# MEETING REPORTS

# THE LONDON UNDERGROUND MAP: DESIGN CHALLENGES AND CHALLENGING DESIGNS


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Over the years, the challenge to produce clear attractive maps that 'keep to the rules' places increasing demands on designers. Max Roberts asks: 'why do maps based on Henry Beck's design principles help us plan journeys; does following the rules always give us the best possible design and what happens when we break the rules?'.

This talk is less about the content of the London Underground map than how the diagram serves as a testbed to explore basic design principles. As a complex metro system, we can use the Underground to test different methods of mapping a network and ask why different sets of mapping 'rules' are more successful than others. London is an ideal case-study as its diagram has evolved over eight decades and has been challenged by a growing network and competing demands of geography and geometry.

Maps prior to Beck's design tended to be geographically-based (albeit in a modified form). Stingemore's map from the early 1930s enlarged the representation of central London but was unable to capture far-suburban destinations to the west, east and north. This 'fussy' design was the standard until Beck introduced his diagram in 1933. The uncluttered, 'octilinear' design (verticals, horizontals and 45-degree angles) of this diagram proclaimed Underground travel to be quick, effortless and direct. By the first decade of this century, the growth of the network as well as the overlay of notes, fare zones and other information has caused compromises in the clarity and coherence of the diagram. It is starting to look 'fussy' again.

The primary function of a network map is as a way-finding aid. The discipline of Cognitive Psychology gives us useful tools to test how well a particular design performs that task. Key concepts for a map designer to consider are the quantity and quality of information (cognitive load); the ability of an individual to process that information (cognitive capacity); the familiarity of a person with the network or city depicted (expertise); and information salience – the way information is structured to direct or capture the user's attention. Using a transit diagram is basically a reasoning task in much the same way as an intelligence test. Performance is largely dependent on the cognitive load presented by the map, the intelligence of the individual using the map and the expertise and familiarity of that individual in the use of a particular network. A good map works like the simplest intelligence test: the questions 'where do I start?' and 'what do I do?' are easily answered and not buried under a complicated mapping structure that makes these basic tasks more difficult.

Beck's depiction of the Underground is subject to design rules that (in a London context at least) make it a simpler 'test' than maps that preceded it. Its rigid adherence to octilinearity, as well as tightly-radiused curves has led many to hail these rules as the 'gold standard' for a successful transport schematic. Beck's design certainly makes routes easier to find when planning a journey, with simplified information reducing the cognitive load required to use the map. A structure largely uncomplicated by geography makes the network easy to understand and therefore expertise is easier to acquire – reducing the cognitive load still further. The key points are clean geometry (which reduces kinks and gives each line a clear trajectory); balance (clear focal points and avoiding information being distributed too unevenly); geography (avoid overt conflicts between the diagram

layout and the actual city plan); and keeping supplementary information to a necessary minimum. As mentioned before, the proliferation of fare zones, limited service indicators, accessibility symbols and other overlays to the current Tube Map may be desirable for some, but can be viewed as information pollution. Additional data leads to a lack of coherence in the diagram that detracts from the basic task of way-finding, and increases the amount of work required to comprehend the layout.

Getting the correct geometry for a transport schematic is full of challenges. Beck's rules may not be appropriate for all networks. A set of rules is only as good as their application to a particular system. For instance, kinks and corners that detract from straight lines raise the cognitive load and there are several examples of this on today's map. Taking zig-zags, corners and kinks to an extreme can show how this is a major obstacle to good design and improved understanding. There is however a trade-off between clear geometry and distorting geography to fit 'the rules'. How geographically correct must a diagram be so as not to conflict with a user's 'mental map' of a city? To be fair to all levels of expertise, it must be geographically accurate on all sections of the system – a depiction of which requires an enormous amount of compromises to clear geometry, given the reach and complexity of the Underground and associated railways. Scale distortion is still necessary in order to make a geographically useful Tube map comprehensible, otherwise the size of the map would need to be a metre wide. To test geography against geometry accurately, a completely non-geographic map would need to be created. An example is cited with the Central Line as a vertical baseline with Epping at the top and Ealing at the bottom of the map. When seen, a Londoner may feel unsettled by the unfamiliar orientation and the lack of allowance made for the city as it is actually laid out. Although the tests are yet to be conducted on these models, the cognitive load would change for different users dependent on their network expertise.

The dimensions of a map as it is actually printed can also affect the clarity and cognitive load for the user. Beck's early designs fitted into a standard three-fold pocket map; the much-extended network of today is required to fit into the same space. Even Beck had to make compromises – east London ends at Bow! These page constraints lead to a much more cramped presentation of the Underground and the geometry of the map has to be altered to fit, which increases the amount of kinks and corners. A 'widescreen' version of the diagram that relaxes the page size allows greater coherence and clarity at the extremities of the network and positions the West End and City in a more central fashion.

Is there an objective method to decide 'what is a good map'? Journey planning studies can test different map designs for planning speed and journey quality. These measure how quickly a customer can use the map to plan their journey as well as whether that journey is optimal in terms of directness, speed and transfers between lines. Tests of the current TfL map, a map with exaggerated corners and some 'improved designs' (that improve geometry and information coherence) is revealing. While the quality of the planned journeys differs little between the studied designs, the 'improved' maps enabled faster planning of routes by approximately 20% over current designs. The slowest planning speed occurred when using the map that had needless kinks and corners added to it. We can objectively say that improved geometry – and fewer corners – leads to better planning outcomes. It was noted that better maps could have consequences for platform clearance during service disruption; people planning routes quicker may mean less requirement for staff to provide way-finding advice. It was also noted that TfL do not share this opinion!

Having established that maps with simpler trajectories have clear usability benefits, can we break Beck's 'rules' and make the Underground map even better for passengers? Beck's rules are but one design methodology; there is no particular psychological reason for the ordering of map elements in this way – Beck just happened to get there first. Other rule sets are possible and may indeed be a better way of presenting the London system. With the aim of eliminating corners paramount, can a trade-off be found between this objective and the visual coherence of the map. A 'hexilinear' map (lines at 60 degrees and on the horizontal) can cut the corners inside the Circle Line from 13 to 6. A 'dodecalinear' rule set where lines are shown at 30,60 and 90 degree angles cuts the number of corners still further, but visual coherence begins to disintegrate. Abandoning angle-rules to remove

as many kinks as possible is the ultimate expression of this pursuit and results in the 'Crazy Tube Map'. However, do we need to show Underground routes as straight lines? By imposing curves on the design, and relaxing linearity, corners can be smoothed out and a strict angle-bound rule set can be dispensed with. Because it departs so much from the familiar diagram, reaction to the 'Curvy Tube Map' is polarised. This diagram demonstrates the perils of changing the eighty-year old conventions in the search for clarity and utility. People have long-held expectations of what a journey planner should look like, not to mention their own spatial perceptions. In the future, perhaps passengers should have a choice of diagrams so they can pick the one that works best for them? With a vast range of potential mapping solutions to explore, the quality of rule-set implementation is key.

Different networks demand different solutions. London Underground has a fairly consistent mapping history, but what of another transit system where no such tradition exists? Such a place is Paris. The 14 Métro and 5 RER lines have a vast number of interchanges on many twisting routes. Current mapping preserves geographical relationships but has many kinks that mask what actual structure exists. Beck attempted to simplify the Métro according to his rules without a great deal of success, so perhaps an angle-based approach to Parisian map design should be jettisoned. Applying the curvilinear method to the Métro lightens the cognitive load dramatically and allows important route structures to become more apparent, such as the circular route afforded by Lines 2 and 6. Geographical relationships, such as those defined by the River Seine, were also preserved. Testing this map against two angular designs showed a 30% speed advantage for the curved diagram and no significant degradation in the quality of journeys planned during the test. Furthermore, further analysis of subjective opinions on the tested maps showed that the usability of a map is not related to people's acceptance of a particular design. There was no relationship between the improved planning speed of the curved design and whether people would choose to use that map over the official version. 'Map engagement' seems to have no root in which maps objectively work 'better'.

The Madrid Metro is a rapidly expanding network lacking a clear design tradition. For such systems, a consistent design solution is difficult to develop and refine, and poor mapping choices have not helped. One design did not prioritise the core central area's highly interconnected routes in an attempt to preserve Madrid's geography. Superfluous kinks were left in suburban lines. Problems with paper dimensioning led to a redesign with a rigid 'tetralinear' rule-set (verticals and horizontals only). As this map showed, the fewer angles available to the designer, the less flexibility there is to display interchanges clearly. A schematic transport map should seek to simplify a network and reduce the cognitive load on the user; an objective apparently lost on the creator of the redesigned map! A map using curves had been considered for Madrid's system previously, but like its angular cousins, it prioritised topography over route simplification and failed the 'quality of implementation' test. Revisiting the all-curves approach, but this time using the methodology applied to London and Paris (sweeping lines, reduced corners), vast improvements in planning speeds and quality were recorded in a journey planning test. The official map also failed heavily in subjective assessment, showing that Madrilenos deserve better.

In conclusion, good design does make a difference. The choice of rules is important in designing a diagram, but the quality of the implementation of those rules makes an enormous difference to the end-product. Objective assessment of the effectiveness of different rule-sets is important – it is not enough to just ask focus groups what they like or dislike about maps. Testing a map's cognitive usability is critical to determining whether you have the right design application. Following from this, Beck's 'rules' may not always be the most effective way to map a network. Many different rule-sets exist; rigid evaluation and research is needed to figure out what works best.

**QUESTIONS FROM THE FLOOR**

*What would a future map of all London's underground railways look like?*

The final build of Crossrail will affect what an integrated map of London's underground railways looks like. For instance, the decision on whether the Abbey Wood branch goes ahead has implications for the overall layout of the map, as do all extensions to hitherto unserved parts of the capital.

*How important is it that rivers are shown on a diagram?*

Rivers are 'benign clutter' and depending how they are depicted are easily filtered out by the user. Some diagrams (e.g. Beck's map of Paris) need a river to establish a geographic framework for an otherwise abstract representation. For those with low expertise (e.g. tourists) a river can be a useful device for orientation.

*Why is there no comparison made to Paul Garbutt's designs of the early 1980s?*

Quite simply, the network has changed so much since then that any new version would cease to be a 'Garbutt' map. The Docklands Light Railway would distort the display of east London to such an extent that Garbutt's principles (such as a flat Central Line) would result in some unacceptable geographic compromises today.

*Is the Underground map conflicted between being a journey planner and a platform for TfL to show all their railways?*

We need a proper choice of maps that are appropriate for different purposes. For example we need a map aimed expressly at tourists. Some commercial publishers have attempted this with varying degrees of success.

*Should different areas be mapped with different rule-sets within the same diagram?*

Different areas of London respond better to different rule sets depending on the density of the network to be mapped. The hexilinear map suits areas of the east, but has several compromises in the depiction of west London. As ever there is a trade-off between visual coherence and the elimination of corners, and some angle combinations can be harmonious, whereas others can be rather jarring.

*Does the weighting of lines affect journey planning? Can the use of alternative routes be promoted by different thicknesses?*

Paris highlights the RER network by thicker lines but in an already crowded map this can add complexity to the route structure. This question has not featured in any of the research to date, and is not featured on the London map. Many potential alternative routes such as Hainault – Woodford and Gospel Oak – Barking have limited service patterns. The more corners in a line depiction are however likely to make it less attractive when journey planning.

*Do electronic mapping applications have implications for traditional maps?*

Journey planning software tends not to show a holistic view of a network and so can reduce familiarity with the overall shape of a transit system. In many ways computer mapping is associated with 'deskilling' users of paper maps, resulting in a reduction of system expertise.

*Can the subjective analysis of maps be further broken down by 'personality types'?*

There are clear preferences for curvy and angular maps, but there are no clear relationships to obvious differences such as age and gender. Deep-seated psychological reasons for these preferences are even harder to investigate at this stage.

*The standardisation of line colours – how important is this?*

Paris has an unfortunate set of colours for its diagram. For those with high expertise this is not an issue, but has problems for occasional users. Colour choice is important, but it is hard to know where to start resolving this.

*What thoughts are there on using the Underground Map for geographic navigation?*

The schematic map has a number of compromises in the positioning of stations (viz. Euston Square), but system signage should be sufficient to direct you when actually at one of these places. The Tube Map is generally correct in its orientation but perhaps should come with a warning such as “Do not use this map for spatial navigation (at least without a compass!)”.

*The size of the ‘pocket map’ – should it be increased to A4 size to make it easier to see?*

The dimensions of the current map are not optimal for showing the network and foldable maps between A4 and A3 could be considered for improved clarity of typeface and route. This change in size would mean that some of the better map designs that have been demonstrated could be used to their full advantage. You can always tell a good map because the bigger you make it, the nicer it looks – not a recommendation that can be applied to the current mapping of the Underground.

Several of the maps discussed in Max Roberts’ talk are reproduced in *Underground News* No.566 (February 2009) pages 87-92.

Max also has a website – **www.tubemapcentral.com** – that displays his interests to the full, including his alternative designs for the Underground.

**Dan Scott**