Public Transport Choices Report

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Association of Municipalities in the Capital Area in Iceland (SSH)

JARRETT WALKER + ASSOCIATES

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1 Introduction

Introduction

This report examines the design, goals and outcomes of the public transport network of the Iceland Capital Region, Strætó. Through an assessment of current market conditions and a detailed analysis of the existing network, this report seeks to provide an interesting and thought-provoking input into the local conversation around public transport. More specifically, through consideration of these factors, we identify several key questions that the public, stakeholders, and elected officials will likely consider in future planning for public transport in the region.

Background: A Growing Region

The Capital Region is in a favorable position to consider its public transport options. As the chart at right shows, the recent past (since 2003) has seen sustained population growth; ridership on the public transport system has grown steadily over the past five years, and as of 2014 stood at more than 20% above the early-2000s level.

More ridership in conditions where the population is growing is not unusual; in fact, we would expect to see a similar trend in any city where the public transport service is not subject to substantial service cuts. What is striking in the case of the Capital Region is that the ridership uptick actually outstrips the growth of the population, leading to a strong growth in ridership per capita, a useful high-level indicator of the relevance of the public transport network to the population. These are encouraging trends, which are expected to continue as the region is currently forecast to add another 70.000 people in the next 25 years.

In the past, much of the growth in this region has often been accommodated through the construction of new homes, businesses and neighborhoods on previously undeveloped tracts of land. However, the long-term 2040 plan anticipates that much of the population increase in coming decades will be absorbed by areas that have already been developed, in order to to contribute to better utilisation of the existing transportation system and utilities, and to reduce development pressure on uninhabited areas. Additionally, traffic studies referenced in the 2040 plan cast doubt upon the ability of the region to accommodate all the new trips this growth will generate through efforts to improve road capacity.

If these predications are accurate, more people will be living in the Capital Region, in closer proximity than ever before, making more trips each day for all sorts of reasons. Since the great majority of people (76%) use a car as their primary means of public transportation, this presents future issues around automobile congestion and the dedication of urban space to an inherently space-inefficient travel mode; the 2040 plan,

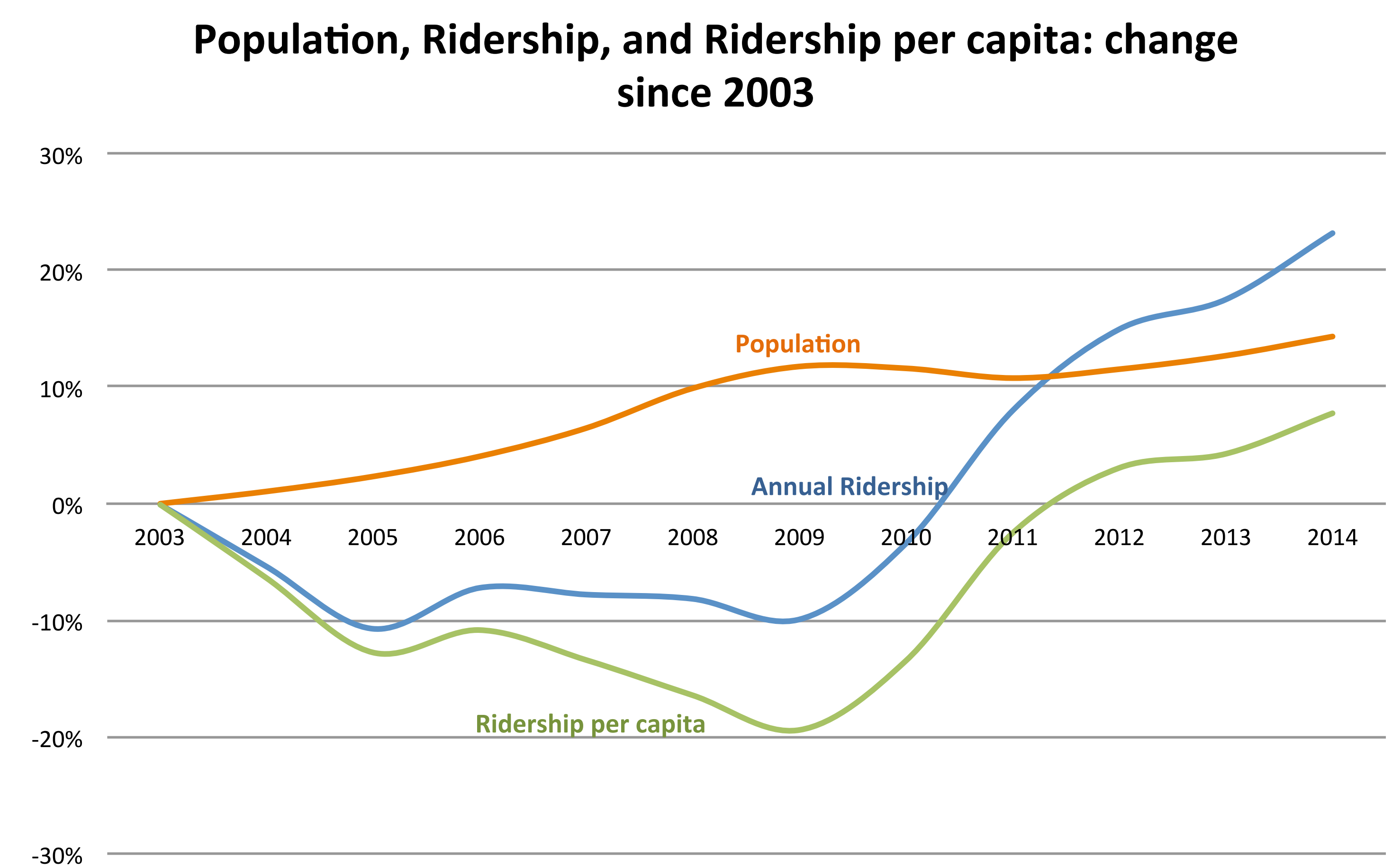

Figure 1: Population, Ridership and Ridership per capita since 2003

foreseeing this, sets an ambitious goal of 12% public transport mode share as a way of alleviating some of these issues.

Goals of Public Transport

Strætó's ridership, and its ridership per capita, a measure of the relevance of the mode to people in region, have grown since 2009. In order to achieve the 12% public transport mode split goal in the 2040 plan, this growth in ridership must continue. To do this, the network must become more a more useful travel option than it is today for all sorts of trips. 12% public transport mode share with today's population would mean more than doubling ridership, from 10.2 million annual boardings (2014) to more than 20 million.

The strategies to accomplish this sort of ridership growth are well known, and can be summarized as continued investment in high-frequency, convenient service targeting the dense, walkable markets that can be served most efficiently. In the context of a stable or slowly growing level of public transport funding, progressive changes to the public transport network to achieve these outcomes require trade-offs to be made among different goals of the service, which are tied to important community values. Increasing ridership is one of these goals, but actions in its pursuit often require choices that negatively impact other goals, such as the overall coverage of the network.

Only the citizens, stakeholders and elected officials of the Capital Region can direct the public transport network to pursue particular goals. The purpose of this report is not to say what the system should do or how it should change, but to identify the goals it is currently serving, assess how they fit with the imperative to grow ridership, and offer choices between network priorities.

Features of this Report

This report includes 4 major sections, each of which examine a different aspect of public transport in this region.

Introduction

Chapter 2, Market Assessment discusses the necessary land use and urban design characteristics that serve as a prerequisite for public transport ridership. When high ridership is a major goal of public transport, the network must be designed in order to focus on places with the attributes conducive to making public transport a useful option: dense, walkable places, which are arranged across the landscape in such a way that they can be served efficiently by public transport. This section reviews these concepts, and explains where these land use attributes can be found in greater or lesser abundance in the Capital Region.

Chapter 3, Public Transport Service Analysis, focuses on the attributes of the network itself. While land use, street layout and urban design are very important determinants to whether public transport can generate high ridership in a place, they are only important to the extent at which they are matched by an appropriate service design, capitalizing on these elements to deliver a truly useful service. This section examines aspects and indicators of the existing system to identify ways the current service succeeds at doing this, and ways in which it could be potential be improved. It concludes by comparing some key public transport statistics for the Capital Region to other peer cities.

Finally, **Chapter 4, Key Questions**, poses a number of questions about the purpose and design of the public transport network. These are questions which a public conversation around the system would likely consider, and which can only be answered by the public, stakeholders and elected officials. By clearly identifying these questions, we hope to clarify the major issues at hand for future decisionmaking processes, and provide a framework for the effective translation of policy-level guidance into planning for network changes.

2 Market Assessment

Market Assessment

Urban Form Drives Demand

Public transport service, ridership, and performance are overwhelmingly governed by the pattern of urban development. This pattern determines how many people will be near a stop, whether they can walk to it, and whether public transport can follow a path that will be useful to many customers. When designing for high ridership, public transport agencies will naturally focus service on places where these conditions are favorable.

The image in Figure 4 offers a simple distillation of the key ways that the built environment governs public transport ridership. Four facts about the environment are critical:

- Density: how large is the market for public transport within a given distance of each stop? This is the first-order measure of public transport potential. The more people or jobs are located in the fixed area around a stop, the larger is public transport's potential market.
- Walkability: how easy is it for people near each stop to actually reach it? If there are physical barriers to this access, including poorly connected street patterns or difficulties crossing a major street, the market of people who can reach a stop is smaller.
- Linearity: can public transport serve an area in straight, efficient paths, or is time-consuming deviation required to reach destinations? Wherever destinations are set far back from the street, or accessed only from circuitous roadways, it is harder to combine its market with other markets to build strong and durable public transport lines.
- Proximity: are there long gaps between destinations and strong markets that public transport must traverse? For example, linking two towns that are far apart is a less productive market than if the two were closer since the distance determines the cost of providing the service.

In some cases, the diversity of land uses can also matter. This helps to determine whether demand is evenly distributed in both directions and throughout the day, both of which use service more efficiently. Mixtures of housing, retail and jobs are generally much better on this score than large areas that are all residential or all employment.

These factors determine both the costs of providing public transport in a particular place and how many people are likely to find the service useful. Density and walkability tell us about the overall potential of the market: are there are a lot of people around, and can they get to the place where the product is available? Linearity and proximity tell us about cost: are we going to be able to serve the market with short, fast, direct line or will our costs be higher as we must design service that uses indirect or longer paths?

Four Geographic Indicators of High Ridership Potential

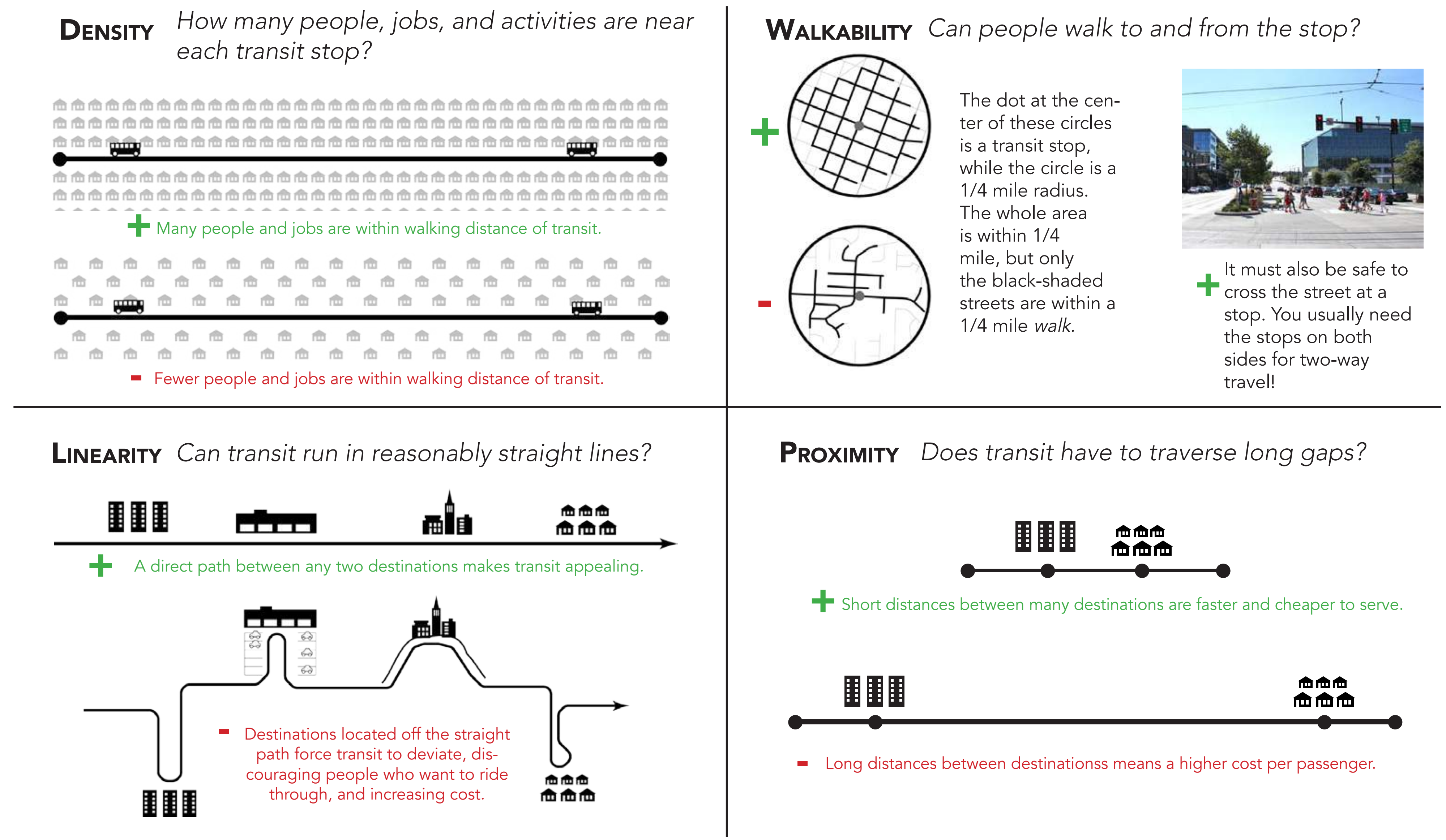

Figure 2: The Ridership Recipe: Density, Walkability, Linearity, and Proximity

Public transport agencies can influence the level of ridership their services generate, and the efficiency at which they do so, by targeting these sorts of favorable land uses appropriately. However, they cannot directly control the urban form of the places they serve. Without dense, walkable places along linear street patterns, where density is continuous along efficient public transport paths, public transport service alone is unlikely to support a high ridership outcome. Only local governments have the ability to directly effect these characteristics of urban form; the public transport agency can seek to provide a level of service that can be useful and competitive with other modes, but ultimately without a development context that produces public transport-oriented places of all types, the ceiling for public transport ridership is constrained.

Market Assessment

Population

Residential density is the simplest measure of public transport's ridership potential. While not all trips start or end at home, nearly everybody makes at least one trip starting or ending at their place of residence every day. This map shows the population by address in the Capital Region, summed for all addresses within each 250-meter hexgrid cell.

Residential density in Strætó's service area is most concentrated in Reykjavík, especially in the historic town extending from the older western portion of the city, through the Reykjavík Central Business District (CBD), and then east along Laugavegur-Skipholt to Hlemmur. This is the fastest-growing area, with extensive highrise development now underway. There are other pockets of very high density outside of the core of Reykjavík, as in Breiðholt, east of the Mjódd public transport hub.

Many other areas of the region are developed at moderate-to-high densities, where the built form of residential dwellings primarily consists of mid-rise apartments of 1-5 stories.

Examples include:

- The town center of Hafnarfjörður, and several areas to the southwest. Recent mid-rise residential development has increased the density of the area in immediate proximity to the Fjörður interchange.
- In the east, Rimar and parts of Engi and Víkur are moderately dense areas, but these developed areas are somewhat isolated. Central Grafarholt follows the same pattern.

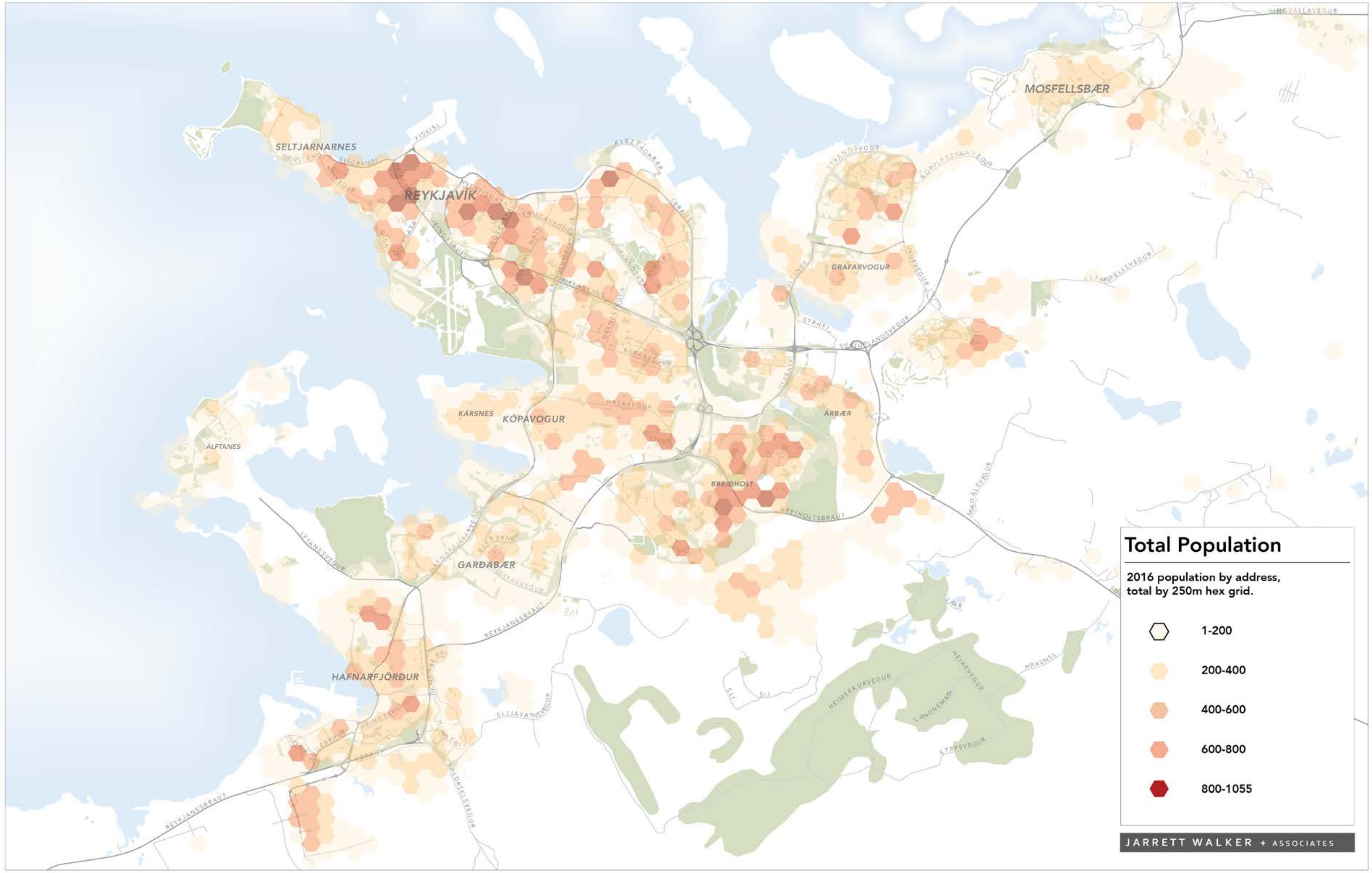

Figure 3: Residential Density

Market Assessment

Employment Area

While most people travel to and from a place of residence in a given day, most people also travel to and from a workplace, commercial establishment or service provider. The more people who work in a place, the more trips must be made to and from that location. Commercial areas also generate customer trip demand, though the next measure, trip density, captures that factor more completely.

Unfortunately, data on employment density is not available in the Capital Region. Instead, as a proxy, Figure 4 shows the total floor area within each 250-meter hexgrid cell classified as "employment"[1]. This lets us identify places where employment functions are more prominent. However, it does not allow us to make easy comparisons about the density of actually employment (in terms of people) between areas. This is a significant limitation, because the number of employees per square meter is highly variable depending on economic sector. Vacant employment sites also show up here but not in a true count of jobs.

Employment area in the Capital Region is focused on the core area of Reykjavík, but substantial concentrations also exist outside of that area. Examples include the vicinity of Smáralind, the northern area of Hafnarfjordur near the 40/41 expressway intersection, and the commercial and service area near the intersection of the 49 expressway and Höfðabakki just northwest of Árbær.

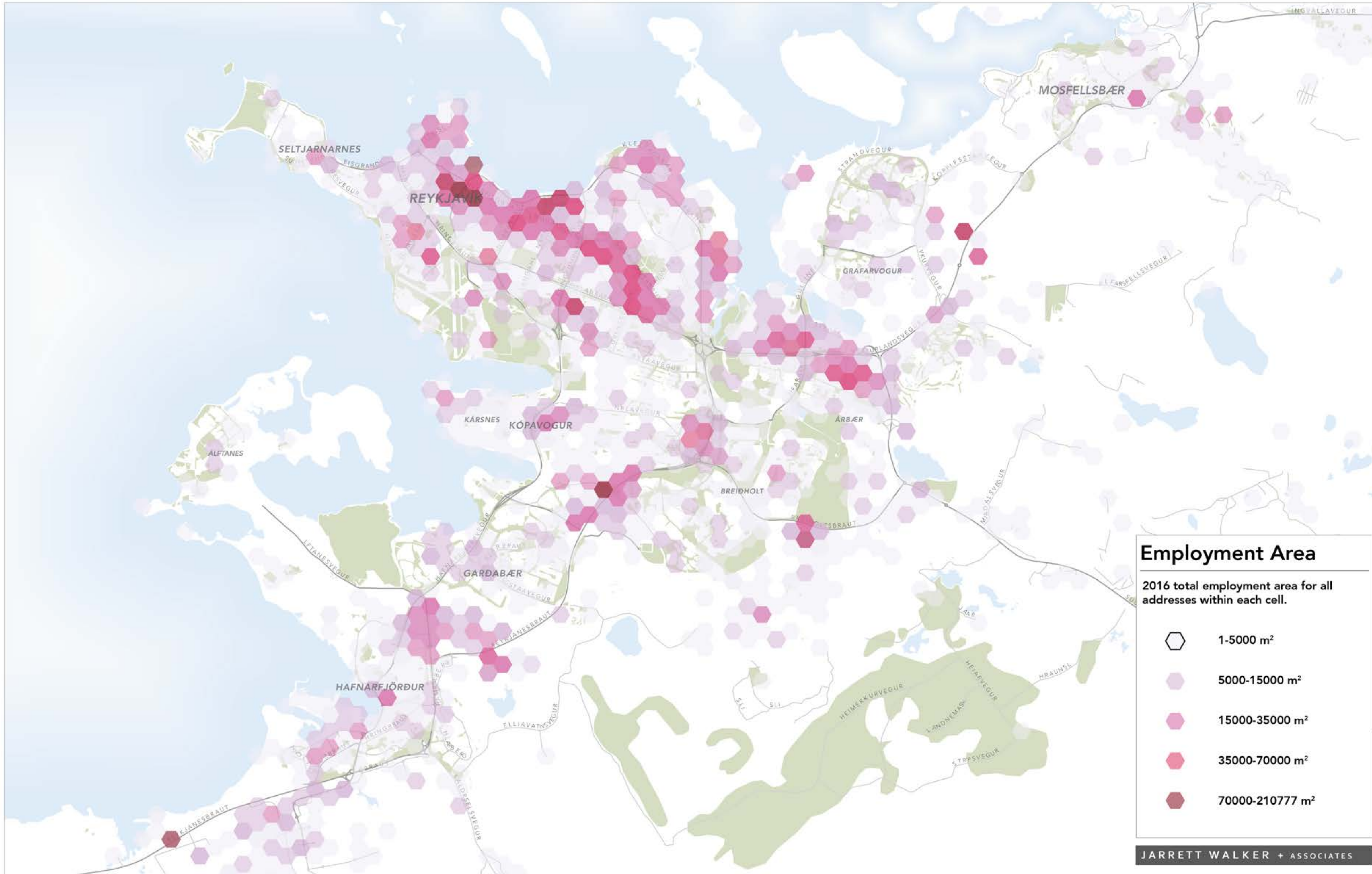

Figure 4: Employment Area

1 This number is derived for each cell by summing the employment area associated with all addresses located within that cell.

Market Assessment

Trip Density 2016

In a typical day, how many people go to, or depart from, each point in the city? Trip density is the number of average trips per square area within each zone of the region. This is a measure of the overall travel demand in each zone, normalized to account for the varying size of zones across the region.

Trip density arises from a relatively simple formula based on the population of each address and the commercial area of the associated location. Given the lack of precise data on employment density, *trip density should be taken as the main measure of demand*, and the previous maps used mostly to assess the separation or overlap of population and jobs.

High trip density is generally good for public transport, walking and cycling and less favorable for cars. Density is also more important than total numbers of trips in any zone. While some larger, less dense areas may have a greater total number of trips, these may also be spread across a larger area, which means that the public transport vehicle may have to traverse a longer distance in order to serve them.

According to current estimates, trip density is very concentrated in the core of Reykjavík, with its tight mix of commercial, government and residential development.

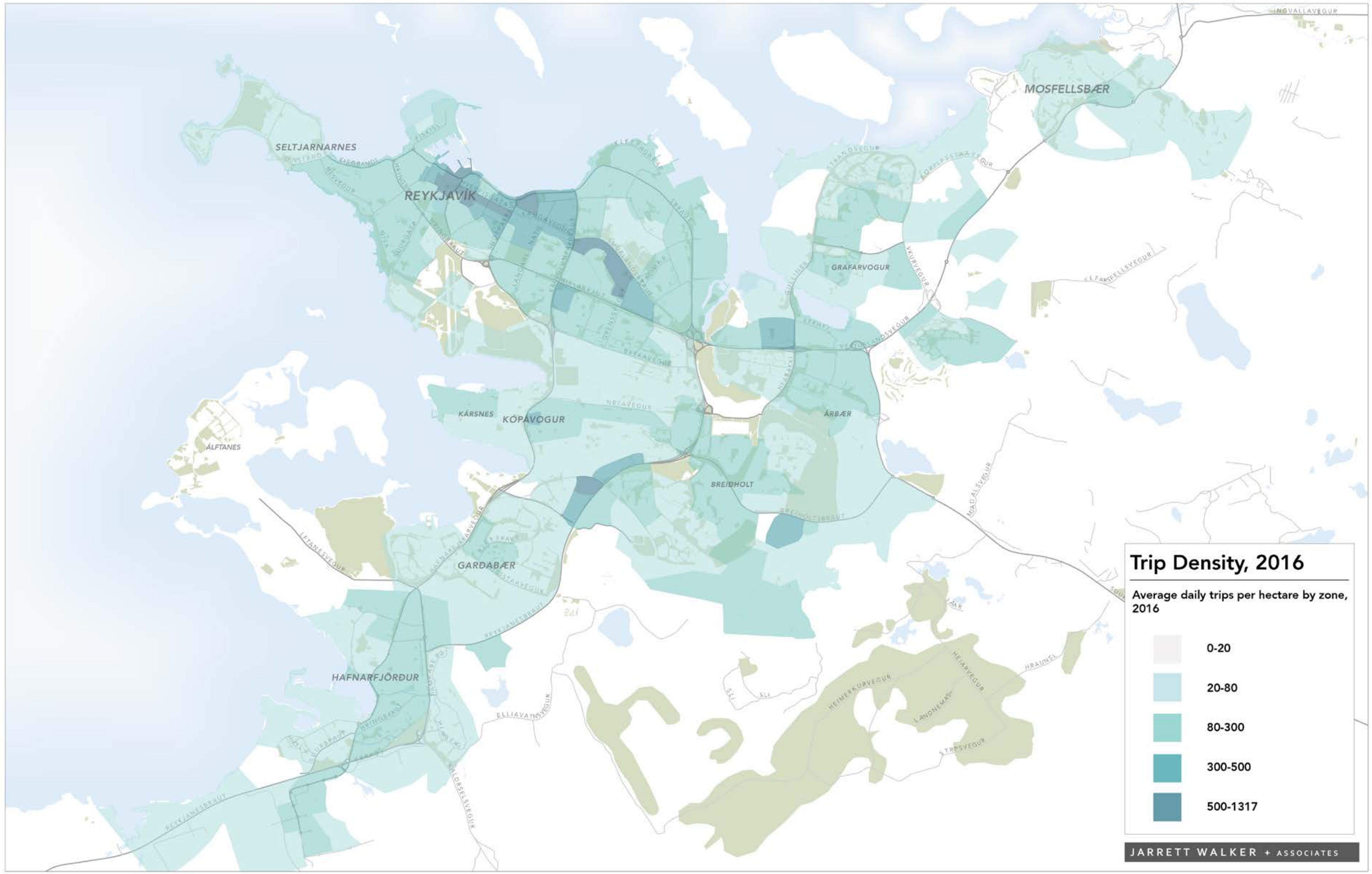

Figure 5: Trip Density 2016

Trip Density 2040

Figure 6 shows the density of trips by zone forecast for 2040. Comparing this image to the previous map provides a

Market Assessment

sense of how much worse traffic will be if dependence on cars remains at its current level, though it is worth keeping in mind that this is only a map of the effects of current land use plans. These plans could change, and actual development tends to depend on the public transport services provided.

Current plans foresee continued intensification of the Reykjavík core, especially eastward along Laugavegur and Suðurlandsbraut, strengthening a long east-west axis that would be a logical corridor for major public transport investment. Growth in almost all zones of peninsular Reykjavík is evident.

Elsewhere, most zones in existing built-up, mixed-use areas are projected for an increase in trip density, as would be expected in a region whose future plans are focused on infill and densification of already-developed areas. Places like the areas around Smáralind or Hafnarfjörður become even busier, as do lower-density areas as they absorb population growth. Seltjarnarnes and the Grafarvogur-Mosfellsbær area are the developed portions of the region where the projected development is most limited.

The Highway 40 corridor, between Reykjavík and Hafnarfjörður, grows even more favorable to public transport as several centers of demand grow along its path.

Figure 6: Trip Density 2040

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Beyond Density

Trip density arises mostly from the overall density of the built environment, and secondarily from the presence of specific employment uses, like retail, that attract visitors as well as jobs. Secondary and university education also matter, as these students are especially prone to rely on public transport.

The other three ingredients of the ridership recipe–walkability, linearity, and proximity–are also very important. This will be evident in the next chapter, where we partly explain existing public transport ridership using each of these factors. Walkability, linearity are especially important in the Capital Region because density is already generally high throughout. The 2040 plan and prior public transportation assessment reports cover these concepts in their own ways. We cover them here specifically in relation to the potential ridership market for public transport service.

Linearity

When destinations and concentrations of activity are arranged in straight paths, public transport is able to serve them more efficiently because they are already on the way. There is no need to deviate or travel long circuitous paths, because that concentration already exists in a straight line along a street that public transport can use as a logical path. If destinations are located away from the obvious straight paths, routes will need to deviate away from those straight lines in order to get near to these places, increasing distance and cost.

We can find examples of both patterns in the Capital Region, as shown using the projected 2040 trip density map in Figure 7. For example, the Laugavegur-Suðurlandsbraut corridor has a continuously high level of commercial and business use along it for its entire extent through the core of the city, which is projected to intensify along Suðurlandsbraut in the future. At a different scale, the entire Highway 40 corridor is a good example of major destinations in an easily served straight path.

In other areas of the city, we can identify places where these attractive direct paths are impossible. To get from the Smáralind shopping center in Kópavogur to the Hvörf commercial and employment area requires a circuitous path either north through Mjódd or south through lower density areas. Public transport cannot connect these places along a straight path, which means that each trip is longer and costs more than it would if a straighter path was available. Thus, Hvörf is a weaker market than it would be if it were located somewhere closer and easier to serve, because service to its location is more expensive and thus less efficient that a comparably dense place in another location might be.

Proximity

When public transport must traverse long gaps between destinations, it is less able to operate productively because the amount of time and thus cost to generate ridership in those destinations is greater. Simply put, it takes longer to get where people want to be. When travel destinations are in close proximity, public transport can serve them more quickly, and thus more cheaply. This means that whatever ridership those places produce will be more efficient, since public transport vehicles don't have to cross long stretches of low density to reach them.

However, when places where many people concentrate are spread apart and discontinuous, public transport must traverse areas of lower density and lower demand to connect them. This means that instead of an unbroken line of places that many people want to travel to, high-demand places are interrupted by places of low demand. The high cost of traversing these gaps increases service cost without adding riders, which means lower productivity (ridership / service cost).

In Figure 8 we can see how the population of the Capital Region spreads out of the core of Reykjavík. The northern, older parts of Reykjavík have areas of high population density (and thus potential public transport riders) in close proximity, which means that it is possible for public transport to connect them along paths where demand is likely to be relatively continuous.

On the other hand, the denser areas of the northeastern part of the region have gaps of lower-density development separating them. This means that public transport must spend time and money driving through places where few people are getting on the bus to reach the places where a stronger market exists. For example, the neighborhoods east of the 1 expressway, as well as Mossfellsbær, are comparably dense with parts of Kópavogur or Reykjavík, but because of the additional cost to serve them, constitute a weaker market than if they were located in closer proximity to other destinations or dense places.

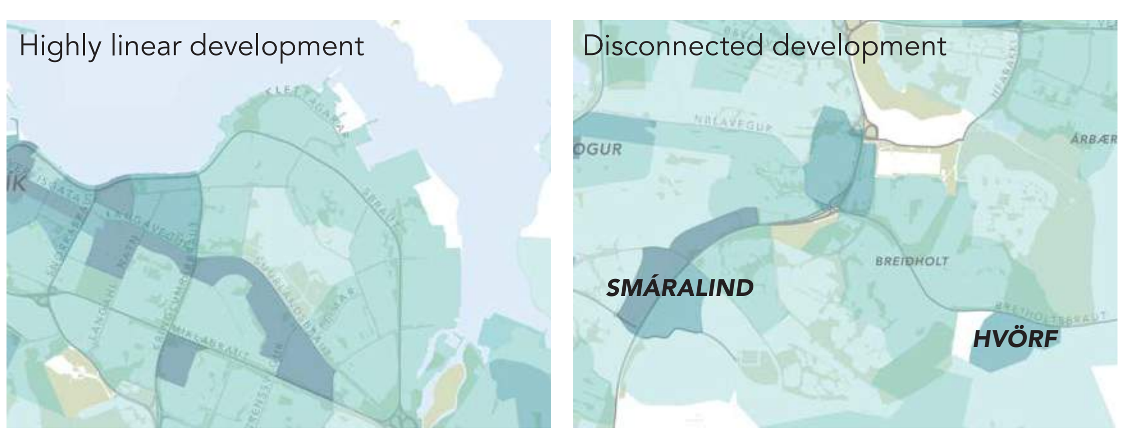

Figure 7: Linearity

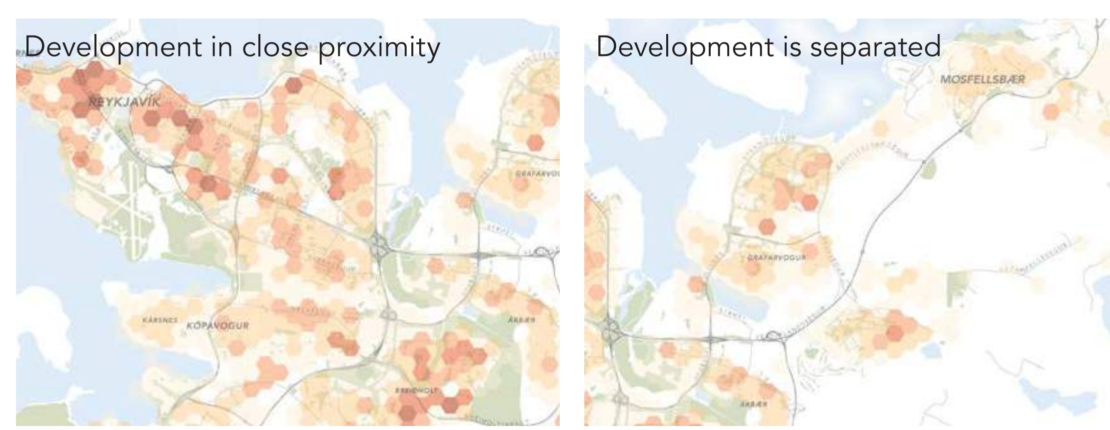

Figure 8: Proximity

Market Assessment

Walkability

No matter the site or density of a place, if people cannot safely and easily reach a public transport stop, the service faces a serious challenge in its ability to compete as an attractive travel option. Since everyone making a public transport trip is also making a walking trip (to and from the stop and their origin and destination), the ease of reaching the stop is a critical factor in how competitive public transport can be in a given market.

When we talk about walkability for public transport, we can imagine several different contributing factors that enhance or detract from the quality of the experience:

- **Distance.** Are destinations located very close to a public transport stop, or must riders traverse a long distance between the stop and their final destinations?
- **Infrastructure.** Are paths and sidewalks that protect people walking from automobile traffic available?
- **Safe crossings.** Since a trip on public transport typically requires the use of both directions of a route, is it safe and easy to cross the street to access stops in either direction?

Figure 9 compares the walkability of the area near public transport stops in central Rekyjavík. The segments marked orange are within a 500m walk of the stop in the center along the street network. The area on the left has a grid street pattern, which allows for more walk paths within the allotted distance. More of the area within the 500m air distance circle are within walking distance to the stop. On the other hand, the image on the right shows a nearby stop which lies in an area with a more disconnected street network. Because of the more limited road network, a smaller portion of the 500m air distance buffer around the stop is actually within walking distance.

Most parts of the Capital Region boast a robust network of pedestrian amenities, including separated paths, abundant crosswalks, and paths crossing obstacles like large expressways, which together help improve the walkability of places like the area shown on the right in Figure 9.

However, differences in the arrangement of buildings among development patterns yield very different walk times and experiences, even with comparable infrastructure. Particularly in the more recently developed suburban area of the city, large setbacks place buildings at a remove from the road (and thus public transport stops), so that even with a highly developed path network, walk distances are simply longer than in urban areas where buildings are closer to each other and to the roadways.

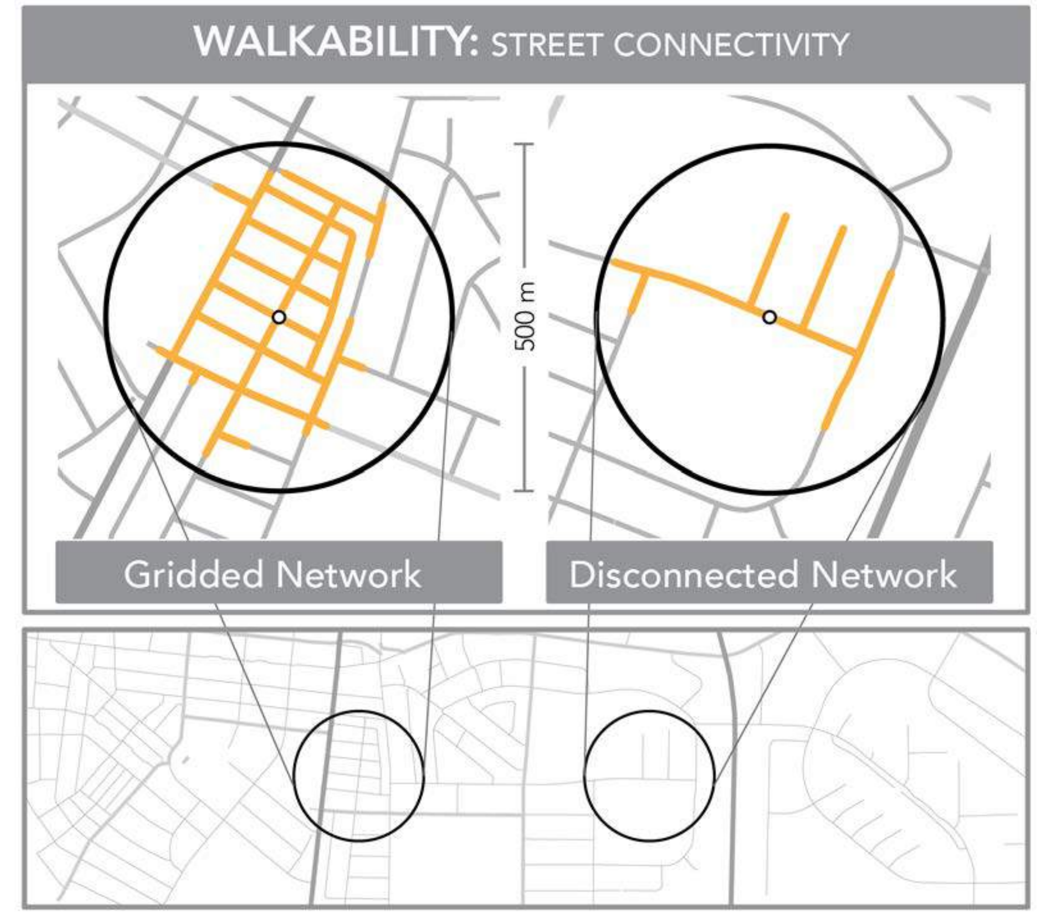

Figure 9: Walkability: street connectivity

Figure 10: Walkability

3 Public Transport Performance Analysis

Public Transport Performance Analysis

Different Goals, Different Metrics

Public transport performance can be measured in many ways, but for these measures to matter, they must align with the service's goals. How well is the public transport network succeeding at whatever major purpose it exists for? Without a connection to goals informed by a community's values and choices, no way of measuring public transport's outcomes is particularly useful at indicating where future changes to network might be desirable. This section discusses several measurements of public transport's success which are directly relevant to two major goals commonly adopted or expressed by operators.

The first goal, ridership, seeks to generate the maximum possible utilization of the public transport service, generally through focusing on frequent service in high demand areas. We evaluate how well a service meets this goal by examining how efficiently it produces ridership given its cost.

The second goal, coverage, focuses on expanding the availability of the network to the greatest number of people, typically by running less frequent, but more extensive service to as large an area as possible. We can analyze how well the network achieves this goal by analyzing the number of people near public transport.

Strætó's performance data—like that of most agencies—reveals that not all services generate high ridership per unit cost. Many services exist despite not just low ridership, but without any reasonable prospect of high ridership in the future. These services run in areas where the development pattern—especially the critical features of density, walkability, linearity, and proximity—largely ensure low ridership potential, at least right now. Rather than judging such services as failing, it is more accurate to describe them as having a non-ridership purpose, and to evaluate their success as a network element on those terms.

A trade-off between these two goals arises unavoidably from the nature of the public transport product. This is not an either/or choice; no public transport agency pursues either goal to the total exclusion of other, and most systems include routes that serve one goal or the other to varying degrees. These goals are discussed in more detail in Chapter 4, Key Questions.

Focus on Frequency

This analysis of the network is centered around the frequency of each route in the network. Network frequency reveals where a public transport system focuses its resources and benefits. Where it is available, frequent service is the most useful service type for most customers. A focus on frequency allows us the center the discussion around major tradeoffs, particularly between ridership and coverage.

High frequency - usually every 15 minutes or better - has several independent kinds of benefit:

- Faster travel times, since wait times are reduced. On a 30-minute route, the average wait will be 15 minutes, but on a 15-minute route, this will be just 7.5 minutes.
- Improved connections. Where frequent services intersect, the short waits for each make connections much easier, since there is no chance that a person will be left waiting for a full 30 minutes if they miss their bus.
- Legibility. Since a bus is always coming soon (within 15 minutes) on frequent lines, assembling trip planning and schedule information is less important, since riders can rely on an arrival within a short amount of time.
- Reliability. Frequent service reduces the delay caused by the failure of a single bus.

Frequent service can help alleviate some of the issues that people often mention as reasons they do not ride: slow service, unreliability, the fear of being left out on a street waiting for a bus that doesn't come for a long time. This is why we say that it is more useful.

Public Transport Performance Analysis

Midday Frequency

Midday frequency, shown in Figure 11, points to where those resources and level of convenience are available all day long—places where people can more easily choose to rely on public transport for all kinds of trips. Many more routes are frequent during the peak commute period, but the lines that are frequent all day - which we call the Frequent Network - is where it is easy to depend on public transport for a wide range of life's needs.

The current all-day Frequent Network comprises two lines: Line 1, between the Reykjavík CBD and Hafnarfjörður and Line 6 between the Reykjavík CBD and Mosfellsbær.

While there is a general match between high frequency and trip density, there are several points where high travel demand is served with low frequency.

Neither of the frequent lines serve the high density employment and residential corridor along Laugavegur east of Hlemmur. Multiple routes (in this case, routes 2, 5, 15 and 17) overlap through this stretch, but their schedules are not designed to provide frequency by offsetting arrivals. Instead, many buses tend to come at once with long gaps between them. For example, during the midday period, these four routes each depart Hlemmur in a cluster between 00:14 and 00:22 each hour, and then between 00:44 and 00:52.

The coverage network of less-frequent routes serves nearly the entire built-up area of the Capital Region; very few places or people are more than 500m from public transport service. Most routes run every 30 minutes during the

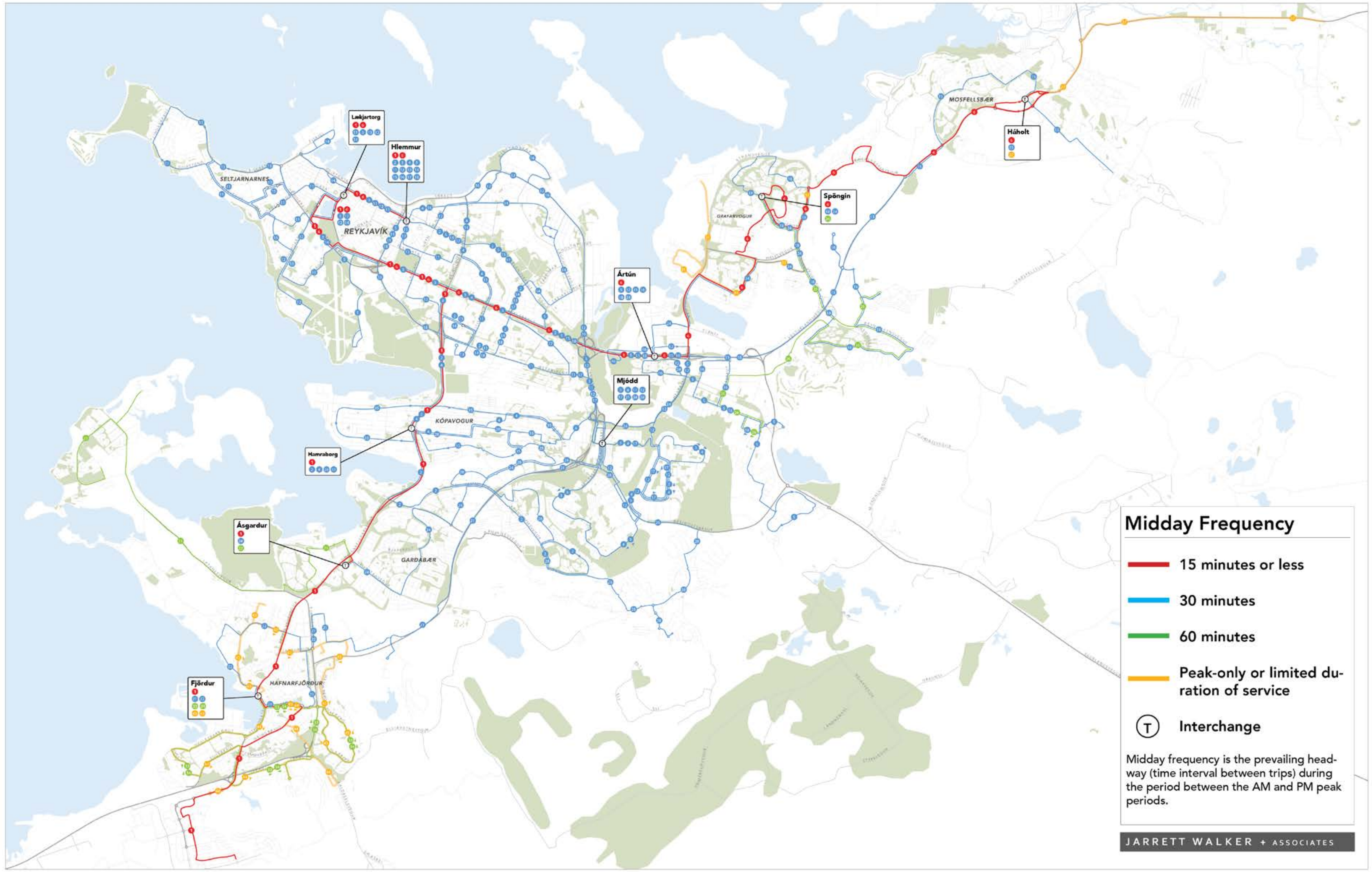

Figure 11: Network Frequency

Public Transport Performance Analysis

midday, with nearly all increasing frequency during the peak for 2-4 hours. Just a few routes around Hafnarfjörður and Grafarvogur operate for a limited duration each day.

Most of Reykjavík's densest areas and major destinations, such as the Smáralind shopping and the vicinity of the Mjódd interchange, are served only by 30-minute service between the peaks. Routes such as 2, 3, 4, and 5 all provide service to dense, high-demand locations, and generate ridership very efficiently as a result.

Peak Frequency

In the Capital Region, nearly the entire network runs every 15 minutes during the AM and PM peak periods. This rich peak network offers a very high level of convenience and reliability during the few hours per day when it is in operation.

Oddly, most routes that do not gain frequency during peak periods are in Hafnarfjordur. This does not have an obvious explanation in terms of differences of density or other indicators. By contrast, the consistency of peak frequent service across the other municipalities is unusual. Usually there is more variation in peak demand, calling for more variation in frequency.

During the peak, connections between many important destinations are substantially improved. For instance, anyone traveling to destinations along Suðurlandsbraut from Ártún can count on two routes leaving every 15 minutes-routes 5 and 15. This means that no matter when they arrive at Ártún during the peak, a bus to their destination

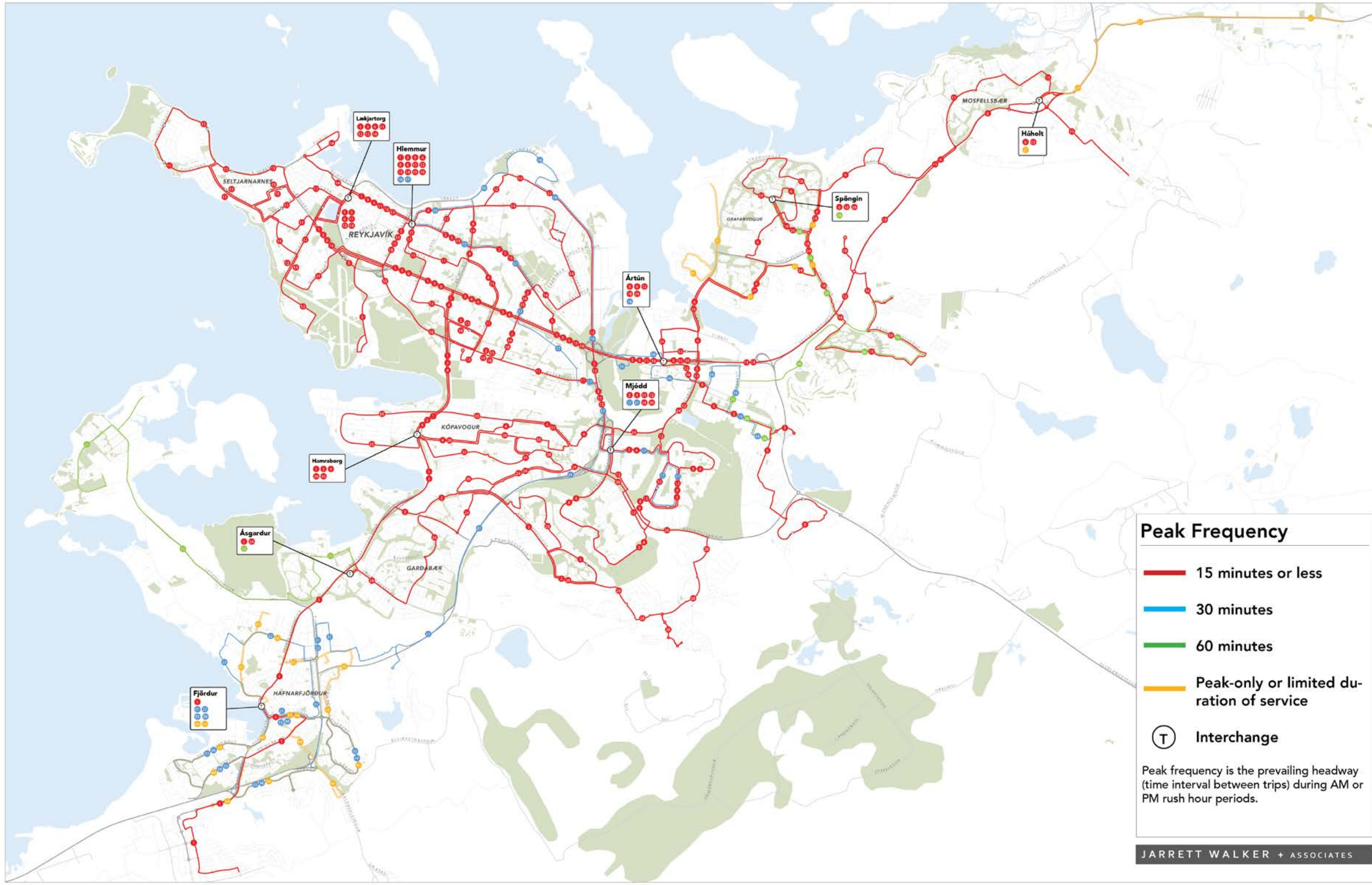

Figure 12: Peak Network Frequency

is probably leaving within just a few minutes, and another one soon after.

Geographic Pattern of Ridership

Figure 13 shows each stop in the network sized by the total number of average daily boardings at the stop for all routes that provide service to it.

Note how strongly ridership follows employment and residential density. The ridership of the suburban residents commuting to the Reykjavík CBD aggregate to form high average daily boardings in the Reykjavík CBD, stretching south and east from the core. Stops within the core area, roughly west of Highway 41 and north of Fossvogur, contribute 44% of the total average daily ridership of the network.

Outside of the CBD:

- Both frequent lines (1 and 6) generate high ridership at most of their stops, though ridership on the 6 drops off abruptly north of Spöngin interchange.
- Most stops on the segments in Kópavogur and southeastern Rekyjavik (apart from the interchanges) that are served by 30-minute routes have fewer than 60 boardings per day. Busier stops are generally located near destinations like schools, community centers, shopping centers, or large residential complexes.
- Segments served only by very-low-frequency service (60 minutes, or for a limited number of hours per day) do not typically generate substantial ridership. Examples of

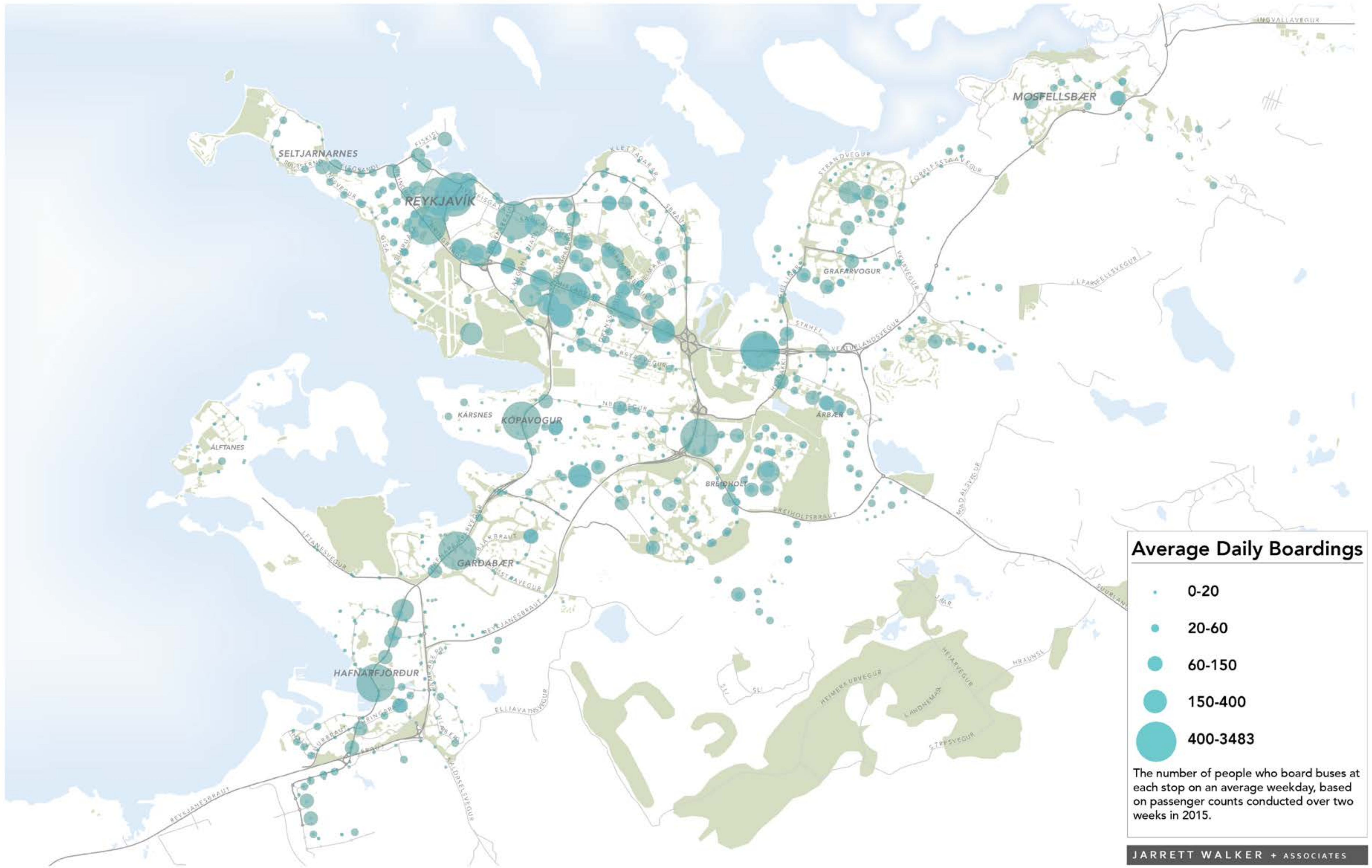

Figure 13: Average Daily Boardings

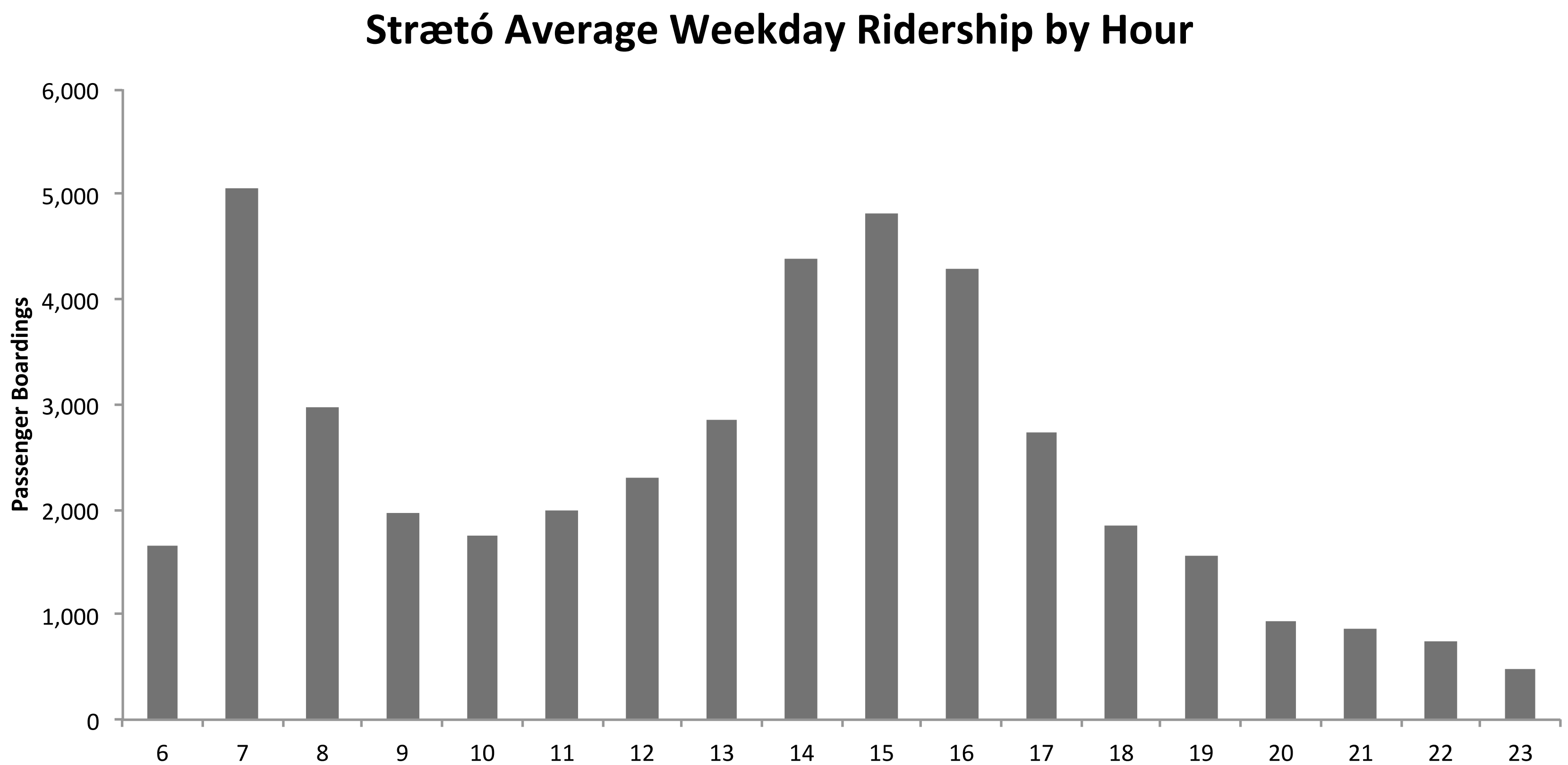

Figure 14: Peaking: Ridership by Hour of Day

low-ridership, low-frequency segments include the Alftanes and Gardabaer portions of route 23, or the streets in Hafnarfjörður served by the low-frequency one-way loop pair of routes 33 and 34, which combine for just 200 average daily boardings.

Peak Ridership

The previous two maps show how widespread frequent service is in the peak period, and how little of it there is during the midday. During the AM and PM peaks, most of the routes in the system run every 15 minutes, generally for 3 to 4 hours during each period. This makes the network much more convenient, improves the utility of connections, reduces waiting times and the need to check a schedule. Overall, this yields a more generally useful system, but only during these limited hours.

This level of service is available from approximately 0630 - 0900, and from 1400 - 1700, with the exact duration of frequent service varying by route and direction.

The chart shown in Figure 14 shows the average weekday ridership by hour on all routes (each 1 hour period starts at the time labeled on the x-axis, and ends at the next time shown). During the peak periods, when this highly useful network is available, ridership is much higher- for example, the ridership level during the 1400 - 1500 hour is more than double the number for 1200 - 1300.

Peak service level and ridership present an interesting relationship. On one hand, the peak periods are typically a part of the day with a high level of travel demand, and traditionally include many people's commutes to or from work or school. On the other, public transport providers often focus their resources on this period, offering a much more useful level of service then. This improved usefulness in turn provides a powerful incentive to public transport during these times but not at others.

We can see an example of this relationship in Figure 15 by comparing several similar routes. Each of routes 5, 11, 15 and 17 run every 30 minutes during the midday, provide service between the eastern part of the service area (Mjódd, Artún, Mosfellsbær) and the Reykjavík CBD. Each of routes 5, 11 and 15 have 15-minute service during the peaks; only the 17 does not.

Observe the difference in ridership between 1200 - 1300 (highlighted blue) and 1400 - 1700 (highlighted red). While each route has higher

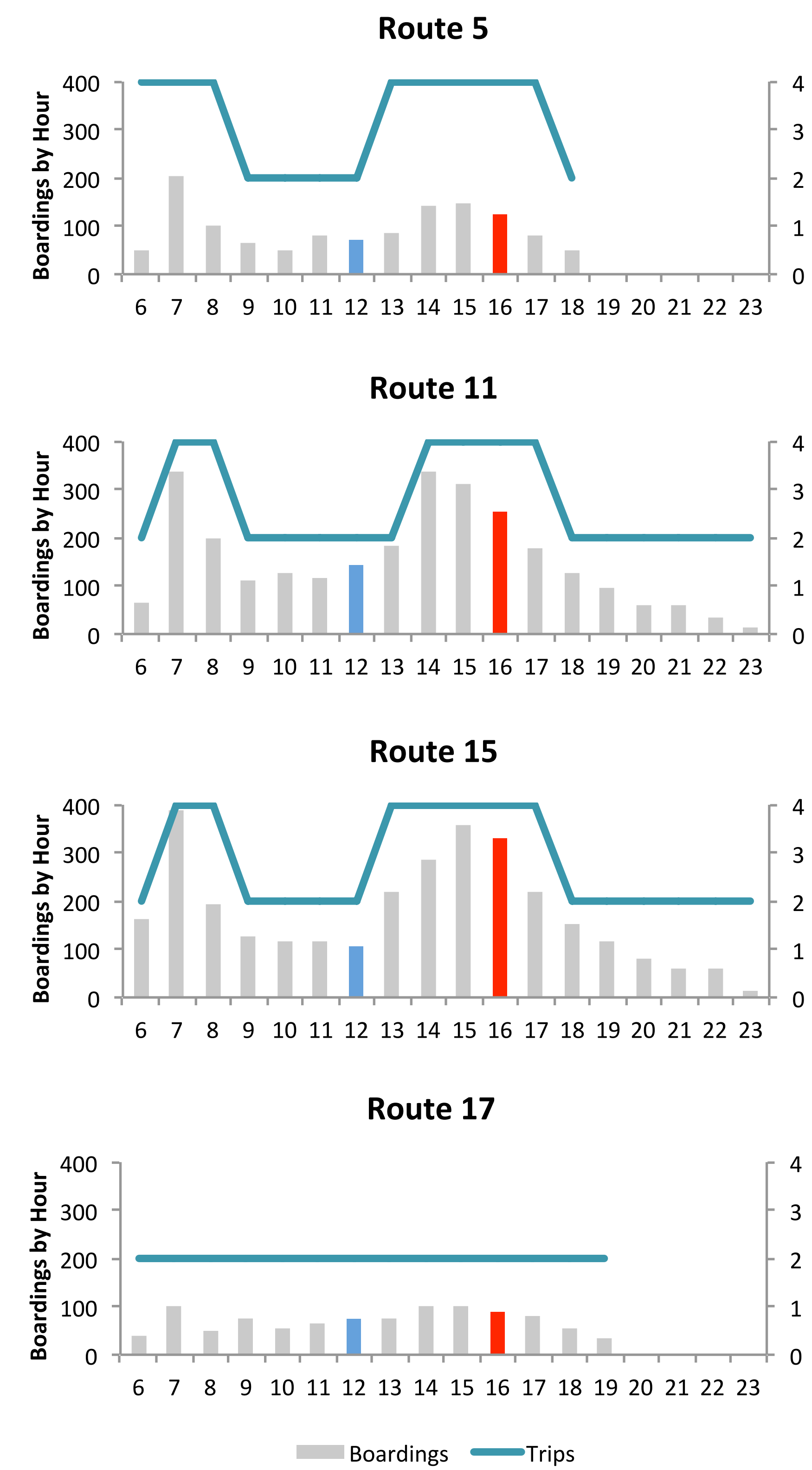

Figure 15: Route peaking comparison

Public Transport Performance Analysis

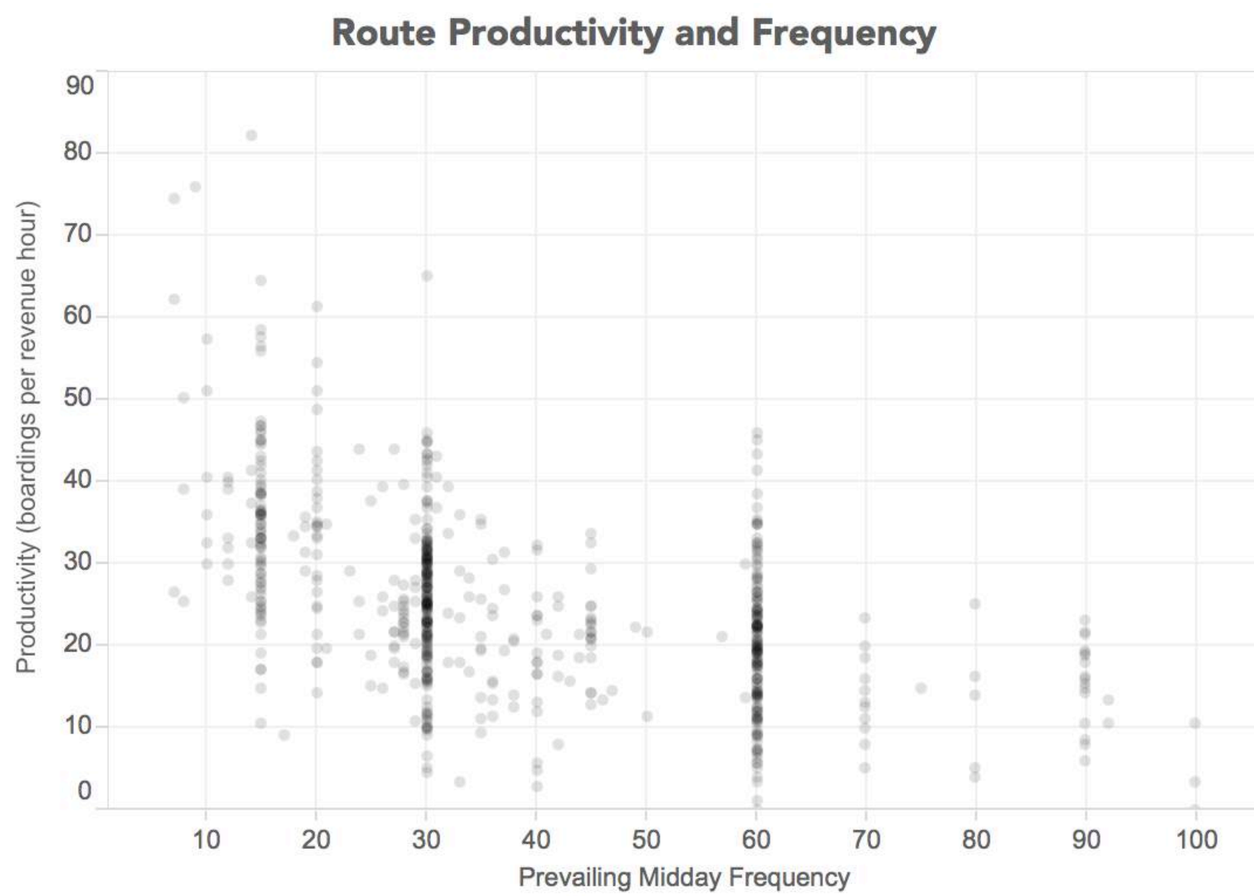

Figure 16: Multi-agency productivity by route

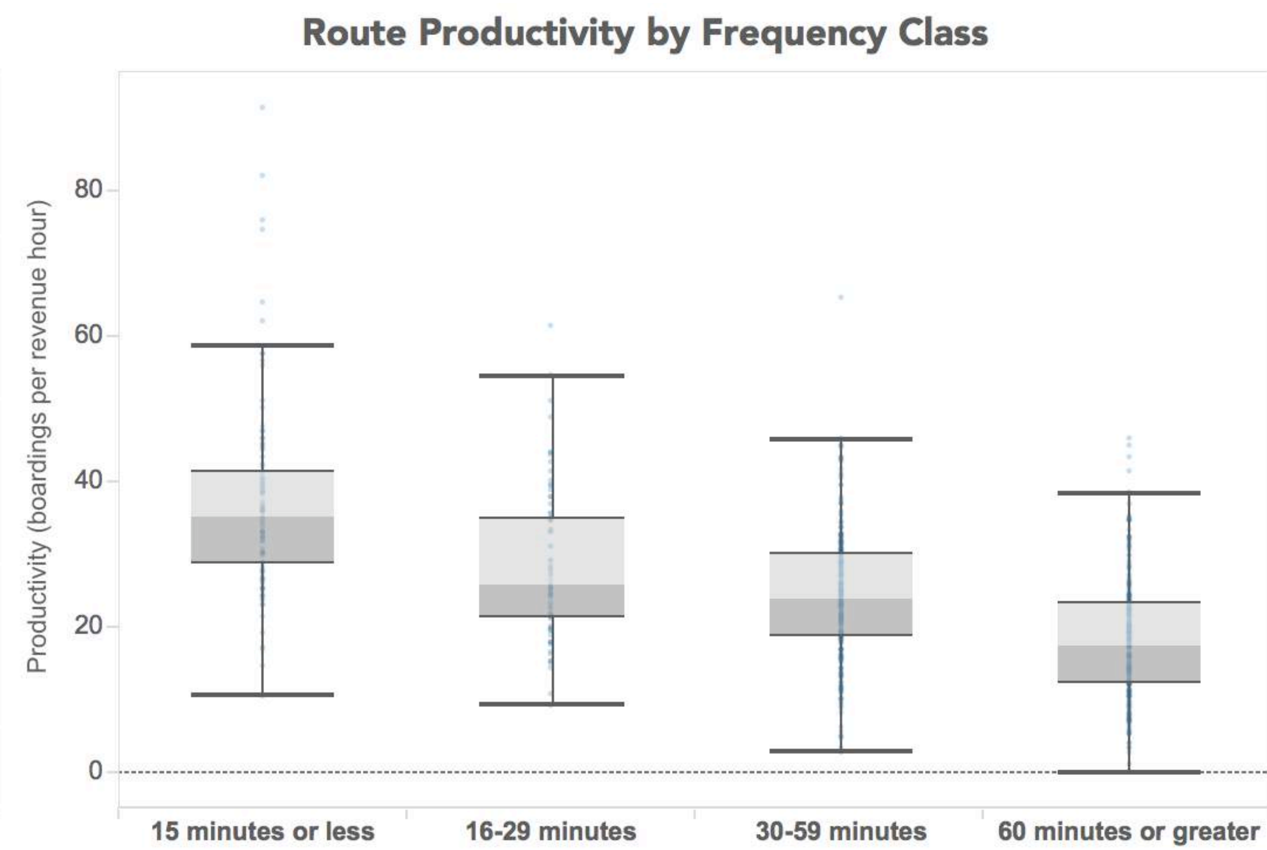

Figure 17: Multi-agency productivity by frequency class

ridership during the peak, each of the routes with frequent service on the peak have much higher ridership during the 4 p.m. and adjacent hours than Route 17. This doesn't mean that the presence of frequent service is the only reason that ridership is higher on the peak, but we can see how in this case, the routes with a higher level of service on the peak are attracting more ridership during that period.

Routes 5, 11, and 15 have twice the number of trips per hour during the peaks as during the midday. However, with the exception of the 15, none of these routes draw twice the ridership during the peak, which means that they are operating less productively during these times.

Public Transport Productivity

Productivity is ridership on a service divided by the quantity of service provided, so it is the key measure of the efficiency of public transport outcomes. We measure public transport quantity using revenue hours, where a revenue hour is one bus operating in service for one hour. So we ask: how much ridership does one revenue hour attract in one area as opposed to another - or at one time of day as opposed to another?

Productivity by Frequency

What do routes that generate ridership efficiently have in common? One answer lies in the built-environment features explored in the last chapter: density, walkability, linearity, and proximity. High ridership services attract riders by focusing frequency in these areas where conditions are favorable. In these cases, there is strong evidence that frequency can attract so much ridership that it increases productivity. In other words, while higher frequency means more revenue hours, which pulls the productivity ratio down, the ridership potential can be strong enough to counteract that effect.

Evidence for this lies in a general correlation between frequency and productivity. Figure 16 and Figure 17 show route-level data for routes in 17 North American public transport systems. (High frequency is to the *left* along the x-axis here.) A moderate to strong correlation is evident, particularly as shown by the boxplot at right. Routes in the higher-frequency classes tend to have higher average productivity.

This is notable, because productivity is ridership divided by the quantity of service, so the cost of frequency pulls this ratio *down*.

This does not mean that increasing any route's frequency will immediately increase ridership to this degree. Instead, we are describing a pattern that arises from comparing many services. The high frequency services in this comparison have developed around favorable land use patterns, and both frequency and land use are critical for success. In the longer run, frequency encourages people and businesses to locate along the path, further building ridership potential. Frequency should thus be considered a long term investment with a long term payoff in ridership - though of course the benefit for individual mobility is immediate.

Public Transport Performance Analysis

When we examine this same data for the public transport network of the Capital Region, we can observe a similar trend.

Figure 18 displays the productivity (average daily boardings per revenue hour) of each Strætó route on the y axis with the number of frequent service hours provided per day on the x axis. Frequent service is defined as a headway of 15 minutes or less. Most routes in the network offer at least a few hours of frequent service each day during the AM and PM peaks, but only routes 1 and 6 operate every 15 minutes or better through the peak periods and entire midday, before dropping to every 30 minutes during the evening. In the chart shown in Figure 16 we used prevailing midday headway because it is the only data point on frequency widely available, but in this case, we can examine each route's level of frequency in more detail.

Routes that provide more frequent service tend to be more productive. This happens because frequent service is the most useful service for riders, since it delivers the shortest waits and offers the security of knowing that if a person misses their bus, another one is coming soon. Usually, public transport agencies target this most expensive type of service towards their strongest markets. This is exemplified by the high productivity of Line 1, which serves the strongest, densest public transport market in the Reykjavík CBD, as well as a string of other important locations and transfer points along its route.

The other high-productivity routes have similar features. Line 6 is frequent all day long, is anchored in the Reykjavík CBD, and serves dense areas such as central Grafarvogur. However, the low-ridership segment north of the Spöngin interchange in Mosfellsbær reduces the overall productivity of the route, since the full frequency is carried through a lower-density, lower-demand area which requires long distances of travel (low proximity) and circuitous routing (low linearity). Without these lower-demand segments Line 6 would probably join Line 1 in the top ranks of productivity. The next two pages explore these two lines in detail.

Other highly productive routes include routes 3, 4 and 5. Top performance in the 30-minute category is usually a good sign that all-day 15-minute service would perform well, at least on parts of their alignment.

Routes 3, 4 and 5 share many of the same favorable features as Frequent Lines 1 and 6. They serve major nodes (the Reykjavík CBD, Hamraborg interchange, dense areas of Kópavogur, and Mjódd), and provide easy-to-use frequent connections during the AM and PM peak periods.

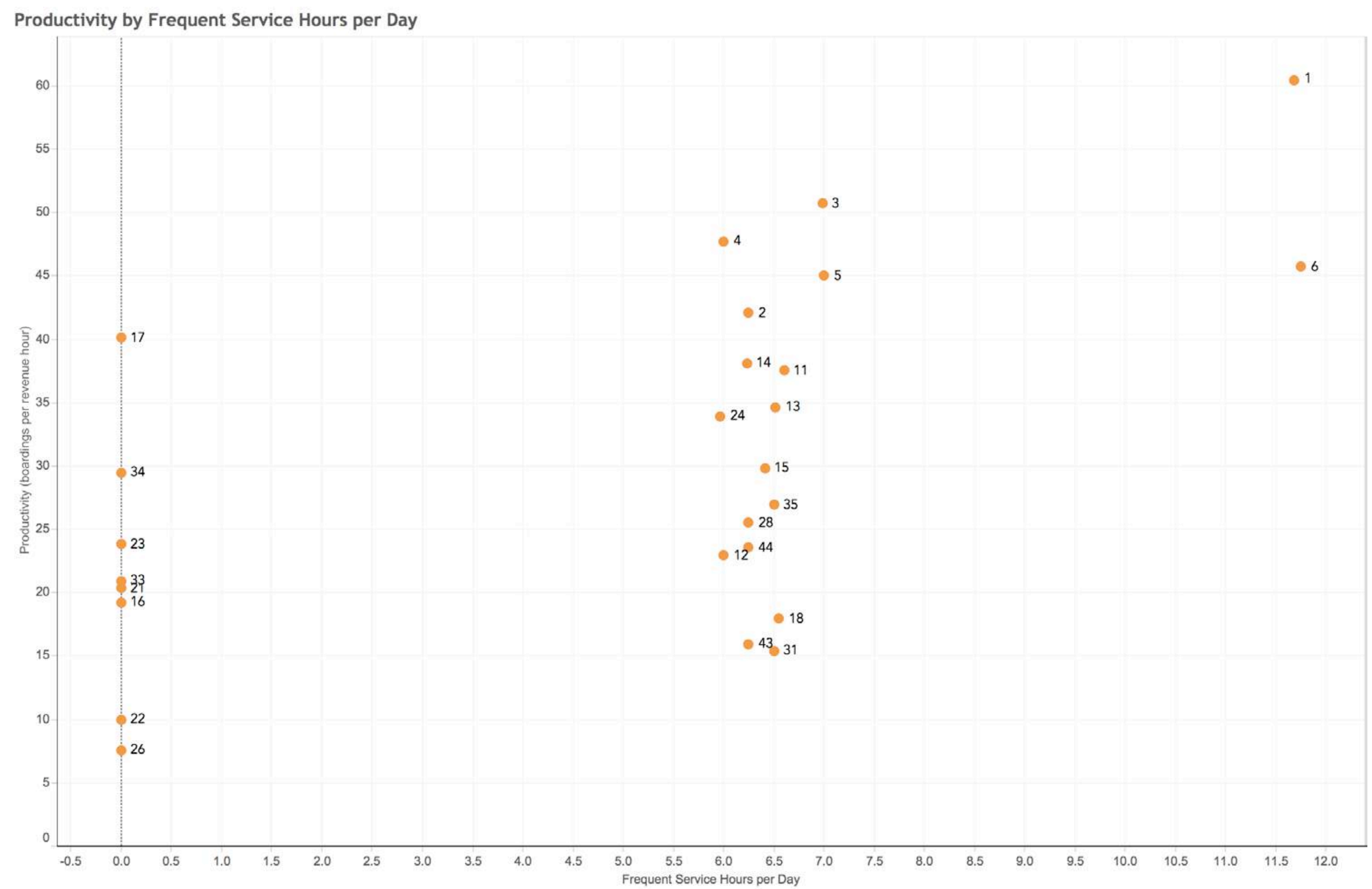

Figure 18: Strætó Route Productivity and Frequency

Line 1 (Highway 40)

Line 1 connects the Reykjavík CBD and all the town centers south along Highway 40, then ends in Vellir south of Hafnarfjörður. What can we learn from the high performance of this route?

Figure 19 shows average daily ridership on Line 1 by stop. Though there is a cluster of very high ridership stops in core area, the interchanges and local stops, particularly near Hafnarfjörður, all have strong utilization, with most recording over 100 average daily boardings. The combination of a frequent, direct, convenient service to dense, mixed-use destinations has resulted in an exceptionally productive service that succeeds in generating high ridership along its entire length. Line 1 is an excellent example of a route that has been designed in a way that is conducive to generating a lot of ridership at a low cost.

Another key to Line 1's success is that other routes do not overlap it much, at least for the southern half. Line 2 does duplicate Line 1 north of Arnarnes and Line 4 also duplicates it north of Hamraborg in Kópavogur. Further south, though, local networks connect with Line 1, requiring connections for travel along Highway 40. Nobody likes making connections, but they are the essence of how a simple and effective service like Line 1 is constructed.

It is helpful to imagine another approach that could have been taken to serving Hafnarfjörður. Instead of having a single frequent line, every part of Hafnarfjörður could have been given its own separate route into the CBD. The result would be many overlapping routes along Highway 40 but lower frequency and thus lower usefulness. This is essentially how the current network works for the area east of Highway 41 and south of Highway 49: many overlapping infrequent routes but not frequent ones. Line 1's high ridership and productivity signals that its style of design - high frequency instead of many overlapping routes - is a successful approach that could be applied elsewhere in the network.

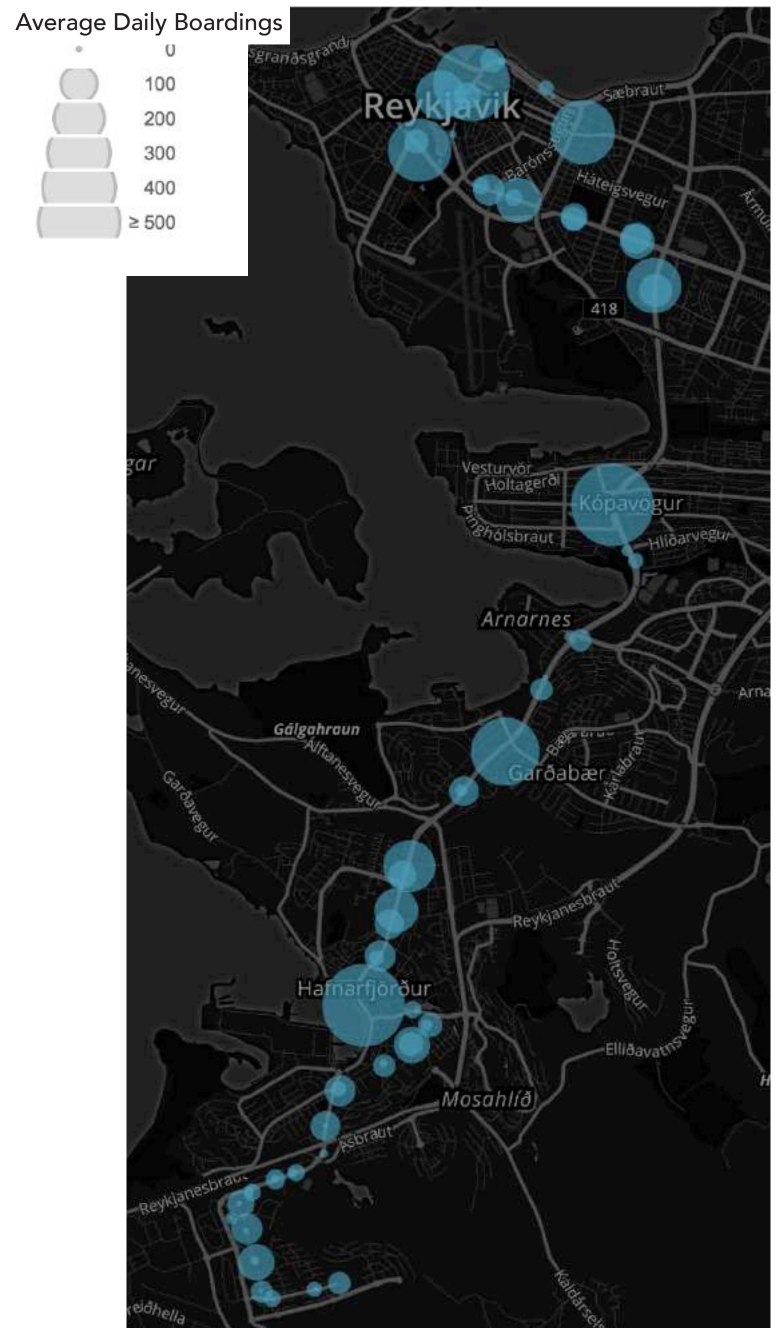

Figure 19: Line 1 Ridership by Stop

Line	Frequency Peak	Frequency Mid	Frequent Hours per Day	Average Weekday Boardings	Boardings per Revenue Hour
1	15	15	11.68	5,768	60.48
2	15	30	6.25	2,004	42.07
3	15	30	6.98	3,133	50.71
4	15	30	6.00	3,343	47.73
5	15	30	7.00	2,703	45.04
6	15	15	11.75	4,273	45.72
11	15	30	6.60	2,365	37.55
12	15	30	6.00	1,788	22.93
13	15	30	6.52	1,623	34.67
14	15	30	6.23	2,379	38.10
15	15	30	6.42	2,510	29.86
16	30	30	-	498	19.24
17	30	30	-	935	40.13
18	15	30	6.55	1,406	17.94
21	30	30	-	456	20.36
22	30	30	-	52	10.00
23	30	60	-	236	23.84
24	15	30	5.97	2,033	33.95
26	60	60	-	79	7.60
28	15	30	6.25	1,670	25.50
31	15	15	6.50	234	15.43
33	30	60	-	83	20.92
34	30	60	-	117	29.50
35	15	30	6.50	506	26.94
43	15	15	6.25	199	15.96
44	15	15	6.25	334	23.58

Figure 20: Route Data Table

Public Transport Performance Analysis

Route 6 (Hlemmur > Haholt)
The other line that runs frequently all day is Line 6, linking the Reykjavík CBD and Mosfellsbær. It is productive, but much less so than Line 1, and less than several half-hourly routes. Why?

Figure 21 shows the ridership by stop for Line 6. Ridership is high along the part of Line 6 that is straight and fast, between the CBD and Ártún. Then, however, the line turns off toward Spöngin, and while Spöngin itself is a high-ridership area the path that must be taken is very circuitous. Beyond Spöngin, ridership drops off sharply. Mosfellsbær, at the end of the route, generates low ridership given the high frequency provided.

An examination of the trip density map can provide some insight into this issue. As the slice of the map in Figure 22 shows, Line 6 serves mainly moderate to high activity areas from the Reykjavík CBD until Spöngin, in a consistent string of high ridership stops. In area of lower trip density from Haaleitisbraut to Highway 41, Line 6 stops only twice, generating moderately high ridership at the Skeifan commercial area and the residential area immediately east. Moderate-to-high ridership stops continue along the route until Spöngin. However, north of Spöngin, density declines substantially.

About 4300 people per day ride this route; the segment between Spöngin and the Reykjavík CBD accounts for about 4000 of these. The northern low-density segment makes up 32% of the distance of the route, and thus a substantial portion of its expense since the full 15-minute frequency is provided all the way to Mosfellsbær, but it accounts for only 7% of the route's boardings.

Line 6 provides another compelling example of how frequency and favorable development patterns combine to produce high ridership. Where the line provides a reliable, fast and frequent connection between dense areas - i.e. between the CBD and Ártún - ridership is strong.

However, after Spongin, necessary features of ridership disappear. Density is much lower, and the circuitous routing means there is poor linearity. So ridership falls off dramatically.

Given what we know about the cost drivers (length) and ridership of the route, it is likely that simply truncating the 6 to terminate at Spöngin would improve the 6's productivity level, and free up resources that could be invested somewhere else, including a lower-frequency but more direct route between Mosfellsbær, Ártún and the Reykjavík CBD. To determine if this makes sense, it would be necessary to study whether many people are using the service to travel between Mosfellsbær and Spöngin.

Figure 21: Line 6 Ridership by Stop

Figure 22: 2016 Trip Density Map (north Capital Region focus)

Network Design Concepts

Radial Networks and Duplication

The existing network of the Capital Region is extremely radial, meaning that most routes eventually travel to the Reykjavík CBD. For example, lines 3 and 4 both provide service to residential areas in southeast Reykjavík, converge at Mjódd, and then proceed to the Reykjavík CBD via two different paths. The 17, which also serves this southeastern area, does the same, with its only unique segment south of the 49 expressway along Sogavegur.

In a radial network, most parts of the city are only a one seat ride away from the Reykjavík CBD. This is convenient for people who travel there often, but it also requires a lot of duplication. Again, thinking about the 3 and 4, these routes share the two directions of a unique segment at their far end, but for most of the way from Mjódd to Hlemmur along either of their paths, they are duplicating other routes, including the frequent 1 and 6.

As a result, multiple routes serve many of the segments entering the Reykjavík CBD and central area, including the 49 expressway and Suðurlandsbraut. Like the 3 and 4, most of these provide important and unique service at their far ends, but duplicate other routes as they converge in the Reykjavík CBD.

This is a common feature of radial networks, given the increasingly limited number of potential public transport paths as multiple routes converge at a single location, and is unavoidable as long as the choice to provide this direct service continues to be made.

If the choice is made that some transfers are permissible, however, the resources spent on duplication at low-frequencies can be combined into unique high-frequency segments.

Figure 23 shows a simple diagram of these two types of network design. In the first, four low-frequency routes all travel the Reykjavík CBD, but they provide the same service (but not combining for a reliable 15-minute headway) over a long segment.

In the second image, each 60-minute route ends at a connection point where passengers transfer to a frequent route to complete their journey the Reykjavík CBD. Anybody traveling along the frequent route can rely on a 15-minute headway throughout the day.

Much of the existing network is more similar to the first type of network; this allows much of the city to have a direct connection to the Reykjavík CBD, but it limits the extent of segments where all-day frequent service is available.

Furthermore, given the 15-minute frequency most routes run during the peaks, for 6 hours of the day, substantial resources are expended to provide multiple duplicate frequent services on a number of key segments and between multiple key connections; for example, between Mjódd and the Reykjavík CBD. Much of this added frequency is probably excessive.

The second option in this drawing has several additional advantages.

First, it allows larger buses to be deployed on the high-frequency segment, where demand is likely much higher, and smaller buses to be used on the local feeders as appropriate.

Second, the connection point can help to anchor orbital services, helping these services rise to high frequency. In the Capital Region, for example, a direct line might be possible linking Spöngin, Ártún, Mjodd, Smáralind, and perhaps Gardabær or Hafnarfjörður. This line might even support high frequency, becuase they make enough frequent connections as well as connecting with local feeder systems at each node. This kind of design is often the product of an effective redesign process.

Thinking about this situation, though, requires also thinking about the options for timed connections or *pulses*, which we discuss next.

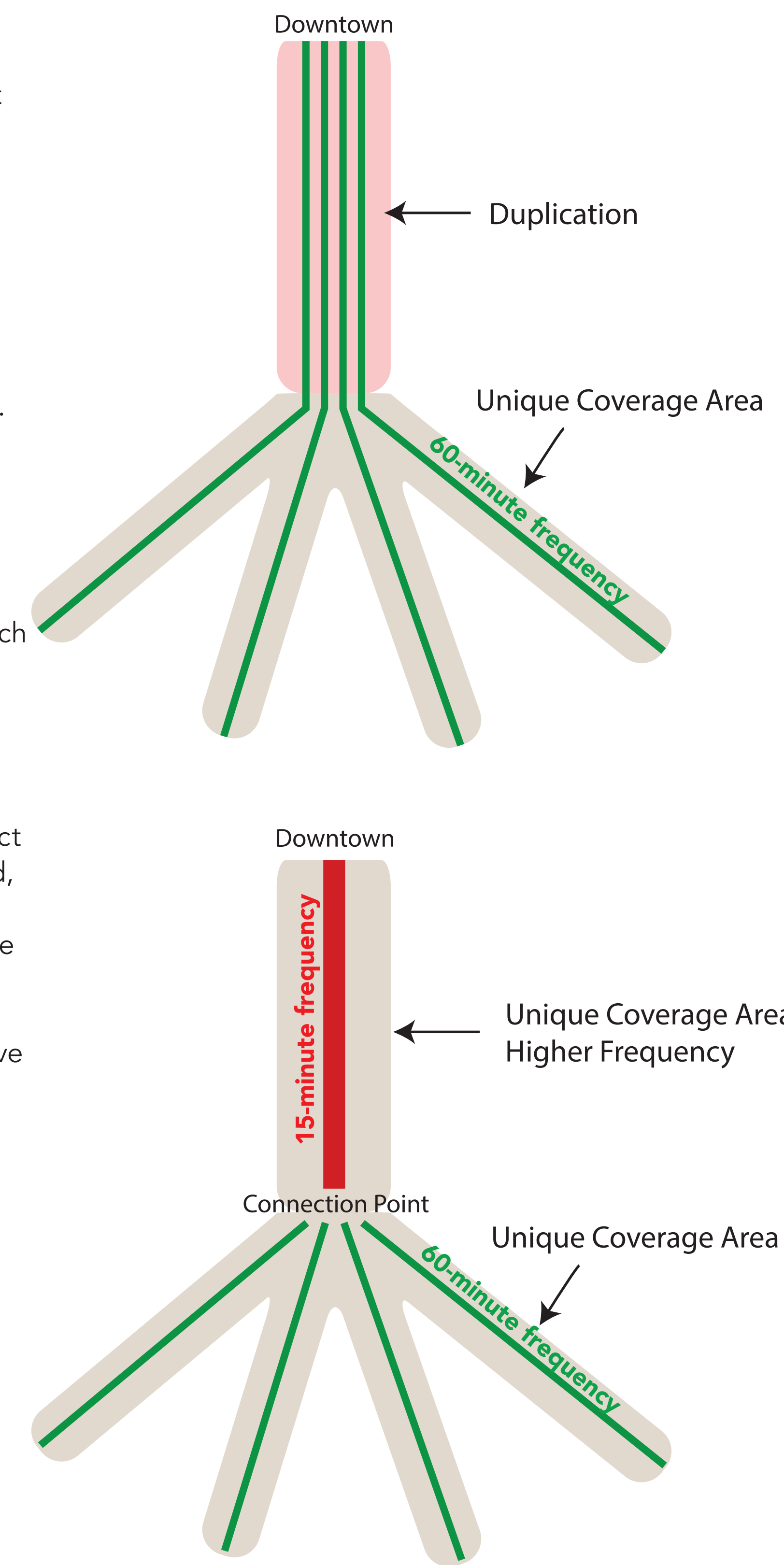

Figure 23: Duplication in Radial Network

Duplication
Four routes, each operating at 60-minute frequency, provide service to unique coverage areas, before using the same segment to reach the CBD.

Connection
Four routes, each operating at 60-minute frequency, converge at a connection point. Here, passengers transfer to a very frequent route that continues to the CBD. Along this route, a scheduled 15-minute headway is always available.

Pulse Scheduling

Reykjavík's existing network features extensive *pulsing* at major interchanges such as Hlemmur, Mjodd, Hamraborg and Ártún. By "pulsing", we mean a scheduling practice where routes are designed and scheduled so that they arrive at key connection points at the same time every hour. At these points, passengers can transfer between buses without having to wait. A simple illustration of this concept is shown in Figure 24.

Pulses are the only way to provide fast connections among many infrequent routes (routes running every 30 minutes or worse). The result is dramatically reduced travel times for trips between many possible origins and destinations. At frequencies of 15 minutes or better, pulsing is not necessary, since connecting buses are departing soon no matter when a bus arrives.

Pulsing has disadvantages. It requires many routes to converge at a point which may be out-of-direction compared to logical paths of travel. This disadvantage is minimized if the pulse point is also a major destination such as a town center or shopping center, and most of the Capital Region's pulse points are well located in this respect.

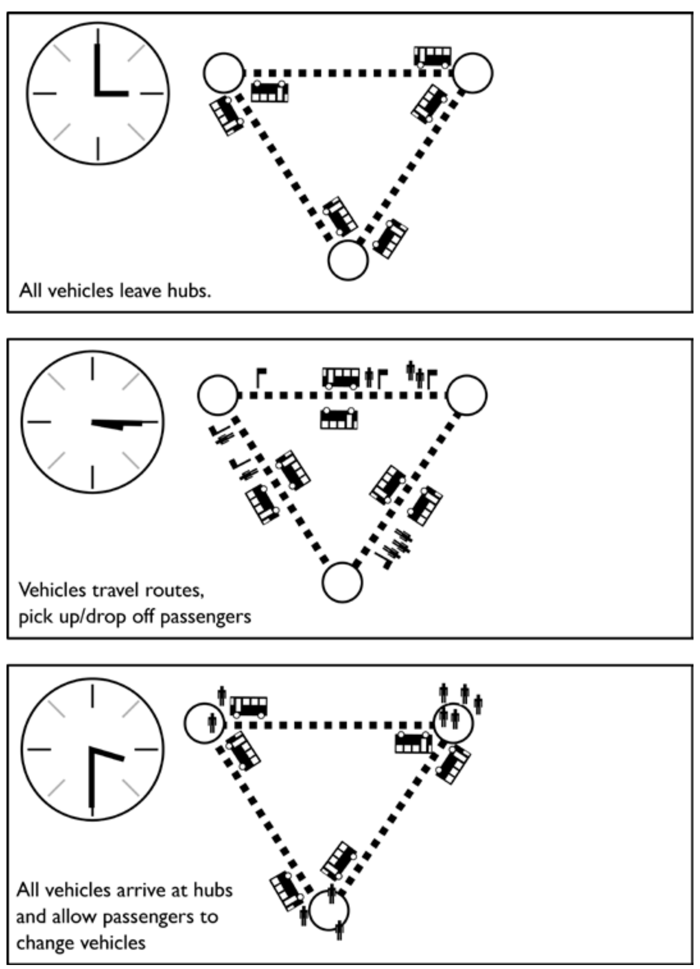

Figure 24: Timed Transfer ("Pulse") Network

Pulsing, however, can also trigger duplication.

We have noted several places where multiple low-frequency routes serve a segment often enough to provide high frequency, but do not. For example, when eight buses an hour come in groups of four every half hour, the result for the customer is a 30 minute frequency even though there is enough service to offer a 7.5 minute frequency.

Pulsing is sometimes, but not always, the cause of this issue. It is sometimes necessary to choose between having a pulse and having high combined frequency.

Figure 25 shows an illustration of the issue, using a simple network where each local route runs every 60 minutes.

In the first panel, four different hourly routes flow through the transfer point and continue along a common path off to the right. This corresponds to a land use pattern that gives lower demand in the west half of the area, and higher demand along the common path to the east.

In this case, the four routes are timed to be at the pulse point at the same time each hour. People on these routes do not need the pulse for going into the denser area to the east, because all their routes take them there directly. Instead, the pulse allows them to connect between local routes, to make local trips within the lower density area on the west half of the map.

But because all four routes continue east from the pulse, they travel in a bunch, which means that every hour, each stop on the eastern segment is served by four buses all coming at once.

In the second panel, the local routes west of the pulse point have been separated from the trunk section going off to the right. Now the four local buses still converge at the same time each hour, but they meet a single bus that is continuing into the common segment.

This means that the other three buses that were running in a bunch along the common segment can be used to build high frequency along that segment. So it's possible to run service every 15 minutes along that segment, instead of a pile of four buses every hour as in the first panel.

There is a third option, which would be to give up the pulse. In that case, all four local routes could flow through into the common segment spaced 15 minutes apart, thus creating the desired high frequency.

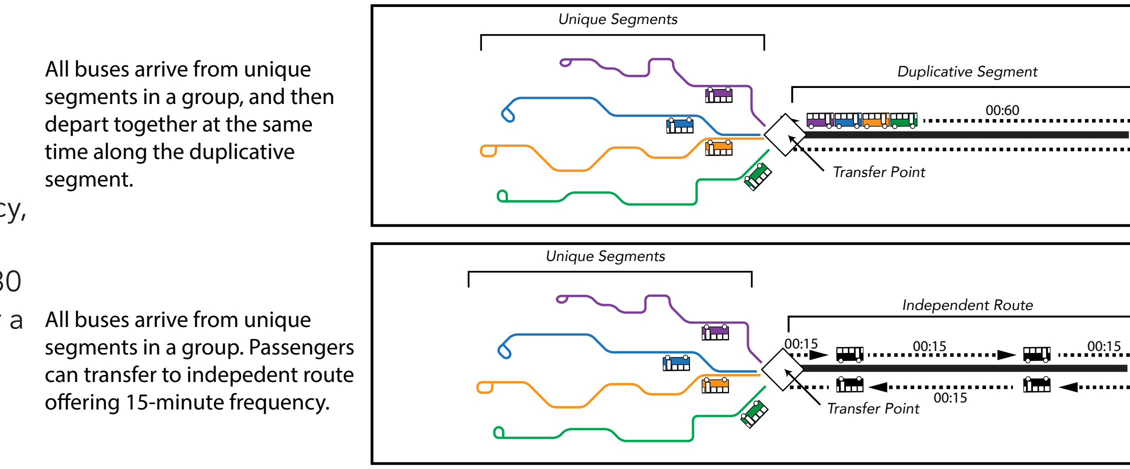

Figure 25: Duplication with pulse

Figure 26: Sudurlandsbraut duplicative segment

One example of this (shown in Figure 26) in the existing network can be found during the midday on Sudurlandsbraut, served by routes 2, 5, 15, and 17. These routes are scheduled such that they connect at Hlemmur at the same time. They then each depart Hlemmur eastbound on Laugavegur - Sudurlandsbraut, at 00:14, 00:16, or 00:17, and 00:44, 00:46, and 00:47 of each hour. So the segment has 30 minutes service even though there are enough buses to run 7.5 minute service.

One of the three steps outlined above could be used to revise this situation. Which step is right requires more detailed analysis, and the problem could also be fixed in the context of a more complete network redesign.

Public Transport Performance Analysis

Loops

Many of Strætó's routes outside of the core of Reykjavík operate along looping paths, where service is available in only one direction for all or part of the route. For example, the 35 runs clockwise only in Kópavogur between Mjódd and Karsnes west of the Hamraborg public transport center, where it is the only public transport service available. Elsewhere, routes like the 2 or 5 end in large one-way turnaround loops, and several routes like the 3 and 4 operate in opposite directions on the same segments.

Loops are an attractive service design option when the goal is to provide some service on as many segments as possible. The nature of one-way service allows for a route line operating in only one direction to be extended for a longer distance.

Long loops like Route 35 in Kópavogur are a good way of maximizing coverage, but they have one major drawback: trips along the loop are almost always longer in one direction than the other, since a person must ride all the way around the loop to complete a return trip. The more out-of-direction travel is required to make a trip on public transport, the longer that trip will take, and the less attractive public transport will be as an option.

One-way loops also add a layer of complexity to the network, since a rider using one to make a trip will need to understand that they must travel around the loop, even if the bus is coming in the opposite direction from where they are traveling to. In some cases, two one-way loops provide two-way service on a limited segment, as with the 3 and 4 in Breiðholt, but then continue along very different paths. Thus, a person standing at the junction of Breiholtsbraut and Jaðarsel could catch a 3 or 4 in either direction, but once either route departed Mjódd, they would be traveling towards the Reykjavík CBD along very different paths.

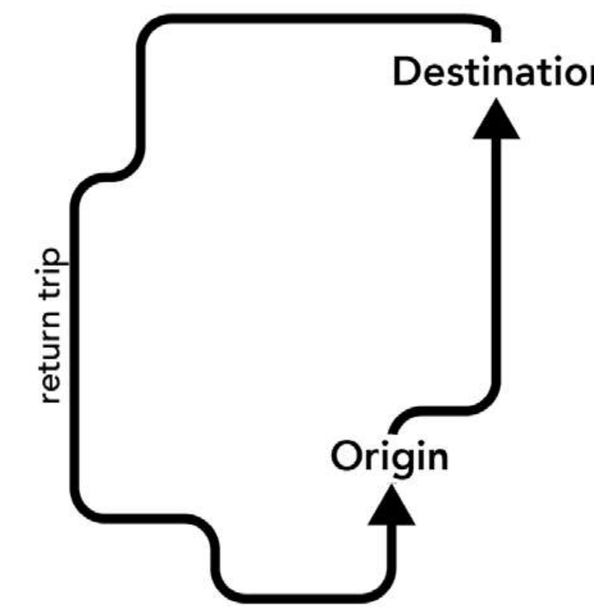

Figure 29: Looping Diagram

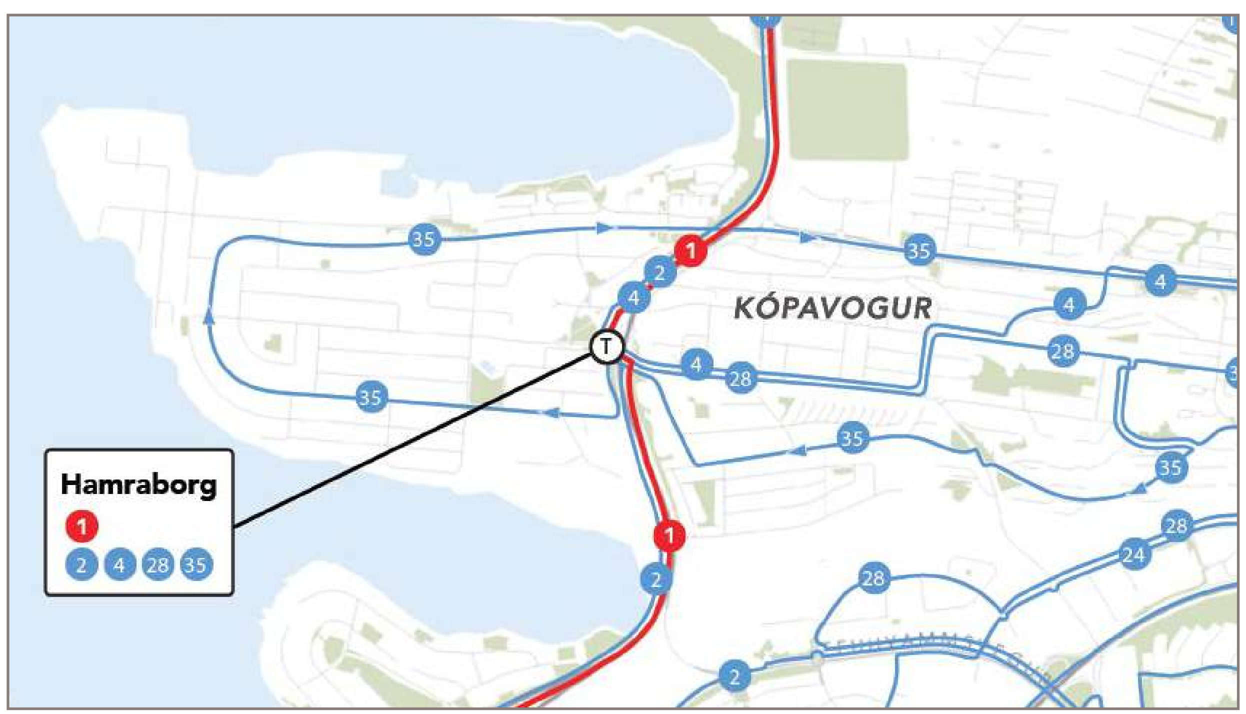

Figure 27: Line 35

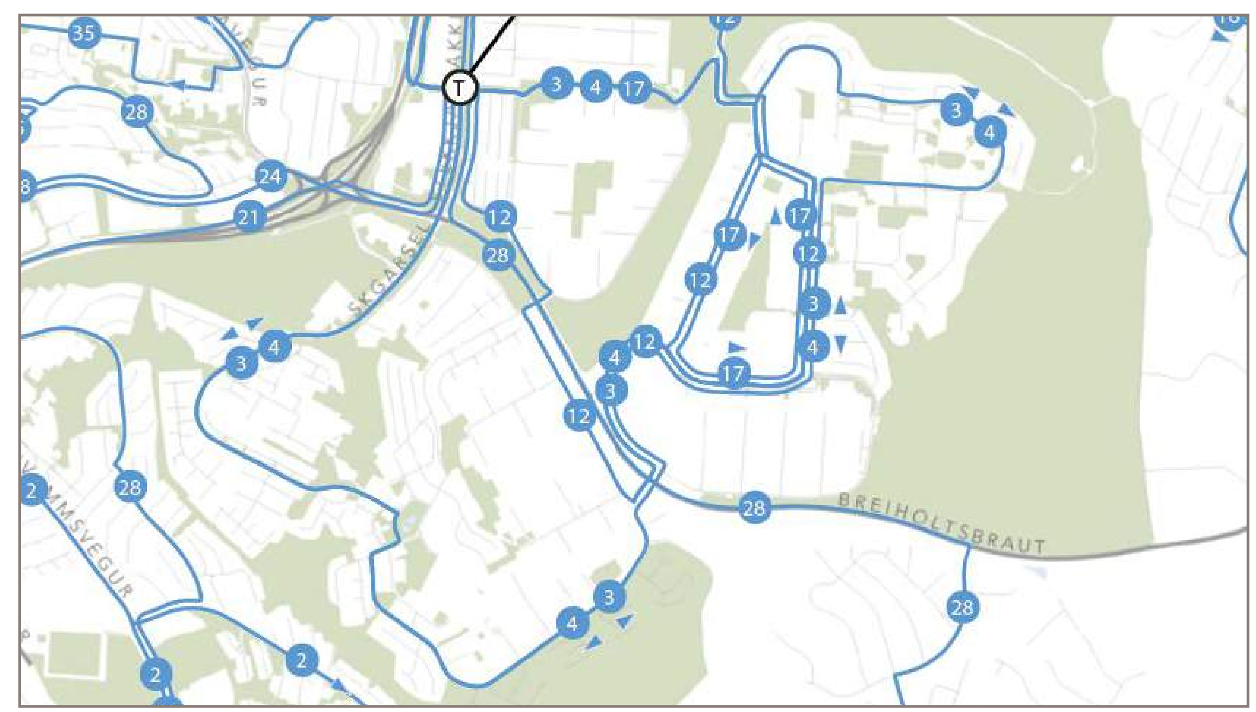

Figure 28: Lines 3/4

Public Transport Performance Analysis

Circuitous Routing
A key element of the Ridership Recipe is linearity: can public transport use direct, efficient paths to serve areas and destinations? The shorter the distance to connect places where many people gather, the larger the public transport route's potential market and the smaller the cost of providing the service.

Strætó's most productive routes follow this principle; recall the earlier discussion of Line 1, which offers a fast, direct path connecting important destinations, dense areas and connection points, and which is the most efficient, highest-ridership route in the system. As we mentioned earlier, the other frequent route, Line 6 (Figure 31), serves markets where the development pattern requires a more circuitous path to reach dense areas and destinations, and yields ridership at a less efficient rate.

Public transport's ability to operate on such efficient and direct paths is limited by the development pattern and road network. Streets may be laid out in curving patterns, leading to the sorts of paths routes serving Breiðholt use. Developed areas can also be located out of the way of direct paths, requiring a deviation off the straight line if they are to be served. Figure 30 shows a simple illustration of these route types.

Examples of this sort of routing can be found in the existing network. Figure 32 presents a snapshot of a the network in Úlfarsfell. This is a relatively dense, compact area, but it is poorly connected to other areas, with major access points only from the west and south. Thus, to serve this area, Route 18 18 (a direct connection between Spöngin, Ártún and the Reykjavík CBD) must deviate off of the 1 expressway, making its way through the entire neighborhood and north to the Korputorg shopping center, before turning back onto the expressway and on to Spöngin. Route 26, a less-frequent, lower-ridership route, serves the area in a similar way, but does not reach Korputorg.

Circuitous and deviating routes are useful in that they allow a direct connection between major destinations to be accessible to areas off the straightest path (which may have more favorable land use or urban design for public transport), but they also diminish the usefulness of that connection for people riding through. Route 18 actually generates more ridership in the segment in Ulfarsfell than near Spöngin, but it also adds substantial distance to the route in order to connect this set of destinations.

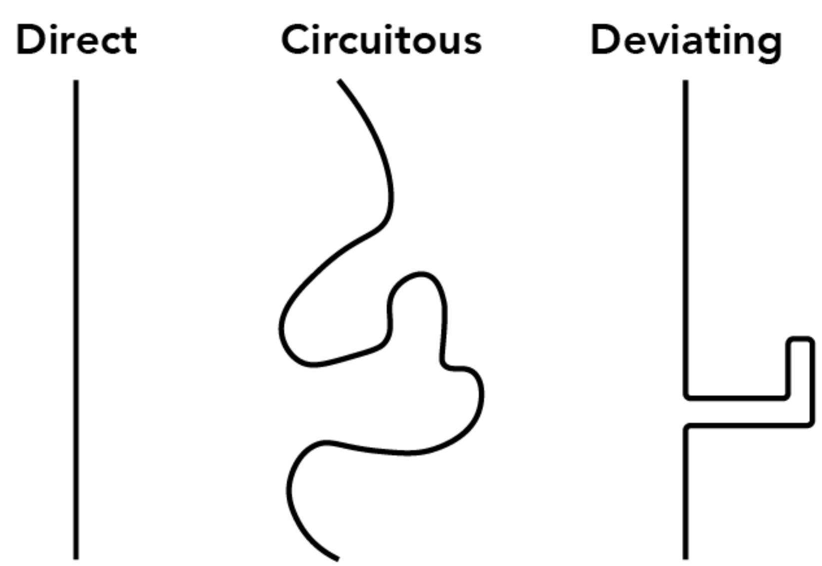

Figure 30: Route Path Types

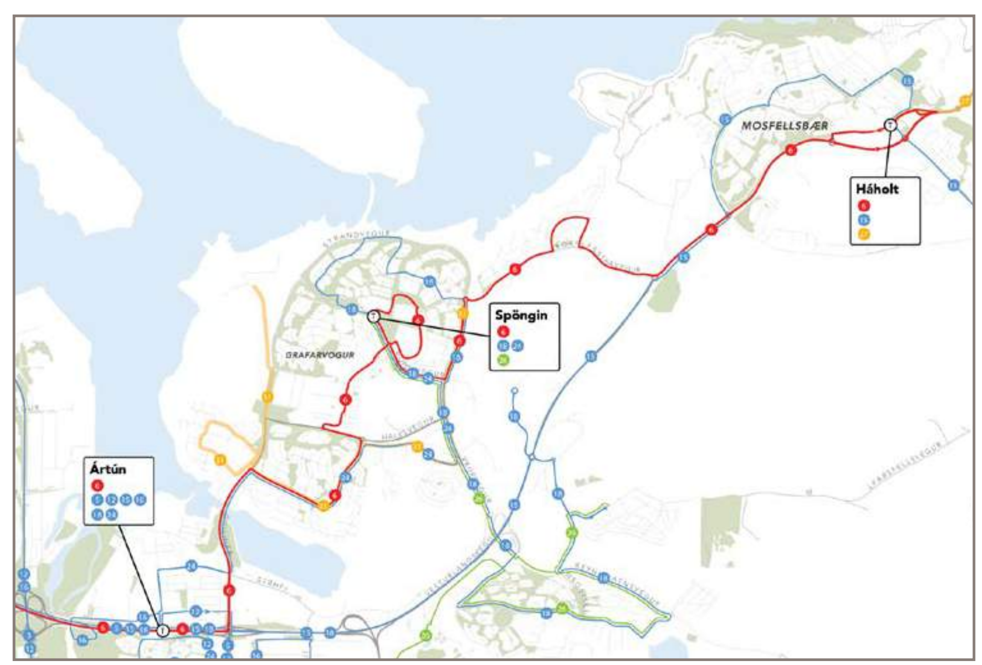

Figure 31: Line 6 circuitous northern segments

Figure 32: Circuitous and Deviating Route Paths near Úlfarsfell

Public Transport Performance Analysis

Frequent Network Access & Coverage Analysis

The prior measures discussed in this section have discussed the performance of the network mainly in terms of how well it succeed at generating high ridership. Ridership is an important goal of any public transport service, but there are other goals public transport can serve as well. Perhaps the most important of these is the coverage goal, which seeks to extend a basic level of access to the public transport system to as many people as possible. We can assess the performance of this goal by conducting an analysis through spatial interpolation to estimate how many people are within walking distance to public transport in the region; the more people are near public transport of some sort, the greater the overall level of network coverage. A simple description of the methodology is shown in Figure 34.

The same tools can be used to assess an important ridership factor - the level of access to frequent service, those routes where a bus is always coming soon, all day long. This is accomplished by performing the same analysis, but limited to the area within close proximity of only frequent routes.

Since expanding access to frequent service expands the number of people who have the option of choosing the most useful, most convenient public transport service as a travel mode, the overall level of frequent service access tends to be a useful indicator for the ridership potential of a network. Public transport networks that seek to generate high ridership often extend this type of service as widely as budget and politics allows. On the other hand, public transport networks that offer a very high level of coverage service may sacrifice potential ridership, because operating resources that are invested in lower-frequency service to lower-density places are not available to focus on the frequent network and key markets.

Figure 33 shows the performance of the current network in terms of the total number of people near some type of service, near all-day frequent service, and near frequent service during the AM and PM peak periods. As this chart shows, Strætó provides near-total coverage to the population of the region; according to our estimate, 96% of people are within 500m of some sort of public transport service.

The number of people living near the frequent network is much more limited- just 36% of people are within 500m of the two all-day frequent services, the 1 and 6. During the peak periods, when many more routes run every 15 minutes, more than 90% of the population is near a frequent service.

An agency seeking to maximize coverage will seek to expand the total network coverage to encompass as many people in the service area as possible. An agency seeking to expand ridership will move to make their highest tier of service, which is most useful and competitive with driving, available to as many people as possible, increasing the number of people near frequent service.

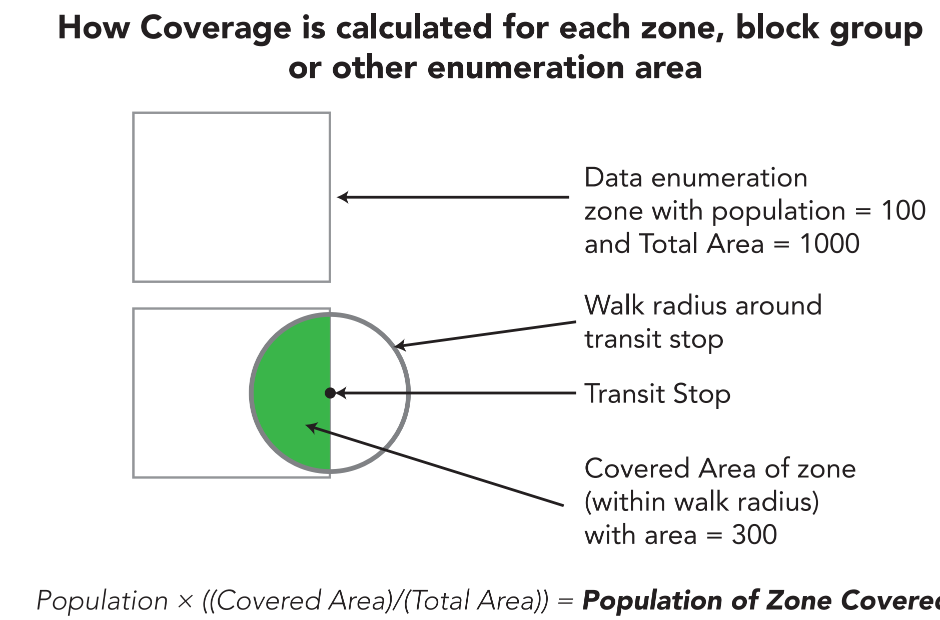

Figure 34: Coverage Analysis Methodology

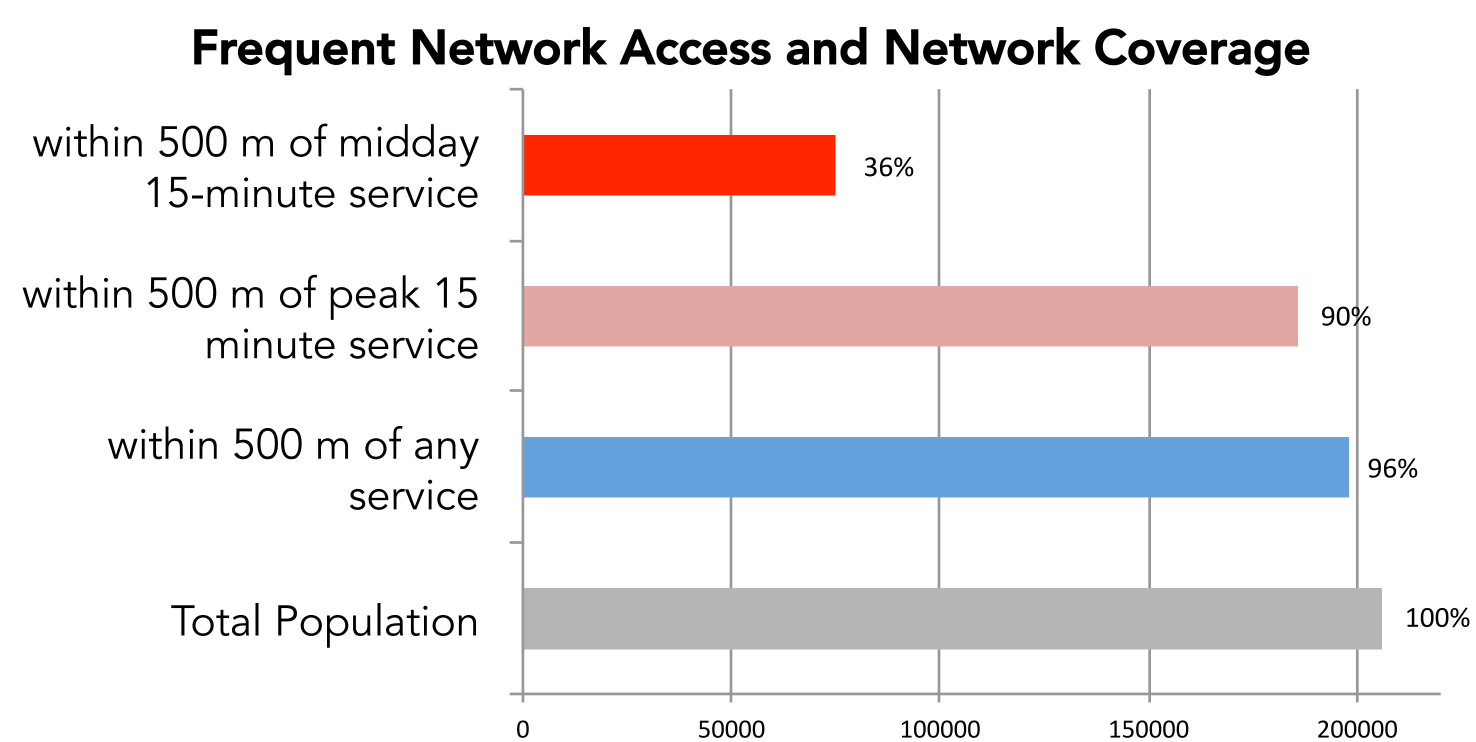

Figure 33: Frequent Network Access & Network Coverage

Public Transport Performance Analysis

Peer Review

We surveyed a number of cities to compare several high-level measures of public transport availability and relevance. The cities chosen were mainly Scandinavian and Canadian cities of comparable metropolitan population, with several significant outliers (Malmo, Victoria[2]) included to provide a more diverse range. No city precisely replicates the economic, demographic and development conditions of the Capital Region, so a group of peers provides a range of variation rather than a prescriptive target. For each city, we collected data on public transport mode share, annual ridership per capita, annual service hours per capita, and annual vehicle kilometers per capita, as shown in the charts at right. These data were available for nearly all peers, but where they were not, an empty bar is shown.

Service Relevance

One of the simplest and most general measures of how important the public transport network is to a region is the percentage of trips that are made using it: mode share. As of 2014, the Capital Region's public transport mode share stood at around 4%. This was one of the lowest rates among peers surveyed, comparable to Örebro. This makes sense when we consider the context of urban form of the Capital Region: much of the development of the region has come in recent decades.

Another method of gauging the relevance of the public transport network to peoples' travel behavior is in terms of per capita ridership: how many rides are taken on the public transport network each year for everyone living within the service area?

Per capita ridership in the Capital Region is most comparable to Orebro, as well as the Canadian cities of Victoria and Halifax, . As discussed earlier, the Capital Region's performance on this metric has increased substantially in recent years, from 37 annual boardings per capita in 2009 to 50 in 2014. This is a positive trend, but Reykjavík's performance on this measure still lags its Scandinavian peers. In cities like Victoria or Stavanger, there are 25 and 40 more boardings recorded, respectively, each year per person than in Reykjavík.

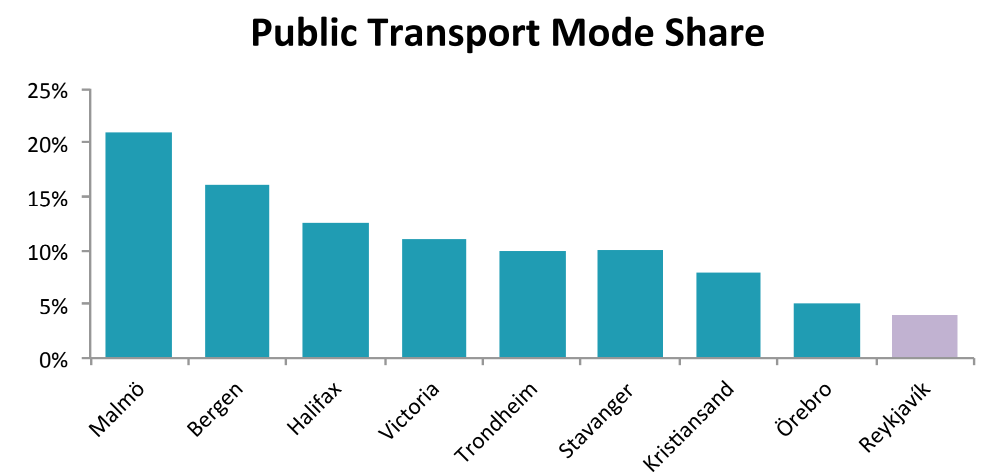

Figure 35: Peer City Public transport Mode Share

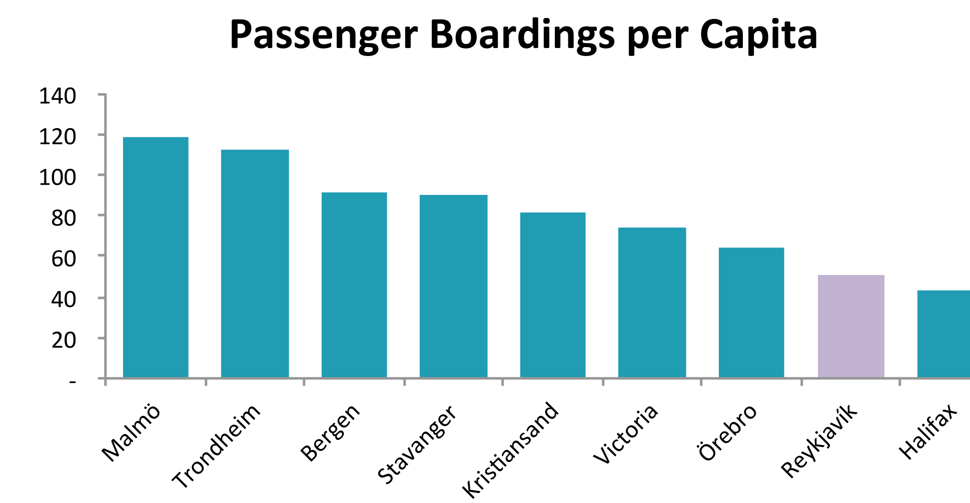

Figure 36: Passenger Boardings per Capita

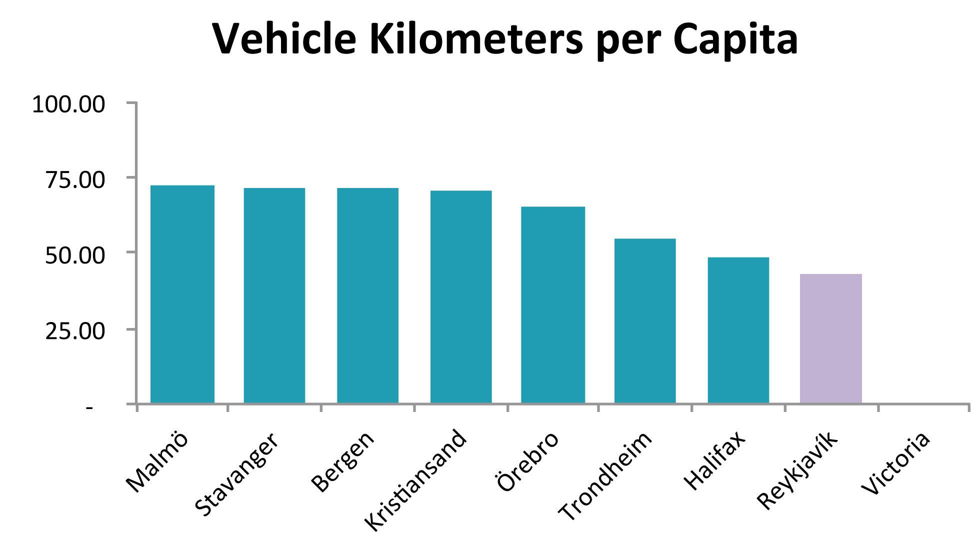

Figure 37: Vehicle Kilometers per Capita

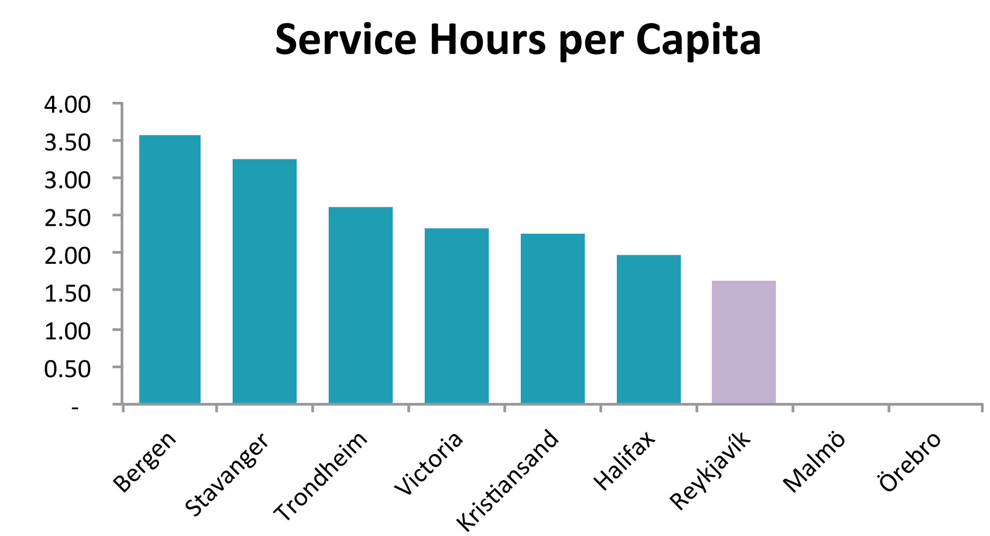

Figure 38: Service Hours per Capita

Service Availability

We've observed that the Capital Region's mode share and boardings per capita are low or middling compared to a group of its peer cities. However, it is also important to place these numbers in the context of the level of investment in the system as a whole. Figure 37 and Figure 38 show two measures of the supply of public transport service: kilometers and hours per capita. In other words, the distance and amount of time transit vehicles drove in a year for each person in their region, or simply, how much transit service was provided. We survey both in order to include all of the peers on at least one measure of service quantity.

The Capital Region has the lowest per capita vehicle kilometers and service hours of the peers surveyed for which data was available. This means that there are simply fewer resources available to spend on all sorts of public transport services, from low-frequency coverage routes in lower-density places, to high-frequency core services like lines 1 and 6.

We can also observe that cities that invest at a higher rate, like Bergen, Malmö, Trondheim, or Victoria, tend to have higher public transport mode share, and higher boardings per capita. This suggests that in these cities, a greater level of investment is being met with a greater level of utilization of the network, and ultimately a higher level of relevance as a local travel mode.

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2 Reykjavík is comparable to other European cities in density, but in age and development pattern it resembles North American cities. The aspect of city age that matters most is how large the city was in 1945, when development planning began to favor the private car over other kinds of public transport. Halifax and Victoria are very comparable in this regard, as are numerous cities in the northeast of the US. Unfortunately, US levels of service tend to be much lower, but Canada's are more comparable to Iceland's.

4 Key Questions

Key Questions

When the future of public transport in a region is discussed, trade-offs between different things that available resources could be used to accomplish inevitably arise. Resources are always constrained in some way, which means that hard decisions about what public funds should be used for are necessary in order to develop policy directing the public transport network to make major changes.

In the Capital Region, a major imperative to consider these questions is the direction of the 2040 regional plan to improve the public transport mode split from its present-day 4% to 12%, more than tripling its uptake. This is a policy directive that requires Strætó to grow its ridership over time, but to do so, a number of key questions on the service design of the network much first be decided.

The Ridership / Coverage Tradeoff

Strætó's performance data—like that of most agencies—reveals that not all services generate high ridership at a high level of efficiency. Many services exist despite not just low ridership, but without any reasonable prospect of high ridership in the future. These services run in areas where the development pattern—especially the public transport-critical features of density, walkability, linearity, and proximity—largely ensure low ridership potential. Rather than judging such services as failing, it is more accurate to describe them as having a non-ridership purpose.

Every public transport network is a mixture of services designed for high ridership and those designed for a competing goal, which can be called *coverage*. This trade-off arises unavoidably from the nature of the public transport product. This is not an either/or choice; no public transport agency is at either extreme; every public transport agency operates services geared towards either goal. Identifying the goals clearly is necessary to translate policy-level direction on the purpose of public transport into service planning.

Ridership Goal: "Maximize Ridership"

Do you want public transport to be designed for maximum ridership for the budget? This goal serves several common intentions for public transport, including:

- Low subsidy, because more of the revenue comes from fares.
- Vehicle trip reduction and emissions benefits.
- Support for dense urban development, because a focus on ridership tends to serve these areas well.

The Ridership goal is often what is meant by "running public transport like a business." Unlike government services, businesses are motivated by the goal of maximum profit. In the case of local public transport, where the fare paid by each customer is reasonably constant, this would mean maximizing the number of customers at a given cost.

Government services have a more complex set of motives, but they resemble businesses when they are trying to maximize the number of users within a set budget. So it is important to understand both why public transport sometimes runs like a business and why sometimes it intentionally does not.

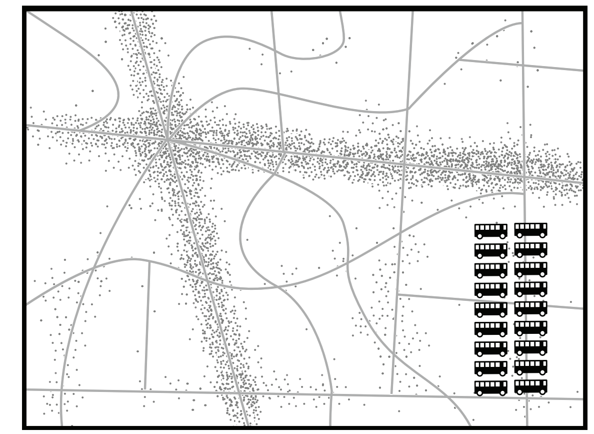
Every private business chooses which markets it will enter based on where it believes it can realize the strongest return on investment. If the Capital Region wanted its public transport to work in this way, this would mean deploying all of the service in places where the greatest number of people are the most likely to use it.

If Strætó's network were designed for maximum ridership, it would focus only on serving areas where the built environment meets the necessary conditions for high ridership, places where many people (and thus many potential public transport customers) are present, and which can be easily served by efficient public transport paths linking important destinations. The system would have far fewer lines, but they would be much more frequent. Large parts of the capital area would have little or no service at all, just as a private business feels no obligation to offer its product in places with low demand for it.

Coverage Goal: "Access for Everyone"

It's very common to hear that the goal of our public transport services should be "access for everyone." This goal reflects desires such as:

- Service to every city and every part of the service area.
- Lifeline for people with severe mobility limitations, no matter where they live.
- Support for suburban and rural styles of development.

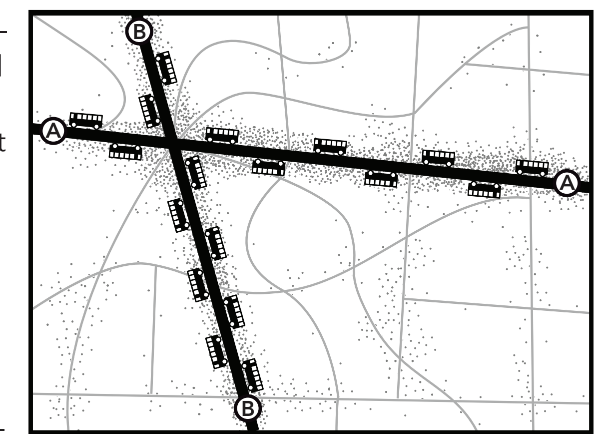


Imagine you are the transit planner for this fictional town. The dots scattered around the map are people and jobs; the streets shown are ones on which transit can be operated. The buses are the resources the town has to run transit.

Before you can plan transit routes, you must first decide what you want transit to do.

Ridership Goal

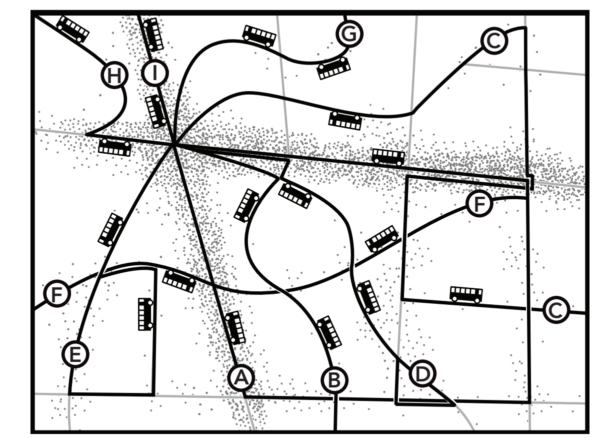
"Think like a business"



This transit network is designed to generate high ridership as efficiently as possible. The transit agency has thought like a business, investing its resources only into the best transit markets.

Coverage Goal

"Access for all"



This network is designed to provide some access to the transit system for all people. The transit agency has divided its resources among many routes throughout the town, none very frequent.

Figure 39: How Ridership and Coverage Goals Produce Opposite Kinds of Network

When you say "for all," you implicitly say "every last one, no matter how expensive it is to get to them." The resulting network would run less service in high demand areas so that it can run more service in low-demand areas, to ensure that everyone has some access. Service is spread out, which also means that it is spread thin. The resulting frequencies are low, and service may not run long hours. Because the service is not very useful, even in areas of high public transport demand, ridership is typically poor.

But while the Coverage goal is not what would motivate a private business, it has played an important role in the shaping of many public transport systems. Excluding a large extent of a service area tends to be politically unacceptable. Concerns about lifeline access—not high demand, but extreme needs experienced by small numbers of people—are also a reason to devote resources to the coverage goal.

The Two Goals in Practice

Why does a Ridership goal cause service to be concentrated in the highest-demand areas? Because as we noted in the Public transport Performance Analysis section, frequency correlates with high productivity (ridership per unit of cost). High-frequency service, serving a favorable built environment, consistently generates the highest ridership per unit of cost.

High-ridership planning therefore starts with high all-day frequency and extends it as far as it will go, focusing on the places where the most people will benefit from it. That, in turn, means dense and walkable places where many people are near stops and can easily get to them. A public transport line along an already-busy corridor can also stimulate some new growth along that corridor, encouraging new retail, employment activity and residential growth.

When coverage is the goal, service is spread out to maximize the number of people who are near *any* service. The result is always low frequencies, because low frequency allows a limited resource to be spread over more area. Most coverage services run every hour, and for shorter hours than other services do.

Much of Strætó's service outside of Reykjavík and lines 1 & 6 is fulfilling a coverage goal, either in terms of the development pattern of the area or in the way the service is designed. Moving towards a ridership goal would mean shifting resources from service providing coverage to low-density areas and investing it in frequent service serving places with the market attributes necessary for high ridership.

Connections or Complexity

In the Capital Region, the existing network provides access to the public transport system to almost everybody. Many routes extend from the regional center in the Reykjavík CBD out into commercial area neighborhoods, allowing the system to offer single-seat rides to the region's job center for the majority of its customers. The current resource level permits the majority of the network to operate at 30-minute headways for most of the day, with 15-minute service during the AM and PM peak periods.

The advantage of this approach to network design is that everybody has an easy trip to the Reykjavík CBD, which is an important connection: the CBD is the center of jobs, and it is critical that it be well-served by public transport.

There are also disadvantages to the current network design, most importantly the substantial amount of duplication it creates along certain segments (Laugavegur-Suðurlandsbraut, many of the streets east of Mjódd) and between important connection points (downtown & Mjódd). Duplication means that multiple routes are serving the same segments, but that this service is not coordinated to offer a consistent, reliable headways. This problem is intensified during the peaks, when multiple frequent routes overlap on segments where peak demand warrants frequent service, but not the volume of trips per hour (8, 12, or even 16) that are currently being provided.

This issue presents an important question for the Capital Region: should the public transport network continue to offer routes from all areas directly to the CBD, at the cost of inefficient duplication of service in some places? Or should additional all-day frequent connections be established[3] to which feeder routes in residential areas would then connect?

How to Serve the Peak?

We've observed that public transport ridership in the Capital Region is very strong (more than double its level at noon) during the AM and PM peaks, and that the level of service increases dramatically during this time. Most routes operate every 15 minutes for at last 6 hours per day. During this time, public transport is a much more useful choice for trips because riders' wait times are reduced, and transferring between routes is much easier.

The peak is important, but peak demand alone does not drive service design. Due to travel on the public transport network during the peak being much easier, it is a much more attractive option during these periods, and thus we would expect to see a higher level of ridership during the peak regardless of the underlying demand, because the service is more useful.

The higher peak service level also has a number of associated costs, which to varying degrees can make these periods more expensive to serve. These include the need to maintain a larger bus fleet, a portion of which is in use and generating ridership less often, as well as the labor costs associated with short and peak shifts. Additionally, compounded with the issues around duplication and highly peaked services.

3 For example, between the Reykjavík CBD and Mjódd via Suðurlandsbraut, already a very high-productivity segment.

While the peak is important and will continue to be important, a regional conversation around public transport could consider whether it should continue to be served to the extent it currently is. Currently, ridership doubles on the peak, and the service level (in terms of total trips per hour) is approximately double as well. The service level is so high that in the current network, it's difficult to imagine strategies that could be implemented which improve peak ridership a great degree.

With this extremely high level of service already in place in the peak, strategies that seek to generate high ridership by targeting frequent service to strong markets must focus on other periods of the day. There are very few remaining segments left to upgrade to 15-minute service during the AM and PM peak. The question for citizens, stakeholders and elected officials is to what degree to seek to grow ridership in other periods by adjusting the peak service level.

Resource Level

Perhaps the most fundamental question about public transport in this region is "how much is enough"? In order to grow ridership, resources must be directed towards services that accomplish this goal most efficiently. However, if the overall level of service is stable, this implies cutting some services to pay for others.

These are hard choices that citizens, stakeholders and elected officials in many cities have had to grapple with, but there is one other option that could be contemplated: simply growing the overall size of the system. With more resources, the public transport system is able to provide more services that meet both the ridership and coverage goals, expanding and enriching its most useful tier of routes, while continuing to offer comprehensive coverage across the urban area.