How public transport accessibility improved in the Dutch Randstad during the 2010s

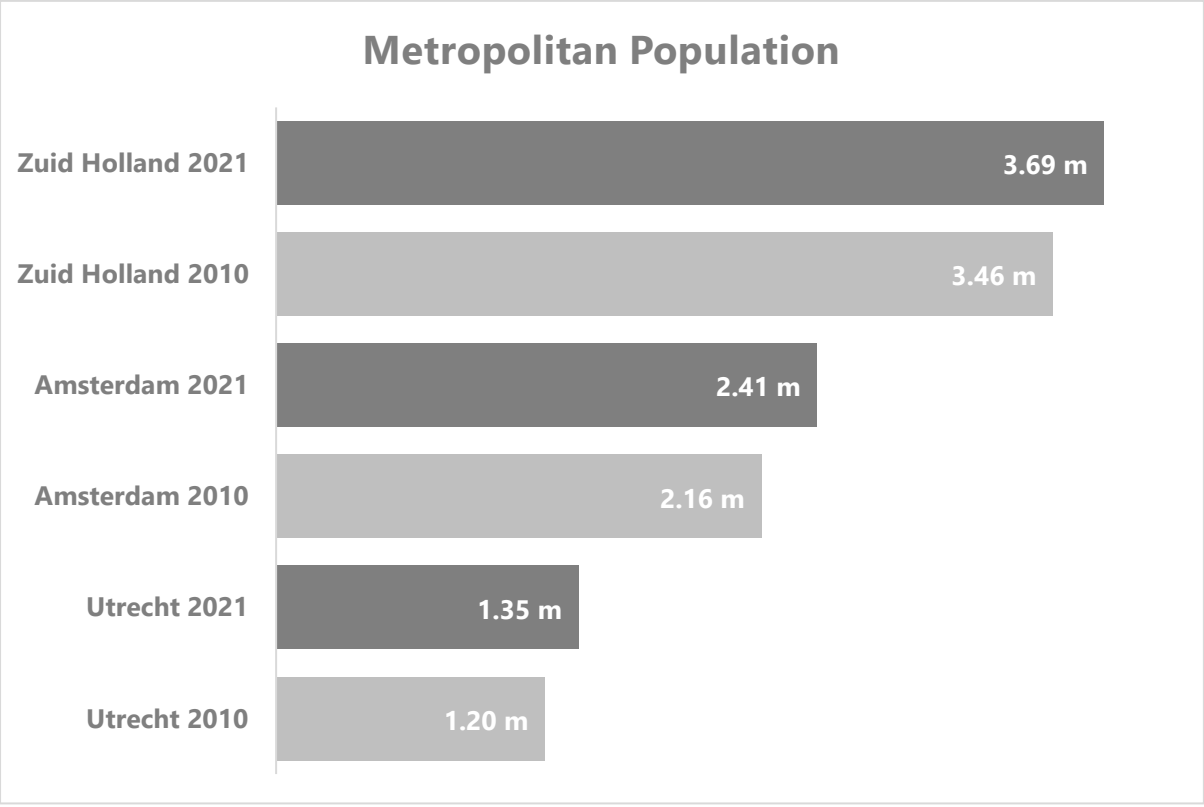
This blog post summarises the SNAMUTS results from two investigations of public transport accessibility and network performance in the Dutch Randstad, taken in 2010 and 2021.

We look at what changed in this urban agglomeration during a decade of rapid population growth and a range of public transport infrastructure and service initiatives.

The three sub-regions of the Randstad in this analysis are defined as follows. 'Amsterdam' contains the entire province of Noord Holland except the region of Noord Holland Noord and the island of Texel, and additionally the city of Almere in the province of Flevoland. 'Utrecht' and 'Zuid Holland' are identical to the provinces of the same name.

A growing region

During the 2010s, overall population grew in all sub-regions – by 150,000 in Utrecht province, and by 250,000 each in metro Amsterdam and in Zuid Holland. Municipal amalgamations in 2019 shifted approximately 35,000 residents between provinces (from Zuid Holland to Utrecht) – this effect is included in the figures.

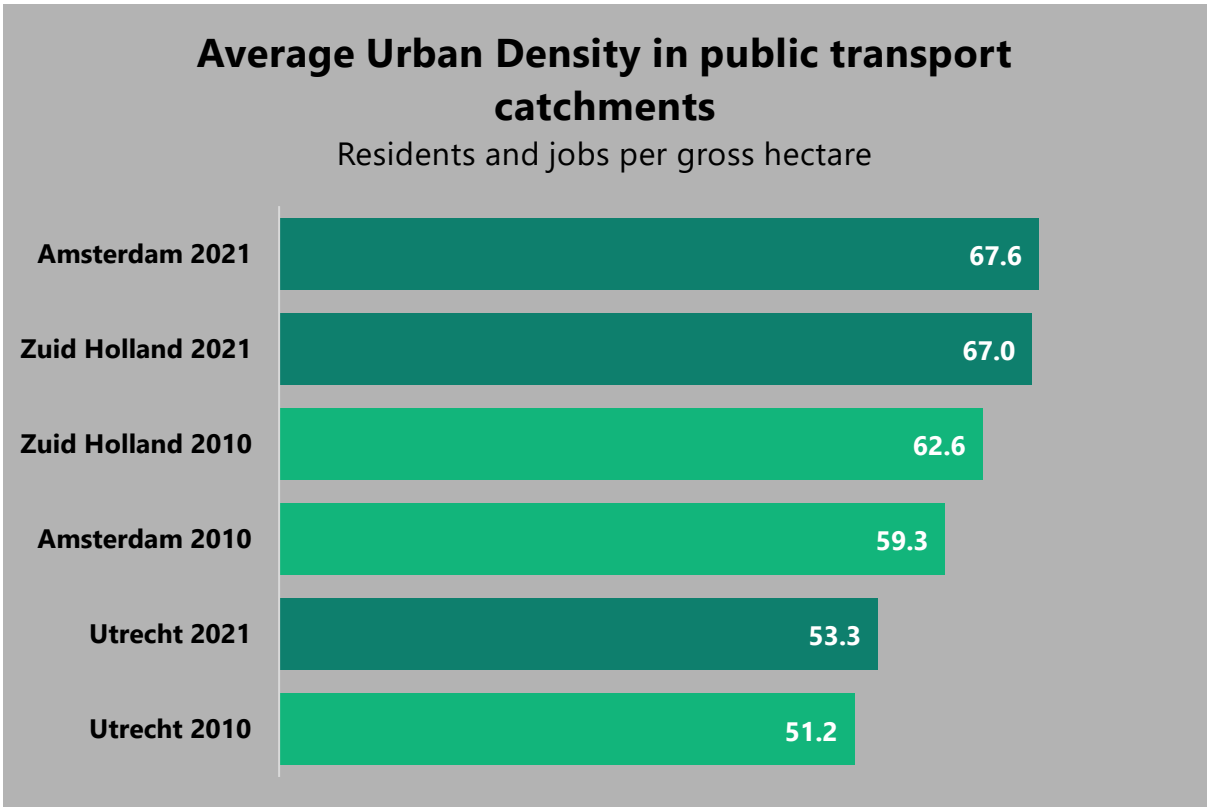


SNAMUTS randstad 2010-21 bar graph (metro population).tif

Randstad cities are getting denser

Urban density around public transport also increased in all sub-regions – though the shift was more pronounced in Amsterdam (+8.3 res+jobs/ha) than in Zuid Holland (+4.4) and Utrecht (+2.1). This is mostly due to urban intensification in inner areas and around selected suburban rail hubs (Rokin-Leidseplein, Jan van Galenstraat-De Baarsjes, Zuidas, Muiderpoort, Diemen Zuid and IJburg in Amsterdam; Vleuten-Terwijde, Vaartsche Rijn, central Amersfoort and Vathorst in Utrecht; central

Den Haag, central Rotterdam, central Leiden, Wilhelminaplein-Rijnhaven and Plaspoelpolder in Zuid Holland).



SNAMUTS randstad 2010-21 bar graph (urban density).tif

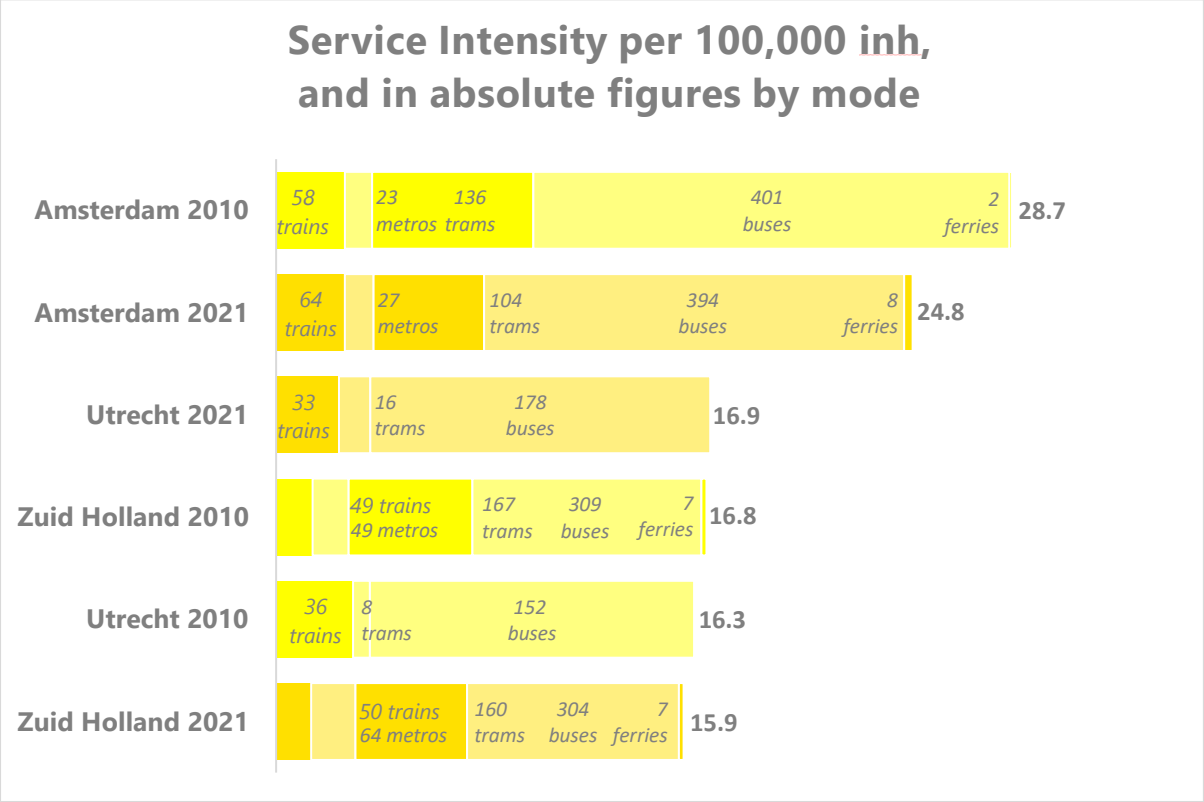
[Note that these comparisons are based on shifting network configurations and thus do not necessarily contrast identical land areas for the two base years.]

Download SNAMUTS network diagrams: Urban Density		
Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

Public transport service output remains unevenly distributed and did not grow relative to population

Public transport service intensity (number of trainsets and vehicles in simultaneous revenue operation relative to population) was nearly 75% higher in Amsterdam in 2010 than in Utrecht and Zuid Holland at the same point in time. In all three sub-regions, this index shows a decline in service intensity over the decade of the 2010s, though only marginally so in Utrecht and Zuid Holland and more tangibly in Amsterdam. However, by 2021 Amsterdam's service intensity was still more than 50% higher than that of its southern neighbours. Moreover, Amsterdam's decline in service intensity had less to do with a geographical contraction or service cuts – rather, it can largely be attributed to the opening of a new metro line in 2017 (a mode that tends to be very economical with operational input) and a concurrent comprehensive reorganisation of its tram and bus network. This

reorganisation led to the reduction of tram and bus frequencies on radial corridors parallel to the new metro line, where they operate in inherently slow environments along busy surface streets and thus inflated the 2010 service intensity figure.



SNAMUTS randstad 2010-21 bar graph (service intensity).tif

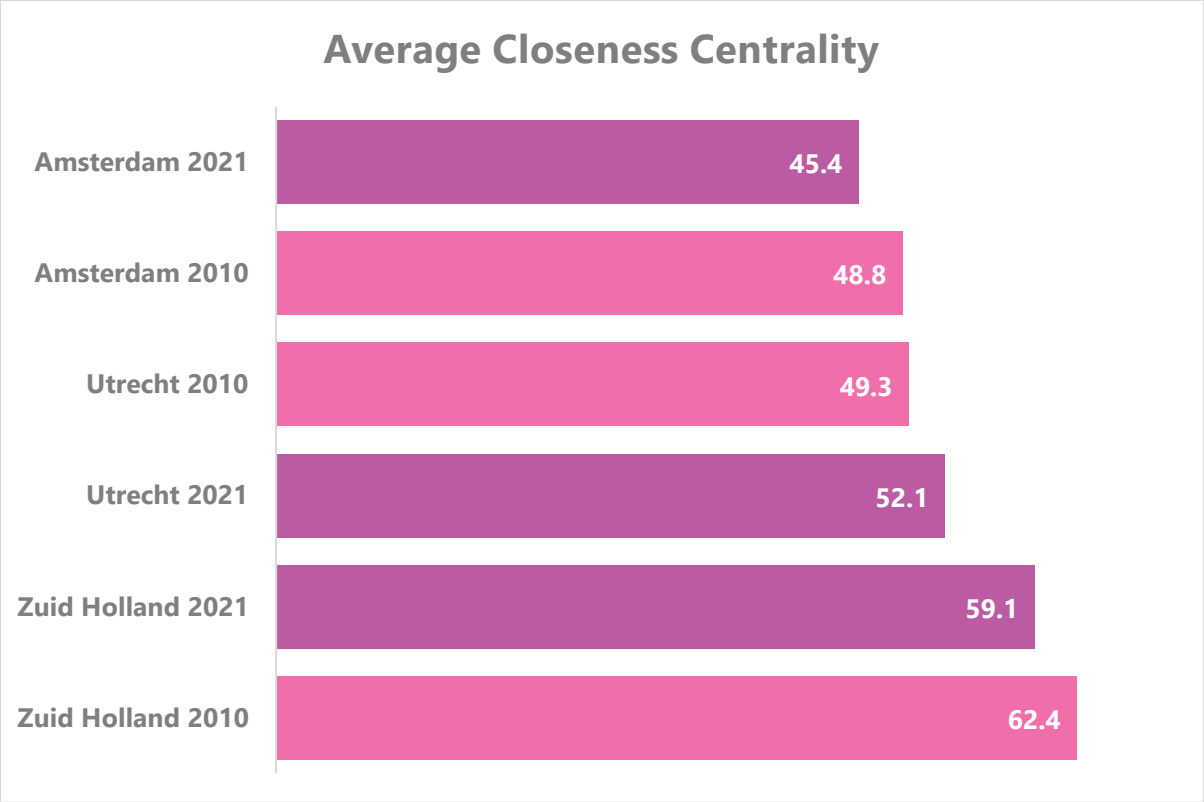
In Zuid Holland, a rail branch line (Schiedam-Hoek van Holland) was transferred from national rail (NS) to metro operation in 2019; this is considered in the figures. Also in 2019, a new sneltram (LRT) line opened between central Utrecht and the university district (Uithof); it represents the only significant tram extension anywhere in the Randstad since 2010. In Amsterdam, a light rail branch line that formed part of the metro network in 2010 (Amsterdam Zuid-Amstelveen Westwijk) has been operated separately since the network reconfiguration in 2017 and is counted under the tram figures in 2021.

In all three sub-regions, examples can be found for both improvements and reductions in service frequencies, leading to some 2010 bus routes falling below the SNAMUTS minimum service standard and others meeting it for the first time in 2021.

Ease of movement: are travel times and frequencies improving?

The closeness centrality index measures the ease of movement on a public transport network, taking in travel time and service frequencies as factors of spatial separation. Lower figures indicate greater centrality. On average, this index improved markedly in Amsterdam and Zuid Holland, but deteriorated in Utrecht between 2010 and 2021. In Amsterdam, this effect can confidently be attributed to the new metro line offering faster movement opportunities, as well as the addition of several express bus routes creating new links along geographical desire lines (for example between Haarlem and Amsterdam Zuid, and between Sloterdijk and IJmuiden). The latter effect is also present in Zuid Holland, as are frequency improvements on some metro and bus routes. In absolute figures however, the relatively high (poor) scores on this index in Zuid Holland relate to a less

compact settlement area that is scattered over a several spatially separate centres with fewer links between them than in Amsterdam and Utrecht. In Utrecht, the decline in average ease of movement is likely due to the inclusion of a greater number of peripheral nodes into the higher-frequency bus network, including Leerdam which moved provinces from Zuid Holland to Utrecht in 2019.

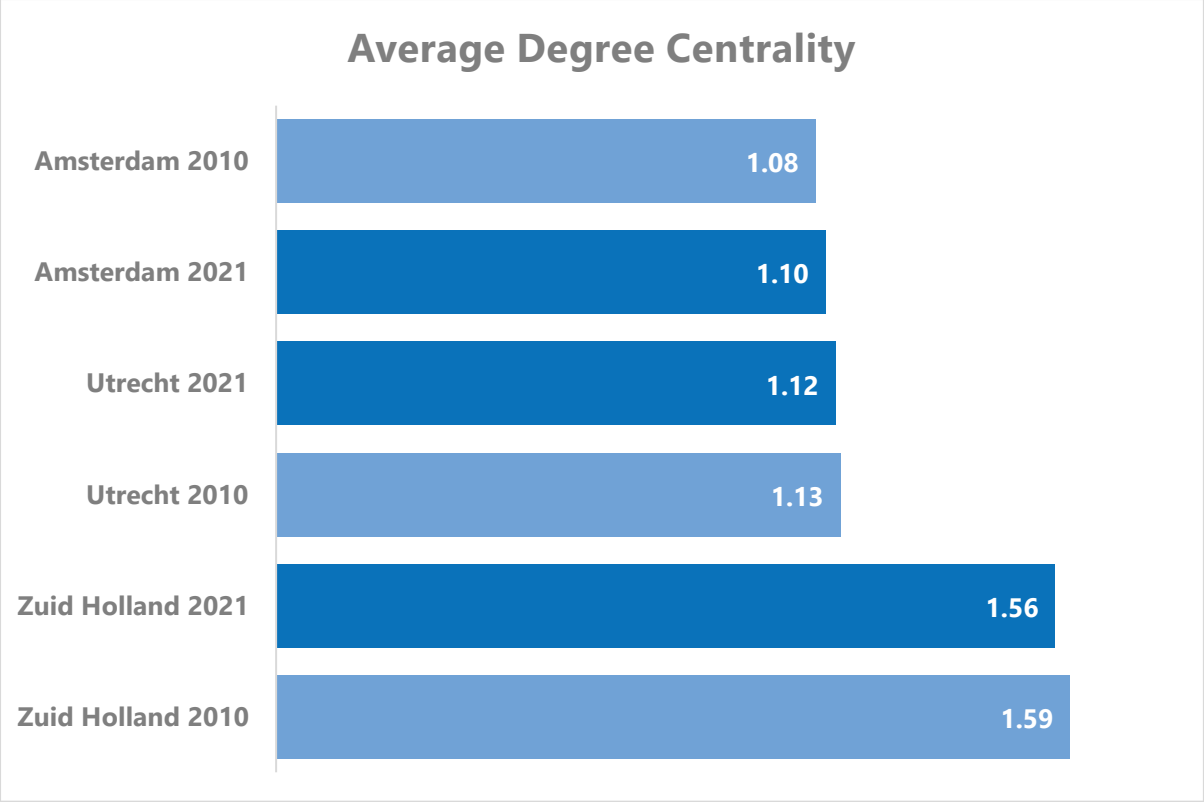


SNAMUTS randstad 2010-21 bar graph (closeness centrality).tif

Download SNAMUTS network diagrams: Closeness Centrality		
Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

Transfer intensity: is the network making us change modes more often or less often?

Degree centrality measures the degrees of separation between origins and destination; in a public transport network, such degrees of separation are experienced as transfers. Lower figures indicate lower transfer intensity. This index saw only marginal change during the 2010s in all three Randstad sub-regions: Amsterdam's public transport became very slightly more transfer-intensive (largely due to many radial lines from the Waterland region north of the city to Amsterdam Centraal being converted to metro feeders at Amsterdam Noord), while Utrecht's and Zuid Holland's became slightly less so. Note again the markedly higher average transfer dependency in Zuid Holland compared to the other two sub-regions; this is due to the relatively self-contained, separate urban networks in Den Haag and Rotterdam (and to a lesser extent, in the smaller cities of Leiden and Dordrecht) having only a limited number of connections with each other.

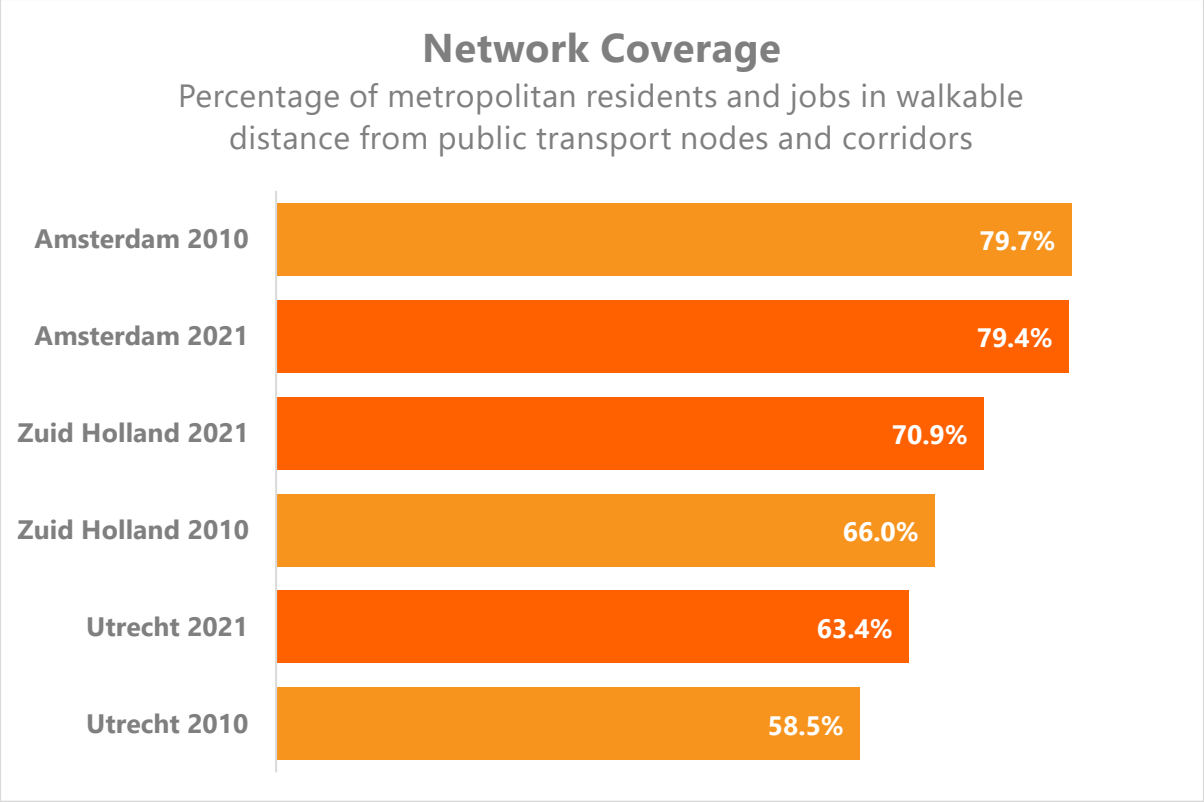


SNAMUTS randstad 2010-21 bar graph (degree centrality).tif

Download SNAMUTS network diagrams: Degree Centrality		
Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

Network coverage and 30-minute contour catchments: who gets access and can we travel further in less time?

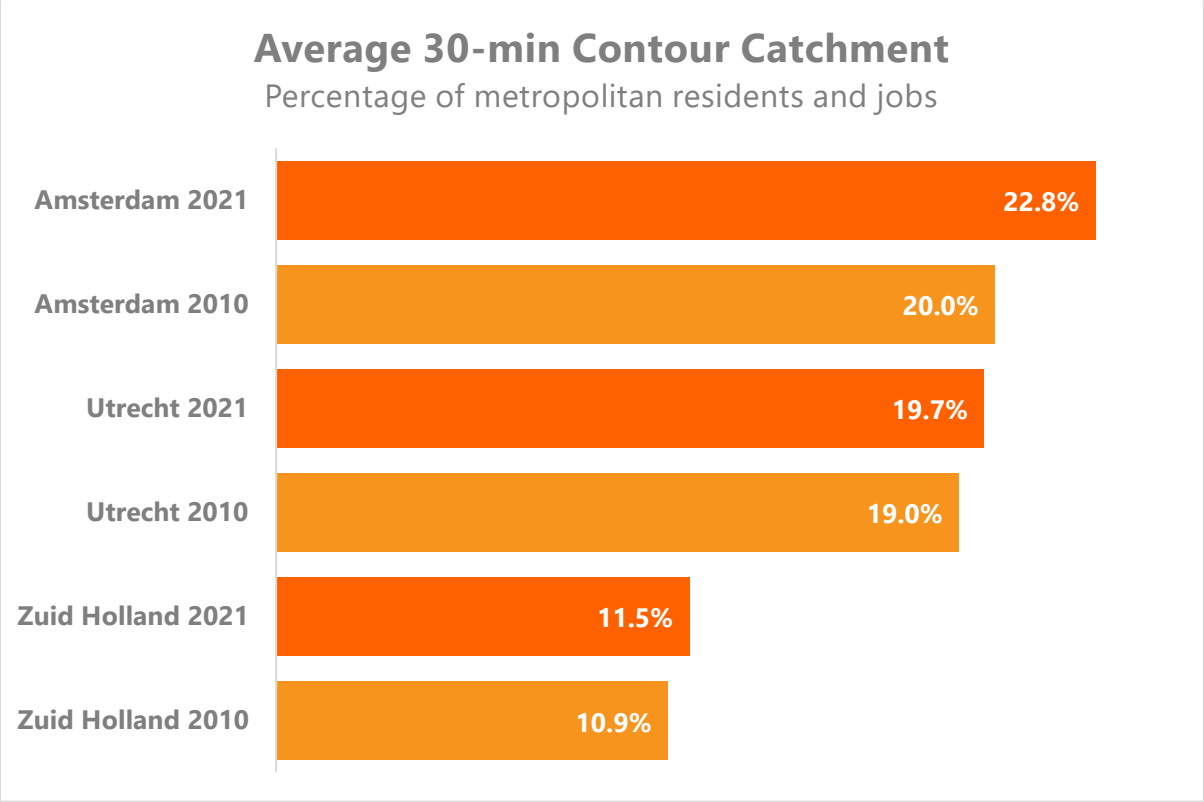
Four in five residents and jobs in the Amsterdam metropolitan region were within walking distance to public transport at the SNAMUTS minimum standard in 2010; in Zuid Holland, this was only true for two in three residents and jobs and in Utrecht, less than three in five. By 2021, the network coverage figures in Zuid Holland and Utrecht had increased by some five percentage points each, an effect of both urban intensification and a larger geographical extension of the networks. In Amsterdam, this indicator saw a stagnation from its already high level.



SNAMUTS randstad 2010-21 bar graph (network coverage).tif

In contrast, the average percentage of sub-regional residents and jobs that can be accessed by way of a public transport journey of 30 minutes or less (contour catchment) increased only marginally in Zuid Holland and Utrecht, but quite markedly (and from an already higher base) in Amsterdam between 2010 and 2021. This difference underscores the impression that public transport improvement measures during the 2010s in Zuid Holland and Utrecht mostly aimed at greater geographical coverage of useful services, with the main beneficiaries being suburban growth nodes (particularly the Leidsche Rijn area in Utrecht and the Pijnacker-Berkel-Rodenrijs area in Zuid Holland). In contrast, in Amsterdam a greater focus was placed on improving speed, capacity and performance within the footprint of the existing network, with the main beneficiaries being the new stations along the north-south metro line opened in 2017, mostly located in the inner city (Amsterdam Noord, Noorderpark, Rokin, Vijzelgracht, De Pijp and Europaplein), as well as some established suburban nodes where new express buses or better connected local buses increase the range of movement opportunities by public transport (Houthavens-Spaarndammerbuurt, Nieuw Sloten).

Looking back to the findings on urban density dynamics mentioned above: in Utrecht and Zuid Holland, public transport development continues to predominantly follow or chase land use development. In Amsterdam, there is now a significant effect of urban development chasing or concentrating around public transport development.

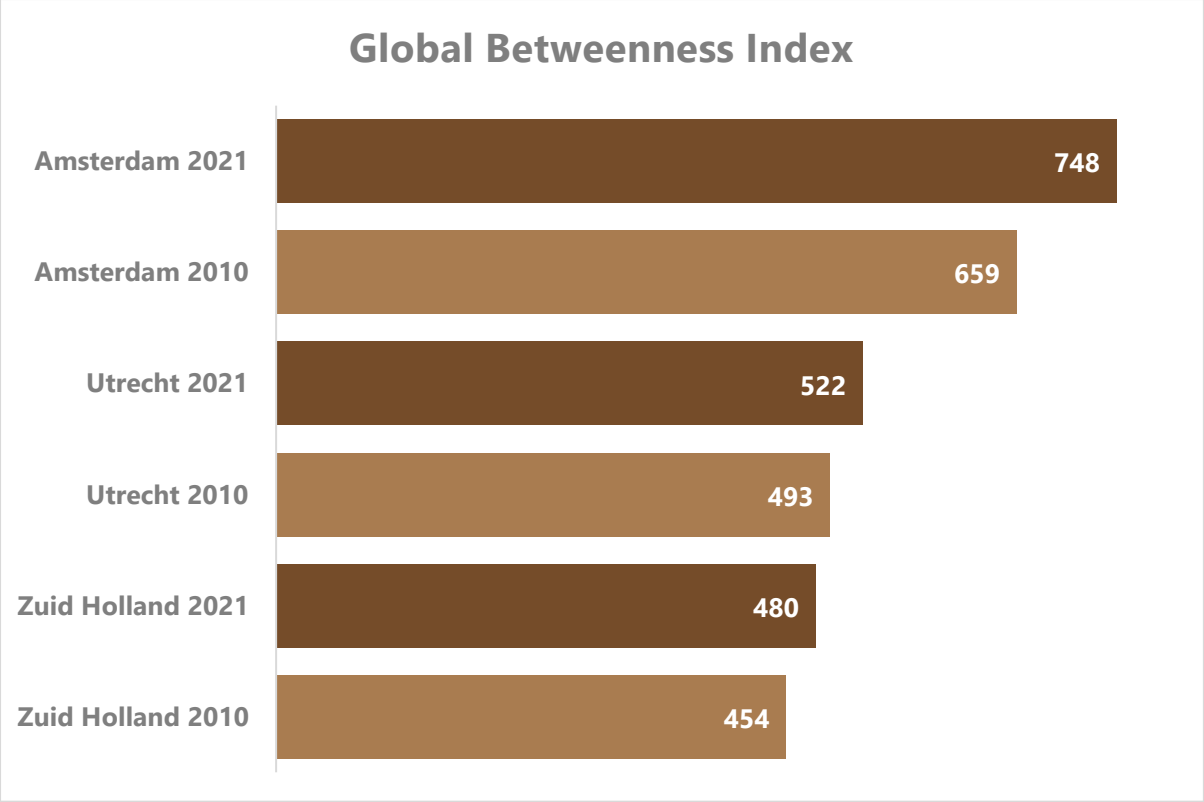


SNAMUTS randstad 2010-21 bar graph (contour catchments).tif

Download SNAMUTS network diagrams: 30-min Contour Catchments		
Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

Betweenness centrality: how does the network channel our journeys?

This index captures and visualises how travel opportunities flow across the network in geographical detail, and the volume they have, dependent on the ease of movement (closeness centrality, see above) and the spatial distribution of land use activities. A network-wide figure (global betweenness) aggregates all origin-destination values in relation to the number of metropolitan residents and jobs, and thus attempts to quantify the overall presence of public transport movement opportunities within a sub-region. On this measure, Amsterdam comfortably outperforms its southern neighbours. Even though global betweenness improved in all three sub-regions – an effect attributable to public transport catchments being subject to urban intensification (see the urban density index above), services becoming faster and/or more frequent (see the closeness centrality index above), or a combination of both – Amsterdam further increased its lead between 2010 and 2021. Put differently, Amsterdam appears to have tapped into a synergistic dynamic where public transport and land use development support each other in a transition process towards a more transit-oriented agglomeration, while in Utrecht and Zuid Holland, improvements in this relationship have an incremental (rather than transformative) character.



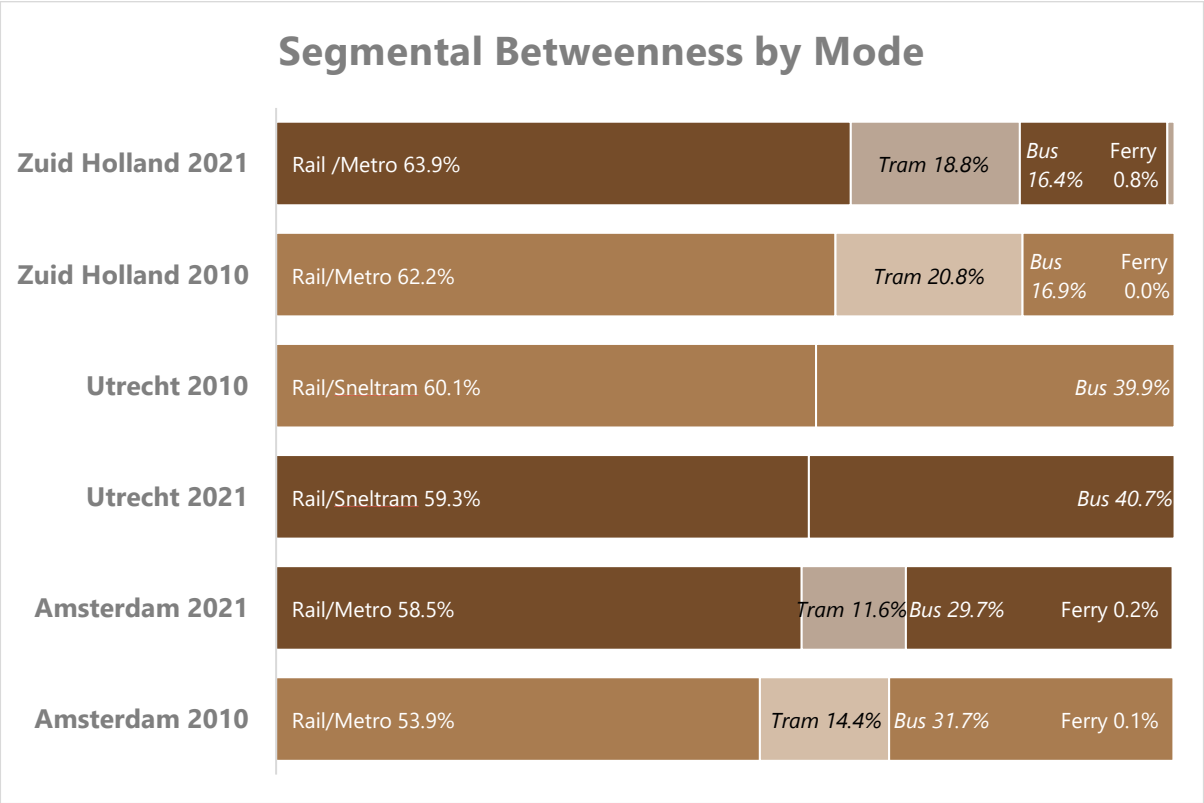
SNAMUTS randstad 2010-21 bar graph (global betweenness).tif

Download SNAMUTS network diagrams: Betweenness Centrality		
Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

The distribution of travel opportunities by modes has seen a tangible shift away from trams (and to a lesser extent, buses) towards national rail and particularly metro in Amsterdam, an unsurprising effect of the network reconfiguration associated with the opening of metro line 52 in 2017. In Zuid Holland, the share of travel opportunities on metro lines also grew, though partly at the expense of national rail. Here, the conversion of a rail branch line (Schiedam-Hoek van Holland) to metro operation in 2019 and improvements on metro line E linking Den Haag and Rotterdam as an alternative to the parallel national rail line become manifest in the figures. In Utrecht, the share of rail modes declined slightly in favour of buses despite the opening of a new light rail line in 2019. A likely explanation is the improvement of several regional express bus and local orbital bus routes in the catchment of the existing light rail corridor, offering alternative movement options (and some relief from excessive performance pressure, as will be explained below).

In Amsterdam, the share of public transport opportunities to, from or passing through the CBD (understood here as the historic centre of the city) remained equal between 2010 and 2021 despite the metro opening in this very location – clearly, the reconfiguration of the tram network to facilitate more orbital movement and the addition of the ‘wormhole’ express bus routes between suburban centres and neighbouring cities and towns counterbalance the metro’s impact. In Utrecht, whose multimodal network is highly centralised on a single dominant hub at Utrecht Centraal, this effect was further exacerbated (if slightly) between 2010 and 2021. In Zuid Holland, it is notable how

Rotterdam's CBD increased in significance for facilitating public transport movement during the 2010s, while Den Haag's CBD declined on the same measure. This may be indicative of regional population and job growth patterns that are more vigorous in Rotterdam than in Den Haag, the former city's role as the dominant hub for the province's metro system which (as we learned above) is increasing in significance, and the post-2010 addition of regional rail services to the high-speed line between Rotterdam and Amsterdam which bypasses Den Haag.



SNAMUTS randstad 2010-21 bar graph (segmental betweenness).tif

Network Resilience: can the public transport service offer cope with the role the land use system assigns to it?

This index can be understood as a troubleshooting tool for public transport networks. By calculating a ratio between segmental betweenness results and the actual passenger capacity offered on each route segment, and to and from each activity node, we can determine whether the service level on a particular network element is well-matched to its significance for metropolitan-wide movement, or whether (and to what extent) it falls short. Positive values, shown in green on the diagrams, indicate a good match. Smaller negative values (between 0 and -12, shown in yellow and orange) indicate a measure of underperformance. Larger negative values (beyond -12, shown in red and maroon) indicate a more severe capacity constraint, at least to the extent that the importance of a network segment as calculated in the betweenness index translates into actual passenger demand. Two critical factors specific to the Dutch Randstad suggest that this might not always be the case.

Daily urban mobility in the Randstad: Bikes not buses?

First, the high bicycle mode share across the region (and particularly in Amsterdam and Utrecht) can be expected to capture a significant proportion especially of shorter journeys that in cities with less

accommodating cycling conditions would be found on public transport (or in cars). In other words, high levels of bicycle use may act to suppress public transport demand especially for slower modes (buses and trams) and in turn, may lead to a configuration of networks and supply of services that takes the associated lower expectation of patronage into account. In Utrecht in particular, but also in Almere and much of Zuid Holland, the inner urban bus networks can be characterised as fairly rudimentary in scale and typical service frequencies when compared to those in cities of comparable size internationally. In Amsterdam, the situation is somewhat different (as reflected in the higher service intensity figures discussed above). The first-generation tram operations in the region (Amsterdam, Den Haag, Rotterdam) present a more coherent service offer, probably related to the pressure to make the most of existing fixed infrastructure and purpose-built vehicles (though in all three cases, there are significant sections of track lying idle without regular passenger services).

How is a polycentric agglomeration used in practice?

Second, the Dutch Randstad does not form a unitary or contiguous metropolitan region around a single dominant centre in the way that other large European metropoles such as London, Paris, Madrid or Berlin do. It is a strongly polycentric region where functional integration, and hence the propensity of its residents to undertake journeys between component cities, may have been on an upward trajectory for decades, but where the component cities also retain a degree of functional self-containment that is arguably greater than that of a London borough or the Paris banlieue. At a sub-regional scale, this effect is most visible in Zuid Holland, where two component cities of roughly similar size and importance (Den Haag and Rotterdam) sit at the top of the centre hierarchy. Amsterdam and Utrecht are both dominated by a singular centre, but even here, secondary centres such as Haarlem and Almere in Amsterdam, and Amersfoort in Utrecht, retain considerable functional and spatial autonomy. Comparable examples in Zuid Holland are the cities of Leiden, Delft, Zoetermeer, Gouda and Dordrecht.

The challenges these circumstances present to an accessibility analysis are both perceptual and functional. Residents of Randstad component cities are likely to consider their regular range of movement (or 'daily urban system') as determined by the identity and boundaries of their specific location to a greater extent than those of, for example, a London borough, and consequently, contain more of their activities and travel locally. Simultaneously, the influence of relative proximity between the component cities and the resulting incentives for cross-commuting to access greater markets for jobs, education and other activities are inarguably significant. Ultimately, the Dutch Randstad presents a spatial and functional hybrid between a coherent metropolis of 8 million inhabitants and a collection of smaller autonomous cities and towns.

To interpret the SNAMUTS resilience results, we will need to keep both these caveats in mind. Poor resilience can either be manifest in actual, observable overcrowding, or in a form of latent demand, ie. a situation in which public transport does not meet its full potential and thus fails to attract the level of patronage that the configuration of the land use-transport system suggests it could.

During the 2010s, average network resilience deteriorated in all three sub-regions but as with other indicators, the situation differs starkly between Amsterdam on the one hand (which remains in positive average figures), and Utrecht and Zuid Holland on the other (whose already poor performance in 2010 declined further during the ten years hence, in the case of Zuid Holland quite dramatically).

Network resilience: Amsterdam

The 2010 map of Amsterdam shows two 'zones of harmony and tranquillity' on the resilience index: one in the inner city where a dense tram network provided for multidirectional, medium-capacity travel, and one in the southeastern suburbs (Bijlmer) where metro branch lines provide high capacity on radial corridors while not absorbing any significant bus feeder services beyond the hubs of Bijlmer ArenA and Diemen Zuid. Conversely, the links from Haarlem to IJmuiden, Amsterdam and Schiphol Airport all appear under significant stress, as does the bus-based radial commuter system to the Waterland area (Purmerend, Edam-Volendam) to the north of the core city. The situation around Haarlem can partly be explained by the effects of relative self-containment overstating the inclination for travel beyond Haarlem's borders. The situation in Waterland is more likely associated to the rationale to the build the north-south metro line in the first place, though it is unlikely to be further extended beyond its current terminus at Amsterdam Noord in the foreseeable future.

Hence, the resilience of Waterland's bus-based public transport improved only marginally with the opening of the metro in 2017. In Purmerend, a post-war new town with limited employment options and hence a greater than average need for residents to out-commute, the situation isn't helped by the poor spatial integration of the bus network with the (low-frequency) regional rail service traversing the township. In Haarlem, the rail link to Amsterdam improved slightly in resilience (following frequency improvements), as did the situation in the suburbs between Haarlem and IJmuiden which benefits from an upgraded direct bus connection to Amsterdam. However, the area retains the poorest resilience performance in the Amsterdam region.

The Bijlmer area's good resilience performance continued through 2021, though it is also legitimate to ask whether these metro branch lines with their high passenger capacity couldn't be worked a bit harder by connecting the hubs towards the end of each line better to the regional bus network, and to encourage greater urban intensification (as has occurred, for example, around Diemen Zuid station in recent years). In Amsterdam's inner city, whatever excess capacity there might have been in 2010 has been reduced with the reconfiguration of the tram network (though the situation still does not appear problematic). It is notable, however, that the new metro line itself has negative segmental resilience figures along its entire route. Its 7.5 minute daytime frequency remains below the standard of comparable metro services in other cities (even that of other metro lines in Amsterdam itself) and quite certainly below the design capacity of the line, so there should be room for further improvement. On the other hand, this relatively short line largely running through a dense inner urban area with low car accessibility arguably competes much more with bicycle travel than with car travel where individual mobility is concerned. It may also be subject to the suppression effect of a high bike mode share on public transport discussed earlier, which the SNAMUTS resilience index does not pick up directly.

Network resilience: Utrecht

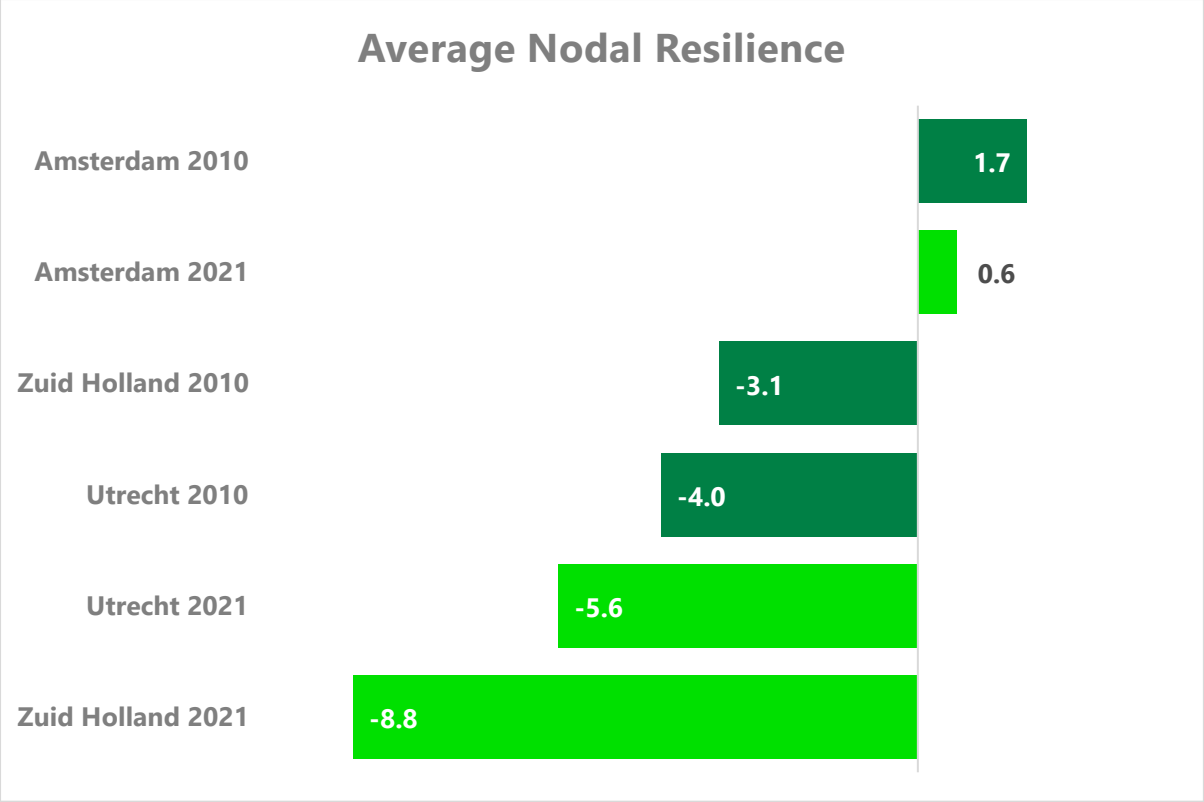
In Utrecht, poor resilience mostly affects the radial bus and LRT lines converging in the centre of the city, while the best resilience scores can be found in the rail-based commuter suburbs of Houten and Veenendaal. The resilience performance of Utrecht's bus network deteriorated further during the 2010s, while improving for LRT – uniquely among Randstad sub-regions, the overall share of network segments with positive resilience values remained constant in Utrecht between 2010 and 2021. It is remarkable that the new LRT line to Universiteit Utrecht was built along one of the radial bus corridors with a relatively good resilience performance according to the 2010 analysis, and now represents the only link in inner Utrecht away from the heavy rail lines that remains in positive figures. The outer terminus of the LRT extension now has a bus connection to the neighbouring, rail-free town of Zeist; however, the configuration of the network does not seem to capitalise on the opportunity to feed a significant number of journeys to and from this area (one of the poorest

resilience performers in the entire province) onto the higher-capacity LRT line. At the opposite end of the city, the upgrade of several regional bus lines (to Schoonhoven and Gorinchem) took pressure off the older southwestern LRT line to Nieuwegein Zuid and IJsselstein. This is welcome, though the comparative performance of buses and LRT turns the modal hierarchy on its head to some extent: for example, by using the freeway with very few intermediate stops, the lower-capacity express bus provides a faster link between IJsselstein and central Utrecht than the higher-capacity LRT line following the main settlement corridor with multiple stops.

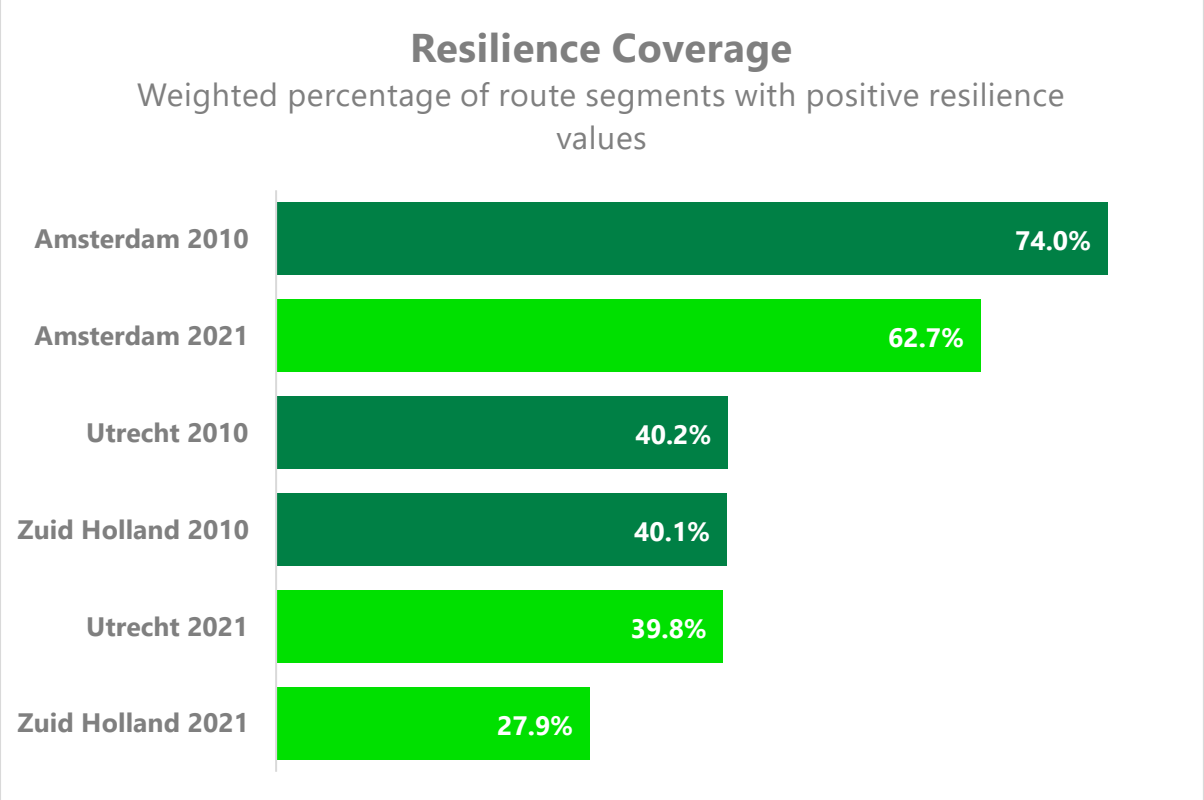
Network resilience: Zuid Holland

In Zuid Holland, whose average resilience performance in 2010 was slightly better than Utrecht's, the most problematic network elements were the national rail link between the two core cities of Den Haag and Rotterdam, and the local bus network around the second-tier centre of Leiden, particularly to and from the coastal settlements of Noordwijk and Katwijk. In contrast, low resilience pressures prevailed in much of Rotterdam's middle suburbs to the south and east, and in the post-war new town of Zoetermeer, linked to Den Haag by both heavy and light rail. By 2021, resilience performance had deteriorated sharply along practically the entire heavy rail spine from Leiden via Den Haag and Rotterdam to Dordrecht, in the aforementioned Leiden coastal region as well as in other areas where regional express buses, some new and/or upgraded, link into settlements away from the rail systems. Additionally, concerningly poor resilience performance had crept into numerous segments of Rotterdam's metro system including the link to and from Den Haag (Line E), and some of Den Haag's light rail system including to and from Zoetermeer (RandstadRail). Only at one outer terminus of Rotterdam's metro network (Nesselande) and in Den Haag's beachside suburb of Scheveningen can we still find nodes with positive resilience scores.

Measures to improve Zuid Holland's public transport during the 2010s included some frequency improvements on metro and light rail lines, and the addition of a number of upgraded regional bus routes. Both these measures have effects that are absolutely desirable from a policy perspective that seeks to expand the role of public transport in the transport mix, but their impact on resilience performance in the sense of this index is negative. Frequency improvements pursued on selected lines have the effect to increase the total number of travel opportunities, but also to pull travel opportunities away from alternative journey paths that have not been improved, thus running the risk of turning the upgraded routes into 'victims of their own success'. Express bus routes linking or accessing centres away from the high-capacity heavy and light rail network have the effect of increasing the pool of potential users with access to public transport at a defined minimum standard (see the network coverage index above which showed an additional 5% of Zuid Hollanders gaining such access during the 2010s) – users who will flow on from the new routes to other parts of the network by way of transfer journeys and exacerbate the pressures there. Add the impact of rapidly increasing population and jobs in the region, and a picture emerges of a public transport system that despite many good intentions, fails to keep up with the pressures of growth as well as the transitional pressures of the zero-carbon agenda. For a metropolitan region now in excess of 3.5 million inhabitants and for all its polycentricity, Zuid Holland retains significant public transport infrastructure deficits: in 2010, the region had 3.5 heavy rail/metro stations per 100,000 inhabitants (a number that would, if anything, have slightly declined since), a bottom-of-the-range figure in a European comparison (Amsterdam and Utrecht had 4.2 and 4.3 stations per 100,000 inhabitants respectively, Munich and Vienna nearly 8, and Copenhagen and Stockholm nearly 10).



SNAMUTS randstad 2010-21 bar graph (nodal resilience).tif



SNAMUTS randstad 2010-21 bar graph (resilience coverage).tif

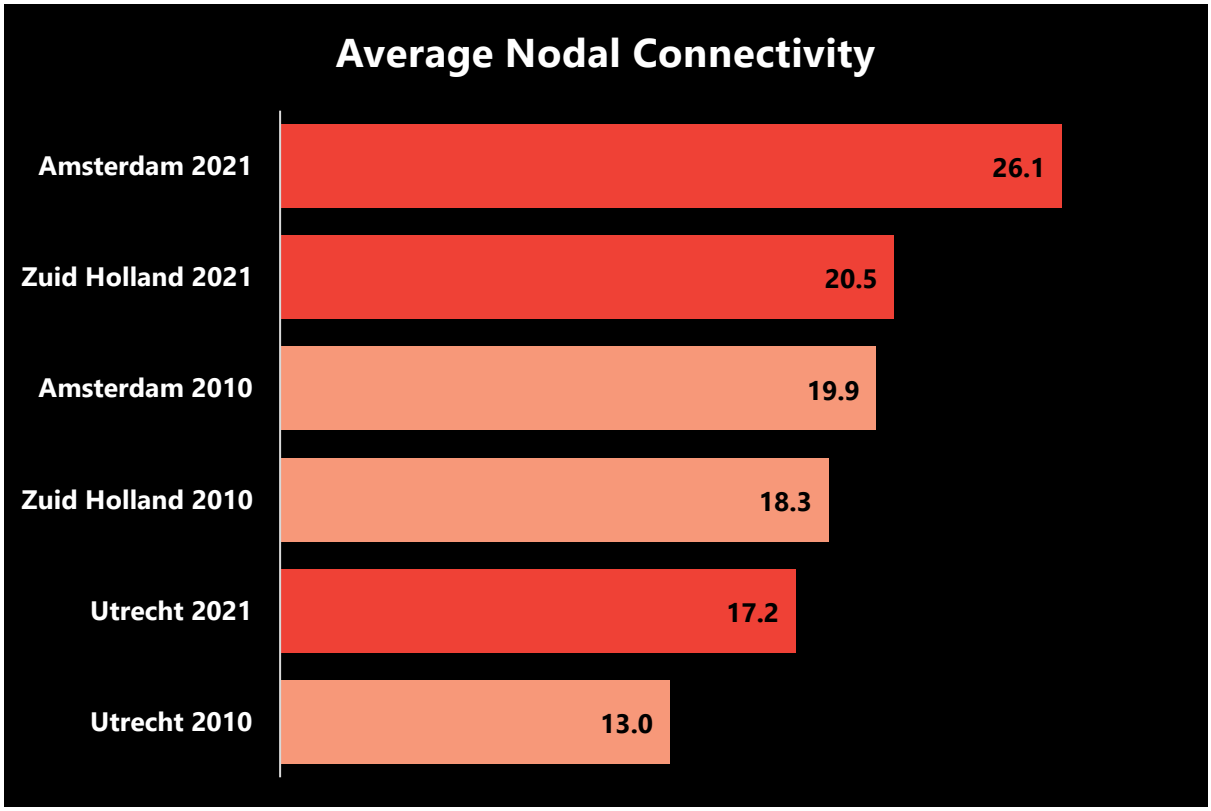
Download SNAMUTS network diagrams: Network Resilience

Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

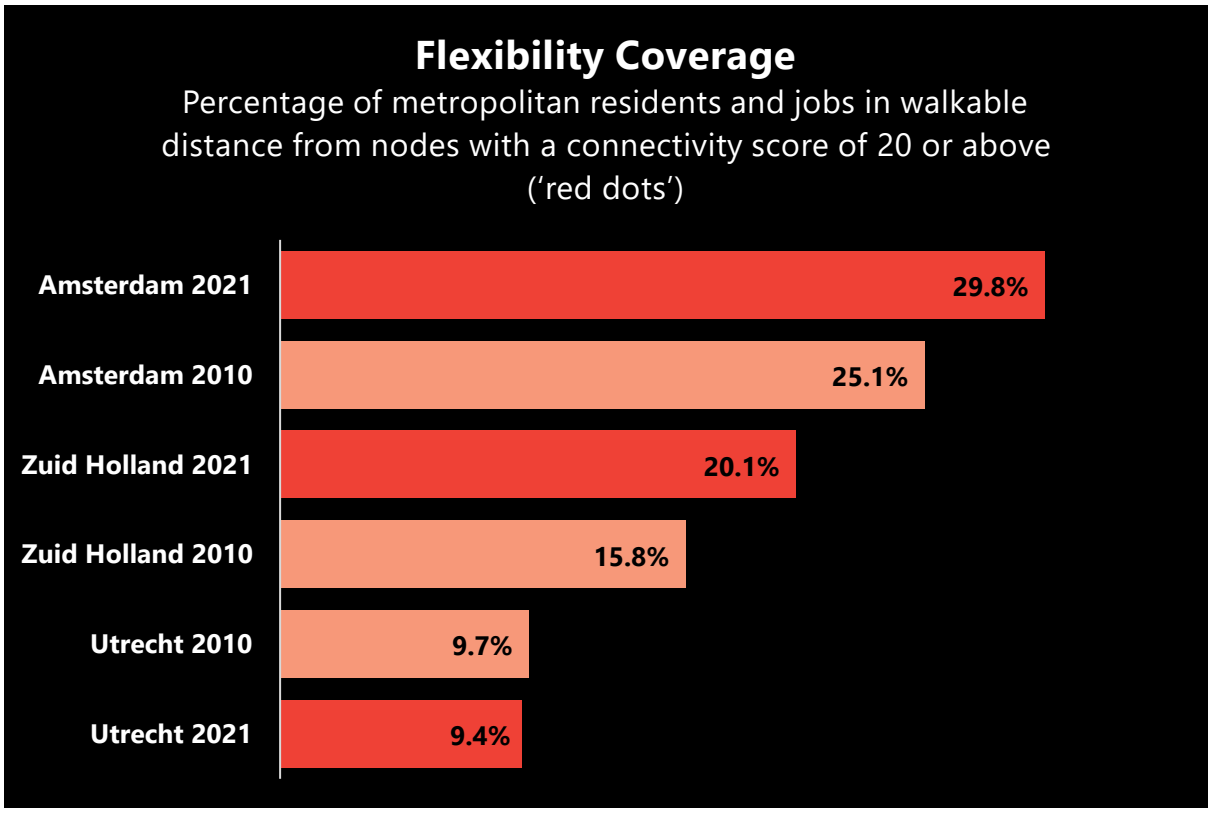
Nodal Connectivity: how freely can we navigate the public transport-land use system?

The nodal connectivity index conveys a sense of how flexibly users can move to and from a particular node on the network, by counting the number of directions one can travel in, the number of departures per hour, and the capacity (average occupancy) of the different modes that converge in each location. This has a bearing on the perception of a location to support public transport-oriented lifestyles and business models, and in turn influences its attractiveness for transit-oriented development. 'Red dots' with a nodal connectivity score of 20 or above can be considered the hotspots of a network for these qualities. The prevalence of such hotspots is naturally greater in larger, more complex networks – however, the average occupancy of each mode also enters this index as a proxy for the number of people boarding, alighting or transferring at a node and is subject to change in relation to betweenness and resilience performance.

Despite being a smaller metropolitan area, Amsterdam has an edge over Zuid Holland on this index, and has increased its lead since 2010 (though Utrecht's and Zuid Holland's average scores also grew). In Amsterdam, the nodes whose connectivity results increased most can be found (as expected) along the new metro line as well as at new rail stations along existing lines that were built since 2010 (Almere Poort and Halfweg-Zwanenburg). Zuid Holland also created some new interchanges (Lansingerland-Zoetermeer as a new hub for heavy rail, light rail and bus rapid transit; Pijnacker, Sassenheim, Sliedrecht Baanhoek and Spijkenisse through improved local bus routes, Keizerswaard through better integration of tram and bus). Utrecht added some 'red dots' between 2010 and 2021 but also lost others to network reconfigurations and average occupancy drops. Since not all nodes with high connectivity scores coincide with high concentrations of land use activities, Utrecht is the only sub-region where the share of residents and jobs in 'red-dot' catchments stagnated during the 2010s, translating into a lower share than in Amsterdam and Zuid Holland of people and businesses who can be confident to build their lives or their operations around public transport use.



SNAMUTS randstad 2010-21 bar graph (nodal connectivity).tif



SNAMUTS randstad 2010-21 bar graph (flexibility coverage).tif

Download SNAMUTS network diagrams: Nodal Connectivity

Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021

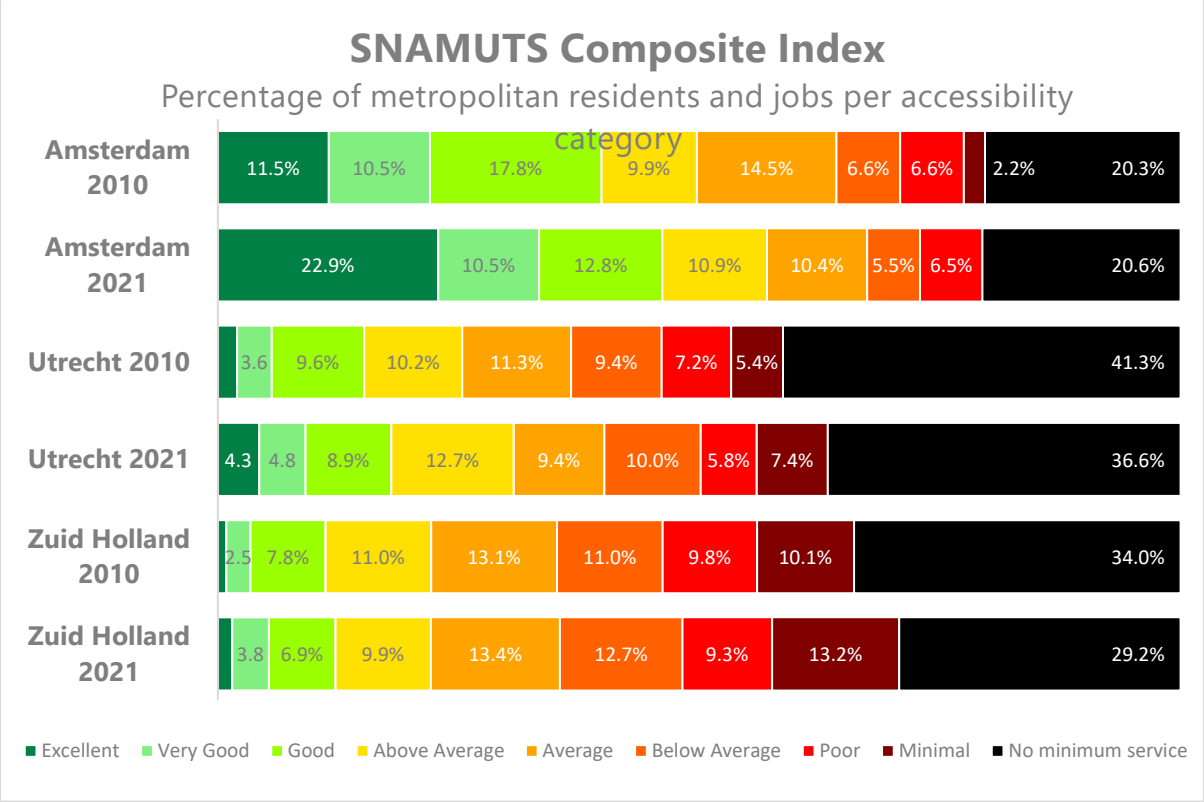
SNAMUTS Benchmark Composite Index

The SNAMUTS composite index takes in results from the component indicators of closeness centrality, degree centrality, contour catchments, betweenness centrality, nodal connectivity and nodal resilience and calibrates them on a scale from 0-60 (maximum 12 points for each component indicators except resilience, where negative values lead to deductions). It is primarily conceptualised as a visualisation tool to quickly identify areas of good, average and poor public transport accessibility on a metropolitan scale map, and to follow their evolution over time.

Of the three Randstad sub-regions, Amsterdam records the highest average accessibility quality and also the greatest rate of improvement between 2010 and 2021. It is clear from the maps how the city's entire metro system with the exception of the outer ends of the Bijlmer branches now services areas in the highest accessibility category, following extensions and frequency upgrades. Conversely, only marginal improvements from a relatively low accessibility standard can be detected in the bus-based Waterland area around Purmerend and Edam-Volendam, and in the suburbs north of Haarlem (where better express bus services were introduced but rail frequencies were reduced during the 2010s).

In Utrecht, the rail corridor to the western suburbs in Leidsche Rijn, Terwijde and Vleuten (where much urban development occurred and frequencies were increased) and the university district (which the new LRT route accesses) are the greatest beneficiaries of improved public transport accessibility. Little progress was made along the older LRT corridor to Nieuwegein and IJsselstein and in the neighbouring cities of Zeist and suburban Amersfoort, despite the upgrade of some regional and local bus routes.

In Zuid Holland, only Delft and some locations along the north-south metro lines D and E from Den Haag via Rotterdam to Spijkenisse saw some tangible (if small) improvements in overall accessibility quality. Elsewhere in suburban Den Haag and to some extent Rotterdam, accessibility quality declined. Away from the train station precincts in the Leiden and Dordrecht areas as well as in other outlying towns, accessibility quality failed to improve from its 2010 rock-bottom level (and not helped by the increasing deductions from declining resilience performance there) – a situation that speaks of a severely inadequate public transport infrastructure and service offer and suggests the highest level of car dependence anywhere in the Dutch Randstad.



SNAMUTS randstad 2010-21 bar graph (composite categories).tif

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Amsterdam 2010	Utrecht 2010	Zuid Holland 2010
Amsterdam 2021	Utrecht 2021	Zuid Holland 2021