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Citation: Clarke, J., Dykes, J., Hemsley-Flint, F., Medyckyj-Scott, D., Sietinsone, L., Slingsby, A., Urwin, T. & Wood, J. (2010). vizLegends : Re-Imagining Map Legends with Visualization. Paper presented at the GIS Research UK 18th Annual Conference (GISRUK 2010), 14 - 16 Apr 2010, University College London, London, UK.

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vizLegends : Re-Imagining Map Legends with Visualization

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KEYWORDS: legend, cartography, visualization, design, Digimap service, online web mapping

1. Introduction

UK tertiary education accesses a large and diverse collection of spatial data through EDINA's Digimap service (Sutton et al., 2007). Digimap clients combine and present data of varying theme, content, scale and format in single maps. Legends are essential in this context but bulky and difficult to navigate if comprehensive. Accordingly we conduct a structured and applied study to explore possibilities for using visualization methods to revisit the map legend. Innovative candidate '*vizLegend*' designs are developed by re-imagining the legend in a collaborative three-phase process involving requirements, review, rapid prototyping, evaluation and redesign.

Phase 1 – 'Imagination Exercise': to establish context, exchange ideas and data and develop broad requirements, guidelines from existing practice, themes that inform design and '*digital wireframes*' to demonstrate possibilities.

Phase 2 – 'Constrained Development': to evaluate themes and their implementation in digital wireframes, develop more specific requirements and generate focussed '*digital prototypes*'.

Phase 3 – 'Evaluation and Deployment': to evaluate prototypes, establish user responses and incorporate themes and functionality into Digimap services.

2. Imagination Exercise

2.1 Legend Requirements

Requirements were established at a structured one-day workshop. Current and prototype Digimap services were presented and novel InfoVis techniques introduced to stimulate creative thinking. Formal data collection followed, focussing on three characteristics of legends:

i. successes / problems in existing Digimap legends
ii. aspirational legend characteristics
iii. Digimap legends tasks and functionality

Responses from individual participants were aggregated, ranked and subsequently summarised in graphical tables. Figures 1 & 2 show examples for the final two characteristics. Indicative statements describe each response (or response set). These are ordered from top to bottom by 'strength of feeling' established at the workshop. In Figure 1 the numbers show progression through a four-stage hierarchical prioritisation process. In Figure 2 the numbers are rankings as determined through discussion within two groups of participants. Bar length is indicative of the number of times a broad characteristic was expressed individually at the outset in both cases.

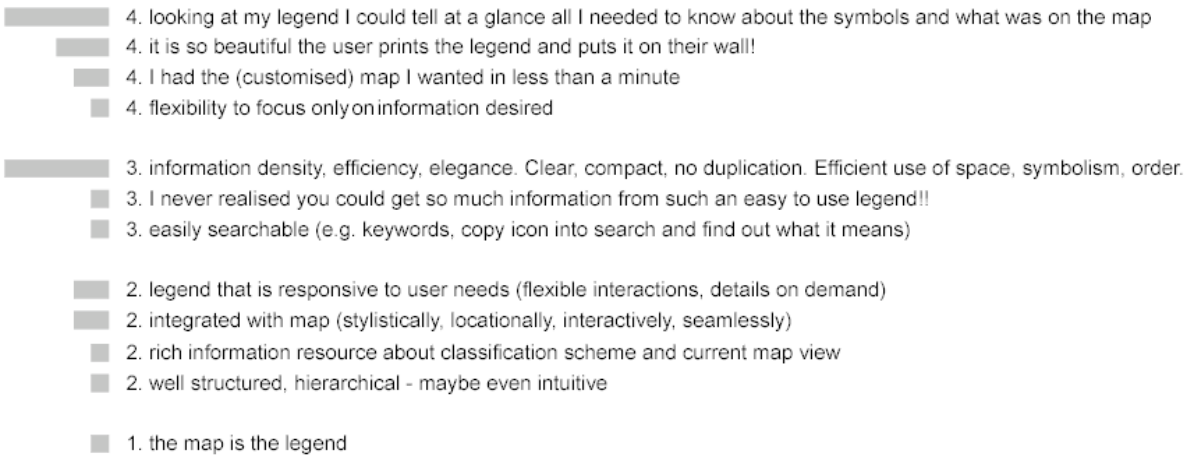

Figure 1. Aspirational Legend Characteristics.

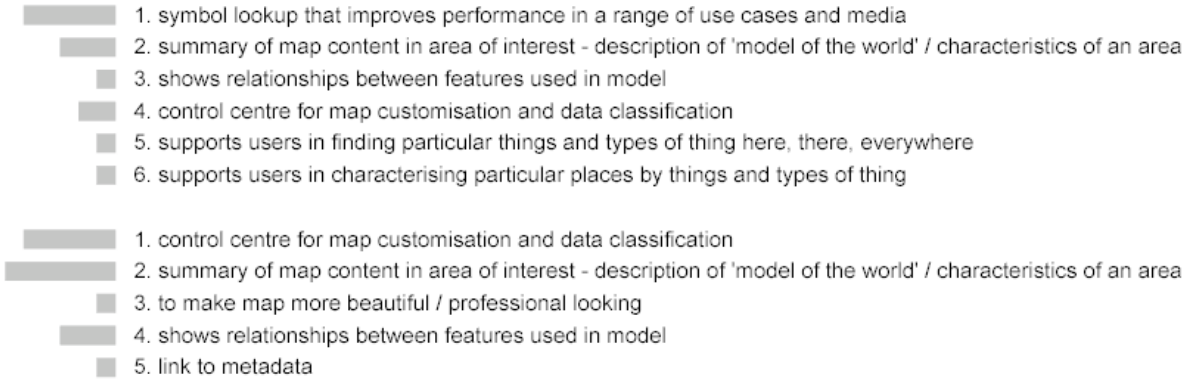

Figure 2. Tasks and Functionality – ordered response sets from two groups (top and bottom).

2.2 Legend Design

Legend design was subsequently informed by a review of 47 sources including cartography texts, journal papers and digital resources. Cartographic text books describe legends as fundamental map components that should include "critical" (Robinson et al., 1995) or "unknown" (Dent, 1990) information that is "not self explanatory" (Slocum et al., 2009). Experimental work shows positive effects of design on performance (Cox, 1976; DeLucia and Hiller, 1982; Aspaas and Lavin, 1989). Guidance on design is very general however, with occasional examples (Slocum et al., 2009) and alternatives (Cuff and Matson, 1982), but few principles, perhaps because it is difficult to generalize between experimental contexts. Six principles for vizLegends were derived from our review:

1. **Process** design the legend in the manner of a map. The seven controls on map design (Robinson et al., 1995) may be helpful.
2. **Selection** should not be comprehensive. Include items deemed 'critical', 'unknown' or 'not self-explanatory' to minimise map-legend references.
3. **Symbols** should relate directly to those mapped, each other (in terms of layout – see below) and the referent.
4. **Layout** should represent information structure (see 'Symbols'). Spatialization may be beneficial.
5. **Position** legends should be encountered before maps – this may vary with task, user, time and data set.
6. **Dynamism** should facilitate map-legend references and variation of selection, layout, symbolism and position as required (by user, data, task, etc.).

Concepts and approaches documented in the literature that may help achieve these principles include 'The Active Legend' (Sieber et al., 2005), bi-directional highlighting (Sieber et al., 2005) and the application of styles (Jolivet et al., 2008, 2009; CloudMade, 2009). Creative thinking, continuous redesign and "vigorous editing" (Brewer, 2005) are deemed to be essential in their application.

2.3 vizLegend Themes

These legend requirements and design principles provided impetus for a creative exercise in which a series of broad themes were developed to frame vizLegend ideas. Each theme describes a novel perspective on the legend that may address some of the established requirements through the identified principles. Themes are generic and may be used individually or in combination to guide the development of wireframes or prototypes. They are neither comprehensive nor mutually exclusive.

1. **The Map is the Legend**
   The roles of map (spatial representation of geographic setting) and legend (spatial representation of map content and symbolism) are blurred.
2. **The Legend as Statistical Graphic**
   A graphical statistical summary of current map content and a query filter for map exploration.
3. **The Scale Independent Legend**
   Data integrated seamlessly from multiple sources with conflicts resolved.
   Sources identifiable but grouped by other characteristics.
4. **The Relevant Legend**
   Shows only what is required… as this changes. May apply to various other themes.
5. **A Legend of Legends**
   Alternative styles displayed with layout reflecting their relationships. Widely applicable.
6. **Map of the Pops**
   Legend items selected and arranged according user community needs. Widely applicable.
7. **The Referent is 'Ground Truth'**
   Symbols augmented or replaced with (local, community contributed) imagery.
   User community determines relevance. May be combined with various other themes.
8. **My Legend, My Map**
   User controls and saves content, layout and order according to task, knowledge, location, symbolism. Can be considered a subset of theme 4.

2.4 vizLegend Digital Wireframes

The themes were used to develop four digital wireframes through which means of addressing the requirements were explored: *The Map is the Legend*; *The Legend as Statistical Graphic – Bar Chart*, *Matrix Plot*, *Hierarchy*. Each is named according to the dominant theme, but may be influenced by others. Requirements addressed by each wireframe were tabulated: the aspirational characteristics that '*The Map is the Legend*' wireframe was designed to accommodate are emphasized in Figure 3.

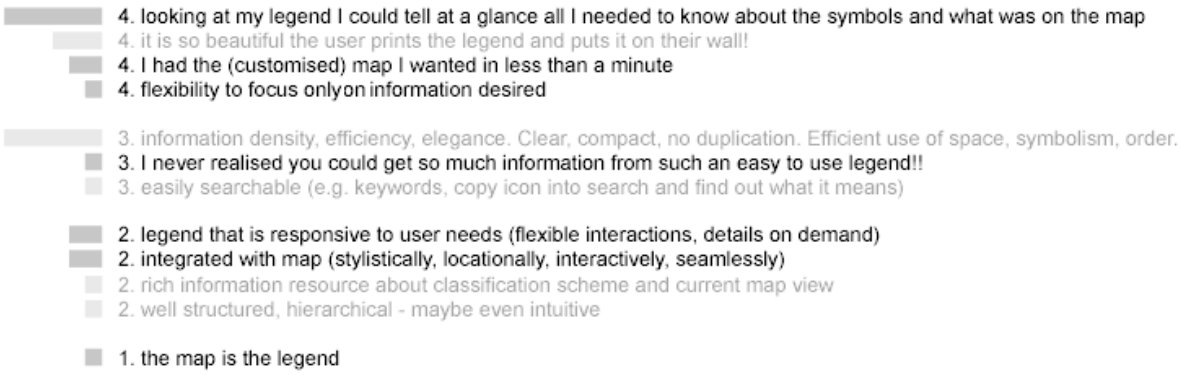

Figure 3. Aspirational Legend Characteristics: '*The Map is the Legend*'.
The requirement sets addressed in the wireframe are highlighted in dark grey.

The '*The Map is the Legend*' digital wireframe (Figure 4) transitions smoothly between alternative combinations of layout and selection with characteristics of themes 1, 4, 5 and 8:

- *Legend* - 1D ordered layout with single case of each feature (Figure 4, left)
- *Map* - 2D spatial layout of all features (centre)
- *Mapped Legend* - 2D spatial layout with single case of each feature at indicative location (right)

Figure 4. *The Map is the Legend*. Three states: legend, map, mapped legend (*left – right*).
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The '*The Legend as Statistical Graphic - Hierarchy*' (Figure 5) uses themes 1 and 2 to show hierarchical bedrock classification through a two-dimensional spatially ordered space-filling treemap (Wood and Dykes, 2008). Bi-directional interactions (Sieber et al., 2005) feature strongly in the wireframe and include zoom / pan to select spatially with legend updated according to map content.

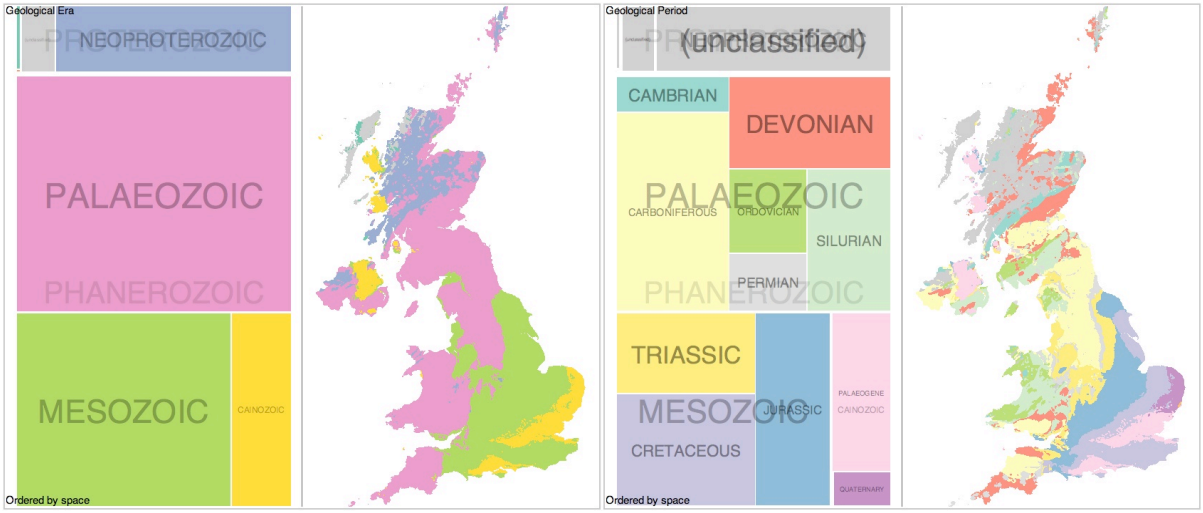

Figure 5. '*The Legend as Statistical Graphic – Hierarchy'*. Geological map in which areas on the legend relate to areas on the map for era (*left*) and period (*right*). Legend can be interactively reordered to show attribute, spatial or chronological orders at each level of the attribute hierarchy
Geological Map Data © NERC 2009.

3. Feedback and Digital Prototypes

The results of the 'imagination exercise' generated ideas for enhancements, developments and evaluation. These included an EDINA mock-up of theme 7 with community contributed styles and locally relevant photographs (Figure 6).

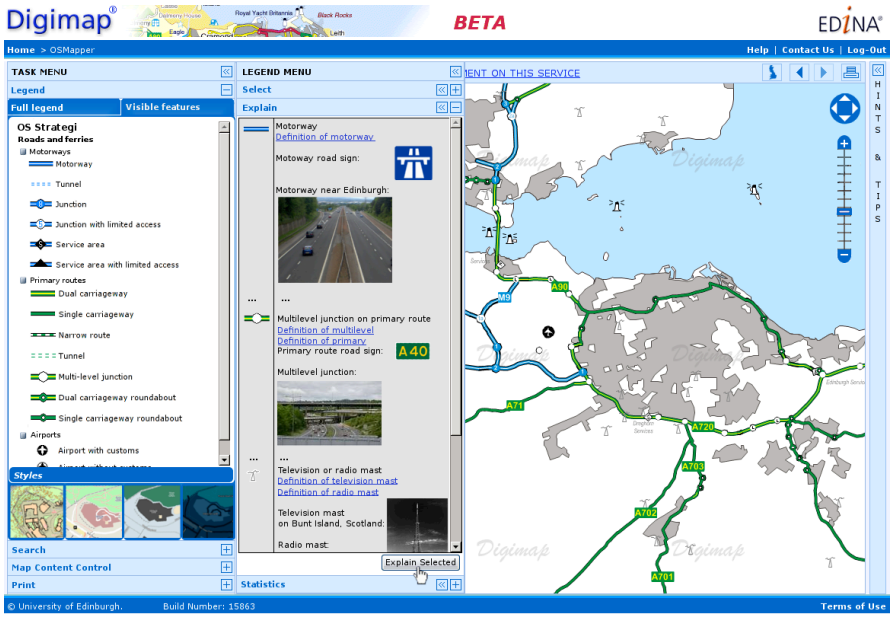

Figure 6. '*The Referent is Ground Truth*'. EDINA mock-up.
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Additional requirements were also derived following interaction with the digital wireframes: using *Strategi;* visualizing the *Strategi* feature hierarchy; extending bidirectional interactions. Two of the digital wireframes were enhanced accordingly. The resultant prototypes are shown in Figures 7 and 8.

4. Conclusion and Ongoing Work

Harrower (2003) contends that "*Digital and Web cartography fails when we try to reproduce paper maps on-screen*" and calls for a creative approach. We show that a structured collaborative design process with rapid iterative development that draws upon real data can result in innovative cartography and candidate solutions that have potential. Our re-imagination exercise identifies various new roles and approaches for legends that may be suitable for Digimap and elsewhere through usable principles, themes and prototypes. These are implementable and can be evaluated.

Visualization methods are best communicated through interactive media and evaluated by map users. The vizLegend themes and prototypes will be further investigated by the Digimap user-base and subsequently considered for use in Digimap clients as we evaluate prototypes, establish user responses and consider incorporating themes and functionality into Digimap services.

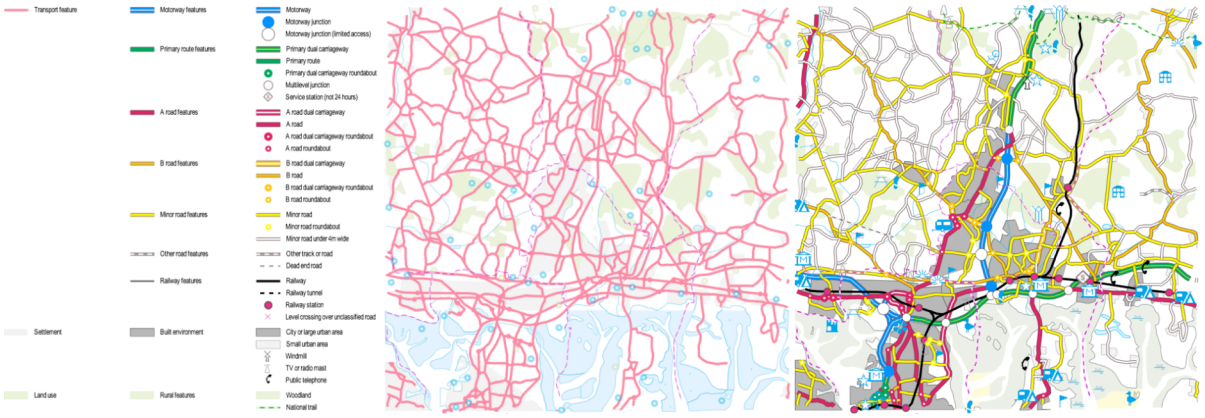

Figure 7. '*The Map is the Legend*'. Digital prototype with legend items arranged hierarchically (left), styled hierarchically (centre) and styled according to current Digimap convention (right).
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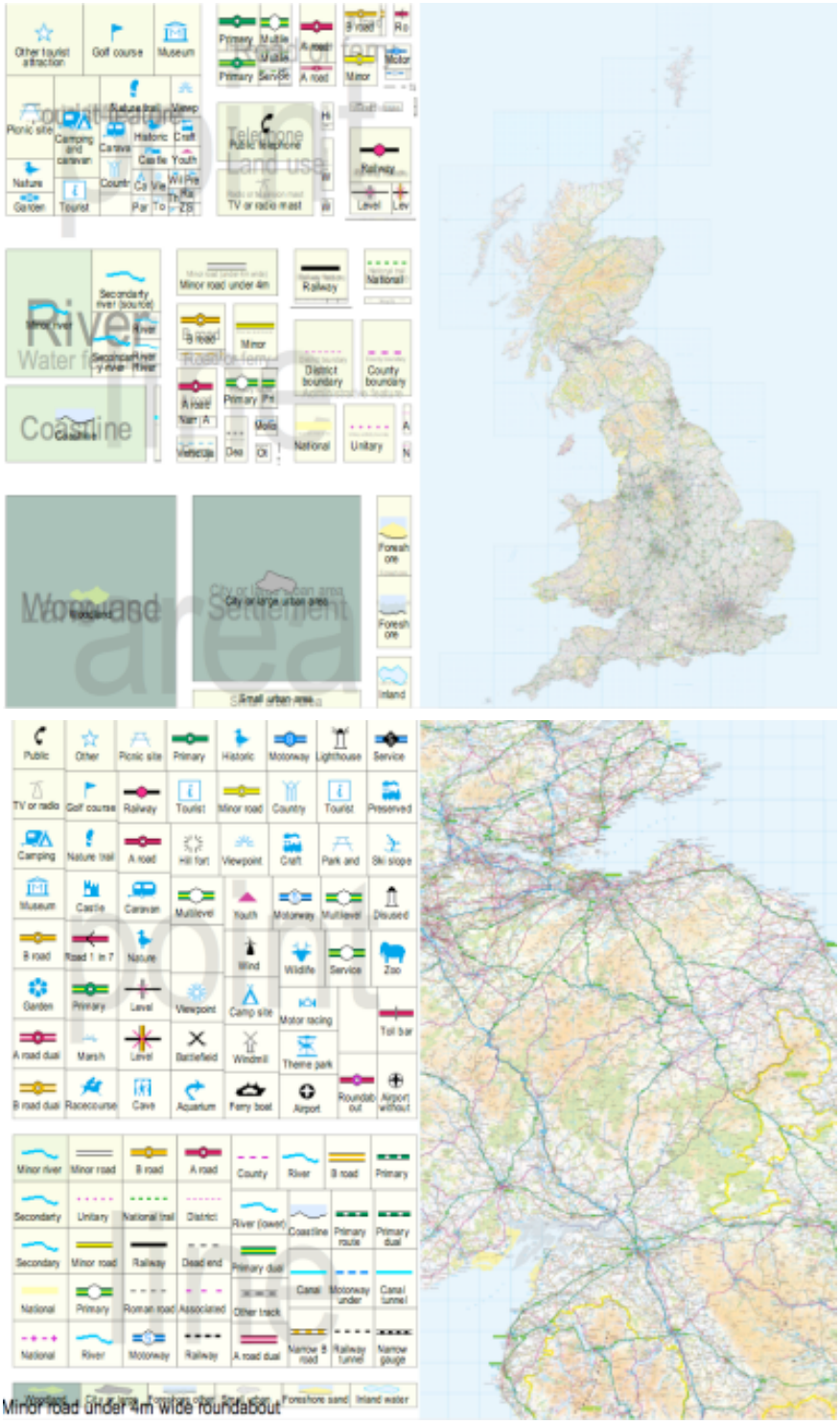

Figure 8. '*The Legend as Statistical Graphic - Hierarchy*'. Digital prototype showing feature hierarchy and occurrences of point, line and area features in national Strategi data set using area and colour (top) and colour (bottom) at national (top) and interactively determined local (bottom) level. Raster backdrops are generalized in the prototype to ensure rapid response.
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5. Acknowledgements

EDINA National Data Centre funded this work through its small-scale development budget. Data provided by Ordnance Survey GB and the British Geological Survey. Thanks to EDINA Geodata Services and User Support for contributing to the three vizLegends workshops.

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