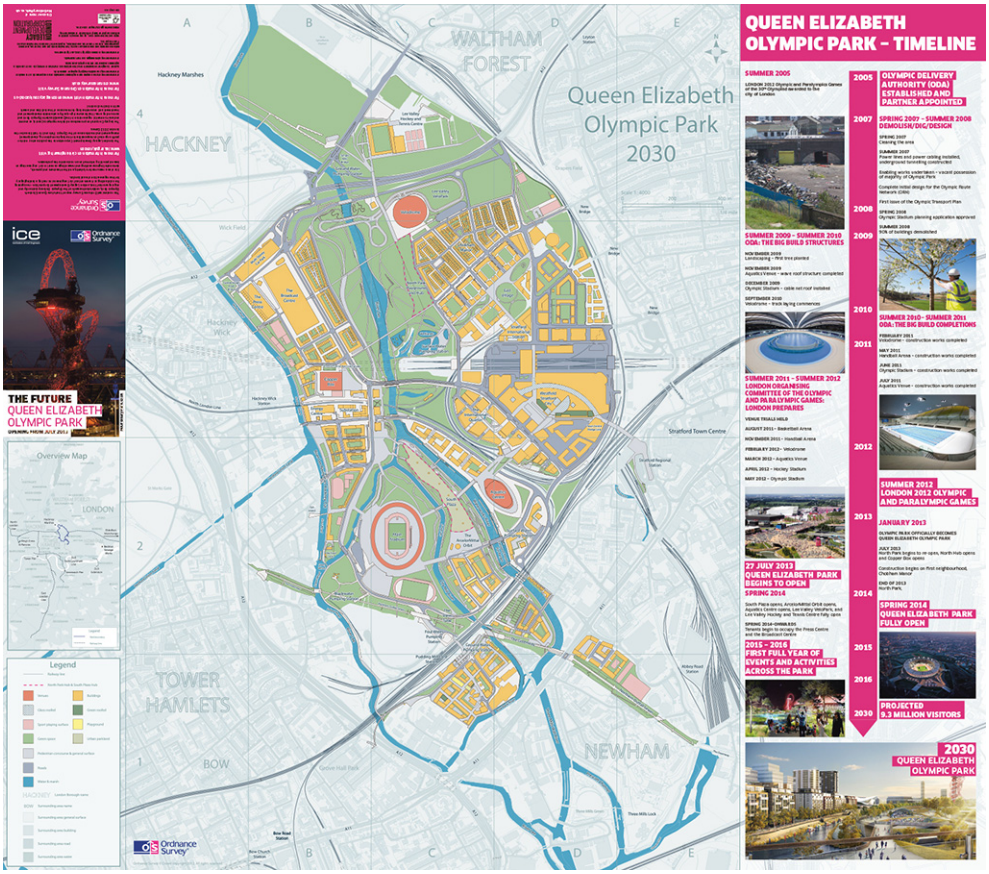

Figure 19: A scaled down version of the map - Queen Elizabeth Olympic Park 2030

5. Summary

We have found that these principles are best applied through an iterative design process whereby they are given due consideration in every decision at every stage. The method of design once, develop, design again should be applied until all of the principles have been satisfied.

'A solution to a problem in math is either right or wrong, but a solution to a cartographic problem is only good or bad', Eduard Imhof

Although personal taste is subjective, we believe that following these principles gives favourable chance of achieving good cartographic design. Though it is worth remembering that 'a map can only be as good as the information that goes into it' (Darkes & Spence 2008) and that these are principles intended to stimulate better cartography: there should be no rules as such. Anything goes, but the final distinction is between a map that works well and a map that doesn't.

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