Planning Cities and Towns for Successful Bus Services

Údarás Náisiúnta Iompair
National Transport Authority

JARRETT WALKER + ASSOCIATES
Public transport network design.

Table of Contents

Cover image: Bus crossing bridge by Karlo on Adobe Stock

This page is left intentionally blank.

I

Introduction

Image: Parallel Connection by Cityswift is licensed under CC BY 2.0

For many years the national government of Ireland has been increasing its investment in bus services across the country. As part of this investment, the BusConnects and Connecting Ireland programmes are:

- Redesigning bus networks for cities, towns, villages and rural areas;
- Simplifying fares, enabling cashless payment and implementing a state-of-the-art ticketing system;
- Building new bus corridors and cycle lanes;
- Improving and adding bus stops, shelters and park-and-rides;
- Providing new accessible vehicles and standardising livery; and
- Transitioning to a zero emissions bus fleet.

The purpose of this note is to guide future planning decisions towards outcomes that are supportive of public transport, especially bus services. This effort has been informed by the challenges confronted and lessons learned by the NTA and Local Authorities during the BusConnects and Connecting Ireland programmes.

The recommendations in this note can inform other planning documents, including:

- The National Planning Framework;
- Regional Spatial and Economic Strategies (RSES);
- Metropolitan Area Transport Strategies, including the definition of frequent public transport corridors;
- County Development Plans;
- Local Area Plans; and
- Local Transport Plans.

National Goals and Nationwide Growth

Not only Ireland's largest cities but also its towns, villages and rural areas are planned to grow in the coming decades. Maintaining a high quality of life in these areas will require absorbing that growth without a proportionate increase in car use.

At the same time, all parts of Ireland must make progress towards ambitious national goals and policies regarding sustainability, social inclusion and climate action.

Public transport is essential to meeting a wide range of Ireland's goals:

- By reducing people's need to own or drive cars, public transport is critical to reducing carbon emissions, pollution and congestion;
- By transporting people further than they can walk, public transport maximises everyone's ability to participate in the economic and social life of their town or area;
- For many people who cannot or should not drive, public transport is a way to access the resources that make life healthy and complete;
- Public transport allows for greater movement of people and greater economic growth beyond what would be possible if all trips were in cars;
- By reducing costs for roads, drives and car parks, public transport makes housing easier to build and more affordable for residents; and
- The use of public transport reduces the need for car parking, which in turn supports compact growth, protects rural land, reduces emissions and energy use, and promotes liveability.

Numerous policy documents adopted by Government call for the expansion and strengthening of public transport. For example:

- The Climate Action Plan calls for "reducing the use of private passenger cars" and "a modal shift toward transport modes with lower energy consumption (e.g. public transport, walking, and cycling)";
- The National Planning Framework prioritises compact and sustainable growth, which will depend on less car use and more public transport use. National Strategic Outcome 4 states that "The provision of a well-functioning, integrated public transport system, enhancing competitiveness, sustaining economic progress and enabling sustainable mobility choices for citizens, supports the overall Framework objectives"; and
- The National Sustainable Mobility Policy identifies multiple goals served by public transport:
  - Goal 3 is to "Expand availability of sustainable mobility in metropolitan areas";
  - Goal 6 is to "Take a whole of journey approach to mobility, promoting inclusive access for all"; and
  - Goal 9 is to "Better integrate land use and transport planning at all levels."

Influence of the Built Environment

Ireland's public transport cannot deliver on these goals by itself. Much of public transport's success will depend on the built environment. An amenable built environment multiplies public transport's usefulness and value, while a hostile one can reduce it to near zero.

At any given bus stop, hub or train station, the built environment will determine how many people benefit from public transport services. The main factors are:

- The number of people and destinations nearby;
- People's ability to get to the public transport stop by walking or cycling, given the quality of the street network, paths and crossings; and
- The appeal of public transport compared to the car.

The built environment also determines whether public transport can operate efficiently. When confronted with barriers such as obstructive street networks, public transport must do inefficient things. Efficiency governs the quantity of service that can be provided – the less efficient a bus route, the less frequency or the shorter hours of service can be provided within any given budget.

All decisions about how to lay out an area or design a road are decisions about public transport. In fact, they are collectively as powerful as any routing or service decisions made by a public transport operator.

This has long been well-understood in the context of railway services. A railway station is widely-understood to be a major infrastructure investment whose return depends on the surrounding built environment. For this reason, railway planning is accompanied by an intense focus on development in the areas around stations. During the planning phase, these station-area plans make a big contribution to the expected benefits of the line and help to justify its construction.

Given the scale of investment being made in Ireland's bus services, a similar focus on the built environment is needed around bus services just as it has been provided around railway stations.

Country of Roads, Country of Buses

Public transport is key to the sustainable development of Ireland. Ireland is mostly a country of roads, and public transport on roads generally means buses. Even once every proposed railway project is built, most of Ireland's population will still live more than 1 km from a railway station. Buses are the form of public transport that can be provided near most people's homes and destinations. However, the mere provision of a bus stop is not enough to attract patrons to that stop, and it is certainly not enough to support efficient bus operations.

Land use planning has long been incorporated into planning for railway services. A rail station is widely-understood to be an investment whose return depends on the surrounding land uses and built environment. For this reason, rail planning is accompanied by development in the areas around stations. These station-area plans contribute to the expected benefits of the line and help to justify its construction.

Given the scale of new investment in Ireland's bus services, a similar focus on land use and the built environment is needed around bus services just as it has been around rail stations. However, there has been little guidance available for land use and urban planners who wish to shape growth for the future success of bus services.

This guide explains how to incorporate efficient bus service and future bus patrons into land use plans, development plans and road designs. It is also relevant to decisions about where to locate a development within an existing urban area. Any decision that determines how much travel demand a site will generate is potentially a decision about public transport, and should be taken in awareness of the principles shared in this guide.

This guidance note is in three parts:

- **Part 1, How Public Transport Works,** summarises the geometric and mathematical facts of public transport that govern its relationship to the built environment;
- **Part 2, The Three Essential Actions,** provides guidance about how land development and location choices should consider public transport; and
- **Part 3, Examples,** looks closely at examples of certain development and observes how land use and street planning decisions have affected public transport.

1

How Public Transport Works

Image: Purple Lightning by Cityswift is licensed under CC BY 2.0

1.1 What is Useful Public Transport?

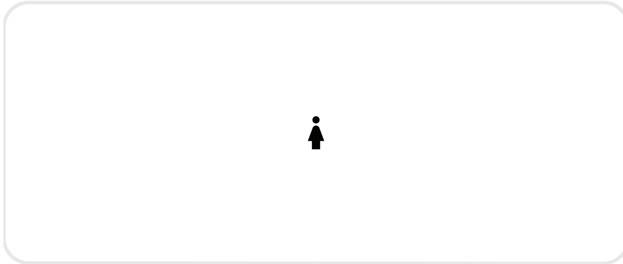
Public transport is useful if people can reach destinations that they value in a reasonable amount of time. Access to opportunity – sometimes called accessibility* – is a way to measure this benefit of transport services.

From any location, within any limited amount of time, there is an area someone could reach by public transport. Their access to jobs is the number of jobs in that area, which can be estimated using Census data and geographic analysis. We can make similar estimates for access to education, or for any other kind of destination for which spatial data is available.[1]

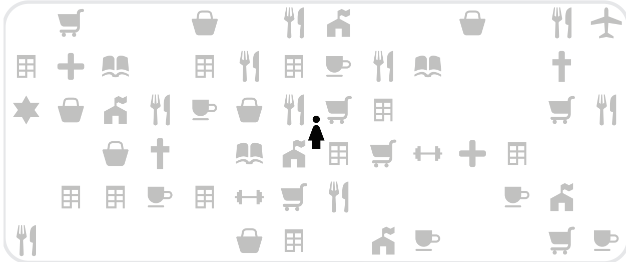
Although many factors affect people's decisions about whether to use public transport, travel time remains a dominant one. Most people have jobs or attend school, which means they have limited time in their day and they need to use their time efficiently. If a trip can't be done on public transport in an amount of time that feels reasonable to them, they are likely to use a car.

It's been widely-observed that throughout history people's average one-way travel time to work or school has been around 30-45 minutes, and that people tend to adjust their lives to prevent it from being much longer.[2] So 30 and 45 minutes are good "time budgets" to use to measure people's access to work and school.

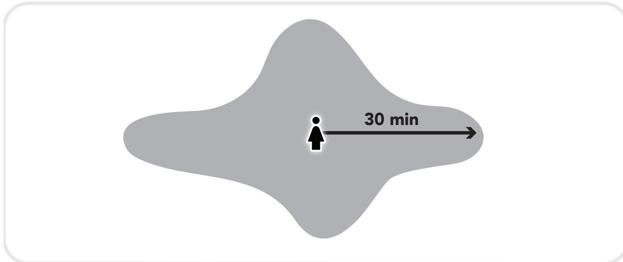
Public transport access to opportunity, illustrated.



Here is a person...



... in a city full of possible destinations.



In **30 minutes**, this person can get to anywhere in the **shaded area.**

Her **access to opportunity** is the **number of destinations in that area.** To estimate her access, count the **jobs** or **schools** or **shopping** in that area.

* In academic settings the standard term has been "accessibility," but some scholars are shifting to "access" because the former term is often specifying services for people with disabilities.

Why Does Access Matter?

This guidance note focuses on increasing public transport access and reducing journey times, because these have historically been neglected in development planning around bus services.

Car infrastructure, and the development that responds to it, has been developed with an explicit focus on minimising car travel time. Here, we bring the same focus to development access by public transport, especially access provided by buses.

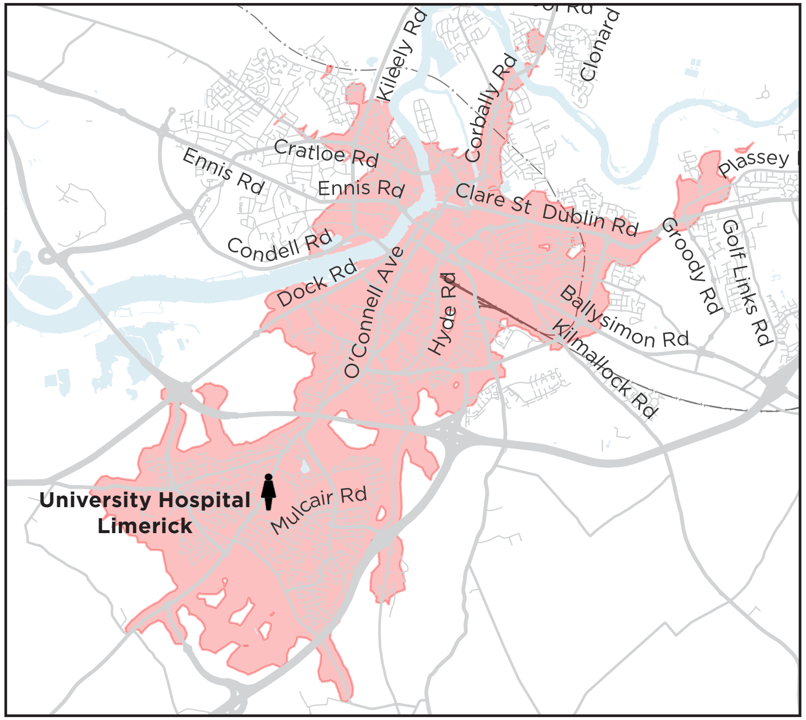
Access is the Foundation of Patronage

Patronage has many causes. It goes up and down for reasons completely external to public transport such as economic conditions, pandemics or car park prices. Access describes how the design of public transport services, and their interaction with development patterns, affect potential for high patronage.[3]

When we increase access, we increase the likelihood that any person, looking to make a trip, will find the public transport journey time reasonable. If they do, they become a potential public transport customer. At that point other factors, such as the price of the fare or quality of the vehicle, become important as well. If they do not find the journey time reasonable, they will likely find some other way to go. Factors such as price and comfort aren't enough to turn someone into a customer if the service doesn't go when and where they need.

The core "product" of public transport is the movement of people to places they want to go, when they want to go. Access describes that "product."

Increasing access to opportunity via public transport increases patronage potential, and the potential for public transport to replace private car trips.



This map shows in red the area that someone can access within 45 minutes from University Hospital Limerick, by any combination of public transport and walking.

Access Has Inherent Value

Access serves goals that are important even setting aside the public transport patronage that results.

- Government policy is to ensure access to opportunity for people experiencing deprivation.
- Access is a measure of personal freedom to choose from an abundance of options. By measuring what people can reach in a reasonable amount of time, access measures the degree of choice they have in their lives.

1.2 Phases of a Public Transport Journey

Each journey on public transport involves spending time in three distinct ways:

- Getting to and from the stop, usually by **walking**;
- **Waiting**, which can happen at the start of one's trip, during an interchange, or at one's destination (when one is forced by the timetable to arrive earlier than desired); and
- **In-vehicle** journey time.

It's helpful to think separately about each of these phases of a journey because different government and private actions will determine how long each phase will take.

The table below describes which entities have responsibility for or authority over the length of time required for each phase of a journey. Especially when it comes to infrastructure, local authorities and national authorities — NTA or Transport Infrastructure Ireland, TII — share responsibility.

Phase of trip	Options during the phase	Amount of time is governed by:	Responsibility and Authority				
			Local land use planners	Local transport planners	TII	NTA	Bus operators
Journey **to** and **from** the stop, usually by **walking**	Walking	Pedestrian infrastructure, street connectivity, development design	x	x			
	Biking, taking a scooter, etc.	Cycle infrastructure, mobility hubs		x			
	Driving and parking	Park-and-ride infrastructure, road congestion		x	x	x	
Waiting time		Frequency, time-tabling				x	x
In-vehicle journey time		Linearity of bus route	x				
		Bus priority on roads		x	x	x	
		Speed and efficiency of operations				x	x

Phases of a journey, and actions affecting the length of each phase.

Phase 1: Journey to and from the Stop

The trip to and from a public transport stop can be made by many modes, but walking is by far the most common. The public transport network therefore depends on the pedestrian network for the completion of most trips, and succeeds or fails depending on whether walking is fast, safe, and comfortable. Accessibility to people with disabilities or using mobility devices depends to an even greater degree on the quality of the pedestrian infrastructure.

The pedestrian network and facilities are largely the result of local development and transport planning done by City and County Councils.

Bicycles, scooters, and any other self-propelled small mobility devices offer many opportunities to extend the reach of a public transport stop. Because space on the bus will always be limited, these vehicles generally must be either parked or rented at a public transport stop. Secure parking requires infrastructure. Any cycle or scooter rental or sharing service requires infrastructure and ongoing operating costs. Such infrastructure and operations are typically planned and managed by local government, often through contracts with private providers.

For journeys that start with a private car, the car will need to be left near public transport. Decisions of where to place park-and-rides and how to design the sites are typically governed by local transport planners at City or County Councils and in some cases by private parties such as major hospitals or universities.

Phase 2: Waiting

A few decades ago, waiting meant standing at the stop, gazing hopefully up the road. Now real-time information allows people do other things while waiting, or at least to spend some of their waiting time in a more comfortable location. It's common to see many passengers show up at a stop only a few minutes before the bus comes.

Still, most passengers must spend at least a few minutes waiting at the stop, so the waiting environment matters. In addition, for journeys that include interchange, waiting time at the second bus stop will be longer and less affected by real-time information. The design of bus stops is largely under the control of local government, with the NTA involved in the provision of shelters and posted information.

However, it is important to broaden our concept of waiting. Even if someone's time at the start of their journey isn't spent physically at the stop, it is still time when they are not where

An unimproved bus stop in an Irish city. This stop provides no seating, protection or information. Because much of the kerb is occupied by cars, passengers must step out into the street to board the bus and accessibility is poor.

they want to be.

Some people have argued that real-time arrival information and the ability to entertain oneself on one's phone have made waiting less of a problem. However, people have varying abilities to tolerate or even make use of waiting time. The tolerance tends to be greater for those who can be more flexible with their schedule, for example setting their start time at work based on the public transport timetable. This tends to be higher income individuals. But many people must be at a specific location at a specific time, for example people going to school, or to on-site jobs with a required start time.

Real-time arrival information cannot reduce waiting time at the ***end*** of a journey. This wait time arises when an infrequent service forces a person to arrive at their destination early (in order to avoid arriving late).

To include the whole population, and all types of journeys, then, it is important to define waiting as **all time spent neither travelling nor where you want to be**. Frequency governs average waiting time. Frequency is therefore an essential element of useful public transport service, as we explore in the next section.

Frequency, and public transport service quantity in general, are governed by the NTA through network planning processes – such as BusConnects – done in consultation with City and County Councils.

Phase 3: On the Vehicle

The time a passenger spends on the bus is the result of numerous decisions about how to lay out developments, design streets, manage streets, and design bus service.

On the longest time-scale, the planning of new development areas and road networks determines whether the bus can follow a direct path or must take a circuitous one. It also determines how far people are from destinations and therefore how many kilometres they need to travel. These spatial planning decisions lie largely with the local Councils though they are subject to approvals at various levels of government.

The efficiency of bus operations is also affected by the bus operator's actions. The procedures for pulling out of and back into traffic at stops, for passengers boarding and paying their fare, and for bus drivers to take necessary breaks all have some effect on speed and reliability. These are planned and regulated at a high level by the NTA but implemented and managed by the bus operator and local authorities.

The speed and reliability with which the bus can proceed down the street is the result of the design and operations of the street, the speed limit, and the degree of bus priority, all of which lies with NTA, Transport Infrastructure Ireland, and local Councils.

The placement of bus stops and especially the spacing between bus stops has an affect on speed. The NTA, bus operator and local Council each have a role to play in this area.

1.3 Public Transport Service that Supports High Access

Public transport services, operating in a favourable land use and built environment, can provide high access to opportunities for large numbers of people. Certain aspects of the service design and operations are key to this outcome. They are:

- Frequency: How often public transport vehicles arrive;
- Connectivity: How routes or lines connect with one another to allow for fast travel among many different origins and destinations;
- Speed: How long it takes vehicles to cover distance; and
- Reliability: How consistently vehicles arrive and how consistently they cover distance at a given speed.

Frequency

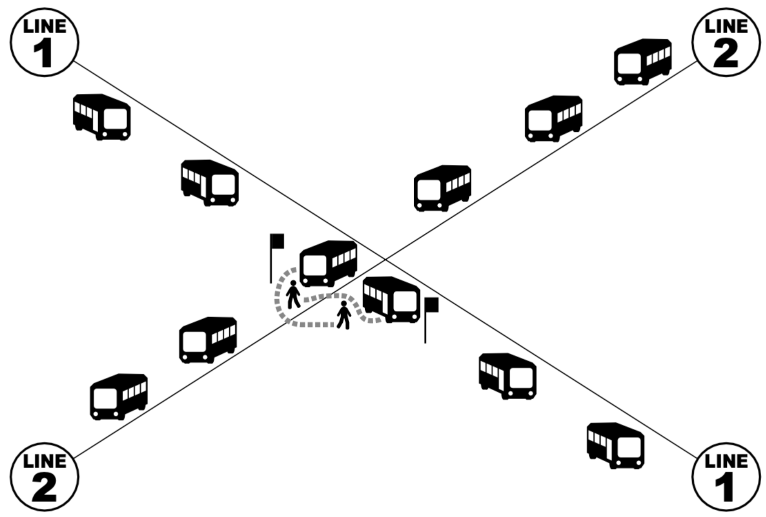
High frequency on a line is a product of three factors: the number of vehicles assigned to the line, the length of the line, and the speed the vehicles can travel.

High frequency is correlated with high patronage, at the level of the network, the route and the bus stop.[4] High frequency expands people's access in three independent ways:

- It allows someone to cover more distance and therefore reach more opportunities in whatever amount of time they have available because they spend less of that time waiting;
- It makes interchange (between two frequent services) fast and reliable, which expands the range of places that can be reached quickly on the public transport network; and
- It improves reliability, because if someone misses a bus or it breaks down, another bus is always coming soon.

Frequency is often under-emphasised because it is invisible. You can't take a photo of the fact that the next bus is coming soon. However, frequency is what makes a line on the map into something someone can use whenever they want, just as a motorist can use a road whenever they want to.

If you don't often use public transport, it can be helpful to imagine a gate across your drive that only opens once an hour. Living in this situation, the gate would be your biggest barrier to accessing to opportunities. The gate would be a far bigger problem than traffic congestion, parking hassles, or anything else that motorists complain about. An infrequent public transport service is no different from that gate. If the bus isn't coming soon, people can't reach opportunities quickly, and the service just isn't useful.



High frequency on a line results when there are many vehicles operating the line at regular intervals from one another. The longer the line, the more vehicles need to be assigned to it in order to provide a high frequency. When two frequent services connect, it's easy and fast to change from one line to another.

Connectivity

A well-connected network means that each route not only serves the people, places, and opportunities along it, but also the many people, places, and opportunities served by other routes in the network.

A connected network results when people can interchange between different services – whether railway or bus – quickly and easily.* This can be achieved in two different ways:

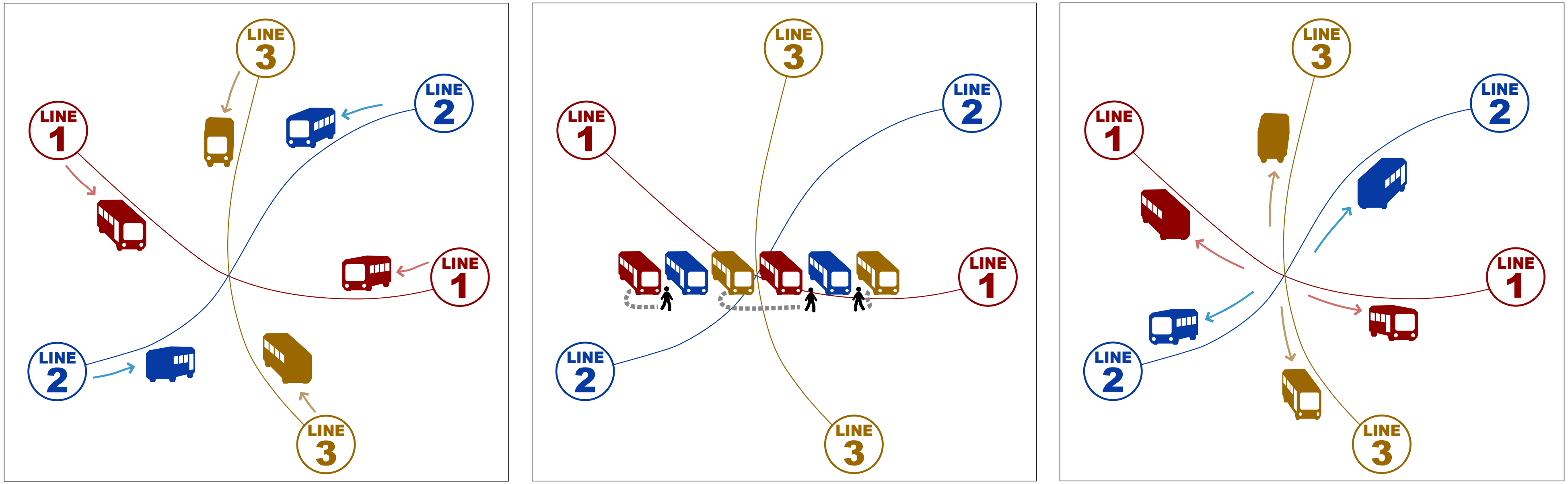
- **By forming a frequent network**, so that wait times to interchange are minimal; or
- **By creating timed transfers or "pulses"** at key locations to offer short waits for interchanges between infrequent routes (coming every 30 minutes or more).

* It's also important that there be no extra fare to interchange. Interchange makes it possible to design a public transport network for high access, and to make it frequent and simple. Every effort should be made to make interchanges easy and appealing to passengers.

Both of these require supporting infrastructure:

- It must be comfortable to walk from one bus stop to another bus stop on footpaths and crossings;
- For routes that cross at a junction, the bus stops must be placed close to the junction to make the walk to interchange fairly short; and
- If infrequent routes are forming a "pulse", there must be enough room for all of the connecting buses to meet at the same place at the same time. They may be lined up at the kerb together or gathering in an off-street facility.

Space for buses and space for pedestrians, wherever interchanges will be made, are critical to the function of a connected network.



Infrequent routes can be part of a connected network, by using a "pulse." In a pulse, bus routes are drawn so that buses come together at a hub at the same time, allowing passengers to interchange between them with a reliably short wait.

Speed and Reliability

Speed affects how far someone can travel, and therefore how many opportunities they can reach, once they've boarded a public transport vehicle. Services that are very slow limit people's access to destinations and compete poorly against cars. **Reliability** describes how consistently a service operates at its scheduled speed.

The average speed and reliability of a public transport service depend on the causes of delay that a bus will encounter. Broadly speaking, these delays can be caused by:

- Serving passengers at stops;
- Signals or other traffic control devices;
- Traffic or other obstructions in the lane, whether recurring (daily) or unpredictable;
- The movements of other vehicles with higher priority (such as trains or trams); and
- Unpredictable events such as maintenance problems with the bus or medical emergencies on board.

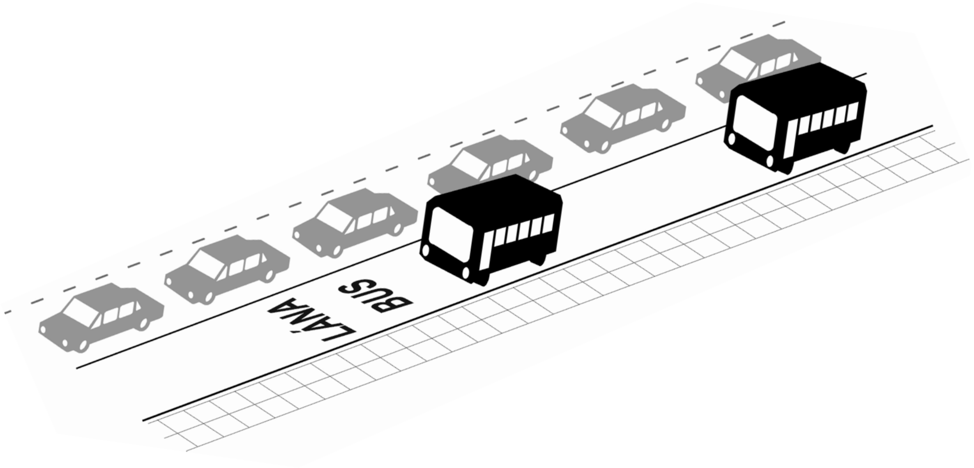
The BusConnects programme is addressing the first item through fare technology improvements that will speed up boarding and alighting by allowing customers to use all doors, and through the standardisation of the fleet using vehicles that are easy to enter and exit for a wide range of people.

Another part of passenger stop delay relates to the placement of bus stops themselves. If bus stops are numerous and close together, the bus's average speed will be quite low. It is possible to design areas so that bus stops do not have to be too close together. That issue is discussed on later pages.

The other items on the list all have to do with whether public transport is protected from predictable and unpredictable delays on the roads. These are addressed by improvements to **bus priority**. The BusConnects programme includes bus priority measures on major corridors, including bus lanes which give bus passengers the same degree of protection from traffic that light rail passengers enjoy.

Bus priority must be an ongoing programme, rather than a one-time effort, because additional major bus corridors will be developed and traffic conditions will change over time.

The last item on the list – unpredictable events – can never be planned away. However, bus schedules are always written with a small amount of "buffer" time, most of it at the ends of routes (when the buses are empty) but some in the middle of routes as well. This protects the bus's reliability from unpredictable events, though it does so by sacrificing a bit of the bus's speed, even when nothing has gone wrong on that particular trip.



The biggest source of delays for buses is nearly always motor vehicle traffic. Other factors matter as well, such as the speed of fare payments, the number of passengers boarding and alighting, and the spacing between stops. But protecting public transport from traffic – by running trains on exclusive tracks and buses in exclusive lanes – is a powerful way to make public transport nearly as fast and reliable as a private car, or even more so.

The fact that bus priority measures make passengers' journeys faster is obvious. Less obvious is the fact that they save public funds and make Government investments in bus service more effective.

Slow service is not just unattractive to passengers. It is also more expensive to operate. The number of buses and drivers needed to operate a route at a certain frequency depends on how long it takes the buses to drive the route out and back.

This formula describes the relationship between a desired frequency, the length of the route, and the speed of vehicles:

$$\text{Frequency} = \frac{\text{Vehicles assigned to the route}}{\text{Length of the route}} \times \text{Speed of the vehicles}$$

The following forces can cause the frequency of a route to erode, or its operating cost to go up:

- Slower speeds, due to traffic congestion, more turns, or sometimes even growing patronage;
- Longer distances, as a route is extended farther into new areas or sent on a new deviation; or
- Less predictable driving times, which the bus operator must account for by assuming a slower average speed.

Conversely, within any limited budget for service, higher speeds mean higher frequencies. Shorter routes mean higher frequencies.

Land use and urban planners control two of the factors that decide the potential frequency of bus (or light rail) services: they have the power to make public transport vehicles fast, and they can plan the city so that bus routes can be relatively short whilst getting close to large numbers of people and destinations.

1.4 Land Use and Transport for High Access

Public transport does not deliver access by itself. High access arises from the interaction between the public transport service and the land use pattern.

In discussing land use patterns, we will often be talking about people's existing communities and homes, and it is natural for people to feel some defensiveness about the place they live. For this reason, we emphasise that this section is describing purely geometric facts. No area, and no type of area, is good or bad, but there are unavoidable facts about how the layout of an area affects what public transport can achieve there.

The features of land use and the built environment that govern public transport access are:

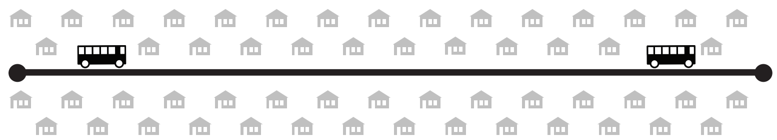
- Density
- Walkability
- Continuity
- Mix of Uses
- Linearity

Density

High density means that there are more people, jobs, and activities in the fixed area around a public transport stop. This means that access to many destinations from that stop will benefit more people.

How many people, jobs, and activities are within walking distance of a bus stop?

Better: Many people and jobs are within walking distance of a bus stop.



Worse: Fewer people and jobs are within walking distance of a bus stop.

Walkability

The connectedness of the street or path network determines people's walking distance to a bus stop. On a disconnected street network, the walk to the stop might be much longer than the "as the crow flies" distance. It is therefore possible to place bus stops in dense areas yet the service will be within reasonable walking distance of few people.

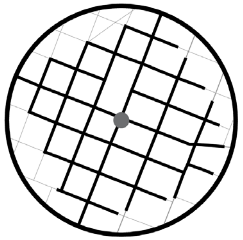
Obstacles to walkability include:

- Disconnected street networks that require pedestrians to walk an indirect path;
- Fences or walls separating adjacent developments;
- Lack of consistent footpaths along roads;
- Lack of lighting on footpaths, at junctions and at other road crossings;
- Lack of a safe place to cross the street near a bus stop;
- Building orientation that puts front doors far from the street, and thus farther from a bus stop; and
- Dual carriageways or train tracks, lacking regularly-spaced pedestrian crossings.

Walking time is part of the total public transport journey time, so more walking time to and from public transport stops means access to fewer opportunities within a reasonable journey time. Time isn't the only issue; if the walk is unsafe or uncomfortable, many people won't walk at all. This reduces patronage in the area,[5] making it harder to justify high levels of service there.

Poor walkability can also affect the directness and linearity of services, if bus routes must deviate into certain areas because people in those areas can't be asked to walk to a stop.

Is the walk to the bus stop direct and comfortable?



Better: In a connected street network, most nearby places are a short distance away by foot.

Worse: In a disconnected street network, walks to nearby places are long and circuitous.

Better: For people to use a bus service both ways, it must be safe to cross the road near the stop.

Continuity

Continuity of development reduces travel time by all modes: walking, cycling, public transport and car.

However, the effect of distance on public transport is unique among travel modes because public transport includes public operating cost, in addition to capital cost. The longer the distance public transport vehicles must cover, the less frequency can be provided. Within any limited operating budget for service, distance trades-off against frequency.

Longer journeys on the vehicle – and worse frequencies – both reduce access. Continuous urban development allows people to make shorter journeys and allows operators to provide better frequencies.

Do buses have to traverse large areas with little demand?

Better: Short distances between many destinations are faster and cheaper to serve.

Worse: Long distances between destinations means a higher cost and therefore worse frequency.

Mix of Uses

At the local neighbourhood level, a mix of land uses reduces the need for motorised transport by allowing people to meet more of their needs by walking or cycling. At a larger scale, a mix of uses has a particular value for public transport.

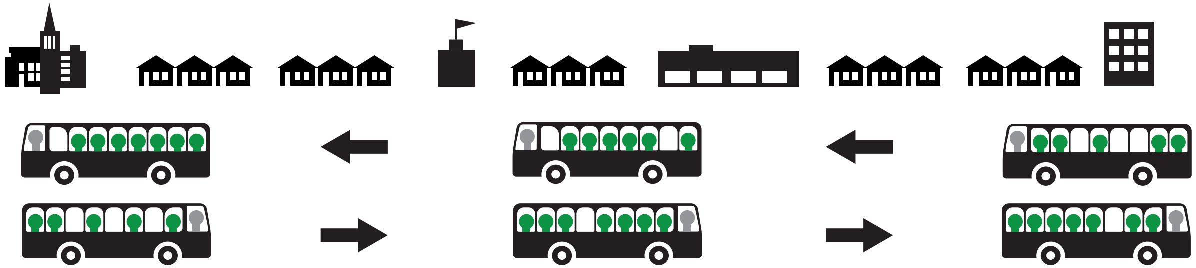
In a highly-centralised city, as most Irish cities were 50 years ago, most people travel into the centre in the morning and outwards in the evening. This one-directionality is quite costly for public transport, because buses or trains may be full in one direction but are empty going the other way.

This is not to say that major public transport hubs don't belong in centres — in fact, it is essential that bus routes converge in a town centre, as it allows people to make interchanges between routes to reach every part of the city.

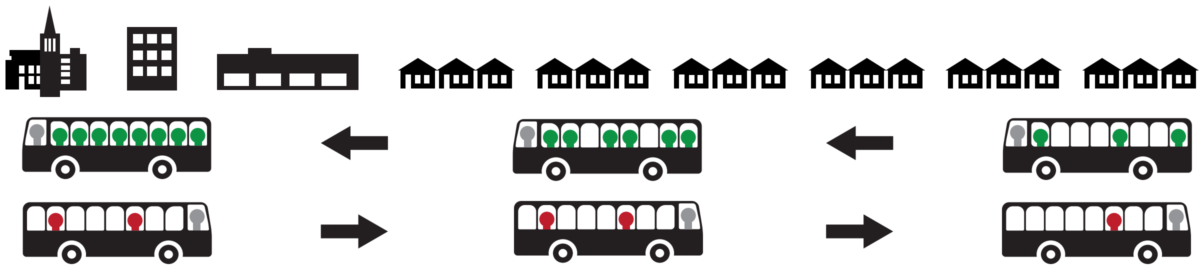
Commercial development distributed across cities and towns can be positive for public transport, by making buses and trains useful in all directions at once, all day and all week. However, for any outlying developments to be served efficiently, they mustn't be built as unwalkable, car-oriented archipelagos, nor can they be at the ends of long drives or cul-de-sacs.

Just as in urban developments, developments on the edge of a city or town must be dense, walkable, and arranged in continuous patterns along linear through-roads.

Are buses well-used in both directions, at many times of day and week?



Better: A mix of land uses means buses are used in both directions during weekday rush-hours, and throughout the day and week.



Worse: Buses serving purely residential areas tend to be used mostly during rush-hours, and mostly in one direction.

Linearity

In a high-access public transport network, most of the investment in service will be in long routes that follow relatively straight paths. Routes may curve with the topography or to follow the street network, but they should curve no more than a car would for the same trip. These linear routes get close to many busy places whilst offering a reasonably direct path between any two of them.

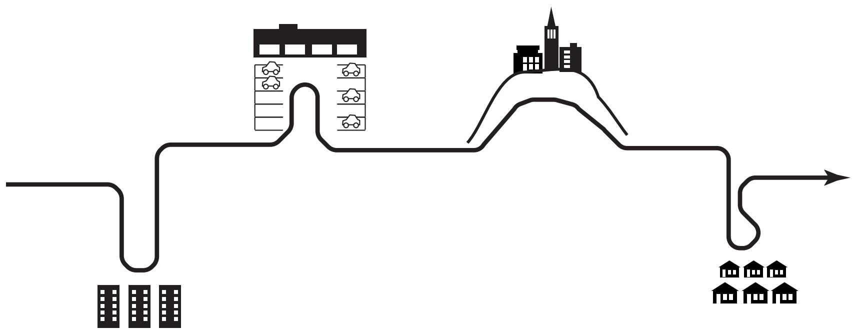
In most of the areas built before the use of private cars was widespread, destinations and residences are within a short walk of streets that provide direct travel to many other places. This was a natural pattern of development when nearly all travel was by foot, bicycle or shared transport.

With the advent of the private car, developments can now be put in disconnected street networks and at the ends of cul-de-sacs. When an important destination for public transport is at the end of a cul-de-sac, a bus route must deviate from a direct path to serve it, adding travel time for everyone going through.

Deviations don't just cost passengers more time – they also cost the bus operator. The longer a route, the higher the operating cost, and the less frequency can be afforded within any limited budget for service. If more of the bus operating budget must be spent covering distance or deviating, then frequencies can't be as good as they ought to be, and this will undermine access and patronage.

Can buses follow routes that feel direct for most passengers?

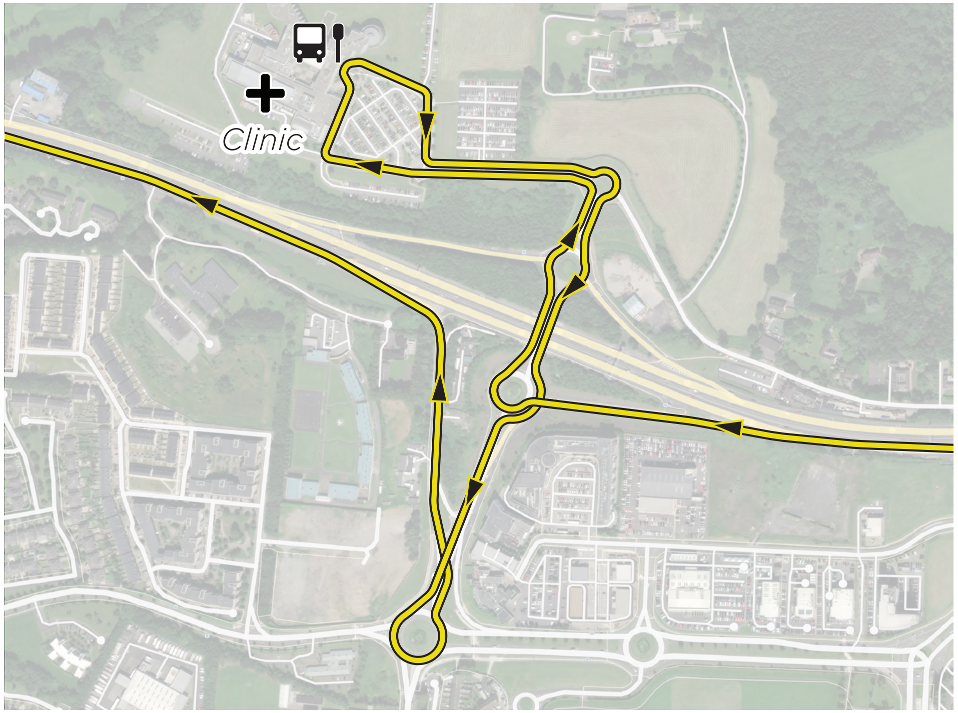
Better: A direct path between places makes public transport more appealing.



Worse: Deviations from a straight path discourage people who want to ride through, and increase costs.

Of the five principles listed here, linearity is the least often considered in urban planning, perhaps because it is only an issue for public transport. For the individual modes (walking, cycling or driving a car) each person can travel to the end of their particular cul-de-sac without inconveniencing anyone else or increasing public costs. But for public transport operators and passengers alike, deviations are disastrous.

New developments should **"Be on the way!"** if public transport is expected to serve them well. They should be located so as to benefit from bus routes going by en route to other dense areas and destinations.



This medical clinic, on a cul-de-sac alongside a dual carriageway, lacks good public transport due to a lack of connected local streets. Someone traveling through the area towards the west must journey through the long deviation to the clinic and the circuitous return to the carriageway. The deviation imposes high costs on the system and lengthens travel times.

Summary

Public transport is most useful when it enables people to reach many destinations that they value in a reasonable amount of time. This outcome is called ***access***.

There are three key phases that make up a public transport trip:

- Going to and from the stops;
- Waiting for a vehicle; and
- Journeying in the vehicle.

Each phase may be subject to delays that are under the purview of a number of different stakeholders.

Access in public transport is improved when services are frequent, connected, and reliable.

In order to provide high access, developments and major destinations should be built:

- At high densities and with a mix of uses;
- In walkable and permeable forms;
- In linear patterns along roads that buses can easily operate; and
- Contiguous with other urban developments.

These patterns make high levels of service less costly to provide, improving potential for high patronage.

2

The Three Essential Actions

2.1 Organise Development Around the Frequent Network

When you see buses operating in a city, it’s easy to imagine that there’s one kind of thing called "bus service." In fact, different kinds of bus service have different consequences for development. In terms of how they create access to opportunity and support urban development, bus services are often more different from one another than they are from railway services.

Most bus services fall into one of three categories:

The Frequent Network is made of lines on which the next bus (or train) is coming soon, at most times of day. In urban areas, best practice is to reserve the designation of "frequent" for services coming every 12 minutes or better (5 buses per hour).

A well-designed Frequent Network will do most of the work of maximising access across a city. It will attract the network's highest levels of patronage. Given the cost of providing high frequency service, it should be fairly efficient to operate.

Coverage services run at worse frequencies. Their purpose is to ensure that some basic service is offered to most people in the service area. In urban areas, coverage services are usually offered at frequencies of 30-60 minutes, and may not be offered late in the evening or on Sundays. They serve areas where expectations for patronage are low, or costs of providing service are high. High patronage is not the purpose of coverage service.

Peak services operate briefly, when a particular demand occurs. School services, for example, are narrowly-designed around school trips in the morning and afternoon.

"Commuter Express" trips are typically offered mostly or only at rush hours. They are often designed for long commutes to "9-to-5" jobs, rather than commutes to jobs starting at other times, which are common in the retail, service or industrial sectors.

Peak Commuter Express services may be crowded when they operate, and this can give the impression that they are efficient. But they tend to be more costly to operate than all-day services, whether they are railway or bus, because they:

- Require short driver shifts that increase costs;
- Require extra empty-running kilometres between the depot and the route, at the end of the morning peak and the start of the afternoon peak;
- Attract few passengers in their non-peak direction; and
- Use vehicles inefficiently, as the cost of the vehicle is justified by only a small number of hours of service (and a small number of passengers) per week.

The bus network will deliver the most access – and operate most efficiently – when we make the greatest possible investment in the Frequent Network. This requires minimising coverage and peak services so that they are adequate to meet the need but not in excess of it.

Development that generates high travel demand or intense needs should never depend on coverage services or peak services, because those services are inefficient to provide. Frequent services, on which the next bus is always coming soon, generate good access to opportunity and should be the focus of development planning.

Type	Frequency	Hours of service	Patronage potential
Frequent	Minimum of every 12 minutes (5 buses per hour) in urban areas.	18+ hours per day 7 days per week	High
Coverage	Every 30 to 60 minutes in urban areas.	12+ hours a day 5+ days per week	Low
Peak	Varies depending on the type of demand.	Only during specific times of high need or high demand	Medium

A sign from Portland, Oregon, USA indicating a stop receives "Frequent Service" and is therefore part of the Frequent Network.

Frequent Network Policies

Bus services don’t always have fixed infrastructure, as railways do, so how can planners know where they are? And should property investors believe that a frequent service is permanent if they can’t see physical evidence such as rails in the street?

To answer these questions it is important to know that **the cost of public transport is dominated by perpetual operating cost, not the one-time cost of construction.** This makes public transport fundamentally different from buildings or roads, for which the cost of construction is high but the ongoing costs of operations and maintenance are small.

Because of the high cost of operations in public transport, the permanence of a public transport service does not lie in its infrastructure, but rather in the permanence of demand to justify ongoing operating costs. There are many examples of railways that previously had service which have since been abandoned or ripped out. When their operating cost could no longer be justified, their infrastructure wasn't enough to save them.

Public transport service is permanent if and where the demand for it is permanent. The permanence of the demand comes from the development pattern. **When density walkability, linearity and continuity are baked into the urban form, there will always be many people who find public transport useful, and it will always be efficient to provide** – whether by bus or train.

It is extremely important to organise future development into patterns that public transport can operate efficiently, because those development patterns are themselves the source of permanent demand for service.

Vancouver, Canada, and Planning for Growth on the Frequent Network

Some public transport authorities identify a subset of the bus and railway network on which the highest levels of service will be provided, over many years into the future. The existing Frequent Network is generally a part of this permanent network, along with future corridors that will justify higher levels of service once they are developed.

For example, TransLink, the public transport authority of Vancouver, Canada, has long presented a "Frequent Transit Network" to the public and decision-makers. A map of Vancouver's Frequent Network is shown on the next page.

The Vancouver-area regional government, in its turn, set aggressive goals for the percentage of new housing and jobs which should be located on the Frequent Transit Network. As a result of this policy, enacted nearly 20 years ago, public transport access for the average resident has increased and development has taken a more sustainable form.

Shaping development and urban growth in this way would not have been possible around the railway network alone. The success in locating growth on the Frequent Transit Network required collaboration between the public transport authority and the land use authority. The very first step was the definition of the Frequent Transit Network.

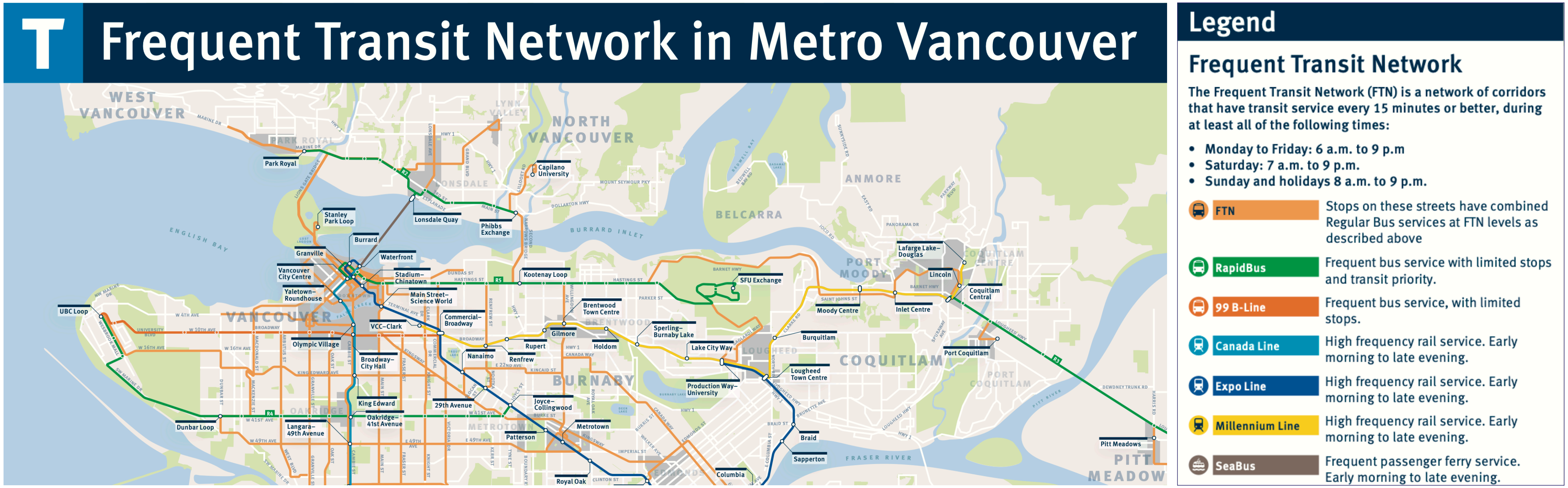
In Ireland, developing and adopting such Frequent Network policies for each city is possible. The goal would be to create confidence that a supportive development pattern on the right corridors will be met with excellent public transport service, and that continued investment in service and infrastructure will go towards efficient public transport that attracts high patronage.

How Frequent Is Frequent Enough?

For urban services, Frequent Service should run **every 12 minutes (5 buses per hour) or better**, at least during the day on weekdays if not also into evenings and weekends. This is a widely accepted threshold across many western countries.

However, any definition of Frequent Service must recognise that our tolerance for waiting depends on the length of the trip we are making. We experience the wait for public transport as a percentage of the total trip time, and are generally willing to wait longer (or plan our trip more carefully around a timetable) when we are traveling further. Conversely, we tend to tolerate only short waits to make short trips.

For that reason, Frequent Service should actually be more frequent than every 12 minutes in the densest areas. The higher frequency not only provides more capacity to meet the higher demand, it also makes shorter trips easier and more attractive.



TransLink, the public transport authority of Vancouver, Canada, makes its frequent transit network highly visible as in this map. This is done to market the services to passengers, but also to show planners and developers where development should be concentrated.

Time-Span of Service

The Frequent Network should have a defined minimum time-span, which is the hours and days when service is provided. The right span of service can vary by city, depending on the economy, culture and level of funding available for public transport service.

As a general guide, the span for routes in the Frequent Network should be: high frequency for at least 14 hours a day (such as 6 AM - 8 PM) on weekdays, and at least 12 hours a day on Saturdays. Outside of those times, a lesser frequency of every 20 or 30 minutes may be appropriate.

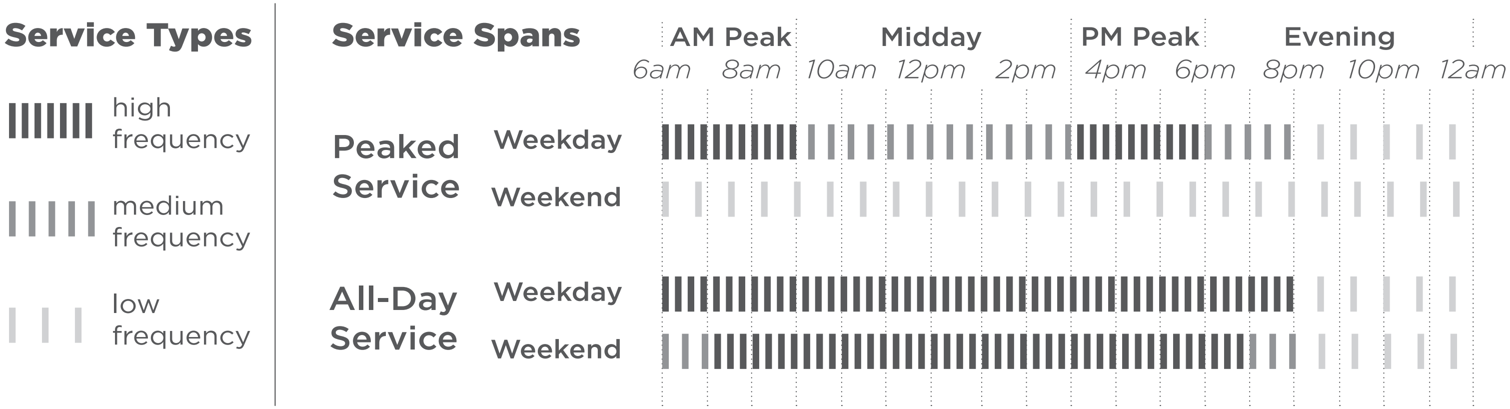
If public transport is expected to attract a large share of journeys, then it needs to be available nearly all of the time, and it should be available for most of the day at its best frequency. High frequency over a long span allows public transport to offer people freedom and flexibility similar to that offered by a private car.

Bus Stop Locations

Finally, the Frequent Network should have a standard for the distance between bus stops. Much of the delay imposed by stops is unrelated to the number of people getting on or off there. Rather, it arises from the bus slowing down, pulling over to the kerb, and then leaving the kerb and in some cases waiting for a break in traffic to rejoin traffic. Because these delays are incurred per-stop, rather than per-passenger, the number of stops per kilometre has a big impact on the speed of the route.

When passengers gather at fewer stops, the bus service can be faster. This can increase walking distances slightly, but there are corresponding benefits to passengers: the higher speed results in a faster journey time and allows the operator to provide better frequency (as explained in "Speed and Reliability" beginning on page 17).

When the available capital budget for bus stop amenities is divided over fewer bus stops, it results in better amenities for more passengers. In some cases there are good arguments for



This chart illustrates the times and patterns of service that make up a network's span. In a network focused on traditional peaks, frequent service is mostly offered during AM and PM weekday rush-hours. In a frequent network, high frequency services are available most of the day and on weekends as well as weekdays.

stops more closely-spaced, such as when a lack of pedestrian facilities makes walking unsafe, or when a group of people with difficulty walking or reaching bus stops is located nearby. However, in general, better amenities can be provided to passengers when they are divided amongst fewer stops.

Stop locations should be selected with these considerations:

- Stops should not be less than 400m apart in new development. Shorter spacing can be justified in existing areas due to a lack of pedestrian infrastructure, but new areas should be planned to this standard;
- Each stop should be located at nodes in the walking network, such as at four-way junctions or places where footpaths provide access to an area; and
- There must be a safe place to cross the street near every stop.

When a new street or area is planned, actual bus stop locations should be defined using these principles. Those stops should then be the focal points for planning high walkability and for any required pedestrian and bus stop investments by developers.

Evolving the Frequent Network

As a city grows, new corridors will be added to the Frequent Network. These may include extensions of frequent routes or upgrades of non-frequent routes contingent on further transit-oriented development or observed demand.

To create the necessary clarity, consider distinguishing these categories of routes and corridors in planning documents:

- **Existing** Frequent Service, where frequent service is already provided;
- **Planned** Frequent Service, where the local authority and NTA agree that Frequent Service will be extended in the future; and
- **Candidate** Frequent Service, which are corridors that currently have a lower level of service but which might support upgrades to Frequent Service in the future.

"Planned" means that the frequent service will definitely exist when the development reaches an agreed level of build-out. (Less-frequent service may be provided in the meantime.)

"Candidate" frequent service means that some of the necessary conditions for Frequent Service are present but some are not. For example, there may be patches of high density but long segments of low or zero density. Or there may be dense developments but without the local street network that allows bus routes to connect them in a reasonably linear way. Planning for such "candidate" frequent service corridors should call for specific improvements that will support Frequent Service in the future.

Guiding Development & Location Choices

There are three ways the Frequent Network should guide development.

1. **Any use where high public transport patronage can be expected, due to the density of housing or activity, should be on the Frequent Network**. This category includes all apartment buildings, major job centres, large shopping centres, hospitals, large health clinics, universities and large schools.

2. **Any land use that is intended to serve people experiencing deprivation should be on the Frequent Network.** Examples include social housing, social services, hospitals or clinics, and major low-wage job or training centres. Such destinations should have frequent service,

for the benefit of the people visiting them. Locating these destinations on the Frequent Network ensures that the frequent service can be provided efficiently and permanently.

3. **Development that generates sparse travel demand, and that is not heavily used by people experiencing deprivation, should be kept away from the Frequent Network.** For example, low-density residential, low-density industrial such as warehouses or logistics facilities, and low-density recreational uses such as golf courses.

Note that these principles apply to two very different kinds of activity. They apply to land use planning, but they also apply when individual organisations or companies are making location decisions. This is why the Frequent Network should be presented publicly, reflected on public transport maps and other types of service information, as well as in policy documents and plans.

The Frequent Network should become so well known that there should be no excuse for someone to locate a business or destination in the wrong place and then complain about poor public transport service. When they chose their location, they chose their public transport.

2.2 Make It Easy to Walk to Service

There are several ways to get to public transport, but walking should be the focus in land use and development planning. (We use “walking” here in a broad sense that includes the use of wheelchairs and similar mobility devices.) Walking is the foundation because:

- It requires very little land and no operating cost;
- It affords people the greatest spontaneity; and
- It is extremely sensitive to details of land use and development planning at all scales.

Other modes of access are important, but they should not have as great an influence over land use and development planning as walking.

Bicycles and scooters are very important to consider in the design of streets, junctions and hubs. However, at the larger scale of land use planning, access to public transport by these modes is improved through the same decisions and investments that benefit walking: a mix of land uses on a well-connected network of streets and paths.

Car pickup and drop-off, including by hired cars, should be managed through street design because of its use of kerb space. It is also an issue in the design of hubs, discussed below. However, at the larger scale of land use or development planning it does not need much special treatment.

Park-and-ride allows for combined car and public transport access from rural and exurban areas. However, it uses a great deal of land and construction investment, and does not scale well as patronage grows. Large amounts of parking make sense only where land value is low, whereas cities and towns – especially the areas around successful public transport – are places where land value is high.*

Land use and development planning has enormous influence on the most common and most efficient way people reach public transport, which is by walking. The key to making walking easy is to:

- Concentrate development close to Frequent Network stops, so that average walking distances are short, and
- Provide direct footpaths into developments from likely bus stop locations on the main street.

Concentrate Development Close to the Frequent Network

Residential Areas

In laying out new communities, the highest densities should be closest to Frequent Network's stops, similar to the way nodes of dense development are typically organised around a railway station in transit-oriented development.

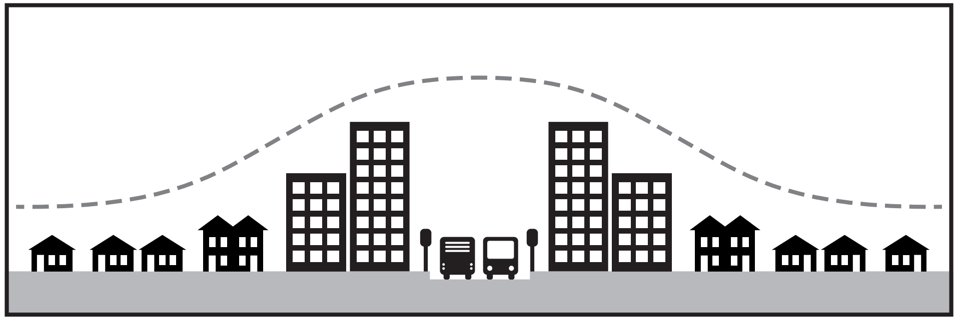
Such a pattern of concentration increases the number of people near a bus stop, and thereby reduces walking distances for the most people. It also helps justify capital investments in good footpaths, street crossings and lighting at the junction, because the investments benefit not only bus passengers but also the many other people walking in the area. The development and high quality of public space in turn make the bus stops and footpaths feel safer and more appealing.

* Car parks around high-patronage bus or railway stations tend to produce less patronage than buildings on the same land would produce. This makes them hard to justify in the long term. Park-and-rides should therefore be used on the edges of cities or towns as a way to intercept travellers from rural and exurban areas. They should be considered temporary facilities and likely to be moved further out once the station area intensifies and the land becomes more productive as housing, shops or employment.

Areas that are more distant from planned Frequent Network stops, such as at the back edge of a development far from the main street, are where lower-density uses should be allowed.

Concentrating development close to main streets and junctions can conflict with the tradition of buffering residential development against the effects of car traffic. It is common to see main streets built almost as parkways, with few junctions, few street connections into adjacent areas, a greenspace buffer, and higher speeds. These decisions in the past have resulted in longer walks between public transport stops and actual residences and destinations, as well as making main streets and bus stops feel neglected and unsafe due to their isolation.

If a street or road is expected to be a public transport corridor, with high levels of service and high patronage, then development should be oriented towards the street and major junctions rather than shying away from them. This is consistent with guidance in the Design Manual for Urban Roads and Streets (DMURS) and is important for the success of all active modes of travel.



The parcels along main streets, and especially around Frequent Network stops, should be used for the highest-density developments and busiest destinations (in the middle of this illustration). Parcels farther from the main streets and Frequent Network stops should be used for buildings that generate fewer trips.

Jobs and Destinations

For assessing the locations for workplace and commercial developments, **trip generation** is an important factor to understand. How many times does someone want to go to or from this place in a typical day?

Developments that generate high numbers of trips per square kilometre should be closest to the Frequent Network stops. A position immediately adjacent to a Frequent Network stop is ideal, especially for a development that generates not only peak demand on weekdays but also all-day and all-week demand.

For example, a shopping centre should be arranged with its biggest buildings, and its front doors, within a few hundred metres of Frequent Network bus stops. This means that large car parks should be behind the buildings (from the perspective of the main street) rather than in front of them. The tallest buildings should be near the bus stops. Smaller and shorter buildings located between stops or set back behind the largest buildings.

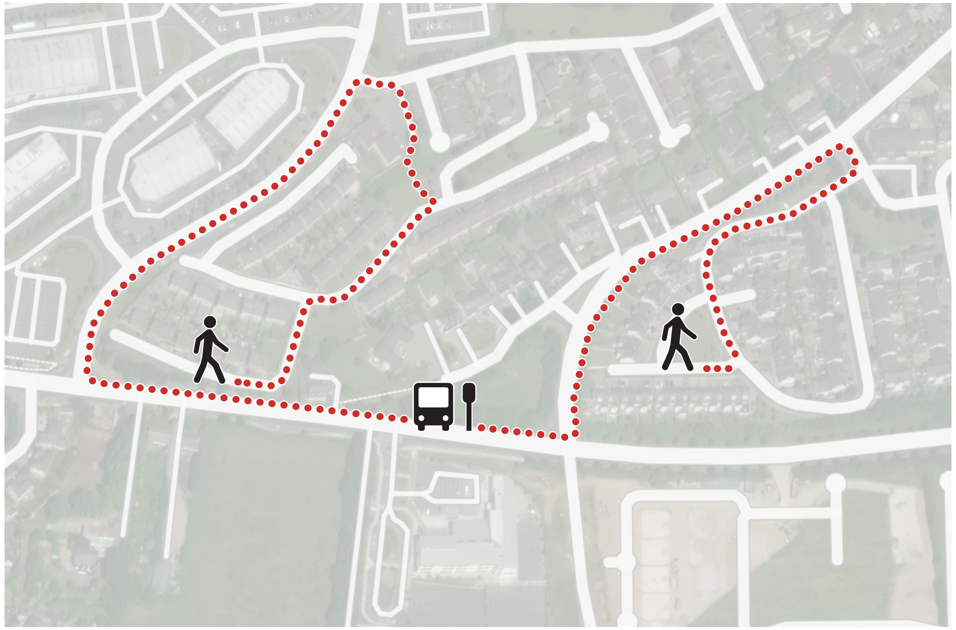
The most intensive land uses should be located at the point where two or more Frequent services intersect, to maximise people's access to and from those developments.

Design Street Networks for Short Walks

The connectivity of main streets and local streets has an enormous impact on walking distances and therefore public transport access.

A disconnected street network can deprive many people of access to public transport even if they are close to a bus stop as-the-crow-flies.

The map below shows the very long and circuitous walks from housing developments to a likely future location for the bus stop on the main street (in front of the school). If short pedestrian footpaths to the main streets had been required during the planning and approval processes for these developments, then residents would have a more reasonable walk to the bus (and pupils would have a shorter walk to school).



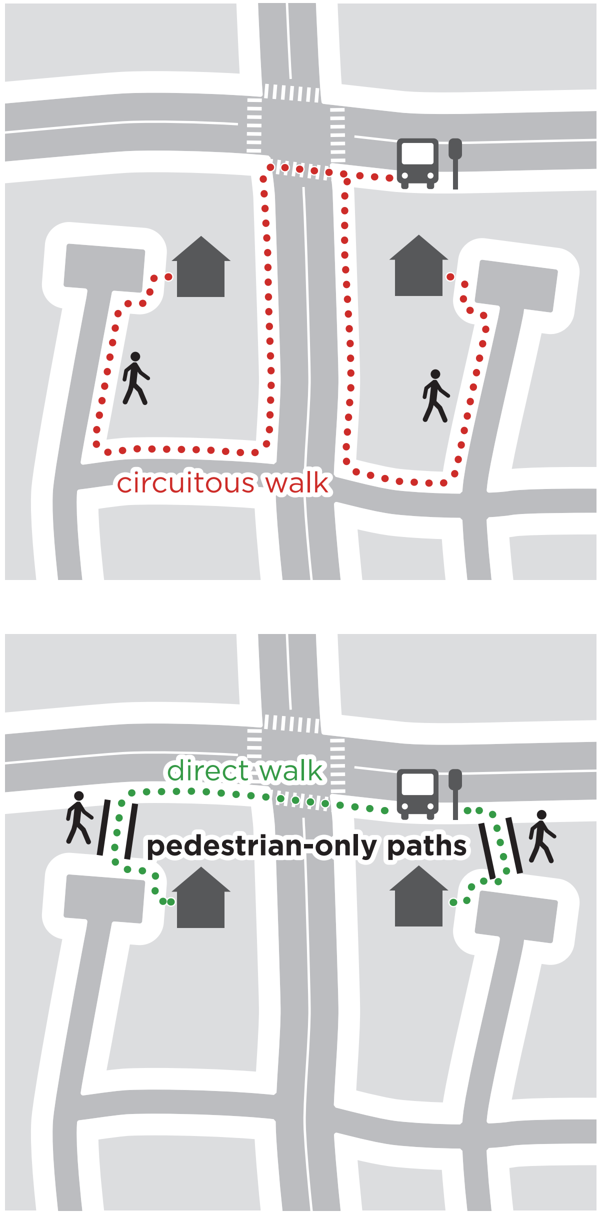
Disconnected and cul-de-sac street networks can make walks to a bus stop (or a school) on the main road extremely long.

Residential developments are often intentionally designed to be isolated so that motor vehicle traffic cannot pass through, in order to provide a quiet and private environment for residents. Industrial and business parks are often designed without any through-streets as well.

It is possible to design street networks to be disconnected for cars, but with high connectivity for walking and cycling. This is the concept of "filtered permeability." It allows people to walk or cycle to a bus stop that is nearby on a main road, rather than being forced to go the long way around because the streets do not go through. It also makes walking and cycling more attractive than the car for short trips to local services.

A long footpath through a development can provide filtered permeability, as can short pedestrian-and-bike-only connections between cul-de-sacs or from cul-de-sacs to a main road, as shown in the illustrations on the right and the map below.

In this filtered permeability scheme, paths (shown as dotted green lines) shorten the walking and cycling routes to a park, the main street and bus stops.



Cul-de-sacs without footpaths connecting them through (as on the left and at top) can make walks long and winding. Well-placed footpaths (as at bottom) shorten walking distances substantially.

Guidance on providing permeability in new developments, and for repairing permeability in existing developments, is available in the NTA Permeability Best Practice Guide and the Design Manual for Urban Roads and Streets.

When applying filtered permeability schemes, **it is essential that existing and likely future bus routes be considered,** so that buses aren't filtered-out inappropriately. If adjacent developments are too far from a main road for residents to be expected to walk to the main road for bus service, this suggests that their street networks should allow for a bus route that connects them directly. An example of this situation is shown on page 39.

There are permeability solutions that allow a bus to follow a relatively direct route between adjacent developments whilst preventing rat-run car traffic. Posted signs prohibiting cars, or even physical barriers that only buses can open, can filter-out private cars whilst encouraging walking, cycling and public transport use.

Design Streets for Walking and Waiting

Streets and roads themselves need to be built and maintained with walking and waiting in mind. At a minimum, this means footpaths on both sides of the street and frequent crossings.

Footpaths should also be wide enough for people to walk side-by-side and pass one another, and for wheeling and mobility devices.

Finally, footpaths will need to be wider at bus stop locations to allow for shelters, benches, signs and others furniture that makes waiting for the bus more comfortable. In an area that is well-planned for bus service, the places where dense development is foreseen, and where crossings are provided, and where links in the pedestrian or street network come together, are likely places where bus stops will be desired and especially useful. These are the places to plan for additional footpath width.

2.3 Make Efficient and Useful Bus Operations Possible

Public transport is expensive to provide, so it is important to use this resource efficiently. When public transport is inefficient, the limited budget for service must be divided across more routes and more kilometres, undermining frequency and shortening hours or days of service. The result of this dilution is that access to opportunity is worse, and fewer people use public transport.

Through good land use and development planning, bus operations can be highly efficient, leading to excellent service that large numbers of people use.

In addition to the land use patterns that support efficiency, access and patronage, these three elements also need to be considered:

- The structure of principal streets where public transport can operate;
- The availability of hubs, where people can interchange between lines; and
- The availability of terminal facilities at the ends of bus routes.

Street Network Structure

Nothing about a city is more permanent than the pattern of its street network. In some historic cores, for example, the street network is older than virtually all of the development occupying it, surviving even as buildings have come and gone over the centuries.

When the opportunity arises to design new street networks, the decisions being made are extremely consequential and permanent. These decisions must take into account public transport efficiency.

In this section we focus not on the allocation of space within the street, but in the pattern formed by the network of streets that may carry public transport services.

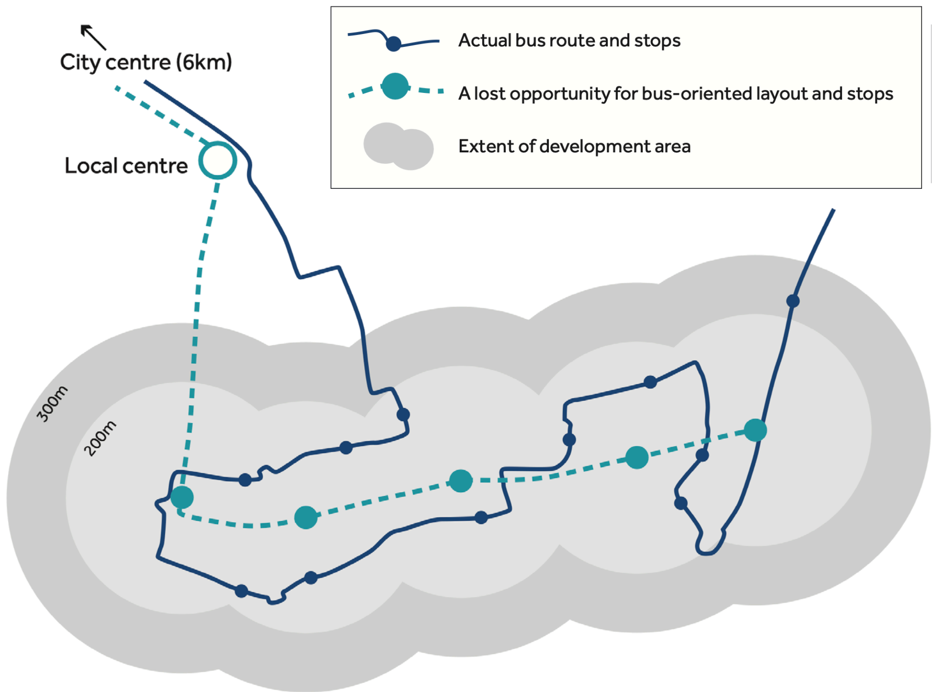
Public transport is most efficient when the main links in the street network have the following features:

- Straightness;
- Reasonable parallel spacing;
- Two-way traffic (at least for buses); and
- Four-way junctions.

Straightness

Ireland is a country of mostly gently winding roads which come together in branched radial patterns in town and city centres. Irish cities have few examples of long straight streets such as the boulevards of Paris or the arterials of US and Canadian cities.

However, the circuitousness of the roads in many Irish developments from the late 20th century did not arise from the landscape. Instead, they arose from desires to offer a particular aesthetic and to reduce through-traffic. The legacy of this style of road network has been poor public transport access and low efficiency.



Missing the opportunity to plan for bus-oriented development, by laying out straight streets through a new growth area, results in circuitous, indirect and inefficient bus services. Credit: "Buses in Urban Developments" by the Chartered Institution of Highways & Transportation in the United Kingdom.

Public transport is most efficient when it runs in straight lines. Why is this?

- Straight lines feel direct and efficient for all passengers. A sharp curve in a line is a source of delay for people journeying through that point.
- They cover more area. Geometrically, a straight bus line maximises the area within walking distance of the line, while a curving line covers a smaller area.
- Straight lines are most cost efficient to operate. They are the shortest distance among the destinations they serve, and distance contributes to operating cost.
- They can be extended indefinitely whilst remaining direct for all passengers. A straight line is useful for travel between any two points along the line, and this continues to be true even as the city grows outwards and the line is extended.
- Straight lines are simple and easy to remember.

Roads do not need to be perfectly straight to be efficient for public transport. They can adjust to the topography while continuing in the same general direction. However, a road network that requires buses to travel in circuitous or deviating patterns undermines public transport success.

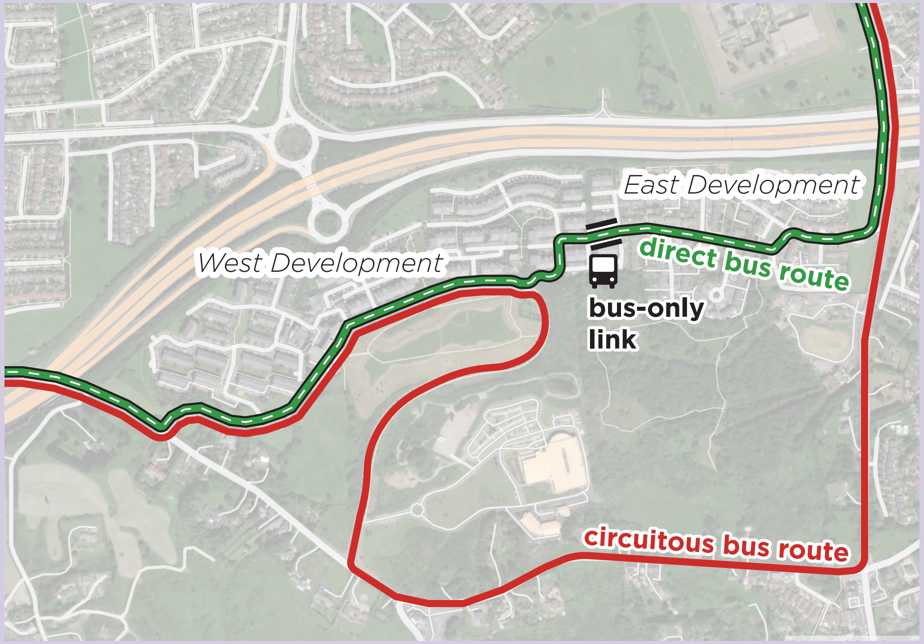
Don't Filter Out Buses

It is possible to provide for pedestrian and bicycle permeability in the planning of streets, yet fail to support public transport usefulness and efficiency.

If adjacent developments cannot be linked by direct and efficient bus routes, then public transport costs will be high and patronage will be low.

The developments in the aerial photo below provide an example of pedestrian permeability without bus permeability.

Both the West Development and the East Development present dead-ends for buses. They are linked by a pedestrian path, but no streets.



The development to the west is very dense, but reaching it with a bus requires driving a bus along the solid red line. This long deviation wastes the time of through-travelling passengers.

If, instead, a bus-only link had been created between the West and East Developments, a relatively straight bus route could have passed through both. This efficient and useful (but imaginary) bus route is drawn as a green dashed line.

Despite the high densities of these two developments, they have only infrequent bus services today. This is because their high densities cannot sufficiently counteract the looping and disconnected bus route required to serve them, with the net effect that they have low potential for patronage.

This example shows the filtering-out of buses in residential areas. It is even more important that buses not be filtered-out in town and city centre schemes, where numerous bus services are providing access for high numbers of passengers. If laudable efforts to reduce the dominance of the car in centres also force buses to follow longer, more circuitous and slower paths, it will increase the costs and reduce the usefulness of those bus services.

Street Spacing

One goal of the BusConnects programme has been to provide some public transport service near most homes and destinations in urban areas, but in some cases the street network makes this impossible. If streets that buses can use are spaced too widely, there may be no way to get close to the homes or workplaces in between them.*

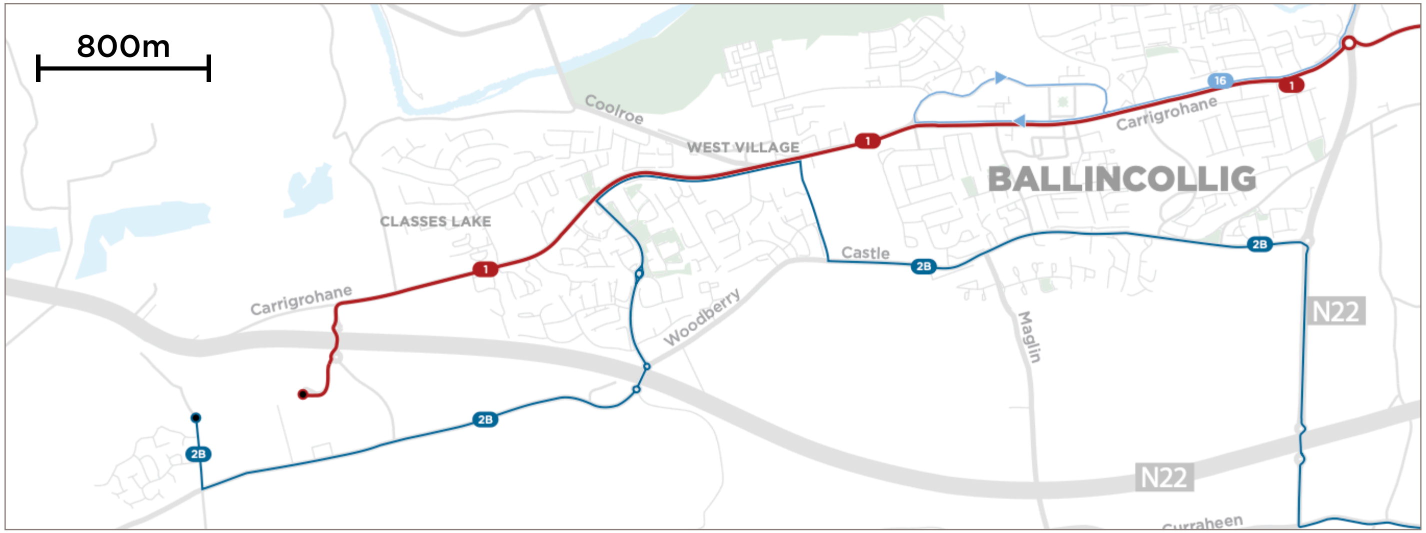
The longest walks to homes or workplaces in a development will be defined by the spacing between the streets that buses run along. These streets must be wide enough and flat enough for a bus to drive on. They should be linear and should continue on to other developed areas.

If such streets are spaced about 800m apart, and if the pedestrian permeability of the area is very good, then the homes or workplaces located furthest from the main streets will be about 600m to 700m walk from a bus stop on the main street.** This is a distance that most people can walk in 7-9 minutes.

If streets are much farther apart than 800m, then many people in between them will be a long walk from service. If streets are closer, then many people will be very close to service on either street – but this is not necessarily a good thing because, especially in radial towns and cities, the buses on the two

* Serving areas with narrow streets or no through-streets can be done using smaller vehicles, either on a fixed route or demand-responsive service. However, this usually requires much higher public expenditure per passenger and a larger number of vehicles, both of which are hard to justify during the day, for the general public, inside an urban area. Such service is usually reserved for low-demand rural areas, or low-demand times such as late at night, or for people with mobility difficulties.

** Counting both the walking distance to reach the main street and some walking distance along the main street to reach a bus stop.



The two main east-west roads this town are 600-800m apart. Their particular spacing, and their continuity through adjacent developed areas, allows just two east-west bus routes to get within a short walk of most homes and schools. Also, because only two routes are required, it will be possible to offer fairly good frequencies. (This map shows planned BusConnects routes which will be refined further and implemented starting in 2025.)

streets may be going to the same place (the city centre). This can sometimes provide people with a useful choice, but it can also be an inefficient use of limited resources. This is why, when parallel streets are less than 600m apart, it is unlikely that they will both have Frequent Service.

The example distances given in the previous paragraphs can inform the spacing of streets in new development areas, depending on the length of walk that is considered tolerable. Thoughtful spacing of main roads supports public transport efficiency whilst giving everyone in the development a short walk to a bus stop.

The principle of spacing roads a little less than twice the reasonable maximum walk distance apart could be taken to a mathematical extreme. The result would be an orthogonal grid of streets. Extensive grid street networks are almost unknown in Europe and the UK, but they have been used in younger cities. Grid cities with main streets at the ideal spacing, such as Chicago or Toronto, have an extremely efficient geography for public transport. The maximum walking distance to a stop is the same in all areas, and the main streets are far enough apart that parallel public transport lines do not compete with each other.

Irish planning could incorporate softer versions of the "grid" concept by using streets that curve slightly but proceed generally parallel. Variations in the spacing between roughly parallel streets can also be managed by putting low-demand destinations, such as green space, in the interior areas that are furthest from a stop.

The NTA Permeability Best Practice Guide and the Design Manual for Urban Roads and Streets both provide additional guidance on designing and retrofitting street networks to support public transport access and efficiency.

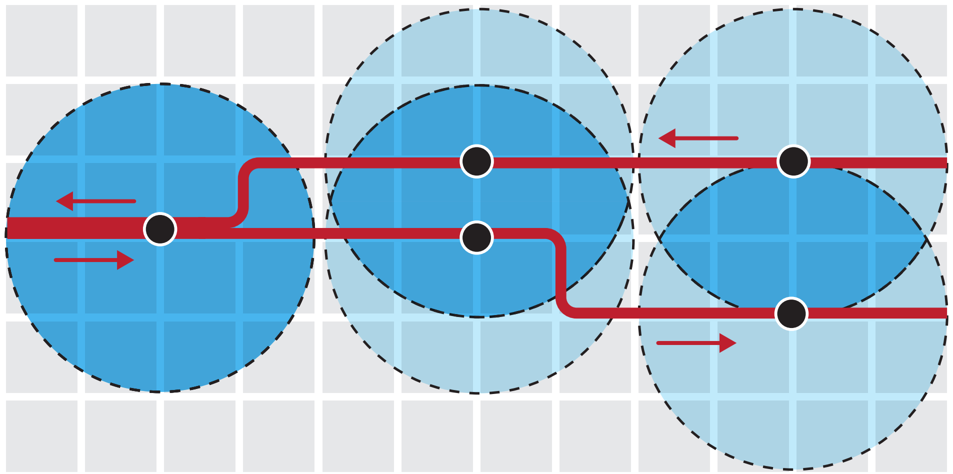
One-Way Street Operations

In historic town centres one-way street systems may be unavoidable due to the narrowness of streets. However, one-way public transport patterns should be avoided whenever possible, as they undermine legibility of the service and the number of people who will find it useful.

Most public transport trips are return trips, therefore a bus service needs to be useful for both directions of someone's journey.

One-way splits actually **reduce** the area covered by public transport. As shown in the diagram below, the area that is within a given walking distance of both stops gets smaller as the two directions move farther apart.

From the individual perspective, whatever length of walk to the bus stop a person considers acceptable, a wide-enough one-way split will put the bus stop for their return journey too far away. From a population perspective, even though different individuals have different maximum walking distances, one-way



When two directions of a public transport service are separated, it reduces the area that is a short walk from service in ***both*** *directions.*

splits reduce the number of people who feel that both bus stops for their journey are acceptably close.

This same phenomenon applies to one-way loops at the ends of routes. Because the bus and driver will likely layover for 5 or 10 minutes at a terminus halfway around the loop, and because passengers do not usually like sitting through that layover, a terminal one-way loop should really be considered a one-way split in service. The loop therefore appears to increase coverage of the area, whilst actually reducing the area that is within a short walk of service in both directions.

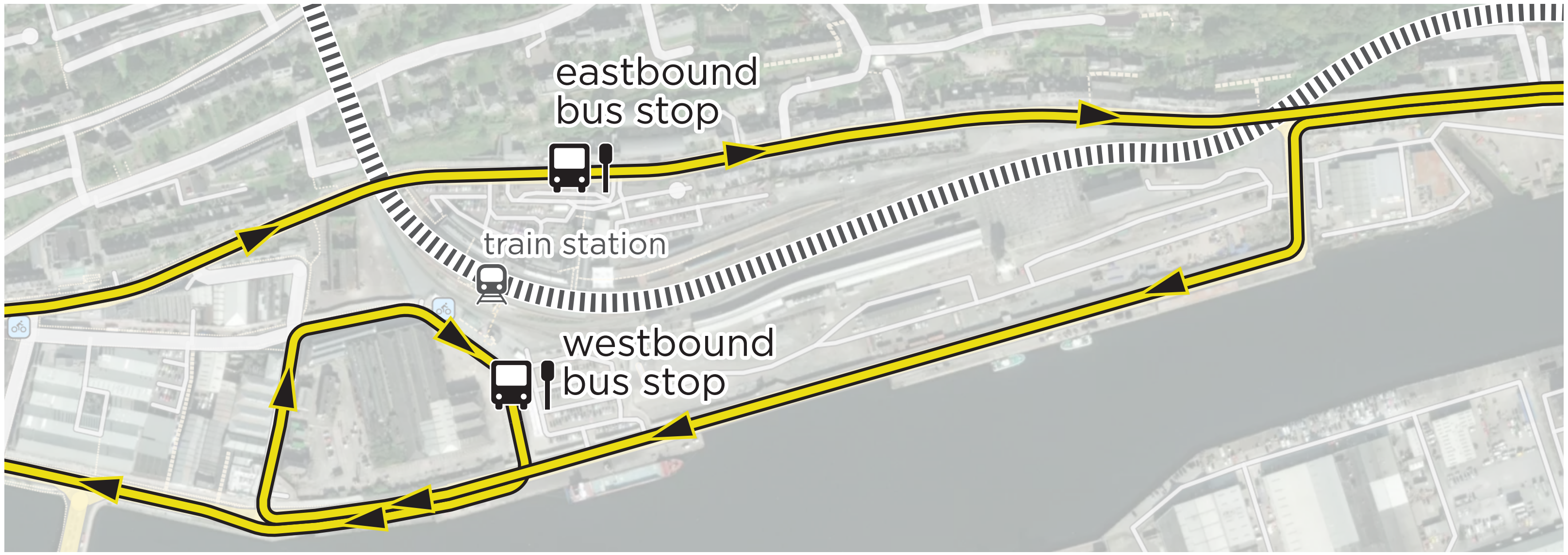
This is why, if the two directions of a bus route must be separated, the separation should be as small as possible.

In the example below bus services (shown in yellow) are split into two directions, one on either side of a train station. Anyone to the north or south of this area will experience a longer walk for one direction of travel than the other. In addition, people making a bus-train interchange for the first time will be challenged to find the bus stop location for their return journey. If they go to the bus stop they used in the morning, it will be the wrong one! By the time they run to the correct stop they may have already missed their bus.

One-way splits tend to make public transport especially confusing to new and occasional passengers. Two-way bus service is easier for people to learn and understand. The place a person goes to get the bus back home is likely within sight of the place they got off the bus earlier in the day.

Growing patronage requires that new and occasional passengers become consistent passengers, which means that their confusion should be taken as a serious problem.

A one-way system for cars does not necessarily have to be a



With a one-way split in bus service, such as on either side of the train station in this image, anyone using the bus for the first time will have a geographic challenge to find the stop location for their return journey.

one-way system for buses. In some cases bus lanes can be used to provide bus-only movement in the opposing direction on an otherwise one-way street. This keeps the two directions of public transport service together, making it easier to understand and maximising the number of people and destinations close to service.

Four-way Junctions

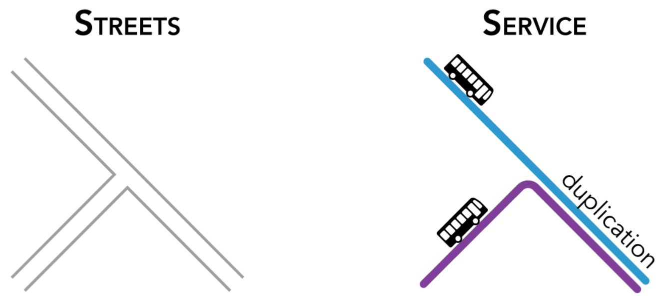
For public transport, three-way junctions are sometimes inefficient because they require duplication of service on at least one of the three paths.

Two roads with bus service connecting in a "T" junction – as shown on the right on top – leads to service duplication on one of the road segments.

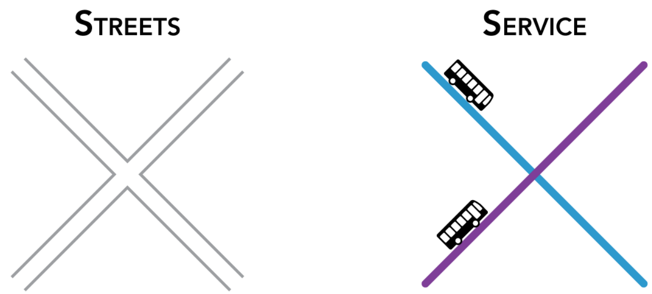
Four-way junctions are more efficient because they do not present this problem. As shown on the right in the middle, both routes can continue through a four-way junction, without duplicating one another whilst allowing for interchange.

If a pair of three-way junctions are a short distance apart and can be made to operate as a four-way junction, then the same efficient pattern can be followed. This is shown on the right, bottom. The two bus routes cross roughly perpendicularly, allowing for interchange whilst avoiding duplication.

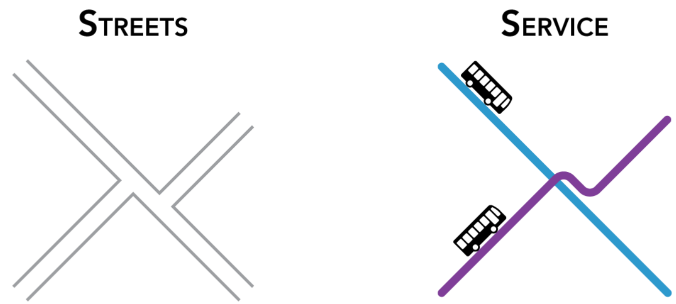
When major streets meet in a T, and we need service on all of them, the result is duplication:



When streets meet in a cross, both lines are straighter and there's no duplication:



A slight offset is also workable:



Hubs in Busy Areas

A hub or interchange is a location where many public transport lines converge. This convergence allows people to connect between any pair of lines in order to travel in any direction. Because of all this service, hubs also offer nearby residents and workers high public transport access to a large area. For this reason, hubs should be integrated into an area of intense development and travel demand such as shopping, universities, train stations, medical facilities and mixed-use developments.

Hubs require considered planning because they can require a lot of space. There must be enough space for several buses to be present at once, along with space for passengers to wait, and a place for bus drivers to take their breaks.

In city centres, space on the road, footpaths and private parcels is in high demand. Yet the extreme importance of a good central hub means that cities typically find ways to shoehorn a good bus hub into the centre, as is the case in Galway, shown in the photo below on the left.

Hubs in less-dense areas can be more expansive, as in the example of Dublin's Liffey Valley, shown below on the right. The Liffey Valley hub is located in the middle of a large car park, which isn't usually ideal. However at the scale of the city, it is located in just the right place to make the overall bus network very efficient, which delivers access gains for residents and workers all over the city.

All good public transport hubs are bespoke, because they must fit into and integrate with the urban form around them. They key thing is that they must be located at strategic places where they support efficient design and operation of the network. This

In Galway centre, the Eyre Square bus hub is squeezed into a dense urban development pattern and narrow streets.

In Dublin's LIffey Valley, a spacious bus hub was built as part of a car park and shopping centre redevelopment.

is why it is worth the enormous trouble of fitting bus hubs into dense places: a hub in the wrong place can sometimes be worse than no hub at all.

In city and town planning, hubs should be identified, with a rough sense of location and scale, when a larger area plan is being developed. Then, as major destinations emerge, the hub should be presented as a necessary feature of the development. It is much more difficult to fit hubs into development after it has occurred. However, in terms of the number of people brought to the development per square metre of land used, a hub is generally more productive than a surface car park.

Local Authorities, the NTA and other stakeholders should collaborate in locating bus hubs to support an efficient and useful bus network, and to ensure the hub is the right size to meet future needs for bus service.

Setting the size of a hub is a difficult issue. Hubs should not be so small that they prevent enough buses from gathering there, but not so large that they themselves become barriers to easy walking to destinations. The decision should not be based only on current levels of service, but anticipating growth in services in the future.

In some cases, the network will benefit from being able to schedule pulses at a hub, as described on page 16. (Pulses allow passengers to transfer between any pair of routes without a long wait.) The need for all buses to be present together at the pulse implies a larger hub than if buses arrive at staggered times throughout each hour.

A somewhat smaller facility may be workable if many of the routes can be expected to be frequent, and therefore do not need to participate in a pulse. On the other hand, even a frequent network may need to pulse at night, when frequencies are worse but passengers still benefit from a reliably short wait to interchange. In addition, any routes that terminate at the hub will require space where buses can dwell whilst briefly out of service at the end of the line.

As a default planning assumption, a hub should be sized to include one bus per route, per direction, plus additional spaces for buses to layover at the ends of any terminating routes.

Terminus Facilities

Bus schedules include time, normally at the end of a route, for a bus driver to take a break. If drivers took these breaks in the middle of a route they would delay passengers, so breaks should be planned at one or both ends of each route.

Planning for public transport means providing terminus facilities at one or both ends of every route. Long routes may require termini at both ends. A terminus requires:

- The ability to turn the bus around, either using the local street network or a turnaround loop;
- A toilet for the driver to use during their break. This is important to ensure that drivers don't have to make stops along the route where they will delay passengers, and that they can do their jobs in good health and comfort;
- Enough space for buses from all terminating routes to dwell while the break is occurring. If the route is long and frequent, and especially if longer meal breaks are taken at the terminus, then two or three buses from a single route may be there at once; and
- A bus stop and shelter for passengers departing this point, although terminus facilities generally have much less passenger activity than hubs. Some termini are even designed as off-street facilities closed to the public, with a departure stop on the street just outside of them.

Hubs nearly always serve as terminus facilities for a few routes, as well as interchange facilities for passengers. Hubs are therefore also terminals, but terminals needn't always be hubs. On the outer edges of a city, routes may logically end in places where a passenger interchange hub isn't needed. In such places the space must be set aside for a terminus facility with room for all of the features listed above.

Given the investment in each terminal facility, it may be a good idea to end multiple routes at one terminus if it can be done efficiently. However, keep in mind that the operating cost of driving buses extra kilometres to reach a terminus adds up fast, and is borne into perpetuity, eventually dwarfing the cost of building a second terminus.

Growth At The Edge Needs A Terminus

How can bus service reach people at the edge of the urban area? Beyond the edge, the roads may be inoperable by buses and unsafe for walking.

In the example on the right, dense housing – including social housing – is at the edge of the city. To the north the roads are hardly more than boreens, too narrow and uneven to be driven by a bus.

If development at the edge of an urban area requires bus service, but there is not a completed street network through and beyond the developed edge, then there must be a bus terminus near that edge where the bus can turn around and the driver can take a break.

But if a city is growing outward, maintaining bus termini precisely at the edge would mean constantly closing and opening new termini, inching the infrastructure along over time. This is costly and impractical.

An alternative is to plan and fund improvements to the road network beyond the developed fringe, so that a bus route can terminate and turn around using the same pattern and infrastructure for many years.

Summary

The three essential land use planning actions to support public transport are:

1. **Organise Development Around a Frequent Network.**

    - The Frequent Network includes services running every 12 minutes or better (5 or more buses per hour) throughout most of the day.
    - Development with high public transport demand or social need should be on the Frequent Network.

2. **Make it Easy to Walk to Service.**

    - Density should increase the closer one gets to public transport stops.
    - Roads and footpaths should be well connected to provide direct walking paths to bus stops.

3. **Make Efficient and Useful Bus Operations Possible.**

    - Design a network of major streets that are relatively straight, evenly spaced, two-way and meeting at four-way junctions.
    - Plan for hubs at major activity centres and for simple termini where routes need to end.

3

Examples

Image: Bus in Salthill by Andrew Downes XPOSURE

This chapter provides more detailed examples of how to apply this note's guidance to specific development types.

This section focuses on the large-scale aspects of development structure that are extremely difficult to fix after an area is built, such as the locations of streets and rights-of-way, which in successful cities tend to last for centuries.

We focus less on issues such as path quality and lighting, only because they are well-understood by most planners and easier to repair in the future.

3.1 Residential Areas

People naturally feel defensive about their homes. Once a new residential area is built and occupied, residents tend to advocate to keep things as they are. Because of this phenomenon, the design of residential areas tends to be more permanent than that of commercial or industrial areas, where the design can change with the normal churn of commerce.

Because residential street networks are so permanent, their design must look beyond the current tastes in the real estate market. They must ensure that government services can be provided efficiently, including bus transport. This means recognising geometric principles that make public transport efficient, and manifesting these in the development design.

It is possible to create a diverse range of housing and development types while observing the principles outlined in this guidance note. In this section we show a few positive and negative examples.

This page is left intentionally blank.

Low Density with Good Link Road Structure

The aerial photo on the previous page shows a residential development in a Canadian city. The pattern is typical of 1950s-era suburban form, with curving and somewhat disconnected local streets and low density housing.

However, the parallel north-south link roads are spaced 800m apart, which is supportive of efficient coverage by public transport. All residents are within 400m as-the-crow-flies, and most are within a 600m walk, from a stop on one of the main streets. The ***maximum*** walk distance is lower than it otherwise would be because in many cases the centres of the "superblocks" – the places furthest from any main street – are given over to parks and schools. However, the ***average*** walk distance is higher than it could otherwise be, because the housing is uniformly low-density, even on the link streets and even near the junctions. This represents a missed opportunity to put a higher proportion of the housing near bus service.

This development arose in the context of a predefined grid of major streets that was extended as the city grew outwards. It is possible to support public transport efficiency without rigidly straight streets. This is done by applying the principle that through-running main streets, even if they curve, should be spaced slightly less than twice as far apart as the maximum tolerable walking distance to public transport.

All of the link roads in this area continue north and south into adjacent areas with different land uses. Nearly all of them continue over a motorway just north of the image, providing continuity and straight journeys over long distances. Whilst roads this perfectly straight are uncommon in Ireland, there are examples in Irish cities and towns of slightly-curving roads that traverse many adjacent areas and feel relatively direct to people traveling along them (as shown in the example on page 40).

By prioritising straight, long and connected link roads across adjacent areas of different land uses, the authority in this

Factor	Rating	Explanation
Density	✗	Low density, detached residential housing, even along the link roads and at the junctions where public transport is abundant. This limits the number of residents who can benefit from the investment in bus service.
Walkability	✓	Walkability within the residential superblocks is good, thanks to paths and parks, allowing people to access multiple routes on multiple roads.
Linearity	✓	Parallel main streets are spaced 800m apart, and continue through adjacent developments, making it possible to run straight bus routes serving multiple populations.
Continuity	✓	The residential area is adjacent to areas with other land uses, and linear link roads traverse these multiple developments.
Mix of Uses	–	Some commercial destinations are within walking distance (though conditions are not pleasant), but most of the area is purely residential.
Justifiable level of service	–	Bus routes can operate efficiently through this development, but are unlikely to attract numerous patrons from the development itself because of its low density.

Canadian city made linear, fast and efficient bus routes possible. People living here have relatively short journeys to nearby shops or jobs, and bus routes are used in both directions, all day and all week.

Mitigations and Improvements

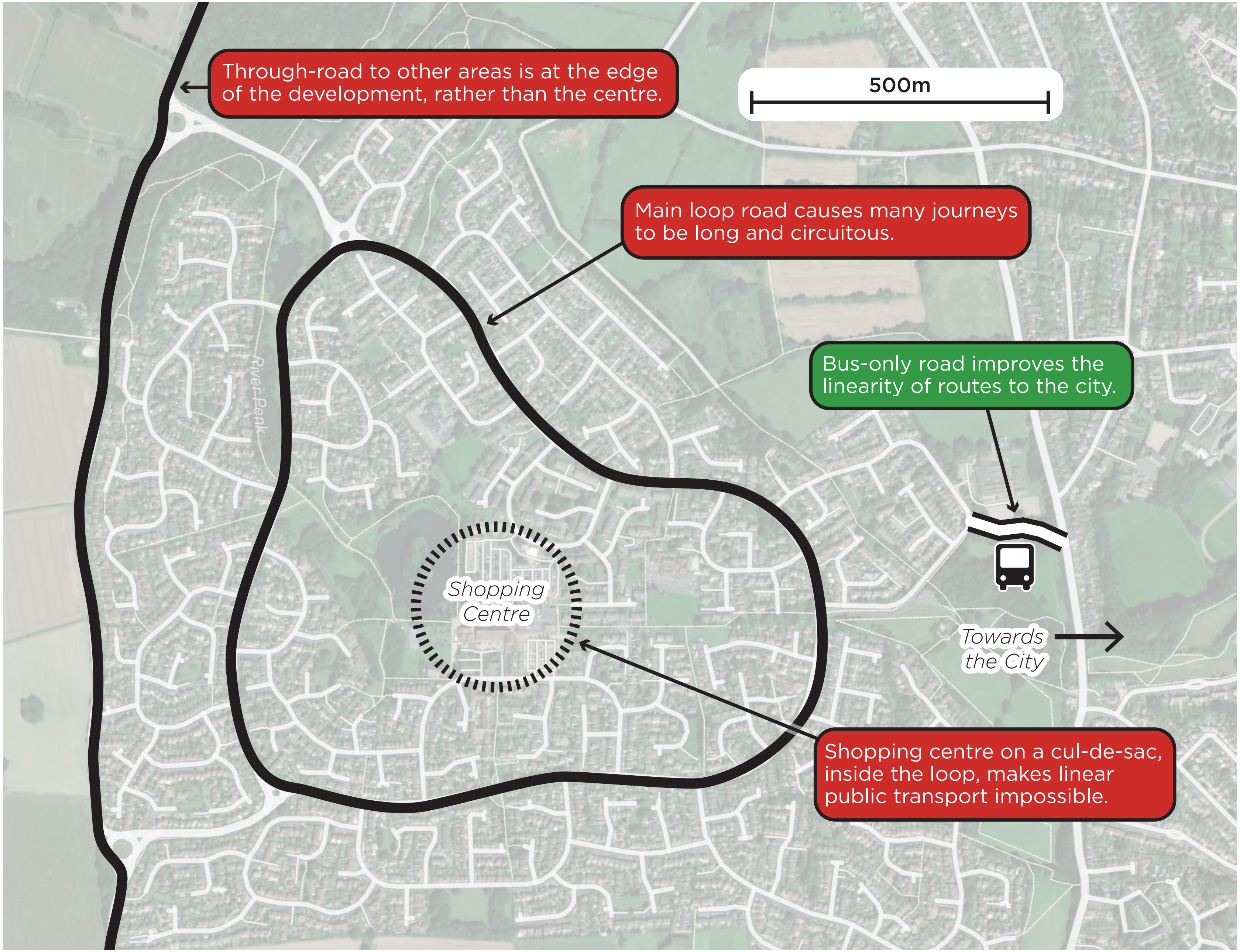
This development is easier to improve than many from the same era, because the largest infrastructure is already done right: the roads.

Density and mix of uses could be improved through changes to zoning. Modest density increases along every link road (which today all have bus service), as well as major density increases around the junctions at the north of the development, are guaranteed to put large numbers of people within short walks of public transport.

Long-term public transport network planning could identify which of the link streets will have the highest frequency of service, and might eventually become a high-capacity or fixed-guideway service. With that plan, more intense land uses could be focused around those corridors in particular.

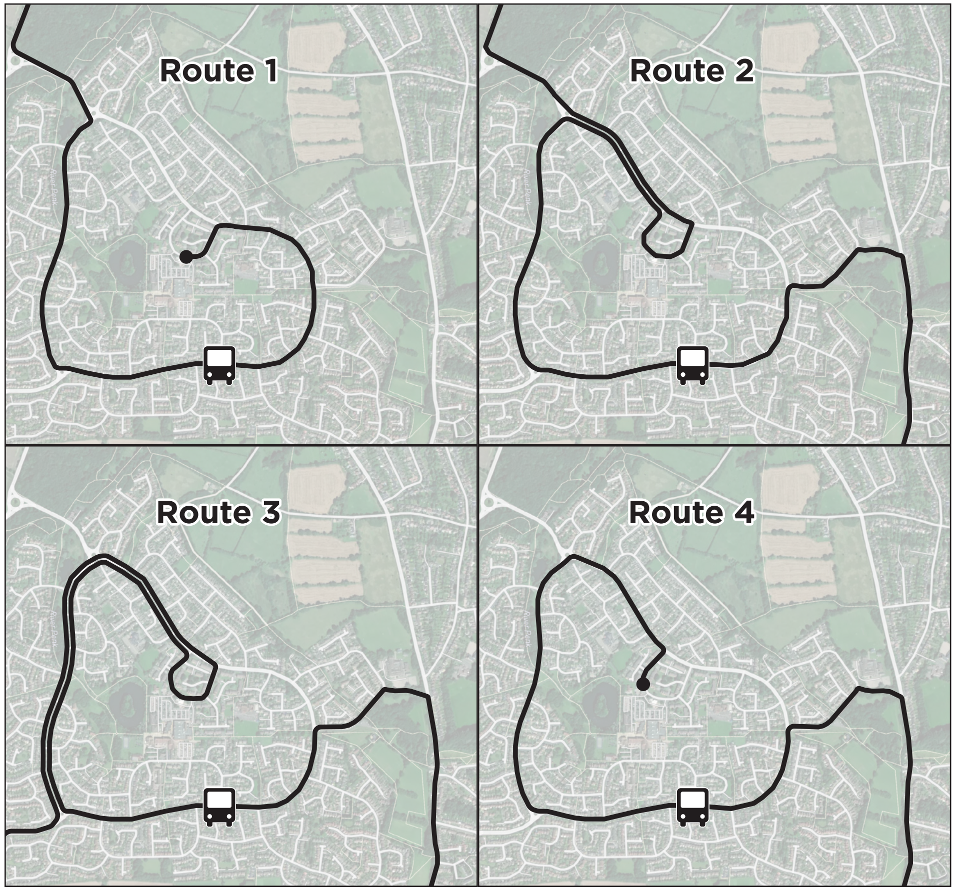
This page is left intentionally blank.

Low Density Around a Loop



It is common to see suburban residential areas organised around a looping road. Unfortunately, this structure makes it impossible to provide public transport that is both efficient and useful.

A large dormitory development to the west of a British city is shown in the aerial photo on previous page. It is organised around a central loop road that is triangular in shape. In the very centre of the loop is a shopping centre.



Service in this dormitory community is divided into four circuitous and infrequent routes. Circuitous and infrequent bus service is unlikely to attract high patronage, but this is the only way to offer bus service near all residents given the design of the street network.

The only way to cover all sides of the triangular loop and the shopping centre in the middle has been to offer four separate public transport routes, as shown in the maps on this page.

But **having more routes isn't always a good thing**. A public transport authority's resources are divided across the route-kilometres it must operate. This area requires a high number of route-kilometres, which means that resources have been spread thinly across all those route-kilometres. The result for residents has been poor frequencies, longer waits and a more complex network.

One good feature in the street network here is the bus-only road at the eastern edge (shown with a black outline on the previous page). This allows bus routes to go east to the city without first going west to exit the development, as other motor vehicles must do.

The location of the shopping centre inside the loop, far from the main roads, is particularly challenging for public transport. It isn't possible to drive a bus through the shopping centre from the north side of the loop to the south side, which means that the shopping centre can't be served on the way to anywhere else. It must either be the end of a route (as in Routes 1 and 4 at left) or a major deviation on a through-route (as in Routes 2 and 3 at left).

For routes that end at a the shopping centre, it's not possible for them to serve all sides of the loop. And routes connecting this area to other places, north and south, couldn't stop at the shopping centre without sacrificing directness and becoming extremely circuitous (as in Routes 2 and 3).

Pedestrian paths connecting the cul de sacs in this development likely help people walk to local destinations and to bus stops, which is good. This might cause someone to think that bus service could be offered on just two sides of the triangle, whilst people along the third side of the triangle could be asked to walk to the other sides.

However, because the triangular loop is 900m wide in places, most people can't be expected to walk all the way from one side to the other to reach a bus stop. Thus if service is to be offered near all residents, bus routes must go down every side of the loop.

Minor modifications to the design of this street network would have made public transport much more effective:

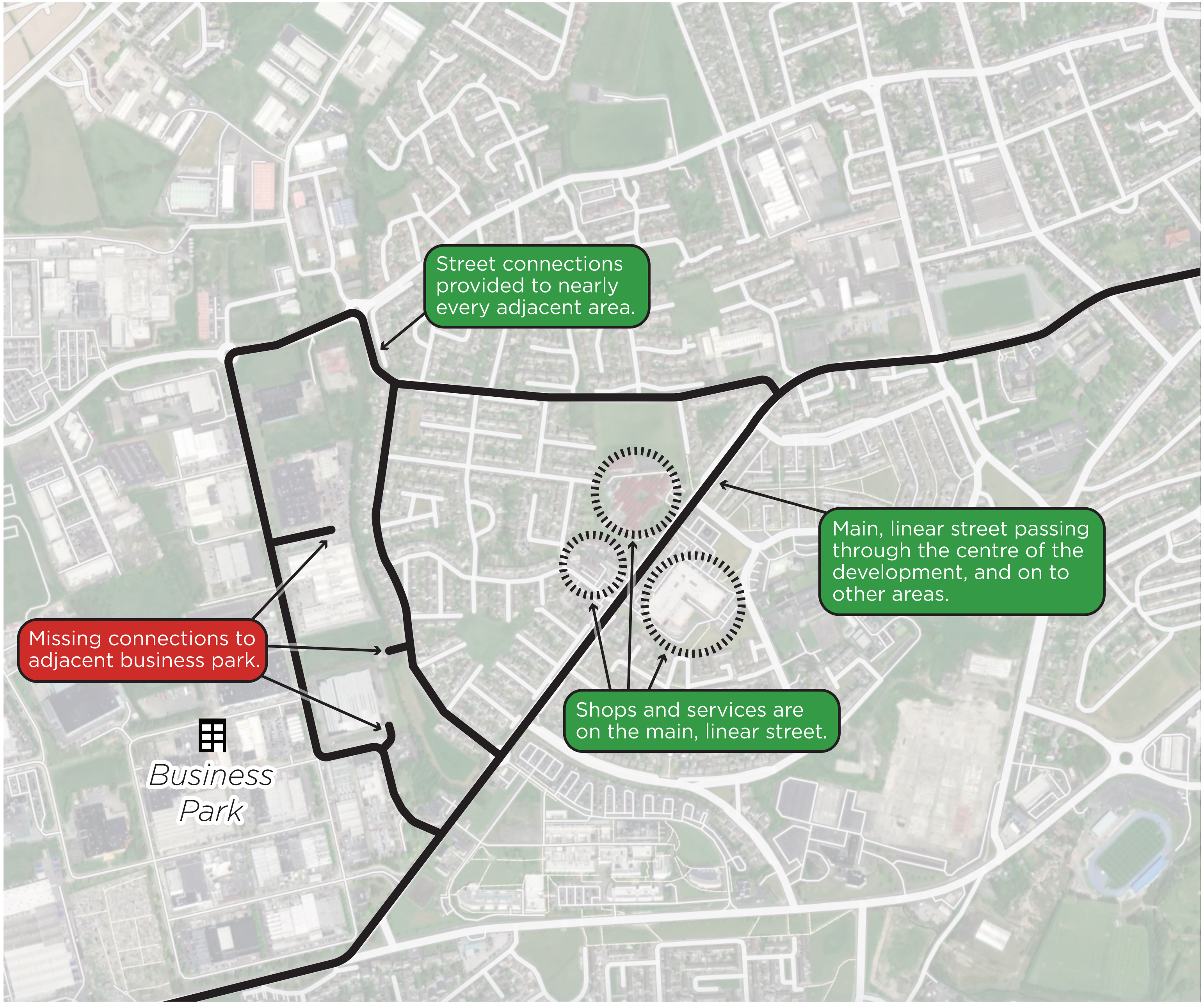
- If the triangular loop were not as wide, it would be possible to serve just two sides of it while still passing within a reasonable walking distance of most residents; or
- If a north-south street connection were provided past the shopping centre, it would have allowed routes from other communities to pass through the development and on to the city in a fairly direct way.

Either of these changes, if they had been made during the master-planning of this area, would have reduced the number of routes and the number of route-kilometres required to serve the area. This would have allowed for better frequencies and more useful service.

Factor	Rating	Explanation
Density	⊗	Low density, detached residential housing.
Walkability	⊖	Curving and cul-de-sac streets make for indirect and long walks, though footpath connections mitigate the effect somewhat.
Linearity	⊗	The main street's wide loop, and placement of the shopping centre on a cul de sac, forces circuitous bus routes and undermines frequency.
Continuity	⊗	Area is isolated from adjacent developments, with agricultural lands and other large green spaces in between.
Mix of Uses	⊗	Development is almost entirely residential, as are neighbouring developments.
Justifiable level of service	⊗	Costs to serve the area are high, frequencies are undermined by the street network and land uses, thus patronage relative to cost will likely be low.

This page is left intentionally blank.

Moderate Density Around a Linear Main Street



The mostly residential development shown on the previous page was built in the 1970s in Ireland. The houses are mostly terraced or semi-detached, and most houses have front and back gardens in addition to numerous shared green spaces. As a result, the overall density is lower than might be guessed based on the form of the housing.

The street network provided with this development is fairly good. A linear, main street runs through the very centre of the development. That main street connects to the city centre in one direction and to employment areas in the other direction. Commercial zoning was provided in the centre of the development, close to the main street. This makes it possible for public transport to stop near the shops and services without any deviation or extra distance.

The development has some cul de sacs, most of which are not connected through to other streets with pedestrian paths. This will add some distance to many residents' walks to a nearby destination such as a bus stop. Notwithstanding the cul de sacs, some minor streets go through and provide for shorter walks within the development and to adjacent developments.

One exception to the quality of the street network is the lack of a street connection, or at least a pedestrian path, between this development and a business park to the west. This makes it harder for a worker in the business park to make use of bus service in the residential area, and vice versa. Barriers between developments such as this will make the network a little less useful, a little more complex, and a little less frequent than it otherwise could be.

On all of the other developed edges of this residential area, a bus stop would be easy for most nearby residents or workers to walk to, supporting simplicity and high frequency of service.

It is possible to provide bus service to residents of this area **on the way** to other places, and therefore provide a level of service higher than this development alone could justify.

Mitigations and Improvements

The overall street structure of this development is quite good, though additional pedestrian connectivity could be added. Connecting more cul-de-sacs to one another with footpaths would shorten some walks to bus stops and nearby shops. Working with some large private property owners to add pedestrian access where fences or walls prevent it would also improve permeability.

The development is connected to adjacent developments to the north, east and south. A street connection with the business park to the west is missing, which means it is not possible for bus service to run through both adjacent areas in a linear and efficient pattern. The addition of a bus-only street would support better bus service in the area. A more modest improvement would be the addition of a pedestrian footpath, allowing workers in the business park to walk to a bus stop in the residential area, or vice versa.

In the long term, intensification and non-residential land uses could be concentrated within walking distance of the main diagonal road through this area. Organising future development that way would support higher levels of bus service and higher public transport patronage.

Factor	Rating	Explanation
Density	⊖	Moderate density of housing.
Walkability	⊖	Some minor streets go through, and street connections are provided to most adjacent areas. However many homes are on cul de sacs, making walks to a main street a bit longer.
Linearity	✓	Linear main street connects to adjacent areas in both directions, with shops and services located on this main street. Lack of street connection to industrial park is the exception.
Continuity	✓	The residential area is surrounded on all sides by urban development, with little undeveloped land nearby.
Mix of Uses	✓	Shopping and services are included in the centre of the residential area, and business and education developments are directly adjacent.
Justifiable level of service	⊖	The relatively low density of the development, and its small size, push against the good land use and street design decisions made during its planning.

3.2 Business & Industrial Parks

All Irish cities face demands for large-format employment sites that do not fit into existing centres. These have been accommodated on the edges of cities and towns, or even in rural areas, in a variety of development forms.

Any development on the edge of a city or town will be more difficult to serve well with public transport, and will enjoy less public transport access to workers or customers, than a more centrally-located development. This arises from the geometric fact that a parcel on the edge of a city is a longer distance, and therefore a longer journey, from most of the city than a parcel inside the city. However, new industrial and business developments on the edge can become part of an efficient, high-access public transport network in the long term, if they are planned with public transport in mind.

In the morning, public transport tends to carry large volumes of people inbound toward a city centre, but all these vehicles must return to the periphery to start an inbound service again. If there are few destinations outside of the city centre, then those outbound buses will typically be empty (as illustrated on page 22). Employment areas outside of a centre can thus provide two-way demand that makes efficient use of existing public transport capacity.

The cost and usefulness of public transport to business parks depends on the exact location of those business parks, and their design. If they are "close to" the edge of the city in car driving terms, but a bus has to cross rural kilometres to reach the business park, that is not very efficient. If they have disconnected and cul-de-sac street networks, poor walkability, and low densities, those are also not efficient for public transport to serve.

Unfortunately, most of the business parks developed in the late 20th and early 21st centuries present large barriers for public transport service and passengers. These barriers are not intrinsic to the land use type. It is possible to lay out employment sites in ways that make public transport efficient and useful, without reducing an employer's land area or substantially altering its operations.

When business parks are planned so that the buildings with high employment density are organised around linear, walkable and connected through-streets, then they can be more conducive to public transport use.

These principles should be applied to employment centre design:

- **Connect the road network internally.** Avoid the use of cul-de-sacs except against permanent barriers such as rivers, railways or motorways. If cul-de-sacs must be used they should be very short.
- **Connect the employment centre with adjacent areas.** It should be possible to drive a bus along a fairly linear path not only to but also **through** the business park, continuing into any adjacent developments.
- **Select a single two-way corridor for Frequent Service and plan for the highest job densities there.** This main corridor should be extensible, in a linear pattern, into adjacent developments. Low-density industrial and warehouse uses should be located away from the main Frequent corridor.
- **Place building entrances close to Frequent Service bus stops.** Do not place dense buildings and their entrances at the back sides of car parks or at the end of long curving drives, unless a pedestrian path offers a more direct walk to the main Frequent corridor.
- **Limit the use of fences** that block direct walking routes.

The first three principles are all about organising density in a way that is linear, so buses following a single path through the development can pass close to as many jobs as possible. The first three principles are also about allowing one bus route to service multiple adjacent areas, which makes the route more useful and also helps justify a higher frequency.

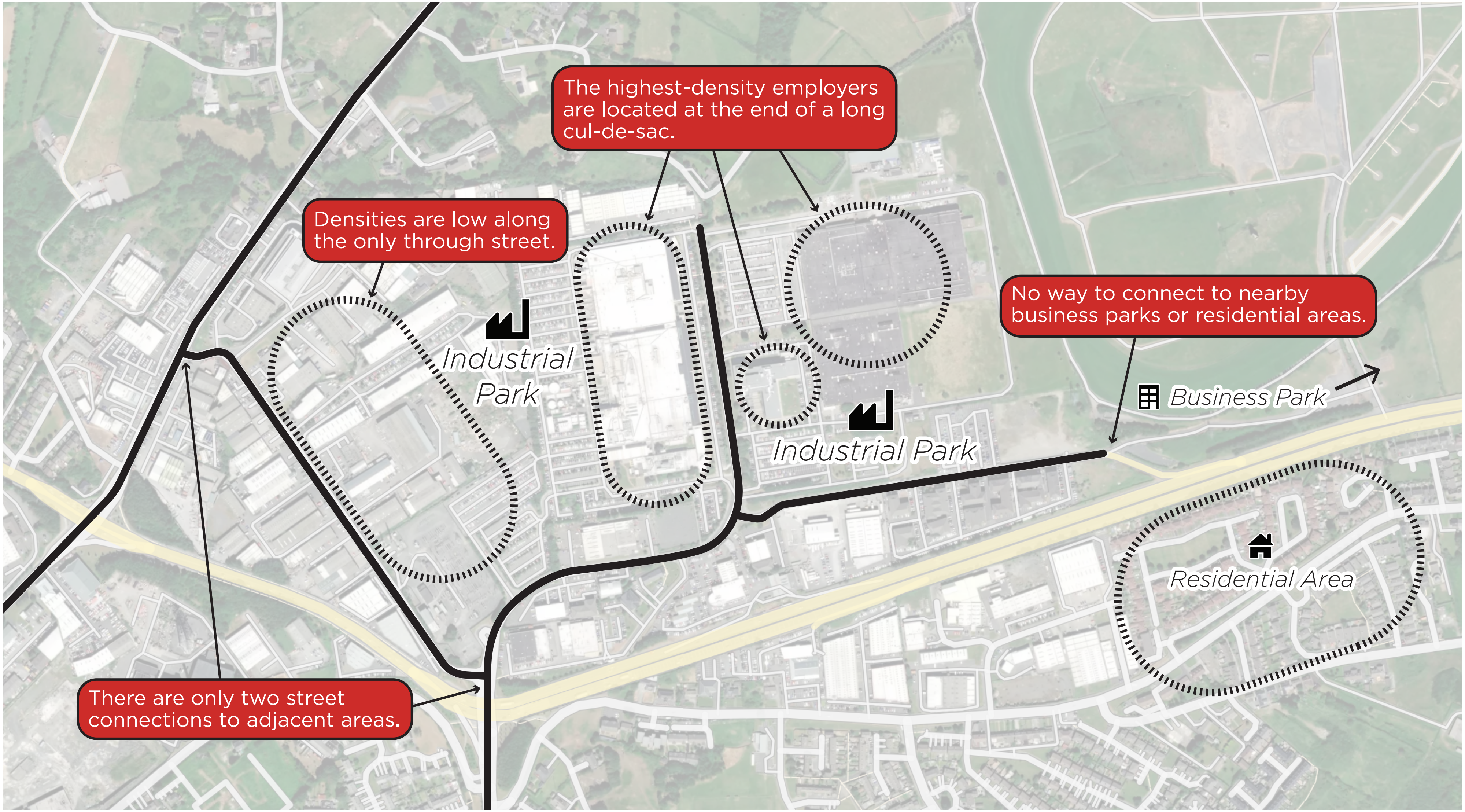
The path of the service through the development must be two way, not a one-way loop. One-way loops at the ends of routes undermine the usefulness of the service. The bus driver must take a break at the end of a line, but that break will interrupt someone's journey around the loop. In effect, the one-way loop reduces the area from which people have a reasonable walk to service for both directions of their journey (as illustrated on page 41).

In addition, one-way loops are impossible to extend further outwards in response to continued outward development. Future-proofing a bus route requires resisting the urge to drive the bus on a "tour" of the development that is currently, but only temporarily, the last development on the route.

An ideal business park has a primary axis street to which the highest job densities are oriented and where service can be concentrated. In this way, the planning of the park would support public transport offering short waits, long hours of service and reliable operations to a large number of workers.

This page is left intentionally blank.

Industrial Park With Few Street Connections



In the example shown on the previous page, an Irish industrial and business park was planned with most employees located on cul-de-sacs or on streets that public transport can't serve.

There are two street junctions providing access into and out of this development. A short street runs inside the park between those junctions, but this through-street is on the edge of the park (rather than the centre) and the lowest-density employers surround it. In fact, the infrastructure that is most central to the park is a very long fence that prevents people from walking between buildings or streets.

Meanwhile, the highest-density employers are located at the end of a long cul-de-sac, ensuring the longest walks to public transport for their workers or the highest public operating cost to send a bus close to their front doors.

The industrial park is surrounded on two sides by agricultural land and open space, and on a third side it has few connections to other areas because of the dual carriageway. Most of the nearby residential areas are to the south, and the best bus service is to the south, but the only pedestrian crossing in that direction is at a large and complex junction due to the barrier presented by the dual carriageway.

On the far sides of the agricultural lands there are in fact other dense developments – housing to the northwest, and other business parks to the east. But with no roads across those lands, **it isn't possible to serve this industrial park on the way to anywhere else**.

Because of the barriers between this business park and neighbouring areas, and its contrived isolation, the quantity of bus service provided into the park must be justified entirely by demand generated within the park.

Factor	Rating	Explanation
Density	⊖	By area, the development is mostly low-density, with many car parks. The densest developments are located farthest from any through-street.
Walkability	⊗	There are footpaths, however walks to a through-street can be extremely circuitous and long due to cul-de-sacs and the fencing-off of car parks between buildings.
Linearity	⊗	With only one through-street, and dense employers located on a cul-de-sac, routes will be circuitous and deviating, or will have to end in the park.
Continuity	⊗	Isolated from nearby developments by rural lands, green space and the dual carriageway.
Mix of Uses	⊗	Exclusively business and industrial uses, with minimal connections to other land uses nearby.
Justifiable level of service	⊖	Given the number and density of jobs here, it will be possible to justify some service into the park. However, it would enjoy much higher levels of service (and patronage) if it were better-planned.

Mitigations and Repairs

The street in this park that has the densest employers on it today ends in a cul-de-sac on the northern edge of the park. If it were connected it to the residential area to the north, and ultimately to the main road, that would support a linear public transport route past the densest part of the business park.

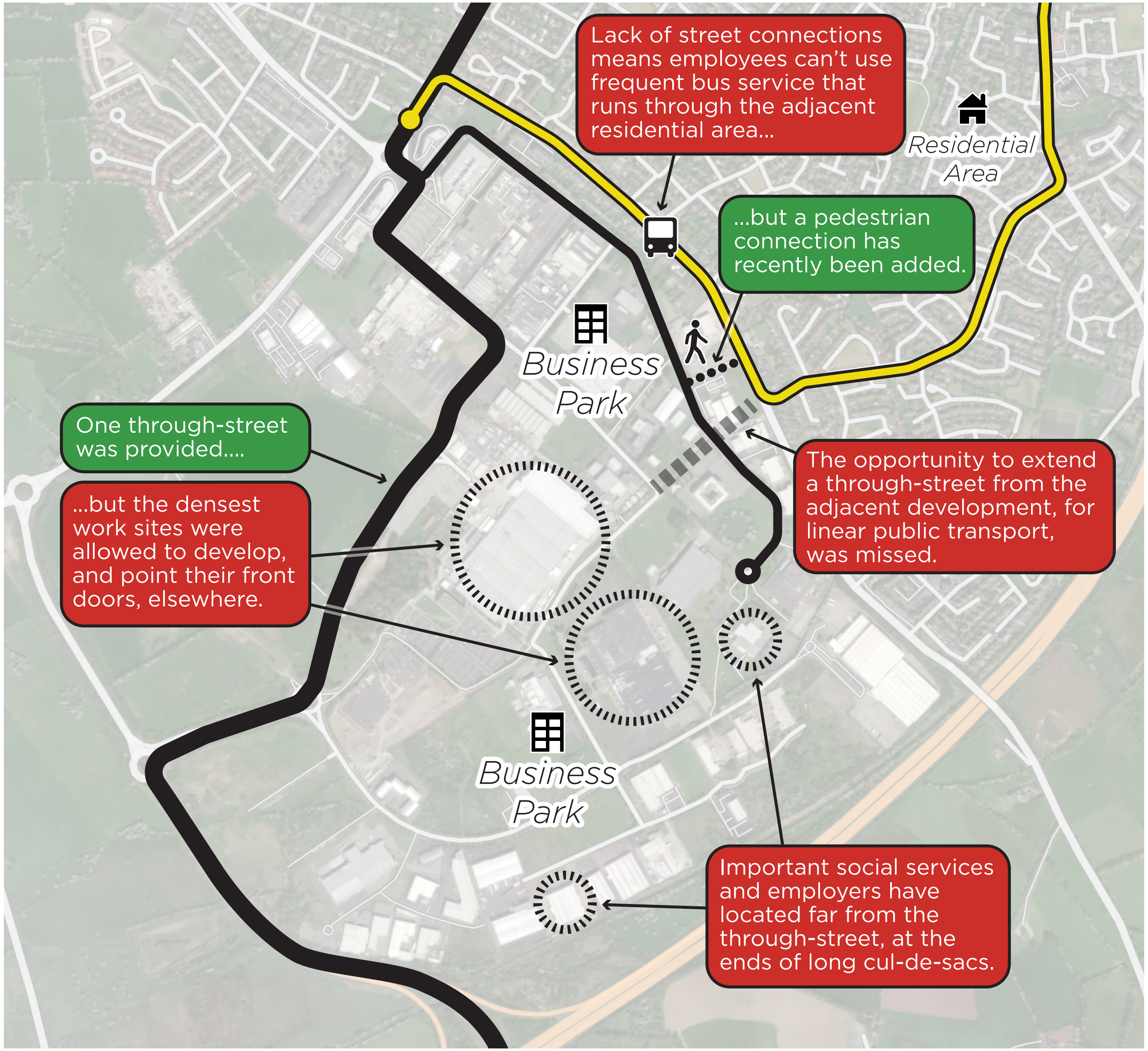
Densities could also be increased on the short through-street, supporting a future route that could pass through that western edge of the business park. Other streets in the park could be extended to connect to future developments on adjacent lands. This would make quick bus journeys between the adjacent developments possible, making it possible to send more service through the business park.

Pedestrian improvements that allow people to walk south to residential areas and to good bus service would increase access both for workers within the park and for residents to the south of the park.

The elimination of fences between parking lots, especially the long fence at the centre of the park, could shorten the distances workers must walk to and from bus stops. The construction of deliberately-direct walking paths across private car parks would improve the directness and appeal of walking to and from public transport.

This page is left intentionally blank.

Development Allowed Far from the Through-Street



In the Irish business park shown on the previous page, planners wisely provided a through-street which a bus route could follow (shown as a thicker black line).

Unfortunately, most of the development, and especially the dense development, has been permitted far from this through-street. Instead, intense and important development has been allowed on cul-de-sacs where useful public transport is nearly impossible to provide. There is even an HSE public health office at the end of a long cul-de-sac.

A frequent bus route is provided today in the residential area to the northeast of the business park (shown as a yellow line). This service is close to the park as-the-crow-flies, but a lack of street or pedestrian connections between the two adjacent developments means that it is a much longer walk away.

One bright note is the recent addition of a pedestrian connection between the residential and business areas. This means that a few buildings in the business park are now within walking distance of the bus route in the residential area.

The local authority was forward-thinking in providing one street that goes through this business park, rather than making the entire park a cul-de-sac. However, the more efficient and useful path for public transport would have been the extension of a through-street from the adjacent residential area (shown in dashed grey line).

Filtered permeability could have allowed the bus to connect the residential and industrial areas, whilst requiring lorries and cars to use other access points to the industrial park. Had that happened instead, a bus route could have provided very direct service to and through both areas, making it easier to justify higher frequencies of service to the residential area and the business park all day and all week.

Factor	Rating	Explanation
Density	⊗	Long distances between buildings result in low density. Nearby residential development is mostly low-density as well.
Walkability	⊖	Footpaths and crossings are provided on most streets, but inconsistently on private property or across car parks. Many building entrances are far from the street.
Linearity	⊗	Development has not been steered to the through-street. A lack of street connections between adjacent developments means bus routes must turn and deviate.
Continuity	⊖	Adjacent to a residential area on one side, but with no bus-operable street connection, the efficient extension of an existing route was made impossible.
Mix of Uses	⊖	A mix of industrial, retail and service uses in the park. Residential land uses are nearby, but with few connections to the business park.
Justifiable level of service	⊖	Serving the job and service destinations in the park requires bus routes that are useful only for journeys to those destinations. This will reduce the frequency of any service below what it could otherwise be.

Mitigations and Repairs

Allowing both pedestrians and buses to move between this business park and adjacent residential areas will be essential to the success of bus service in the area.

One pedestrian path has been added recently to the residential area to the northeast; more such paths elsewhere on the periphery of the park will be important.

The ability of workers and visitors to walk to bus stops within the industrial park is in some places hampered by fences and hedges surrounding car parks or green fields. Unauthorised walking paths worn into grass reveal places where people want to walk through the industrial park, but the infrastructure discourages it. The local authority could work with private land owners to provide well-lit walking routes across the park, to mitigate the low density and dispersal of important destinations and reduce the walking (or cycling) distance to bus stops and adjacent areas.

A bus-only link between the park and the adjacent residential area should also be explored, especially as the park develops further with more destinations and employers.

This page is left intentionally blank.

Industrial Park with Many Through-Streets

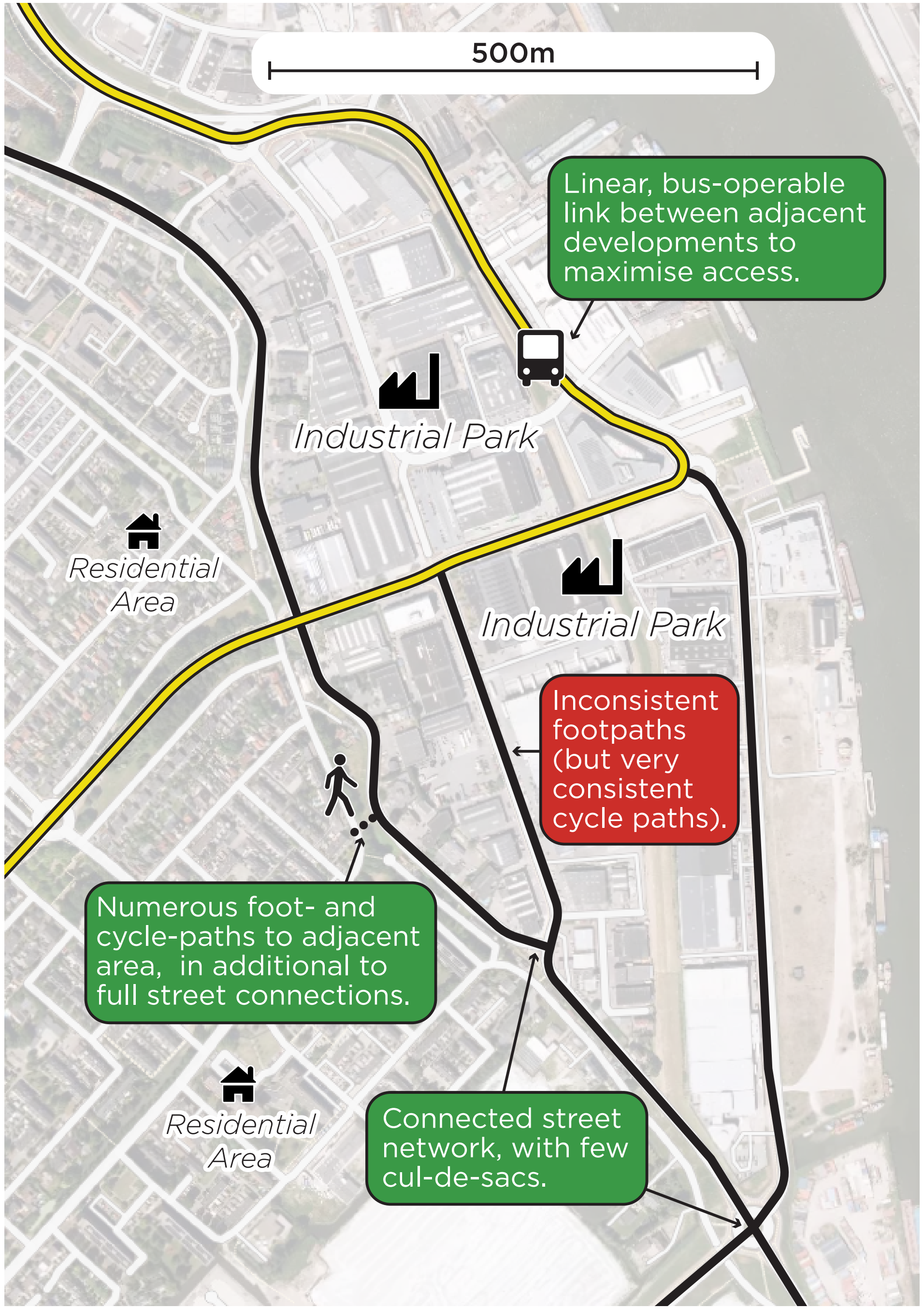
The Dutch industrial park shown on the right has very similar types of businesses as in the previous examples, but is completely different in urban form and street design.

It has a well-connected street network, with three full junctions allowing two-way motor-vehicle access to the park, and multiple additional entrances for people entering on foot or by bike. It has an east-west corridor in the centre that is the continuation of a linear public transport route from the adjacent residential area. The result is a single direct bus service to and through the industrial park (shown as a yellow line in the map on the right).

Buildings face the street, and car parks are small. Having little surface car parking means that the density of workers is quite high, and many people are within walking distance of any given bus stop. In the residential area, small terraced homes with gardens are mixed with large apartments. Street and path connections between the adjacent areas mean that jobs in the park can be reached from other bus routes in the residential area. The path connections also support cycling which is an important mode in the Netherlands.

The Dutch tolerate longer walks to public transport than we tend to in Ireland, so some large employers in this area are a half kilometre from a bus stop. One measure by which this development scores poorly is the quality and consistency of footpaths – some streets in the business park do not have footpaths, though cycle paths are provided very consistently.

This industrial estate has warehouses, light industrial, and retail uses, in addition to the residences, schools and shops in the adjacent area. Such a mix of uses, close together and connected by abundant streets and paths, likely generates patronage that justifies service all day and week. The yellow route shown on the map, for example, runs until midnight seven days a week.



Factor	Rating	Explanation
Density	–	Despite being an industrial area, job density is moderate due to the lack of car parks and empty parcels. Density of the adjacent residential area is also moderate.
Walkability	–	Pedestrian permeability across the business park, and to the residential area adjacent, is very high. However, footpaths are not provided consistently.
Linearity	✓	Direct and efficient routes are provided for east-west bus service and north-south bus service, and nearly all buildings are close to one or both patterns.
Continuity	✓	Surrounded by other urban development in all directions.
Mix of Uses	✓	Within the park there are multiple types of businesses (retail, warehousing, light industrial), and there are residences, schools and shops in the adjacent housing area.
Justifiable level of service	✓	Hardly any unique, extra kilometres need to be driven for the business park alone. It should be easy to justify ample all-day, all-week service despite the moderate density of the area.

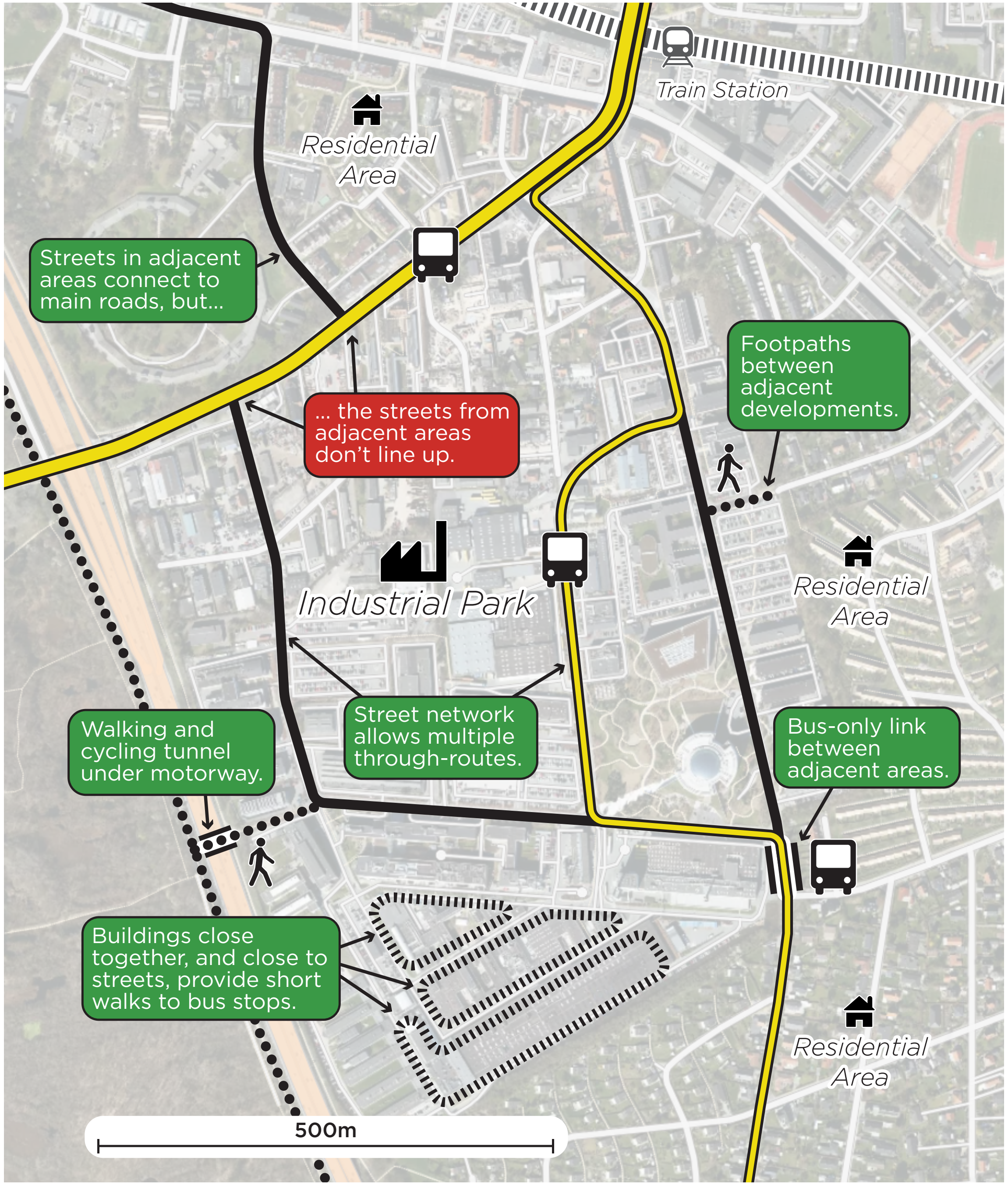
Dense and Connected Business Park

The industrial and business park shown in the map on the right is located in the suburbs outside of Copenhagen, and is home to a major biotech and pharmaceutical manufacturer. It has been fit into the continuous development pattern of a small town. The town train station is at the top of the map.

To give a sense of just how snugly this industrial park has been fit into the town, the most remote building in the park (at the bottom of the map) is only 20 minutes' walk (1.5 km) from the train station. A huge amount of office and industrial development has been fit into a small area, with the result that most of the workers are within 10 minutes' walk of useful public transport.

The business park is connected to adjacent areas on three of four sides, either by full streets, a bus-only street or pedestrian and cycle paths. There are few barriers to bus access such as cul-de-sacs, walls or fences. Many car parks are designed for pleasant and direct walks across them, not only for people coming from a parked car but also for people walking from a bus stop or adjacent area.

The planning and development choices made here support a high level of service from the bus network. The route passing through, shown as a thinner yellow line, offers three buses per hour per direction. A high frequency service on the road at the north side of the development, shown as a thicker yellow line, offers 18 buses per hour per direction. Public transport access to and from this area is very high, due more to the land use and street planning decisions of the past than to bus route planning decisions.



Factor	Rating	Explanation
Density	✓	High density of buildings, with little space given over to green space or car parks in between them.
Walkability	✓	Street and path networks are well-connected, including paths on private property, allowing for short and direct walks within the business park and to adjacent areas.
Linearity	—	In some cases the main streets inside the business park don't flow into the main streets in adjacent areas, instead ending in T-junctions. However, there are still fairly linear paths through the development itself, and it is all within walking distance of linear service going past on the main road.
Continuity	✓	The park is on the edge of the metropolitan area, but contiguous with a town and with urban densities on three of four sides.
Mix of Uses	✓	Bus routes in this area serve a mix of land uses: housing, office, industrial, retail and schools.
Justifiable level of service	✓	This business park is **on the way** for public transport on the main roads, and easy to serve with a route passing through the park as well.

3.3 Medical Facilities

Hospitals and other medical facilities are major public transport destinations. They can have large numbers of workers as well as many visitors and patients. They are also especially likely to be visited by people with some mobility limitations, due to age, illness, or disability.

Access to medical facilities is of great social and economic importance. In many cases, the transport needs of people traveling to hospitals become a shared public cost one way or another, thus there is a government interest in providing public transport to all medical facilities whilst also making that public transport efficient.

Fixed bus lines are far more cost-effective per passenger than on-demand transport or taxis, so good bus service should be an integral part of planning for any medical facility. The placement and layout of medical facilities, and the design of the street and path networks around them, influence the quality of public transport provided there and how many people will actually use it.

Some principles to apply in the planning of medical facilities for public transport are:

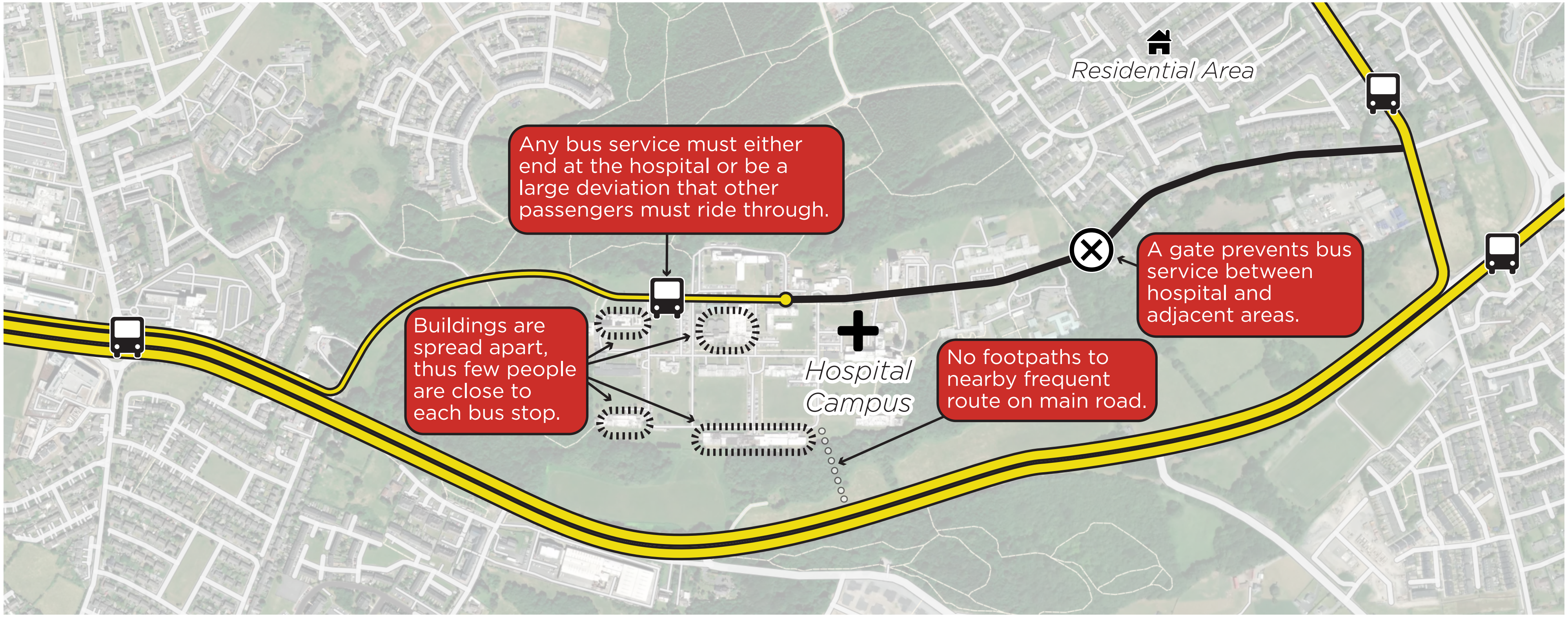
- **Hospitals should be on the Frequent Network**, and should therefore be in places that public transport can reach efficiently. Smaller facilities will also benefit from being on the Frequent Network.
- **Building orientation should minimise walks to Frequent service stops or stations.** Do not assume that the bus will make time-consuming deviations into and out of the campus to reach the front door. It may be necessary to provide multiple active, accessible entrances so that public transport passengers are welcomed on one side even if the building faces a car park on another side.
- **Direct walking routes should be provided from public transport stops on the main street** to all of the large buildings and destinations in the facility.
- **A terminal for bus routes ending at the facility** can support a higher level of service at the medical facility than might otherwise be justifiable.

Some hospitals inside a historic urban street network can easily fulfil these principles. Hospitals which were placed on the tops of hills, common practice in the past, can be very difficult to retrofit for efficient and successful public transport, as they tend to be isolated from other sources of public transport demand.

New hospitals built in suburban or rural settings can be designed for efficient and useful public transport, with attention to these principles.

This page is left intentionally blank.

Hospital on a Cul-de-Sac



It is crucial that public transport reaches hospitals, but a hospital's location, architectural and infrastructure decisions can make it difficult and costly to provide useful bus service.

The hospital campus shown in the aerial image above is effectively a cul-de-sac for public transport services. A bus entering the area from the west is only serving the hospital, as the street network does not permit buses to continue on to serve the dense housing or schools to the north or east, nor to rejoin the main road in a linear way.

This hospital is **on the way** to nothing but itself. It can only be served by a bus route that ends there (represented by the thinner yellow line), which means that the level of service offered can be justified by the demand at the hospital alone.

But high public transport demand almost never comes from just one business, development or institution. Even tall buildings and large companies generate sparser demand per hour than areas that are dense with a mix of buildings, workplaces, shops, homes and destinations.

Planning for high levels of service to any development means making it one of a number of destinations on a route, with their combined demands and patronage justifying the large investment in high frequency.

Factor	Rating	Explanation
Density	⊗	Low density of workers and visitors; no organisation of buildings around a central street; and surrounded by green space. As a result, few people with short walks to a bus stop.
Walkability	⊖	Adequate footpaths within hospital (at least on one side of each street), but sub-standard footpaths to neighbouring areas.
Linearity	⊗	Public transport has to deviate off a linear path to other places in order to serve the hospital, or a bespoke route has to be provided just to serve the hospital.
Continuity	⊖	Location is within the urban development area, however the lack of pedestrian or bus connections to adjacent areas, and the surrounding green space, isolate this hospital for public transport almost as though it were outside the urban area.
Mix of Uses	⊖	The lack of homes, shops or other activities means less all-day, all-week demand for public transport.
Justifiable level of service	⊗	Service to any hospital is of high social importance, but because this one requires either a big deviation or a bespoke route, frequency is likely to be lower than to similar facilities in better situations.

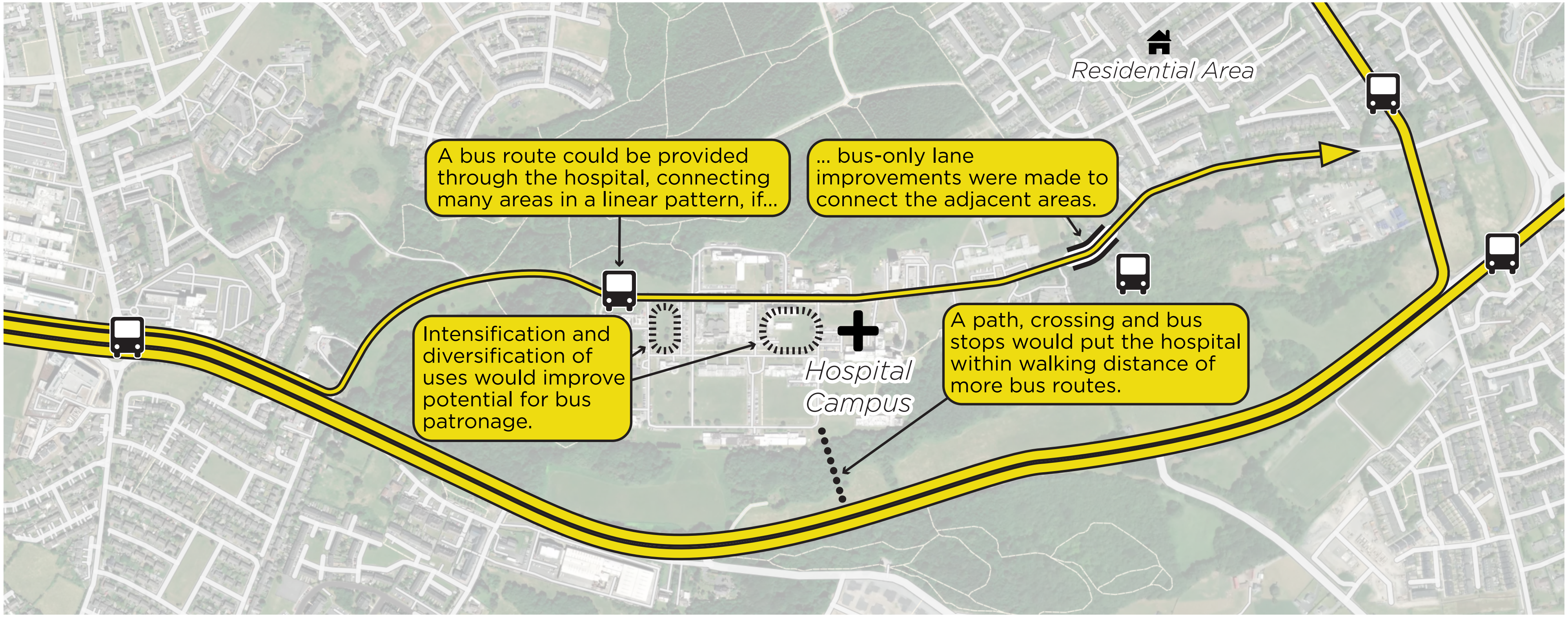
In addition to the cul-de-sac problem which isolates this hospital, the hospital itself has a low design of people per square kilometre. The buildings are set far apart from one another and from the roads. There is no “main street” organisation to the campus, which would concentrate buildings and activity along a single street that could serve as the linear public transport route.

Given the manner in which various departments are spaced out across the campus, and the availability of ample space for private car parking adjacent to each building, it is also difficult for bus services to provide a more convenient alternative than the private car.

Potential Mitigations and Repairs

In the near term, a site such as this one could pursue some modest mitigations to improve public transport outcomes:

- Improvements to pedestrian connections from the residential areas to the north and the east would likely increase the number of people willing to walk to reach bus stops on the hospital grounds;
- Traffic Management within the campus could restrict car movements and provide a competitive advantage to bus services, allowing it to move more quickly around the campus and providing short walks from bus stops compared to the walks from car parks; or
- A hospital in this situation can provide private shuttle service to supplement the level of public transport service that can be justified from public funding sources (which in fact this hospital already does).



Into the future, it might be possible to implement more significant change, which would allow an isolated development such as this to be better integrated into the wider public transport network.

A footpath to the south could be constructed, allowing some hospital workers and visitors to use the frequent through-services on the main road. (The frequent services are marked in thicker yellow lines on the map above.) However, bus stops and a signalised crossing would also be needed on the main road, as none exist there today.

A bus-only gate and street upgrades could allow access for services from the hospital through the residential area to the east (as illustrated by the thinner yellow line). This would greatly improve the usefulness of public transport in the area by making direct access to the hospital possible from the east and by simplifying and concentrating services to make them more frequent.

Alternatively, a different bus-only connection could be built to the main road to the south. Again, this would connect more places directly to the hospital and would allow for fewer and shorter routes and thereby better frequencies.

Future land use changes could be directly linked to the public transport route through the campus. Additional medical buildings, residences, or other uses could be added to the campus and organised around one through-running road that can be efficiently served by buses.

This page is left intentionally blank.

Hospital in Connected Urban Development

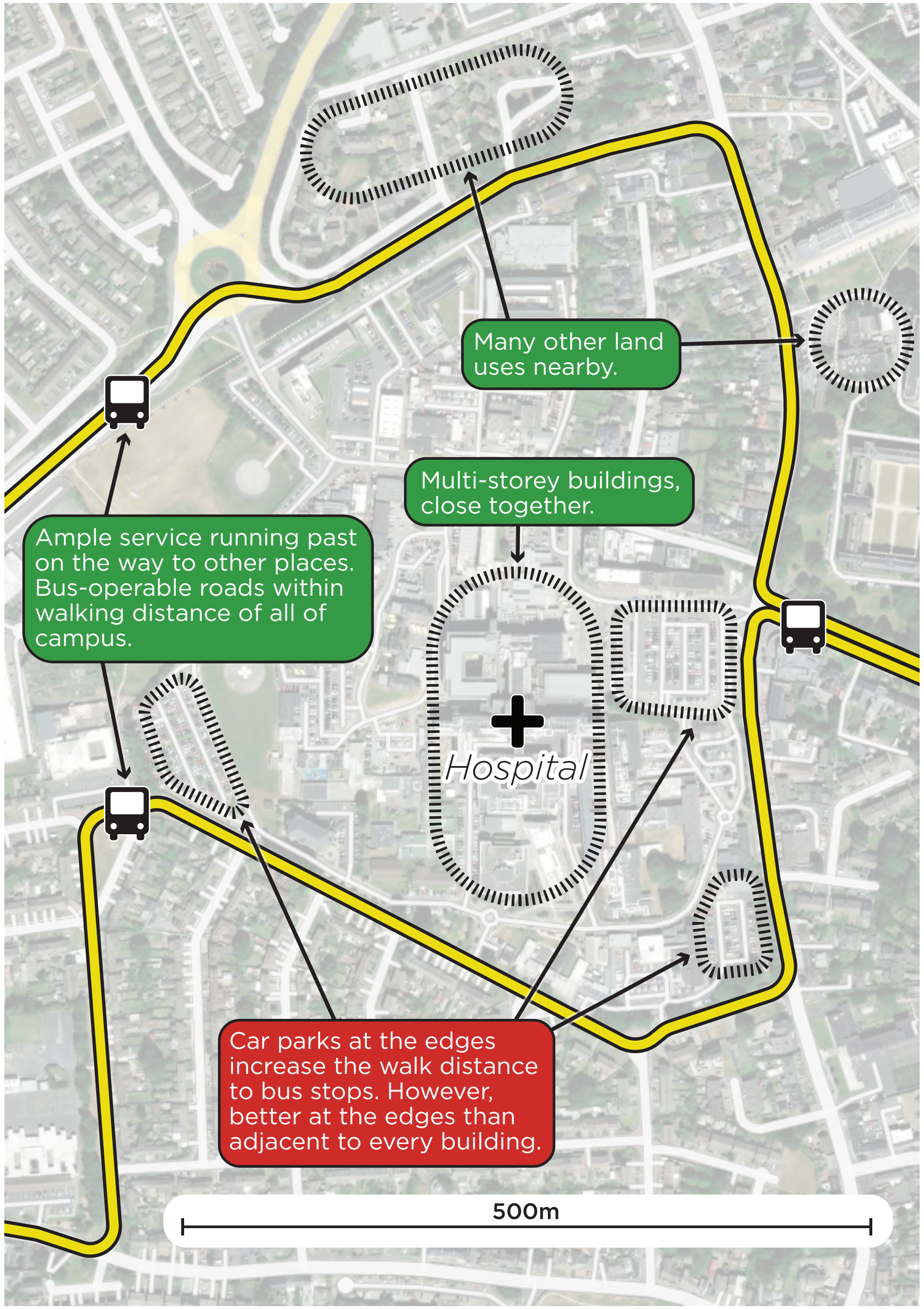
In contrast to the previous example, the hospital shown in the map on the right is surrounded closely on all sides by developments of various types, with bus-operable main roads serving it and those adjacent areas at the same time.

All of the roads around the campus have public bus services on them, and no building on campus is more than 300m walk from one of those bus stops. The hospital buildings are large (some over 4 storeys high) and close to one another, with the result that numerous workers, patients and visitors are within walking distance of the bus stops located around the edges of the campus.

In this dense setting, car parks are harder to provide, and additional car parks are provided off-site. The decision to not provide car parking for all who want it on site provides an incentive to use public transport. For those who park in remote car parks, shuttle buses transport them to the campus.

Conditions on the campus aren't perfect for public transport but they are being steadily improved by the hospital and the local planning authority. The density is quite centralised, which makes it regrettable that the internal (private) street network does not allow a public bus route to pass straight through the campus and out the other side. Such a linear route through the centre of the campus would be useful to the public bus network while also putting bus service nearly at the front doors of many large buildings.

Car parks are located around the edges of the campus, which supports the provision of short and pleasant walks within the campus but also means that people's walks to bus stops are in many cases through or around car parks.



When it comes to getting useful public transport service, this hospital has geometry on its side:

- As it has grown, the hospital has become denser within its small urban footprint, resulting in numerous potential bus passengers near every busy stop, and disincentives to driving to the campus;
- Other land uses are very close by in every direction, which means that a bus on an adjacent road can serve both the hospital and the adjacent homes, shops or schools; and
- Because the campus is central to the city, it benefits from a great deal of service going past it **on the way** to other areas and destinations.

Factor	Rating	Explanation
Density	✓	Buildings are large and close together.
Walkability	✓	Most walks from campus buildings to bus stops are short and fairly direct.
Linearity	–	Bus routes deviate modestly to go around the campus. Whilst they are still close to the dense buildings in the centre a linear path through campus would support a more direct, appealing route.
Continuity	✓	With urban development on all sides, service levels can be high as they are justified by many different demands, including but not only the hospital.
Mix of Uses	✓	Land is used in different ways in every direction: homes, schools, a university, shops, restaurants.
Justifiable level of service	✓	Ample service is sure to go past this hospital not because of its own demand, but because of the many other places and destinations to which it is **on the way**.

3.4 Schools

Schools can generate a great deal of travel by public transport. They are also socially-important destinations for public transport, regardless of how many pupils use the bus, because schooling is such a fundamental need.

For many reasons, Irish national policies and programmes support the principle that most pupils should be travelling to school under their own steam.

Whilst it is common for a school to attract many pupils by bus, **schools are rarely an efficient source of high patronage for the bus operator**. They tend to be very expensive to serve, compared to the many other places and patrons the bus service could be serving. There are three reasons for the expense: peak-only demand, crowding and specialisation.

Peak-only demand

Most school journeys take place during peak times, especially in the mornings. High peaks in demand are difficult and costly for a bus operator to serve:

- They must acquire extra buses, at a high capital expense, which are only used for a few hours of the day;
- This makes the overall bus fleet bigger, which pushes up maintenance and depot costs; and
- Deploying these peak-only buses requires short work shifts that are less appealing to bus drivers, making them hard to staff.

Crowding

Because pupils going to a school are all starting at the same time, crowding is common on bus routes past schools. Crowding tends to be especially uncomfortable for older passengers and people with disabilities, especially if the bus is too crowded for them to get a seat.

To address crowding, bus operators can add an extra bus just before bell times, for each direction of the route that goes past the school. But this pushes up the size and the cost of the peak fleet requirement, as described just above.

To the extent that school bell times can be staggered, the high costs of serving these peaks in pupil demand, without crowding out other passengers, could be reduced.

Specialisation

When schools are located far from other public transport destinations, they tend to generate requests for specialised routes just for them. Specialised routes typically have poor frequencies – in fact, many school-only routes in Ireland consist of one single trip in the morning and one or two in the afternoon.

Sometimes the specialised school route follows a pattern that is similar to an all-day route, with one single deviation to the school's front door. In other cases, the school route does something unique, driving around areas where pupils of that particular school live and then taking them to the school, in a pattern that no other passengers would find useful.

One problem with specialised school routes is that because hardly anyone other than the pupils will use them, it only makes sense to provide them at bell times when most pupils want to travel. This is a common complaint of pupils and their families about school routes. Young people benefit from flexibility and spontaneity, and a bus route that only offers them only one time to make their trip limits their opportunities.

The cost of avoiding interchange

In a well-designed, efficient bus network, some journeys will require interchange. Interchange allows the network to be **frequent** and **simple**. In contrast, a network designed to provide unique routes from everywhere to everywhere else can be a complex spaghetti-pile of infrequent routes.

Because frequency is a strong predictor of patronage, a bus operator should be encouraged to provide a simple and frequent network. But this requires asking some people – including pupils – to interchange between buses.

Specialised school routes are sometimes provided to protect parents and their children from interchange. The journey may be possible on a pair of routes, but a special route is offered with just one or two trips, duplicating the existing routes but without the interchange. This is generally appropriate only at bell times and only when an entire bus-load full of students want to make a particular trip. Whilst this solves the problem of asking pupils to change buses, it does so at all of the costs listed above – and without serving anyone else.

Where demand is too low to fill a special school bus, no-interchange service to schools is not a reasonable expectation of a public transport authority. Instead, the focus should be on making interchange fast, safe and easy. This has been a key strategy of the BusConnects programme across all of Ireland's built-up areas.

The consequences of school location choices

The other force that tends to lead to specialised school routes is when schools choose new locations that are inefficient for public transport. By "inefficient" we mean that they are costly to reach for the bus operator, and have few potential passengers nearby.

The same land use factors that affect public transport access in general (described starting on page 19) are relevant to school locations: density, walkability, linearity, continuity and mix of uses. However, unlike for other land uses, school sites tend to be selected with an emphasis on ample land for sports pitches as well as car parks. Such large, undeveloped sites tend to be in areas with low density, no developed street or path network, and away from a linear, continuously-developed road.

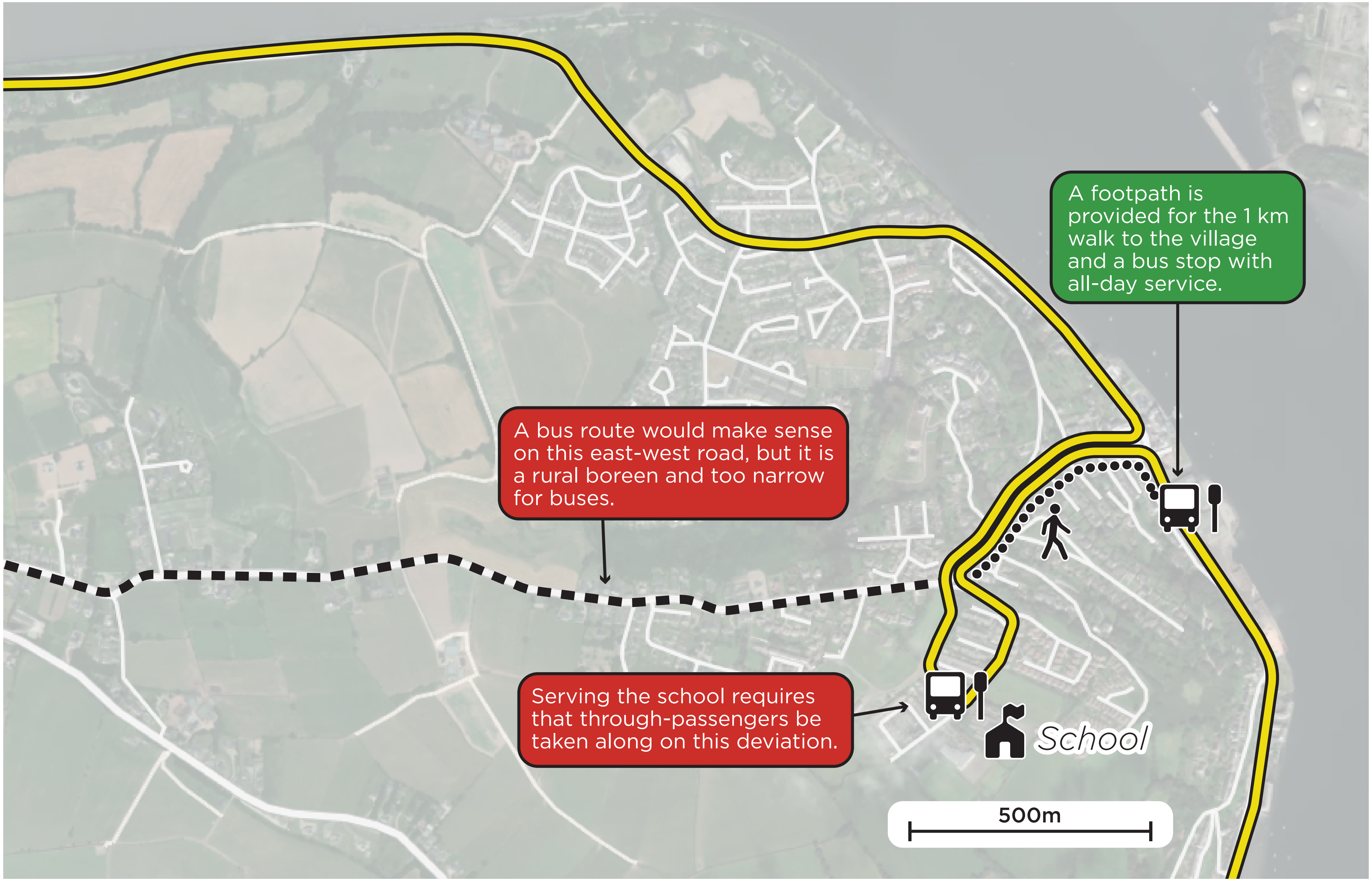
The social importance of connecting families with schools overrides this inefficiency in some cases, and the specialised bus route is provided. But a costly, inefficient route in the bus system represents service that could have been provided elsewhere, serving more passengers and helping the city or town accomplish its goals.

School decision-makers may be unaware that their location choices can affect the costs to provide a bus service, and therefore results in less bus service than they would wish for. This is why land use and town planners should influence school location choices and encourage schools to locating in places that are efficient to serve. Ignoring these impacts pulls the limited supply of buses and service into specialised school routes, undermining the quality of the overall bus network as well as the services offered to pupils and their families.

If, instead, schools locate in places that are efficient to serve, with many other people in addition to pupils who could use the service, this supports high patronage. It may also justify a higher level of service near the school, which benefits pupils and their families.

In this section two contrasting examples of school locations are shown, with very different consequences for the quality and efficiency of bus service near the school.

Disconnected, Difficult-to-Reach School



In the example shown on the previous page, a school has been placed on the developing edge of a town near a major Irish city. However, rather than being located on a road that goes through to other places, it is tucked into a development with poor street connectivity and many cul-de-sacs.

The walk from the school to the closest regular bus stop, down the hill near the river, is 1 km. At that bus stop, service comes every 15-30 minutes.

Because of the length of this walk, and given that it is up a hill, the regular bus service makes deviations to the school 3-4 times per day. The resulting bus route, including the occasional deviation to the school, is shown in yellow on the map on the previous page. Passengers making long trips between other places at school bell times must travel through this deviation.

There could be an opportunity to plan a different bus route, which would stop about 315m away on the main east-west road through the area. This is marked by the hatched line. However, this road is a very narrow boreen, which cannot be driven by a bus. The only way to get close to the school with a bus is from the east.

In this way, development of the school and housing has proceeded in advance of the road infrastructure needed to provide the community with a direct and useful bus service.

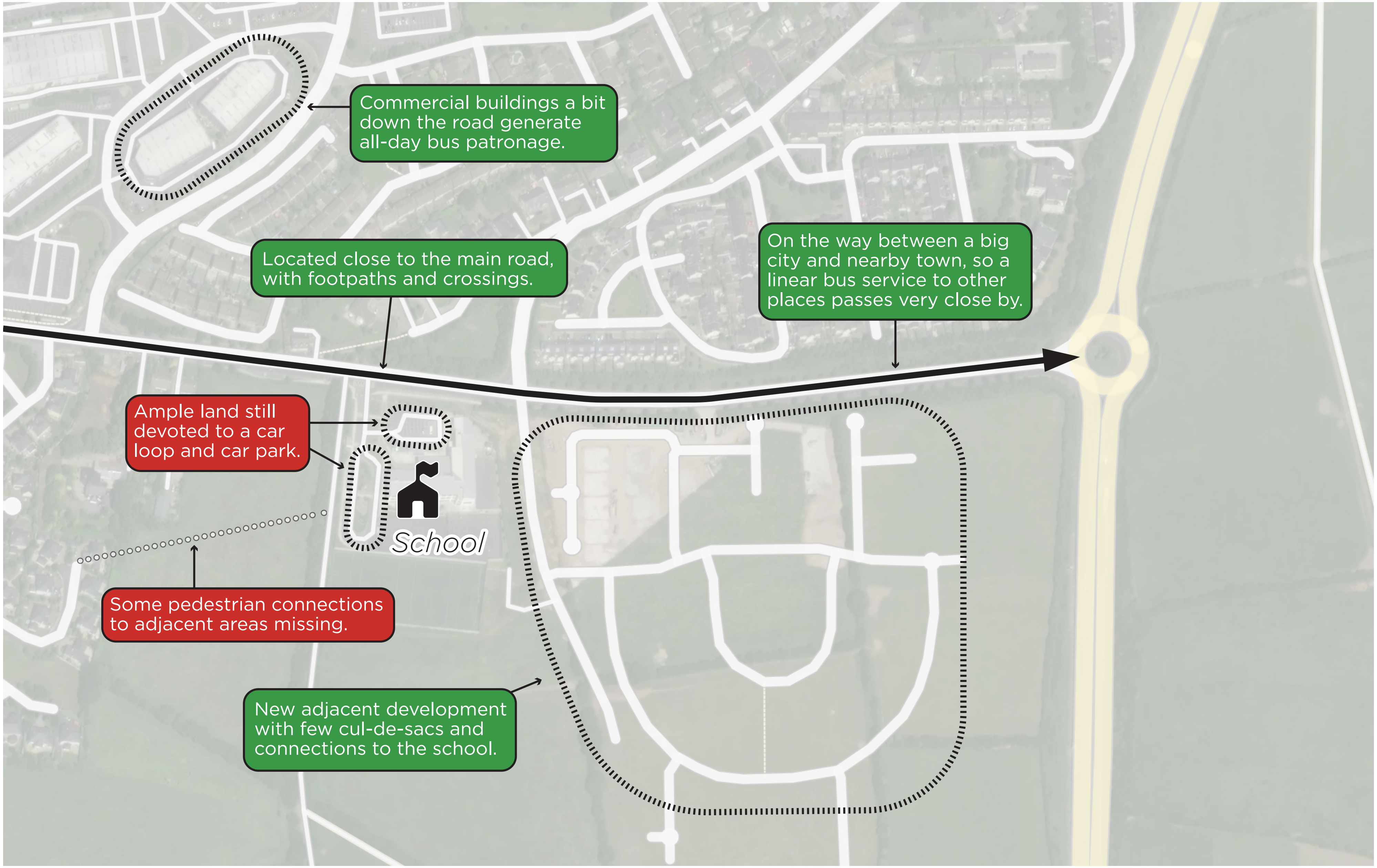
At the local level, street connectivity around the school is very poor. Many houses are on long cul-de-sacs, making walks to any destination, including the school, artificially long.

The lack of local pedestrian connectivity also has specific consequences for public transport in the area. Low walkability means fewer people can be patrons of any bus service provided, whether at the front door of the school, on the east-west road nearby, or on the main road in the village. Making the case for more daily bus trips to the school's front door is surely hard given how few residents are walking distance to that bus stop.

Most public bus systems in the world are expected to serve pupils going to and from school, and bus service for pupils is an excellent way to introduce the habit of public transport use early in people's lives. But the location choices of schools can impose high costs for public transport. The locations of schools are therefore a matter of public interest and should be a focus for local authorities hoping to improve public transport in their areas.

Factor	Rating	Explanation
Density	⊗	Housing in the area is nearly all low-density.
Walkability	⊗	Whilst there are footpaths on most streets, pedestrian connectivity is extremely poor.
Linearity	⊗	The school is located about 300m off the nearest through-road, which would be a reasonable walk from a bus stop. However, that road has not been upgraded to support the development happening around it, and cannot be operated by a bus. As a result, this school requires a major deviation by an otherwise linear bus route to the city.
Continuity	⊖	There is other urban development in the area, though it is interspersed with open fields and greenspaces.
Mix of Uses	⊗	The area is entirely residential.
Justifiable level of service	⊗	Buses stop 3-4 times per day at the school, on school days only. Given the high costs of providing peak-only buses, and how few other people nearby could make use of the service, it is hard to imagine much more provided in the future.

School Located On-The-Way



The school location shown on the previous page is similar to the earlier example in that they are both fairly new, and located in residential areas that are just now developing and still have some fields interspersed among them.

The big difference in their locations relates to linearity:

- Whereas the previous school is located down a cul-de-sac…
- … this school is located on a main road that connects many other developed areas with a straight line, drawn in black in the map on the previous page.

This school has still devoted considerable land in the front of the parcel for a car drop-off loop and a car park. However, the walk from the main road to the door of the school is short and has been provided for with a visible walkway through the drop-off traffic. Sports pitches are behind the school, rather than separating it from the main road.

There are good footpaths along the main road, and visible crossings to allow pupils living north of the road to walk across it to the school. These crossings make the bus stops near the school easier for many people to reach, increasing the number of potential patrons using the bus route past the school.

East of the area shown, a bus route can follow a linear path towards a large city. West of the area shown is a commercial and retail park, followed by 2.5 km of low-density residential development and a large employment site in a nearby village.

Whilst the east-west main road currently has no daily bus service, all-day and all-week service is planned to be added in the coming years. It is justified by the efficient, linear path the bus can follow through continuous development, including the school, houses and commercial buildings, on the way to the employment site. This school will enjoy all-day bus service for its pupils and staff by virtue of having chosen a location that is ***on the way***.

However, walkability in the area is lacking due to a legacy of planning for poor pedestrian connectivity. Even with improvements to footpaths and crossings, the street or footpath connections simply don't exist to support walking from many homes. Some residential developments in this area offer only one way in and out. Walks to the school or a bus stop on the main street can therefore be very long and circuitous.

Factor	Rating	Explanation
Density	⊖	Nearby housing estates are a mix of low and moderate densities. Some commercial and light industrial buildings are also nearby.
Walkability	⊖	The main road is being improved for walkability, and new developments will have good street connectivity. However, many developments are surrounded by walls that artificially lengthen people's walks to the main road.
Linearity	✓	The school faces a linear main road that passes through multiple other residential areas and destinations.
Continuity	⊖	There are still open fields interspersed with low-density housing along the main road, however considerable new development is expected to fill in the gaps in the next few years.
Mix of Uses	⊖	Whilst the area is mostly residential, there are commercial and light industrial uses nearby. The road runs directly to a large employment site 2.5 km to the west.
Justifiable level of service	⊖	Whilst density, walkability, continuity and mix of uses are somewhat lacking, the school is on the way to other destinations, making it possible to justify all-day service here.

3.5 Retail

Many retail areas in Ireland developed when walking was the predominant mode of transport. They are city and town centres, where small buildings and shops crowd together along narrow streets. Without large vehicles to account for, huge numbers of customers can squeeze into these centuries-old shopping districts.

Most modern retail developments are completely different, designed for access mostly by car. Some offer a pedestrianised setting, for the social and aesthetic benefit, and some may provide a bus stop at the main road, but most are designed on the assumption that almost all visitors will drive and park cars. Typically, the retail building is far from the street, behind a large car park. This minimises average walking distance from parked cars but maximises walk distance from a bus stop and footpaths on the main street.

This may be a result of a long-standing assumption that the highest-spending customers travel by car, and that people arriving by foot, bike or public transport are either too few in number, or spending too little, to contribute much to retail success. In fact, recent studies have thrown these assumptions into question,[6] observing for example that:

- People who arrived at a shopping district on foot or by bike were more frequent visitors than those coming by car;
- There was no correlation between the amount of spending by a customer and their mode of travel to a shopping area;
- People living or working near a retail street were much more likely to be "high spenders" on a monthly basis, due to their frequent visits; and
- In some cases merchants over-estimate the number of their customers who arrive by car.

The transport access to a shop doesn't only matter for customers. Merchants must think about how to attract and retain employees. If holding a certain job requires owning a car because it's too hard get there by any other mode, then fewer people will want to keep that job. Even if merchants are confident they can survive without the expenditures of customers who arrive by foot and by bus, they should be concerned if transport problems prevent them from keeping a full staff.

The mix of modes people will use to reach a retail area or park will vary by location and by the type of retail. Regardless, designing new retail parks to work well for the car and poorly for all other modes is a self-fulfilling prophecy. Large car parks, large junctions, cul-de-sacs and wide roads all discourage people from arriving by non-car modes. They make public transport less useful and more costly to provide. The natural result is that most of the people who will shop (or work) at that retail park will have cars and will arrive by car, since those who prefer otherwise are going elsewhere.

More resilient and long-lasting retail developments are planned so that they can be reached comfortably by multiple modes, not only by cars.

In this section we describe two contrasting examples of modern retail developments. One is designed optimally for cars, and only cars. The other is accessible by car but also easy to walk to and through, and efficient to serve by public transport.

Car-Oriented Retail Park

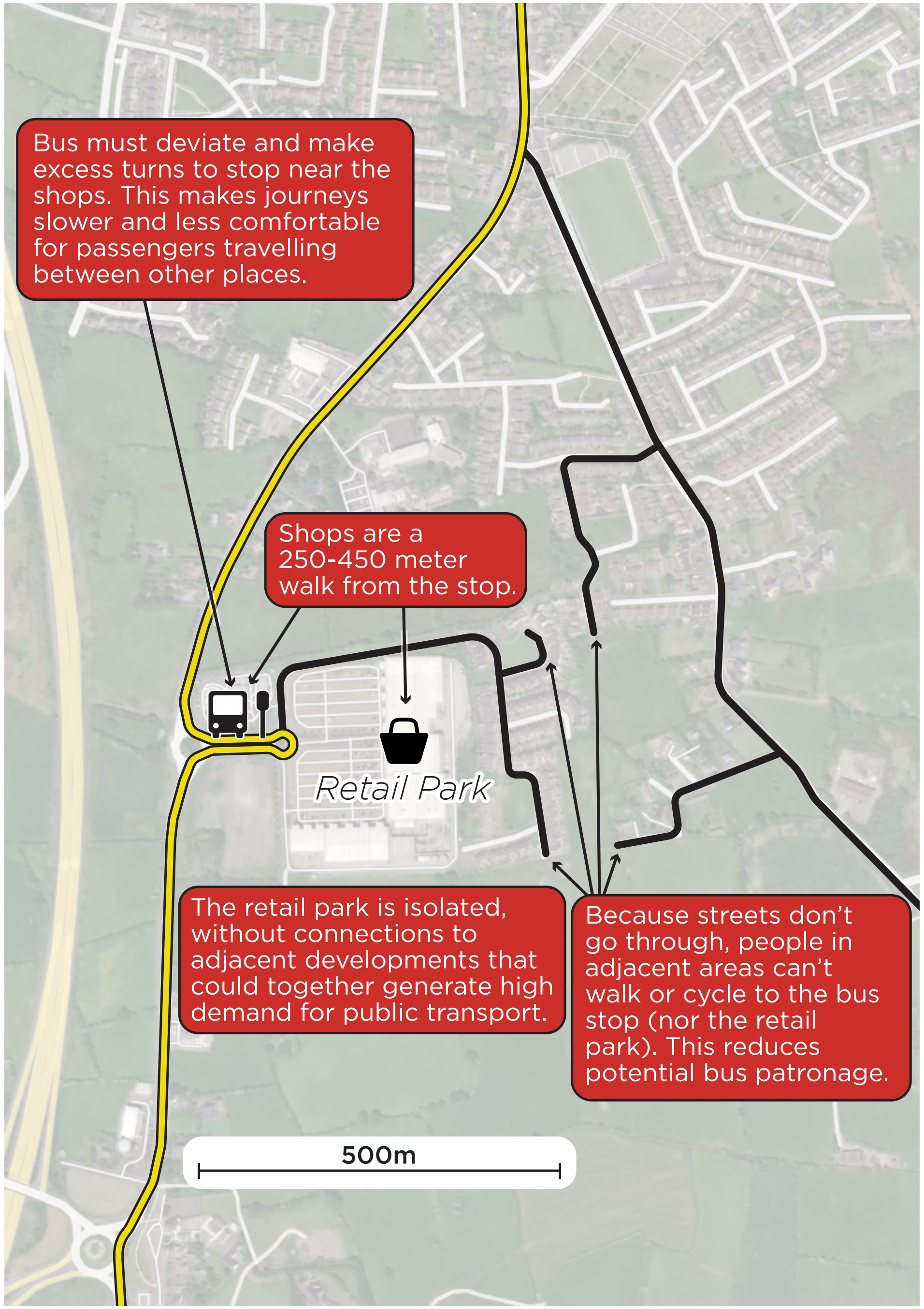
The retail park development shown on the right is on a main road, outside of a large town in Ireland. It is placed off the main road, down a wide four-lane drive.

There is a bus route running nearby on the main road, shown in yellow. It makes a stop near the retail park by turning down the drive, adding delay for any passengers traveling through.

Despite this deviation off the main road, the walk from the bus stop to the closest store is still 250m. Someone going to a store at the south edge of the car park has a long and circuitous 450m walk around the footpaths at the perimeter of the car park.

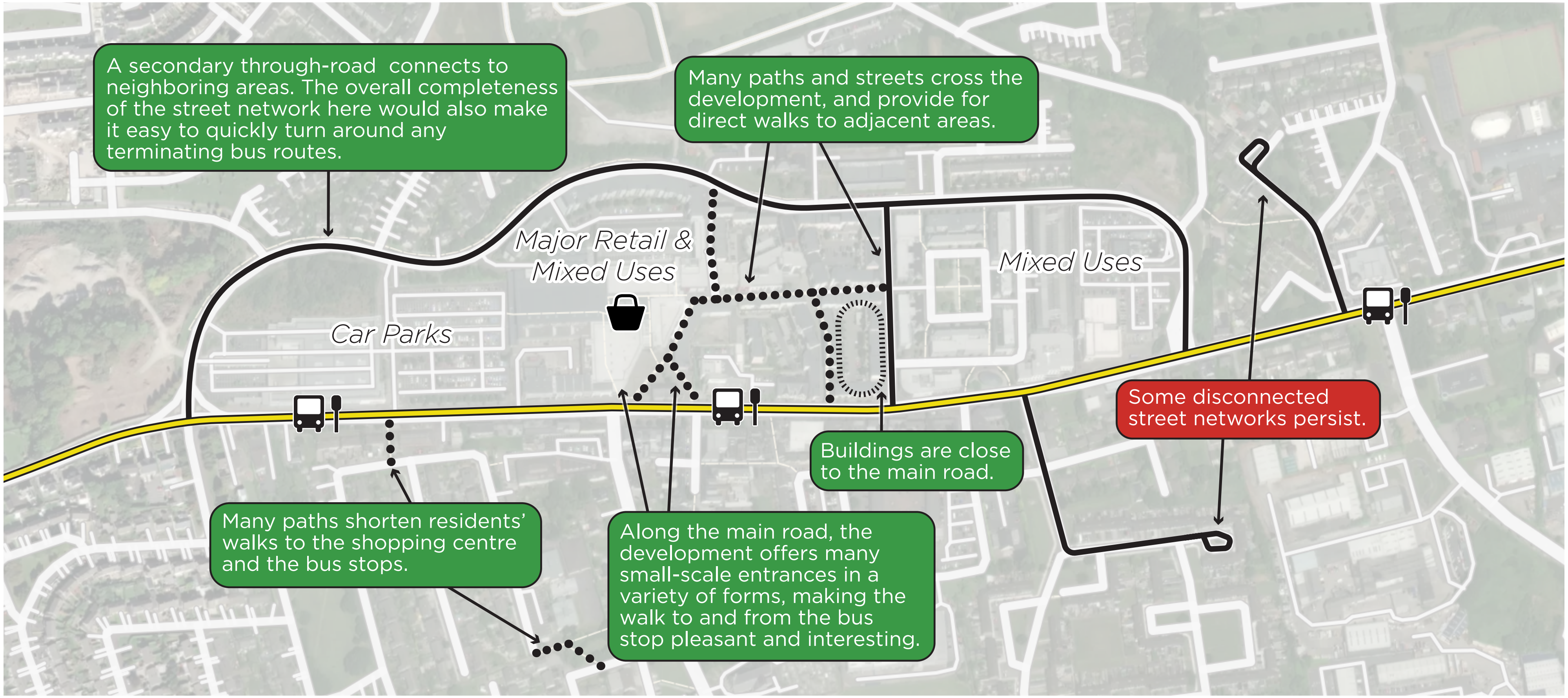
This retail park could have been located on the main road itself, ***on the way*** between two major towns, in which case it would have supported a straight, fast bus route. Instead, by virtue of its location set back down a drive and further back behind its car park, the development requires all through-passengers to sit through a loop-de-loop. And ***still*** the people going to the retail development have to walk through car parks to reach the shops.

Many people have the notion that trains are inherently better than buses because railways are direct and fast whereas bus routes can be circuitous and slow. But it is the expectation that buses will make deviations like this one, expressed in land use and development decisions, that undermine the directness of bus service and reinforce that mis-impression.



Factor	Rating	Explanation
Density	⊗	Density within the retail park is low because of the large car park.
Walkability	⊗	Walks to the shops are long, and not all walks are provided for with crossings or footpaths. Cul-de-sac development in the area reduces the number of nearby residents who might otherwise walk or cycle to the bus stop.
Linearity	⊗	The bus service is expected to deviate and loop to get closer to the retail park, lengthening journeys for through-passengers.
Continuity	⊗	While historical development patterns to the north support linear public transport, in this area the development is scattered and disconnected.
Mix of Uses	⊗	Some low-density housing is nearby, but a lack of street and path connections isolates the retail park.
Justifiable level of service	⊖	The main road connects two large towns and is likely to always have some service. But the deviation may be hard to justify forever. This development is a missed opportunity to grow patronage and support a higher level of service.

Linear Retail Street



In contrast to the previous example, a retail development can be organised in a linear pattern that is easy to serve with efficient, straight bus routes. The aerial image above provides an example of a development built in Ireland in the early part of this century. It includes large-scale retailers similar to those in the previous example, but it has been planned and built very differently.

In this linear development, retail and commercial buildings have been concentrated on a historic main road ***on the way*** to a nearby city. No deviation was necessary to bring bus stops close to the new shops. Neither the developer nor the local authority would have had to convince bus planners to provide service nearby, as service was already there. A high density of new activities along an existing bus route is an obvious new source of patronage, which likely made it easy for the operator to increase frequency as the development filled-up and matured.

The design of the new centre included many pedestrian paths, with the result that walks to and from a bus stop are short. Paths inside the development were specifically planned to line up with connecting streets or paths from adjacent areas so that walks into and out of the retail centre are direct and efficient. In addition, because the retail buildings are oriented towards the main road and its footpaths, rather than the car park, the walks to and from the bus (or from nearby residences) are pleasant and interesting.

With all of these choices, the planners and architects have shown respect for walking as a mode of transport, respect for the value of pedestrians' time, and an interest in attracting nearby residents as customers or employees. They've also treated the bus service as though it were a train by locating near it and pointing front doors towards it, rather than expecting it to slow down and drive in circles to accommodate their design.

This main road, connecting towns and the city, with all of the shops and businesses along it, is only two lanes wide. It is therefore easy to cross on foot, which means it is easy for people to reach the bus stop for their return journey. In contrast, the drive to reach the car-oriented retail park in the previous example is four lanes wide, despite serving vastly fewer shops, customers and residents than does this busy main road.

The linear retail centre does have a secondary through road, which curves around the back of the development. It allows for car, pedestrian and bike connections to some adjacent developments (though some cul-de-sac street networks still prevent connections). It also provides a complete enough street network around and within the development that multiple short terminal-loops are available, should a future bus route terminate in this village centre.

This development is full of potential bus passengers, rich in streets, rich in walking paths and so perfectly ***on the way*** between other important places that it is guaranteed to have a good bus service into the future. All without imposing any extra costs on the public transport system.

Factor	Rating	Explanation
Density	✓	Shops, offices and apartment homes are close to one another and concentrated close to the main road.
Walkability	✓	Abundant paths, well-designed for purposeful walks between destinations, and good building design make walking easy and pleasant.
Linearity	✓	Oriented towards a main road, on the way between other important places, a perfectly linear bus route can serve this entire development.
Continuity	–	On either side, and across the street, other developments also generate demand for public transport.
Mix of Uses	✓	Within the development a mix of retail, commercial and residential generates demand for public transport at all times of day and week. Nearby areas also host a mix of land uses.
Justifiable level of service	✓	Demanding no extra costs from the bus operator, and no wasted journey time for through-passengers, whilst offering numerous potential patrons, this development benefits from a high level of service.

Conclusion

This guidance note has been developed as an input into the decision making processes that create and change cities and towns across Ireland. The purpose of the note is to inform and advise planners, architects, engineers, Councillors, and any other interested parties who want to ensure that public transport, and in particular the bus, succeeds in our towns and cities.

The note has set out the main elements of land use and street development which influence the usefulness and operation of bus services. The note illustrates how public transport services operate, and, conversely, how land use planning and development should be configured to cater for these operational characteristics. The guide also sets out a number of worked up examples to highlight common, challenging land use situations and some planning situations, as a means of bringing real life context to these theoretical principles.

Drawing together the fundamentals of this guidance note, we ask that three take-away actions are remembered:

- **Make bus operations efficient and direct**. Planning urban and suburban areas with continuous, linear patterns of dense, mixed-use and walkable development supports efficient bus operations and makes bus service more useful to more people.
- **Make it easy to walk to the bus.** Walking and wheeling should be available to everyone, everywhere, as fundamental ways of moving in the world. Of all the travel modes, they afford people the greatest freedom and spontaneity. But they are extremely sensitive to the details of land use and the built environment, which are very easy to get wrong.
- **Organise development around a frequent network.** Rather than expecting public transport to chase development to wherever it is approved, development should be planned into shapes that public transport can service efficiently.

The National Transport Authority is tasked with providing an effective and efficient public transport system. The extent to which Ireland's land use plans, development plans and road designs incorporate the principles set out in this guidance note will shape our success in that task.

Additional Resources

The following guidance notes and documents may be helpful as a supplement to the general advice given in this note:

"Design Manual for Urban Roads and Streets" (DMURS) by the Government of Ireland.

"Permeability Best Practice Guide" by Ireland's National Transport Authority.

"Bus Services & New Residential Developments" by Stagecoach.

"Buses in Urban Development" by the Chartered Institution of Highways & Transportation (CIHT) in the United Kingdom.

Acknowledgements

This guidance note is the work of National Transport Authority and Jarrett Walker + Associates. We regret any errors or the omission of valuable context.

The contributions and reviews of staff from the National Transport Authority are greatly appreciated.

This guide will develop and change as Ireland's challenges and best practices change. In this spirit the NTA welcome input, suggestions and queries from readers, and can be contacted at strategicplanning@nationaltransport.ie.

Aerial maps have been provided courtesy of © Mapbox and © OpenStreetMap.

Notes and Citations

1 From or a longer explanation of access, see "Transport Access Manual. A Guide for Measuring Connection between People and Places," Levinson et al, 2020.

2 The original academic observation that acceptable daily travel times have some degree of constancy through history was made by Cesare Marchetti. "Anthropological invariants in travel behaviour," Technological Forecasting and Social Change. 47 (1): 75–88, 1994.

3 Regarding the relationship between access and patronage:

Diab, E., DeWeese, J., Chaloux, N., et al: Adjusting the service? Understanding the factors affecting bus ridership over time at the route level in Montréal, Canada. Transportation. 48, 2765–2786 (2021). https://doi.org/10.1007/s11116-020-10147-3

Cui, B., Boisjoly, G., Miranda-Moreno, L., et al: Accessibility matters: Exploring the determinants of public transport mode share across income groups in Canadian cities. Transportation Research Part D: Transport and Environment, 80, 102276 (2020). https://doi.org/10.1016/j.trd.2020.102276

4 Regarding the relationship between frequency and patronage:

Berrebi, S., Joshi, S., Watkins, K.: On bus ridership and frequency. Transportation Research Part A: Policy and Practice. 148, 140-154 (2021).

Dill, J., Schlossberg, M., Ma, L., et al: Predicting Transit Ridership at Stop Level: Role of Service and Urban Form. Transportation Research Board 92nd Annual Meeting Compendium of Papers, 13-4693 (2013).

Gregory, T., Brown, J.: Explaining variation in transit ridership in U.S. Metropolitan Areas between 1990 and 2000: Multivariate analysis. Transportation Research Record 1986.1:172–181 (2006).

Stewart, A., Attanucci, J., Wilson, N.: Ridership response to incremental Bus Rapid Transit upgrades in North America. Transportation Research Record: Journal of the Transportation Research Board 2538: 37–43 (2015).

Balcombe, R., Mackett, R., Paulley, J., et al: The demand for public transport: A practical guide. Transportation Research Laboratory. Report 593 (2004).

5 Ewing, R., Cervero, R.: Travel and the built environment: A synthesis. Transportation Research Record 1780. Paper No. 01-3515:87–114 (2001)

6 Regarding the shopping and spending habits of people arriving by different transport modes, and merchants' impressions of those habits, see:

Smith Lea, N., Verlinden, Y., Savan, B., Arancibia, D., Farber, S., Vernich, L. & Allen, J. "Economic Impact Study of Bike Lanes in Toronto's Bloor Annex and Korea Town Neighbourhoods." Toronto: Clean Air Partnership, 2017

Clifton, K., Muhs, C.D., Morrissey, T. & Currans, K.M. (2016) "Consumer behavior and travel mode: An exploration of restaurant, drinking establishment, and convenience store patrons," International Journal of Sustainable Transportation, 10:3, 260-270, DOI: 10.1080/15568318.2014.897404

In 2022 NTA observed that a majority of expenditure in Cork and Dublin city shops came from people arriving by sustainable modes. Summaries of the results are available at nationaltransport.ie/publications/nta-shopper-surveys-summer-2022/.

NTA

Údarás Náisiúnta Iompair
National Transport Authority