

# Searching for Shape: Circles on Transit Maps Through Time

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[Previously *The Story of Circles Maps*, published March 2017, updated and rewritten.]

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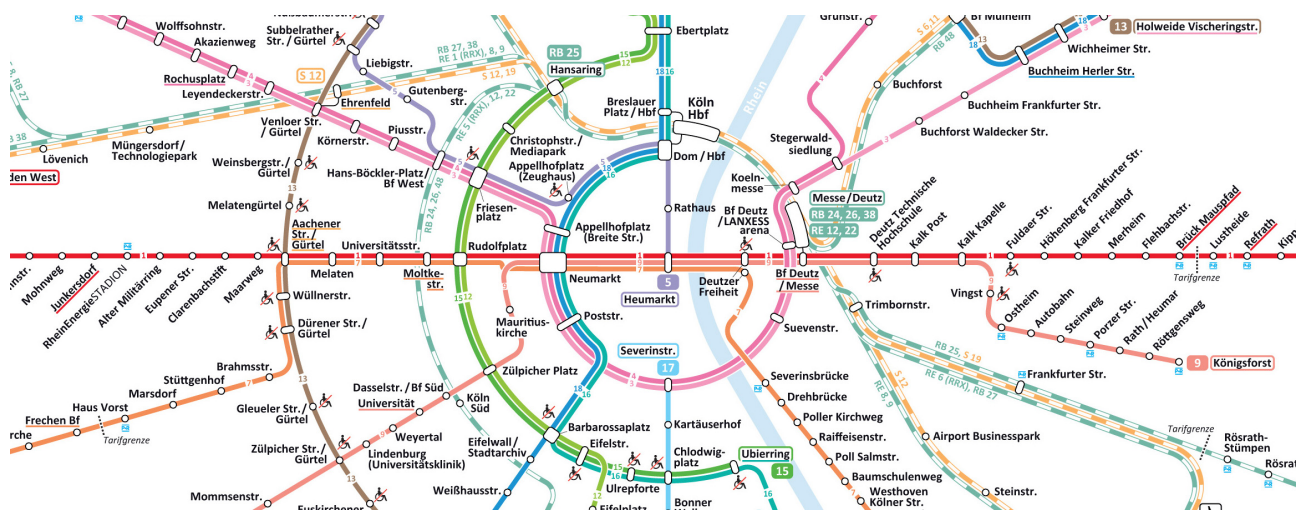
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*This article looks at the use of circles to show line trajectories on transit maps as a method of making them easier to comprehend. I will highlight some historical designs and then investigate attempts to combine circles with spokes to improve coherence, with a focus on some of my own work.*



*Köln U- and S-Bahn map, based on concentric circles and spokes, officially adopted in 2022 and based on a 2016 design by the author.*

## Introduction

When schematising an urban rail network map, one intention of the designer is to simplify line trajectories so that the result is easy to understand and use. For example, one method to achieve this is to select a restricted set of straight line angles. Hence, Henry Beck used just four of these for his famous London diagram: horizontal and vertical lines along with 45° diagonals (this set of angles is named *octolinear* by researchers). Going further than this, a frequent technique is to use easily recognisable shapes to help the user comprehend the map, for example to make key services easier to identify. A circle line or some sort of orbital loop is a good candidate for this treatment and such lines are a physical feature of many urban rail networks worldwide, for example Berlin's *Ringbahn* was completed in 1877 and London's *Inner Circle* (now the *Circle Line*) in 1884.

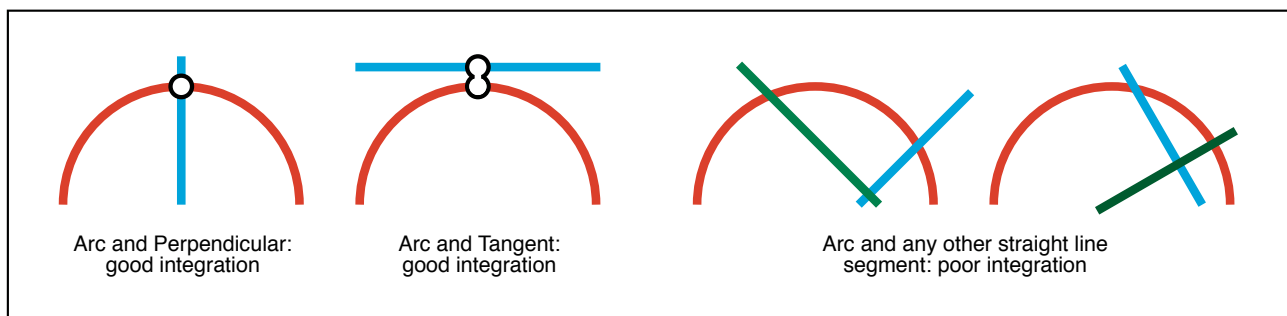
## Circles and straight lines: Early hybrid designs

Faced with such a potentially regular feature such as a circular line, many designers have been tempted to emphasise it geometrically by showing it as a perfect circle. This can then act as a firm visual foundation to a network diagram. The earliest example I know of is the classic Berlin S-Bahn map, first issued in 1931 (in conjunction with the *Great Electrification* scheme). It combined a circle for the Ringbahn alongside octolinear angles for the remaining S-Bahn lines.



*Berlin S-Bahn map, 1931, (nicknamed Netzspinne) showing the Ringbahn as a perfect circle. The other lines are drawn at octolinear angles, another first for a published map.*

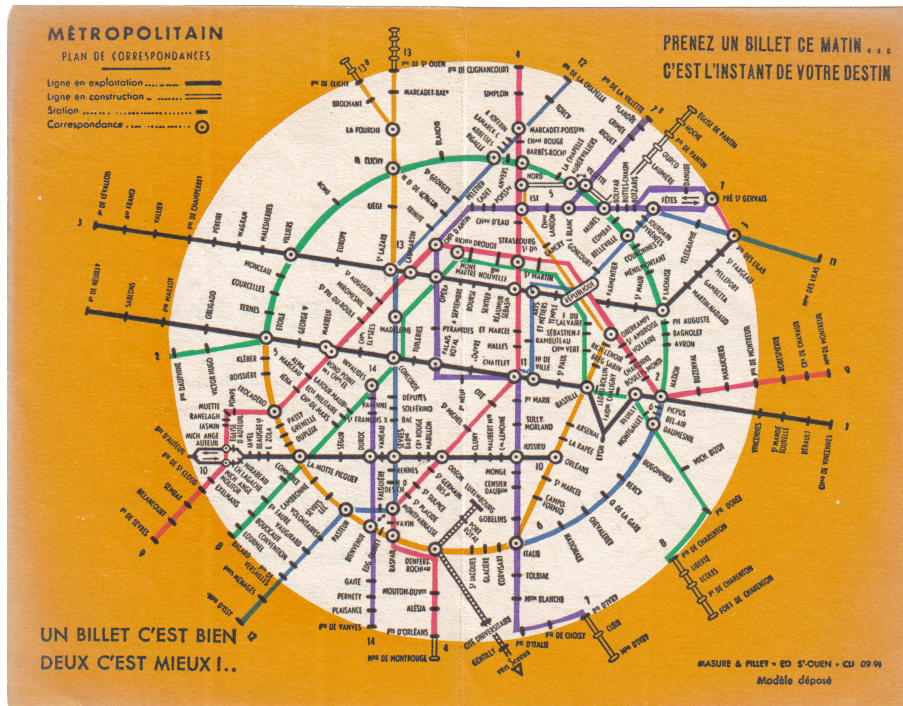
The designer of the Berlin diagram managed to avoid straight lines intersecting the circle at sharp angles. This is important because the map is effectively a *hybrid design* with lines following different rules. Some are straight, at octolinear angles, others follow circular arcs. This gives an extra level of difficulty owing to the need to integrate the lines so that they work together, not conflicting with each other where they meet.



*Where circles and straight lines mix, it is important to try and angle the straight lines so that they integrate well with the curves.*

Turning to the Paris Metro, where lines 2 and 6 together orbit the centre, another early design from 1936 used a circle in an attempt to improve clarity. This was published by the French National Lottery (and so was not an official map issued by the Metro). It has always been a challenge to show the Paris network clearly. The result here shows that a circle, by itself, is not enough. For the straight lines, any angle seems to have been permitted. Those inside of the circle are a chaotic mess. All that the circle achieves is to highlight this. Using simple, easily recognisable shapes to emphasise network structure only helps if attention is paid to making all of the network as orderly as the circle.





Paris Metro map, 1936, issued by the French National Lottery. With the circle highlighting the inner disorder, I call this design outcome a Porthole on Chaos.

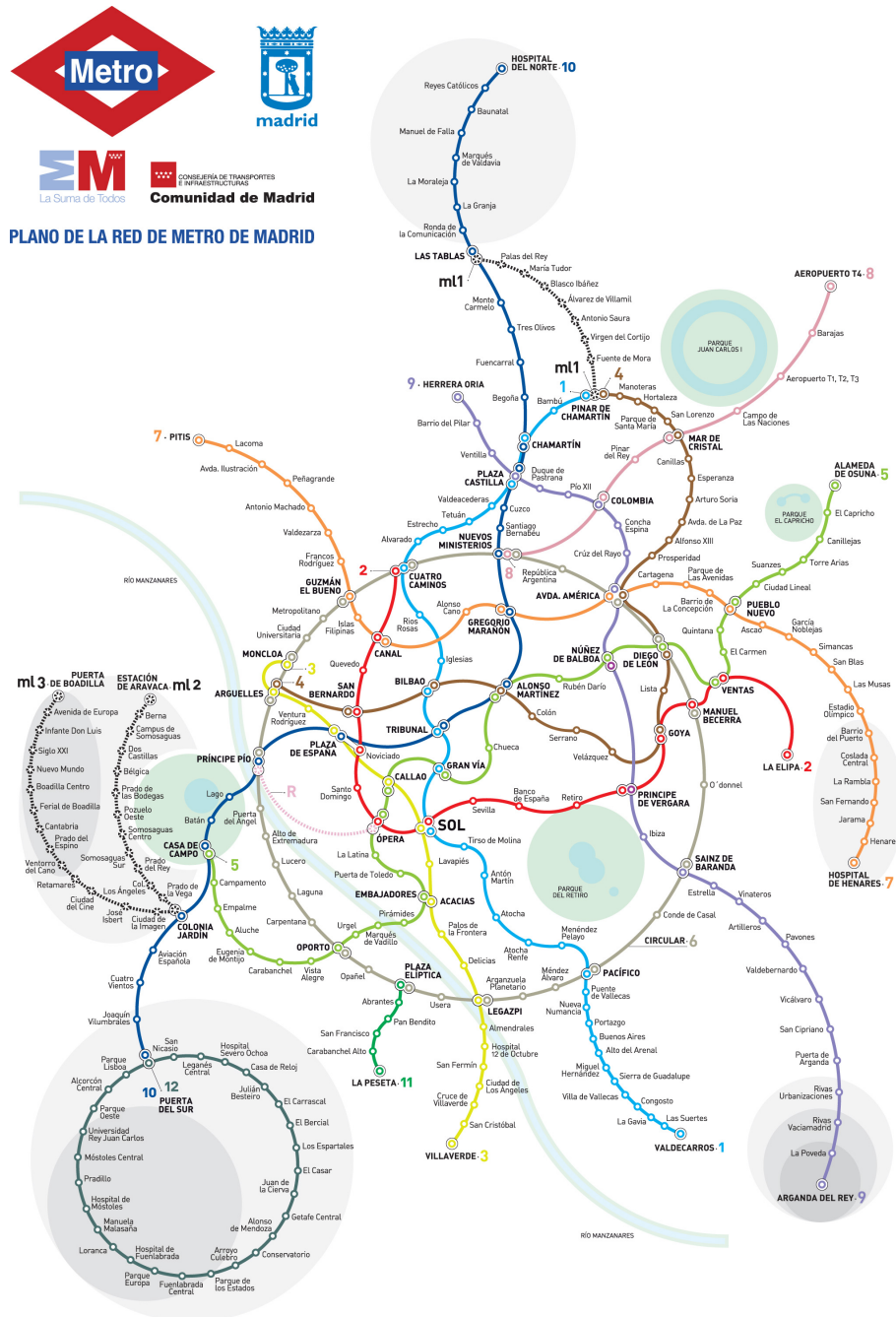
Perhaps the most spectacular of the simple hybrid designs are the various Moscow Metro maps published during the 1970s. These combined a circle for the Koltsevaya Line with perfect straight lines for the rest of them. This achievement necessitated a highly radial network structure (which no longer exists). If any of the radial lines had needed to intersect and diverge with others then these would have required bends and multiple angles, spoiling the effect. However, although these designs are striking in their simplicity, station names were hard to place – especially as different lines sharing the same station complex often had different names – and this would have impacted usability adversely.



Moscow Metro map, 1977, with a circle accompanying perfect straight lines at various angles. The design is striking but note the congested station names inside the circle. Colour-coding the names would have assisted to some extent.

## Circles and something else: Modern hybrid designs

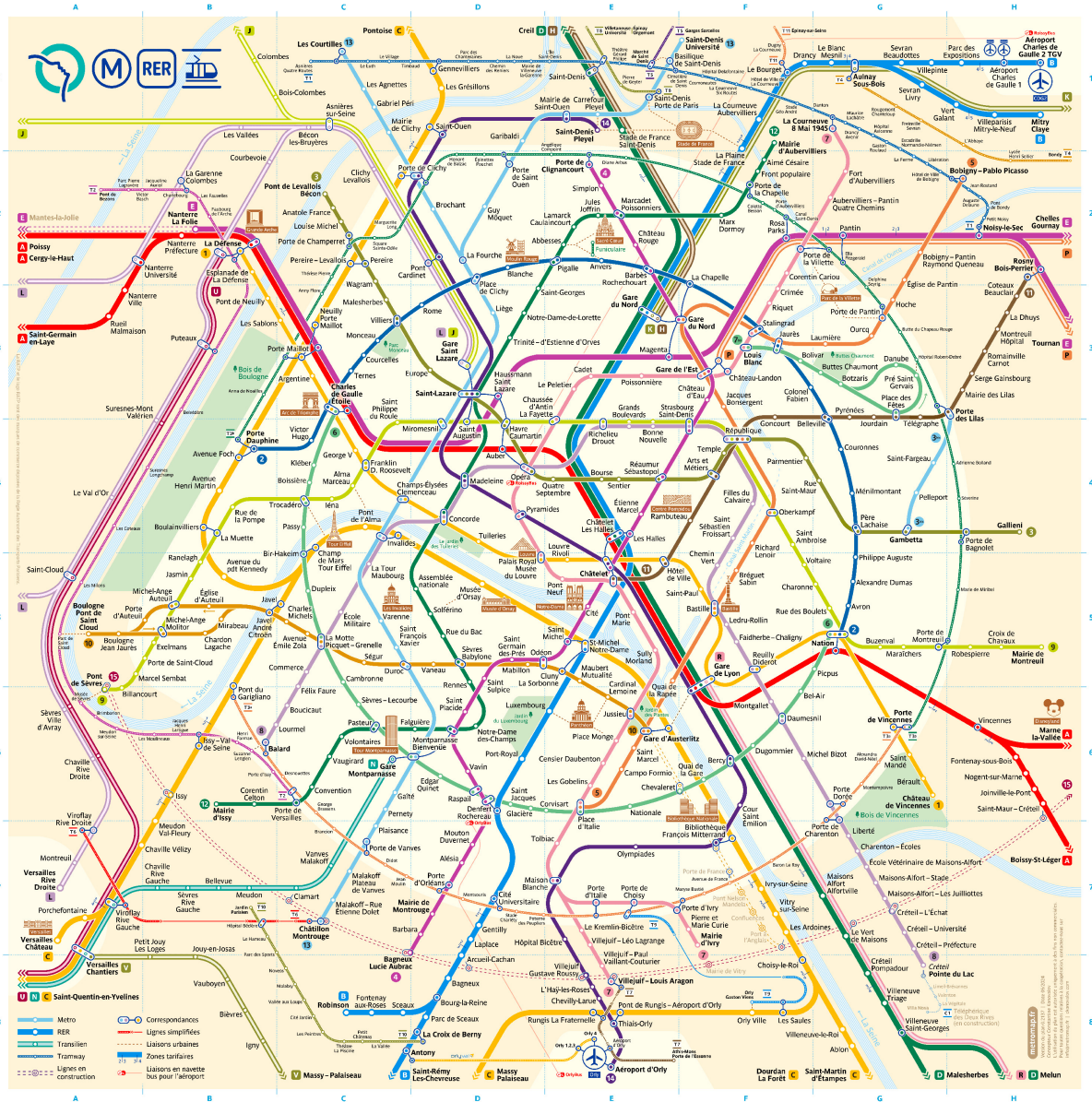
With the advance of computers, any design rules can now easily be combined with a circular arc, and some notable first attempts are included here – although none of these has been officially adopted. The earliest, in fact, is not a hybrid at all. It shows Madrid with a circular Line 6 but every section of every other line is also a circular arc, all combined together with smooth corners. The designer was Rafa Sañudo who, in 2007, put this forward as an alternative to another version that he was working on that depicted Madrid by only using horizontal and vertical lines (this is known as a *rectilinear* design or, alternatively *tetralinear*). Either way, Madrid was to receive a radical new design but the straight lines defeated the curves in this case.



Madrid Metro map, 2007, unpublished, by Rafa Sañudo.  
It is not a hybrid design, every line is a circular arc.



The next two designs are definitely hybrid. The first, originally released in 2016, created by Constantine Konovalov, combines a circle with dodecalinear angles (horizontal and vertical straight lines alongside others at 30° and 60°). However, there are, in fact, no vertical lines, so there are five angles, giving a *decalinear* map. Irrespective of this, there are a lot of angles to keep under control: the more angles a map permits, the harder it is to keep a design coherent. The result is certainly more organised than the 1936 design, earlier, but perhaps the ‘eureka’ map of Paris, where the network structure is revealed with crystal-clear clarity for all observers, still eludes us.



Paris Metro map, 2024 (original version 2016), unofficial, by Constantine Konovalov. Technically, it is a decalinear design with a circle, with a second due to be added in 2030.

The final design in this section, created by myself in 2020, returns to Moscow with a map that is probably as different as is possible from the earlier 1977 design. This maintains the perfect circular *Koltsevaya Line* (Line 5) but two further circular services are now added, Lines 11 and 14, which are difficult to show as circles without topographical distortion and an unbalanced design. I identified that making these egg-shaped would give a compromise, semi-regular configuration. To accompany these on this particular attempt, I made the rest of the lines Béziers: irregular curves in which I tried to minimise visible changes of curvature, sharp bends, and inflection points. This gives a flowing organic feel to the design and permits keeping topographical distortion under control, but perhaps results in a version that might induce seasickness in some people.



*Moscow Metro map, 2020, unofficial, by Maxwell J Roberts.  
Line 5 is the only regular curve in sight, the rest are Béziers.*



## Integrating curves and straight lines elegantly: Circles and spokes

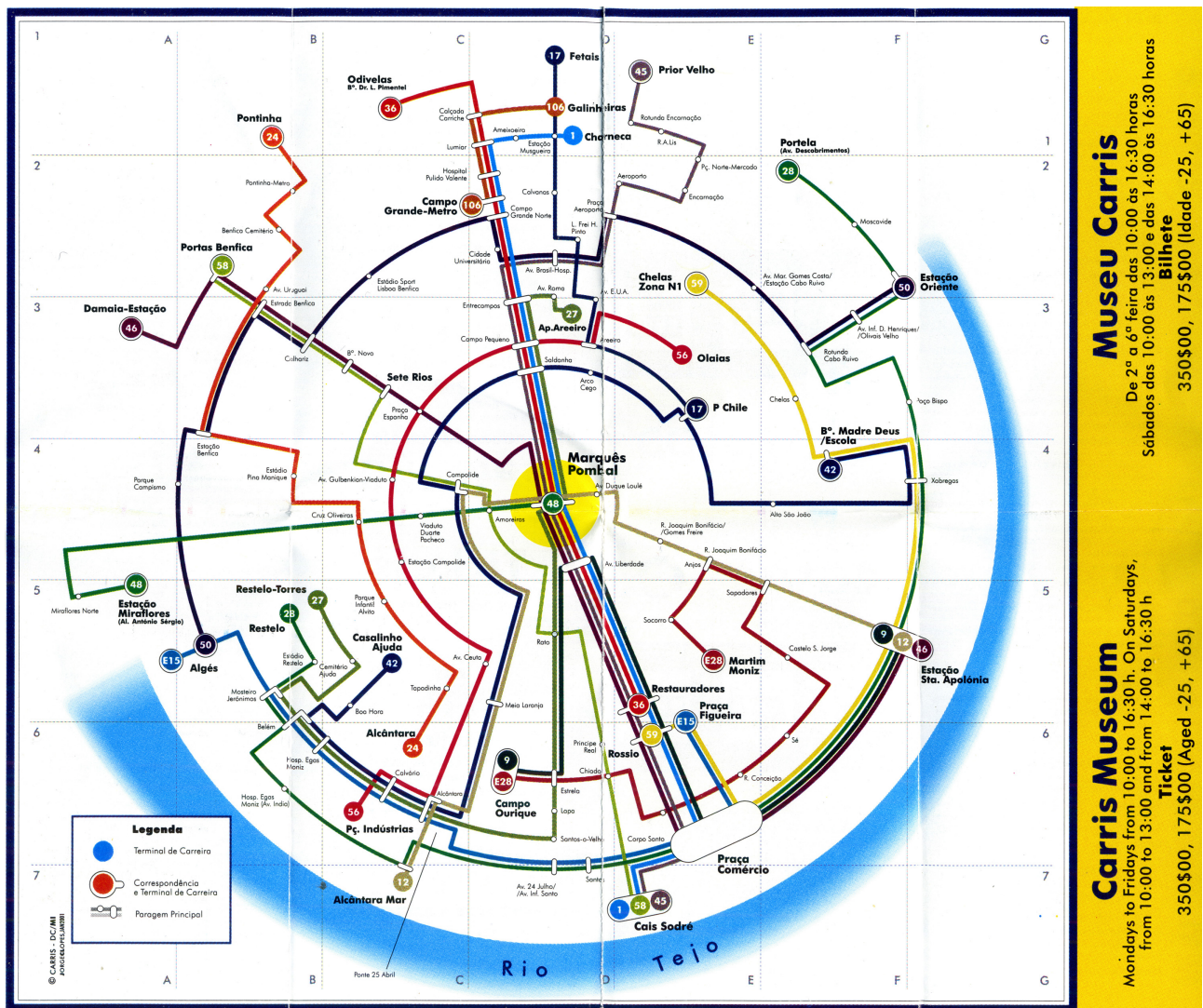
The solution for poorly integrated circles and straight lines is to adopt a more disciplined approach. If all straight lines radiate from the centre of the circle then every intersection between straight line and curve will be perpendicular, which ensures consistently integrated design everywhere. The earliest transit map I know of, which adopted this approach, was designed by Erik Spiekermann in 1989. Here, multiple circles and arcs are all centred on the same central point and, from this, all straight line segments radiate. Apparently, this radical departure from conventional octolinear maps was devised as a symbolic method for unifying the divided transport networks of Berlin after the dismantling of the wall.



*Berlin U- and S-Bahn concentric-circles-and-spokes prototype, 1989, designed by Erik Spiekermann. It was intended, conceptually, to unify the city.*

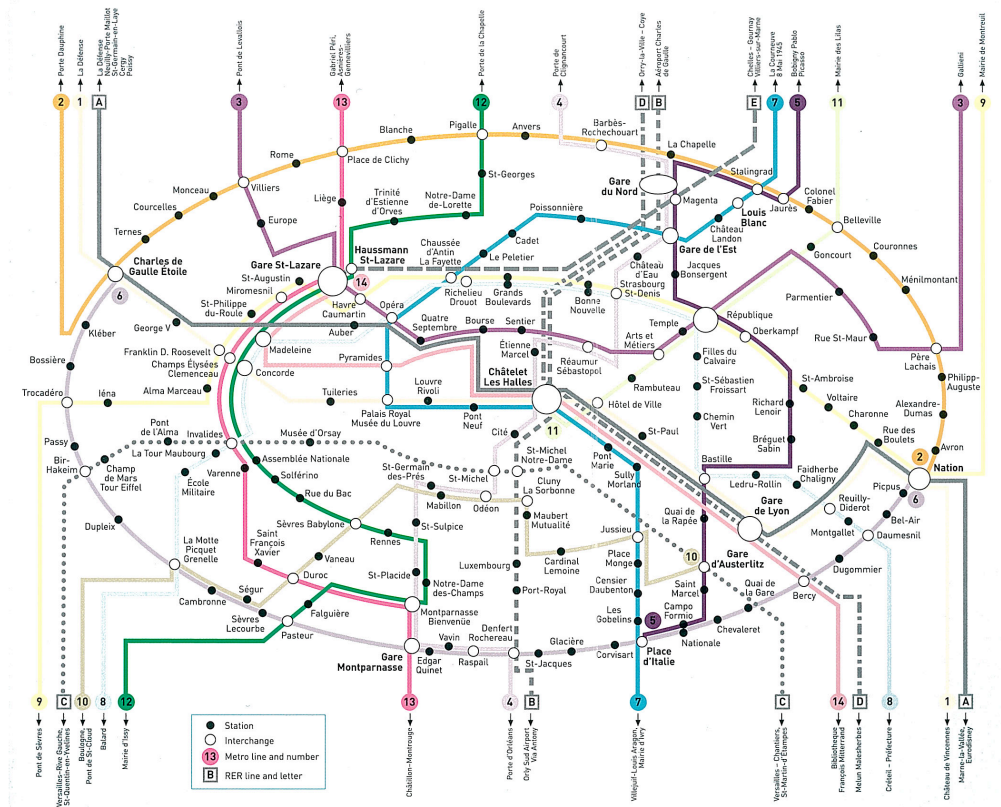
Spiekermann's design appears not to have been pursued and was never published, possibly because of the high level of topographical distortion that it exhibited. His eventual octolinear unification map displays far more fidelity in this respect. The earliest release of a concentric-circles-and-spokes map to the public, that I am aware of, is a remarkable official bus map for Lisbon from 2001. The city itself has some concentric/radial structure but, nonetheless, a lot of distortion was necessary to show the bus routes in this way. Passengers might have become rather confused when observing their buses taking different trajectories to those shown on the map.





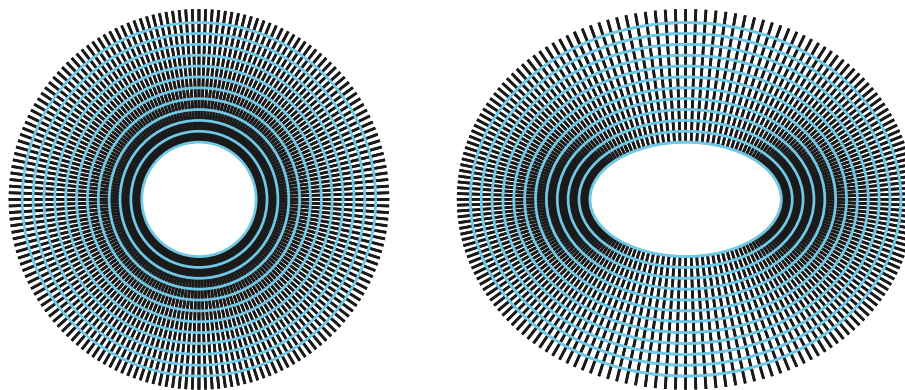
*Lisbon concentric-circles-and-spokes bus map, 2001.  
The central point is a major roundabout/road intersection.*

I did not become aware of the Berlin and Lisbon maps above until years after I had commenced my own explorations. Instead, the first similar design that I encountered was from a 2004 Paris guide book. Despite many cities having circle lines, these are generally not, in reality, circle-shaped. The orbital routes for Berlin, London and Paris are all elongated east-west. Attempts to force them into a circle will therefore result in east-west congestion and north-south sparseness. The guide book map addressed this problem by using concentric ellipses (ovals). It was an interesting idea but suffered some uncertainty regarding the trajectories of the straight lines. These are difficult to configure because there is no central point of radiation: every 'spoke' has to be individually calculated. Despite the resulting confused line trajectories inside the Line 2/6 orbit, the concept struck me as having potential, and was 'filed for future reference'.



*Paris Metro map, 2004, from art/shop/eat Paris.*

*There are four rings of ellipses but most of the straight lines are not perpendicular to them.*

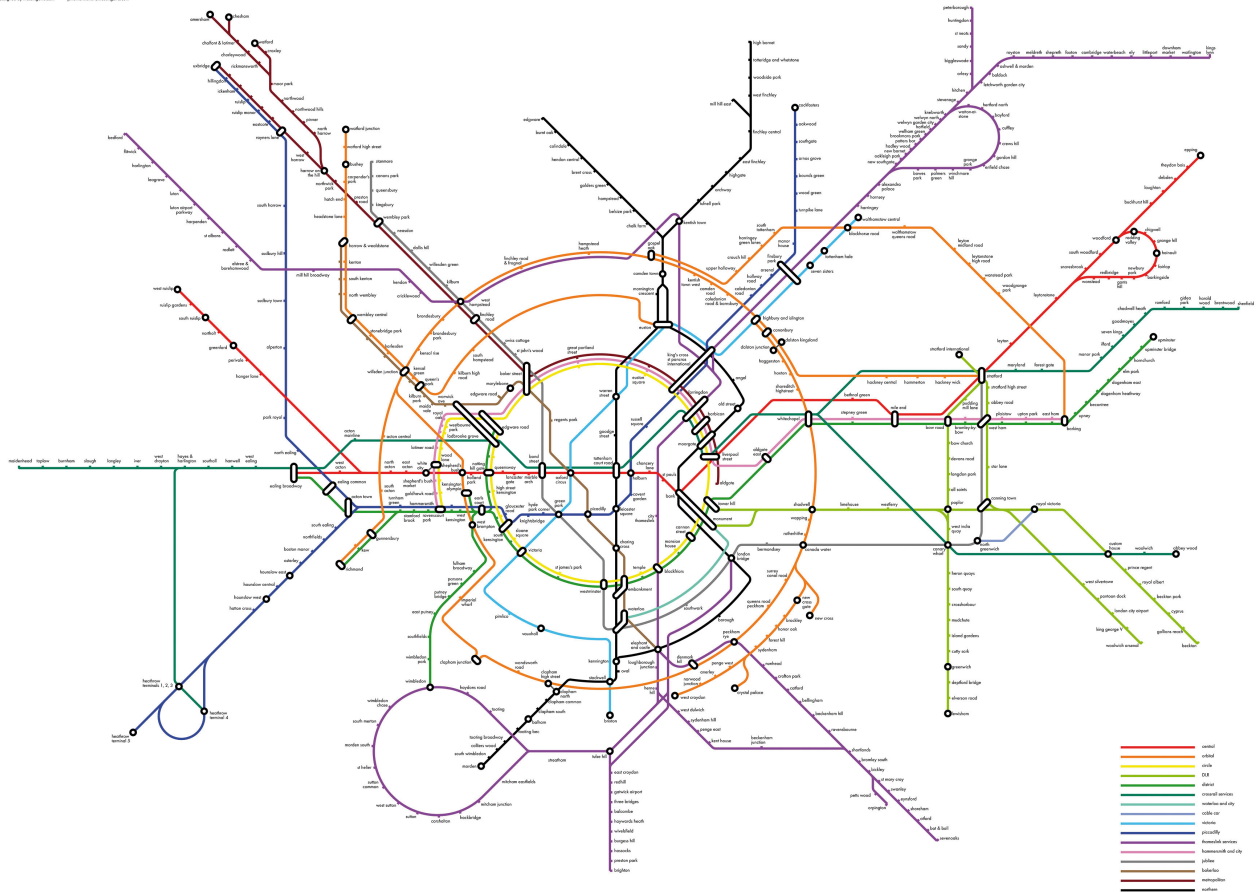


*Comparison of orbital/radial elements for concentric circles versus ellipses. In a vector graphics package the ellipses must be scaled manually to make them genuinely concentric and the perpendiculars must be calculated individually.*

## Round in circles on the London Overground

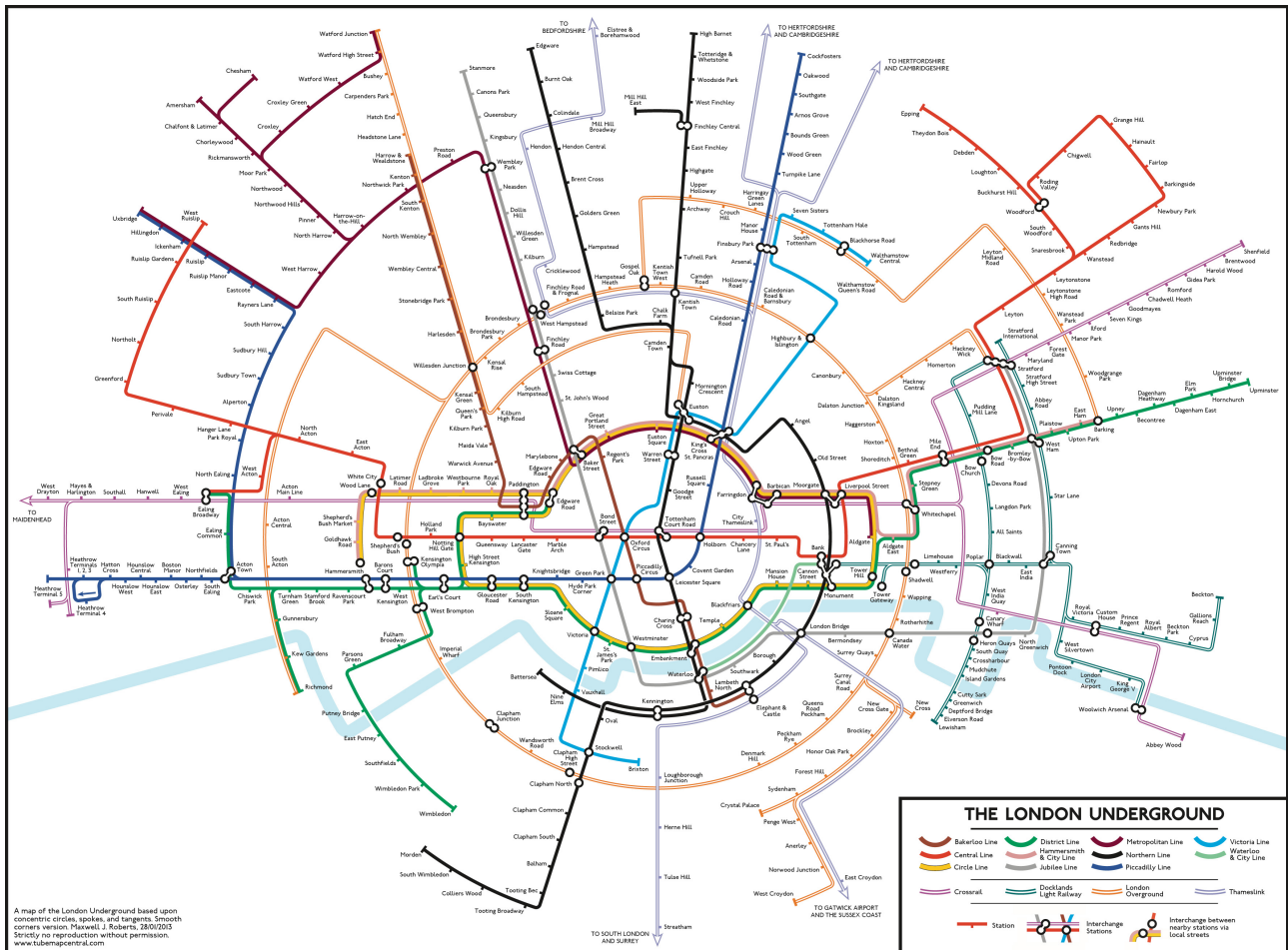
My involvement with concentric circles maps began with the completion of a major rail project to create an outer-orbital loop in London. This formed the basis of the newly-formed London Overground network. A number of people were suggesting that a good way to publicise this development would be for a rail map of London to show the new Overground loop as a circle. The map that implemented this, and caught my attention, was designed by Jonathan Fisher in 2012. It featured multiple concentric arcs but the straight lines were at standard octolinear angles. In other words, there were few actual spokes.





*London Underground concentric circles map, 2012, by Jonathan Fisher, 2012.*

My own observations with Fisher's design were that (1) the Circle Line was a perfect circle, and this was causing a lot of topographical distortion; (2) the overground loop was *not* a perfect circle, and this was, in part, owing to (1); and (3) there were problems with the coherence of this design. There were many circular arcs but many straight lines not perpendicular to them. Remembering the 2004 guide book map, I decided that it would be an interesting challenge to attempt a concentric-circles-and-spokes design. However, at the time my project was intended more as light-hearted entertainment rather than serious design, resulting in numerous compromises. Many of the straight lines are not, in fact, spokes. Some are tangents to curves, some are parallel to other spokes. Also, there are many instances of high levels of topographical distortion which would be out of place on a serious prototype. Nonetheless, I completed the design and let it loose on the world early in 2013.



*London Underground concentric-circles-and-spokes map, 2013, by Maxwell J. Roberts.*

## My explorations of concentric circles maps: The devil is in the data

To say that I was astonished by the collective internet response to my London Circles map would be an understatement. The design was picked up by numerous media outlets and bloggers, including national newspapers. A substantial number of these expressed a desire that London would adopt my design officially. Inwardly I wished that I had taken more care with certain aspects of the map but one thing was clear: a concentric circles map can present a powerful image that attracts people's attention.

I therefore embarked upon a design tour, in which I investigated concentric circles maps for numerous cities worldwide, focusing on those with a loop line of some sort. The purpose of this was for me to familiarise myself with how these maps functioned from a design perspective: which cities seemed well-suited to them and whether there appeared to be genuine benefits to mapping them in this way. A number of these designs are on my web pages, either in my poster shop or my newsletter archive:

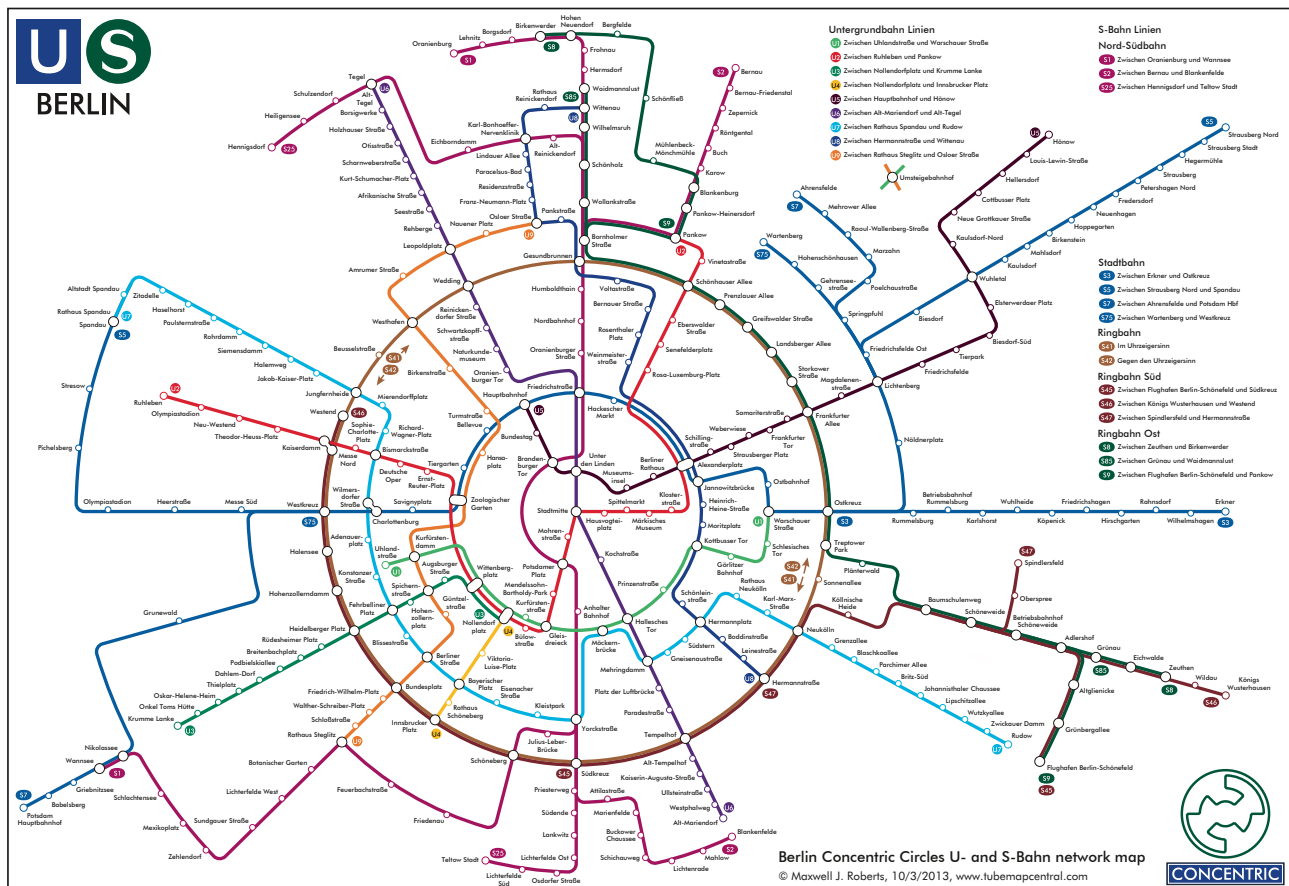
<http://www.tubemapcentral.com/webshop/circles.html>

<http://www.tubemapcentral.com/writing/newsletter.html>

An important caveat is that, just because I publish a map, this does not mean that I am advocating it or making any recommendation. For many of them I was interested in the outcome as a learning experience, and I wished to share this. Mapping is an inherently visual activity and I don't believe that anyone can predict the results of a new approach. The idea has to be implemented before it can be evaluated.



Some highlights of my explorations include Berlin (designed without awareness of Spiekermann's earlier attempt). This was the first circles map that I was able to complete without breaking my own design rules – every straight line is a spoke.



Berlin U- and S-Bahn concentric-circles-and-spokes map, 2013, by Maxwell J. Roberts.  
All of the straight lines are spokes on this diagram.

My New York City Subway map was particularly surprising. The city has a grid structure and the Subway has no substantial orbital component. In theory there should have been a mismatch between the city structure and these design rules. In practice this was one of my most powerful and successful designs. It led me to wonder whether the key to a good concentric circles map might be a strong underlying radial structure rather than clear orbital routes.



New York City Subway concentric-circles-and-spokes map, 2015 (first version published 2013), by Maxwell J. Roberts. Note that the geometric centre of the map is outside the city. Only the G line (light green) provides a truly orbital service.

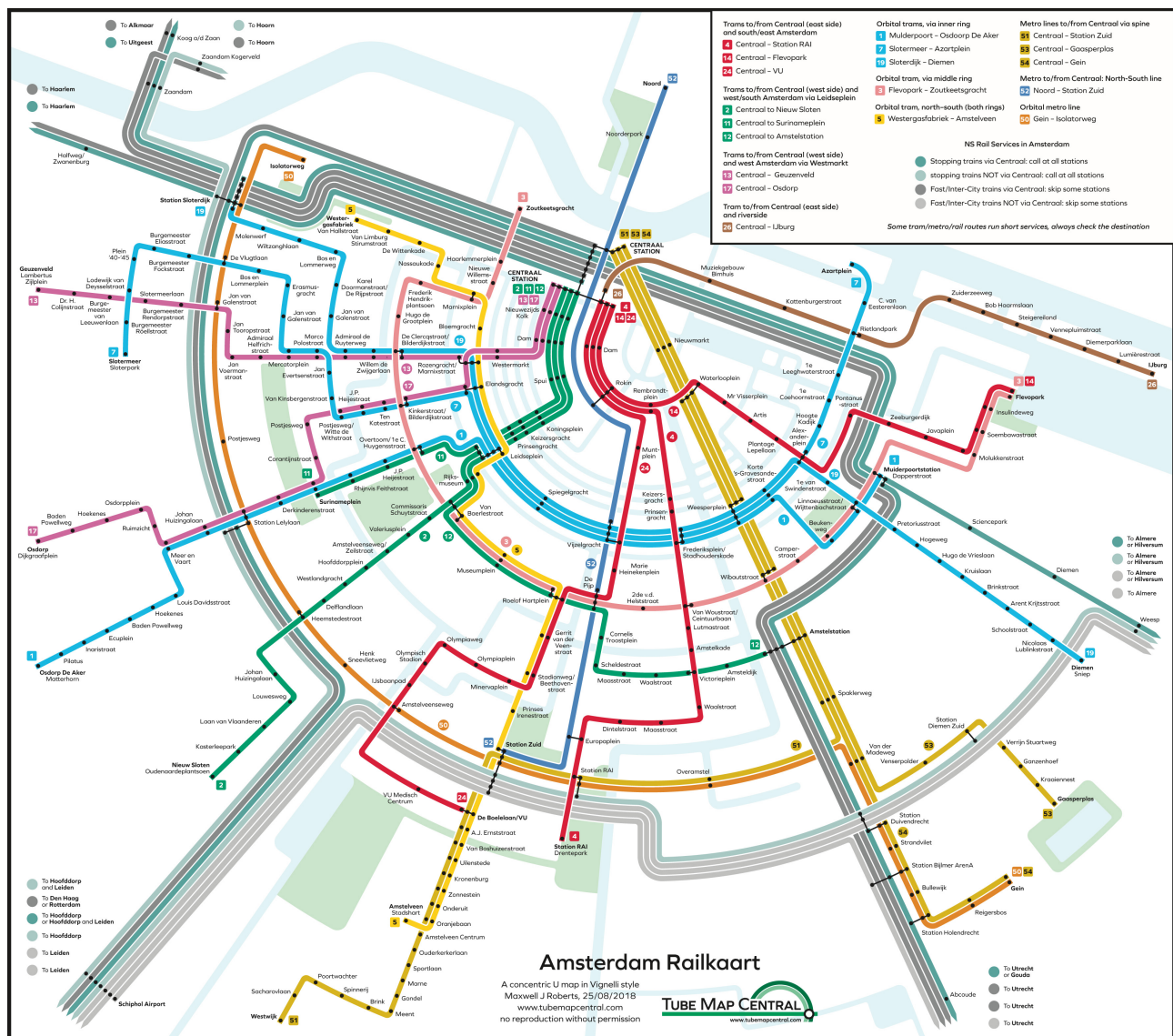
Why might concentric circles maps have such a strong impact? In terms of my framework for effective design, (see [http://www.tubemapcentral.com/showcase/d1\\_transit\\_map\\_design.html](http://www.tubemapcentral.com/showcase/d1_transit_map_design.html)) such maps inevitably have poor simplicity of line trajectories: Each individual line has many twists and turns, necessary because most lines are not perfectly orbital or perfectly radial, and mixing the two necessitates transitions from radial straight line to orbital curved segment and back again. Complex line trajectories are hard to identify and follow. On the other hand, such maps have high coherence: the various elements relate to each other to give the overall design good shape. Designing a map in this way strictly divides the lines into radial and orbital components, making explicit the nature of each and how it relates to the rest. We therefore seemed to have the basis of interesting usability experiments. These would compare conventional octolinear maps with simple line trajectories (but not necessarily high levels of coherence) with concentric circles maps with high coherence (but not necessarily simple line trajectories).

We tested octolinear and concentric circles maps of Berlin, asking people to plan journeys between pairs of stations. We measured the difficulty of this by seeing how much time people needed for the task. We also asked people to express their opinions on the designs by filling in questionnaires in which they rated the maps according to different criteria. The results were clear. The Berlin Concentric Circles map was slower to use and disliked compared with the equivalent octolinear design. The maps might be popular on the internet but once people tried actually to use them, they seemed to have second thoughts.

## Circles for cities

Did the negative results of the usability studies signal the end of circles maps? Are they better as wall art than tools for navigation? Not necessarily. My belief is that every city is different and that one task for the designer is to identify the rules that best-suit the particular one being mapped. A modern grid city requires different techniques to an ancient one with rambling streets. There are, in fact, a few cities which do have a genuine concentric ring structure along with radiating spoke-like streets.

Amsterdam has a clear concentric structure, particularly in the historic centre with its famous canals. The structure is more U-shaped than circular but that is still well-suited to this type of map. The choice of central point is important for any concentric circles design. A poor selection will quickly run into difficulties and unbalance the result. Amsterdam is one of those cities where the most appropriate physical centre is not necessarily the most important commercial centre. If Nieuwmarkt is chosen (rather than the more commercially obvious Centraal Station) then showing the canal rings in a topographically meaningful way becomes a lot easier.



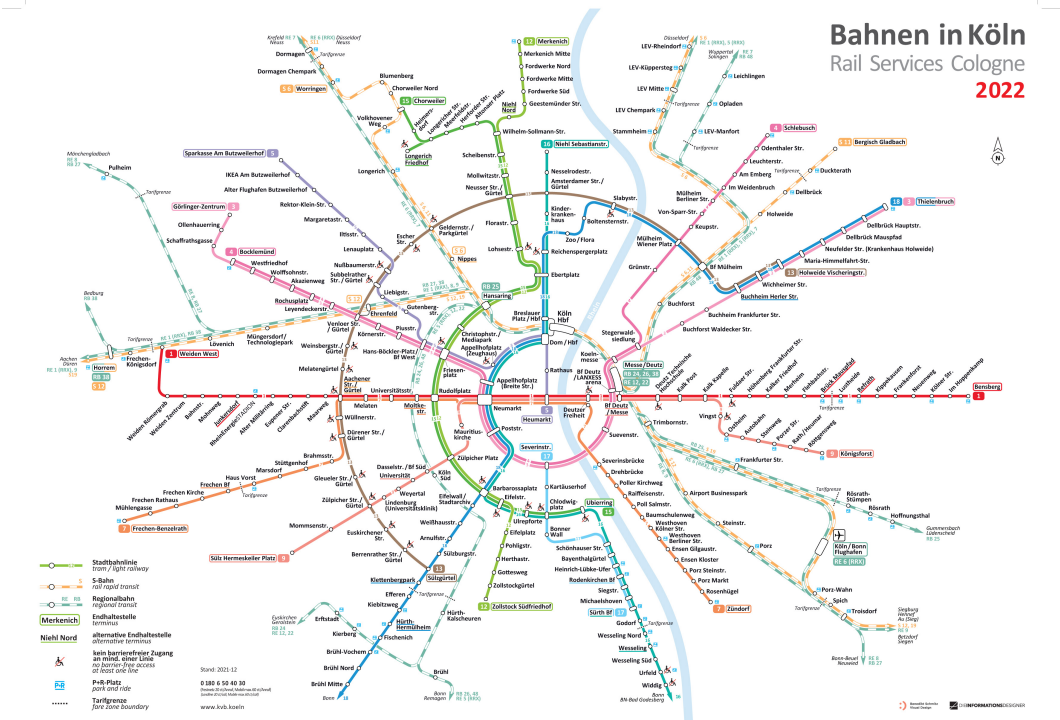
Amsterdam Tram, Metro and Rail concentric U map, 2018, by Maxwell J. Roberts.  
Note the correctly represented, schematised canals.



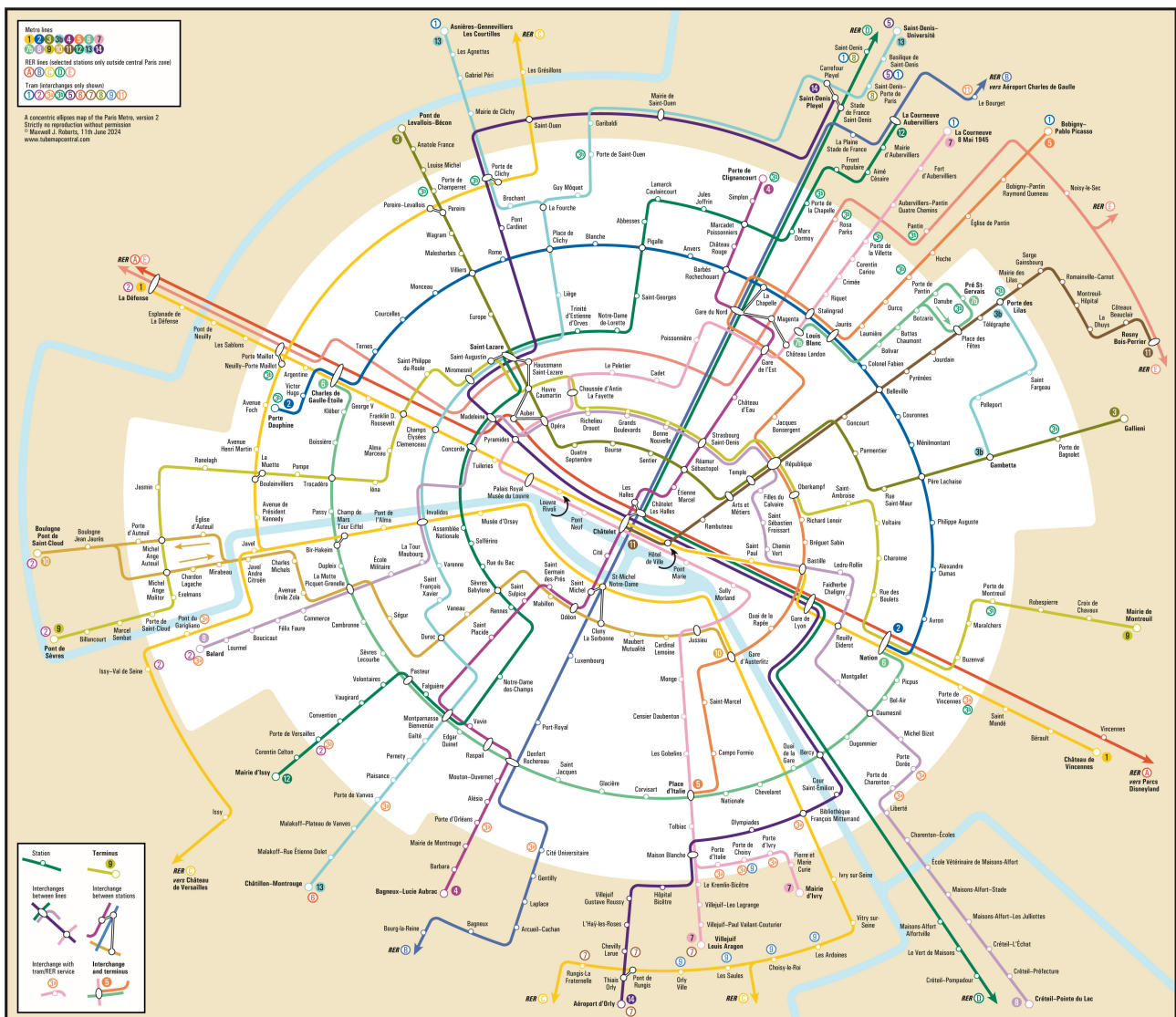
Köln is another excellent example of a concentric city, and I am delighted that the city adopted a concentric-circles-and-spokes map, based on my own design, in 2022.



Köln U- and S-Bahn concentric-circles-and-and-spokes map, 2016, by Maxwell J. Roberts (above), and the officially adopted map, based on this design and issued in 2021 (below).



Paris might be a good candidate for a concentric map for different reasons. The shape of the city itself is not inherently structured in this way, but the Metro network is so knotted that it almost defies attempts to show it in a clear, coherent way using octolinear angles. Here, I have attempted a concentric ellipses map to match the shape of the city and create a more balanced design than if I had used circles. However, as for any map that I create, I would want to see its efficacy established in usability testing before recommending adoption.



Paris Metro concentric-ellipses-and-spokes map, 2024 (first version published 2017).  
Note how the proportions of concentric ellipses change as they enlarge.

### Concentric for a publicity: TfL brings back circles

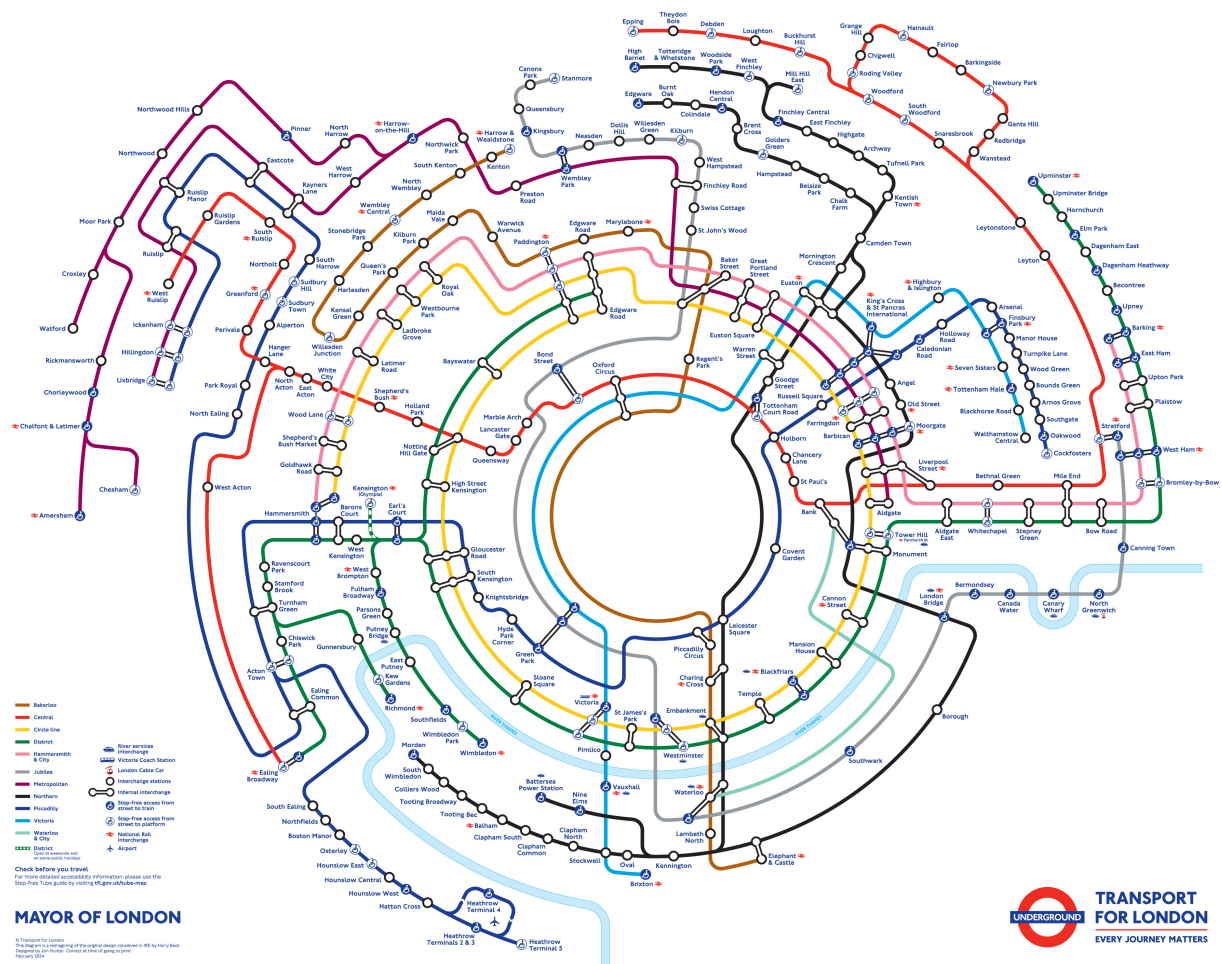
After my burst of circles map creativity in the mid 2010s, I pursued other projects. Concentric designs continued to pop up from time to time, worldwide. Sometimes these were intended for use by passengers to plan journeys. A few of the maps were official designs. Others were intended as speculative designs or works of concept art, in which usability was not an obvious consideration. I noticed that, quite often, these types of map were deemed to have publicity value, such as a 2019 aspirational map issued by the office of the Mayor of Manchester. I am not sure what people were supposed to make of this, except that it looked suitably futuristic.



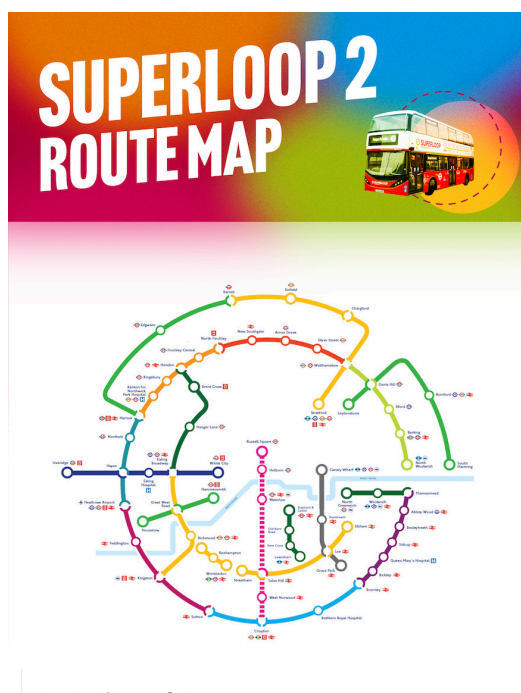
*Manchester public transport aspirational map, 2019. This looks impressive but is more or less incomprehensible. Its purpose seems to be to impress rather than to inform.*

More recently, Transport for London itself has created a concentric circles map of the London Underground lines. This was designed, in conjunction with a mobile phone company, as part of an advertising campaign, but it is also possible to purchase the map without the advertiser's branding. The map serves its purpose as a memorable image but it is not something that I would recommend people use for planning journeys, although it might be fun to try. This level of distortion on a map is very likely to result in people planning inefficient or roundabout routes. However, recent publication by TfL of an aspirational map for *Superloop* bus routes suggests that more concentric circles designs might be on the way.





London Underground concentric-circles-and-spokes map, 2024, issued by Transport for London. Intended to advertise a mobile phone brand, it was not intended for use, although it was placed on stations as part of the campaign.



London Superloop concentric-circles-and-spokes map, 2024. This map of future bus routes suggests that Transport for London might be seeing potential for such designs in London.