The Mobility Opportunity

Improving public transport to drive economic growth.

A research project commissioned by Siemens AG

Contents

"Efficient transport can attract economic activity to cities, and boost productivity by improving connectivity and reducing time lost to travel"

1. Executive Summary

Why transport matters

Transport plays a key role in economic growth
Cities account for around 80% of the world's economic output, and drive an even higher share of global growth. However, in a globalised economy, with businesses and workforces increasingly able to relocate internationally, they must compete to offer the most attractive environment for economic activity. Transport plays a key role in this.

Efficient transport can attract economic activity to cities, and boost productivity by improving connectivity and reducing time lost to travel. Better transport can also improve quality of life. Making a city more attractive to live in helps provide business with the labour force to create its products and buyers to consume them, and so fuels economic growth. Conversely, inefficient transport networks represent a cost to cities and their inhabitants – both in economic and welfare terms – through productive time lost to travel and through poor-quality service.

Transport networks in cities are increasingly under pressure
Growth in the world's population and increasing migration to major cities will place ever more strain on cities' transport networks. In the 35 global commercial centres analysed in this study, the commuting population for public transport will increase by over 40% between now and 2030. The scale of the future demand challenge varies hugely between cities. As figure 1 shows, cities in the developing world like Lagos and Delhi will face more rapid growth than those in the West.

Cities face differing challenges
Population growth challenges the transport infrastructure of cities in different ways. In some of the world's largest cities, such as London or Paris, infrastructure was built the best part of a century ago, to meet vastly different demands from a population with different expectations. These well-established cities face a need to upgrade and supplement existing infrastructure to meet modern requirements.

In other cities, such as Tokyo and Seoul, relatively recent wealth has created high density, compact centres, where infrastructure is more modern. These cities face the challenge of keeping pace with rapidly growing demands on the transport network.

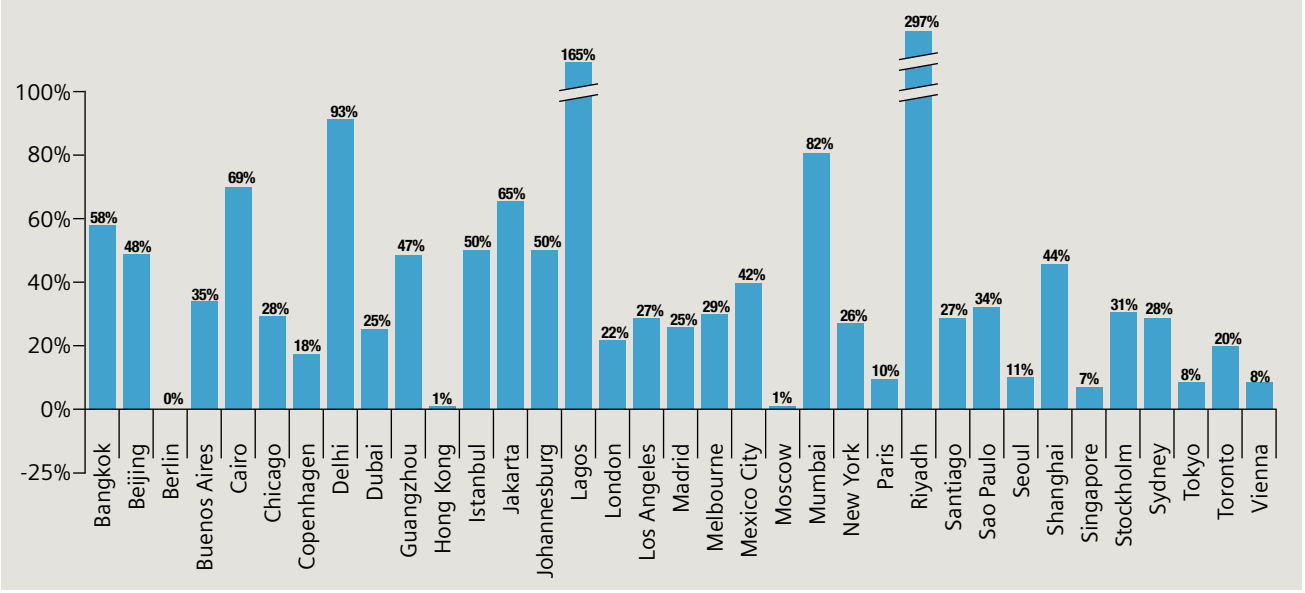
Less wealthy, emerging cities such as Cairo or Delhi are less likely to have invested in infrastructure historically, and face rapidly growing populations that lack mobility. Some cities like Santiago have been able to invest to build efficient networks with sufficient capacity, positioning them for future growth. In other cities such as Lagos, the challenge is very different, as investment capabilities are constrained, threatening to limit future growth.

A unique study

This study is unique in seeking to put an economic value on the cost of inefficient transport to a city's economy and in turn, the economic benefits investing in transport improvements would bring. It quantifies the economic costs by calculating the true cost of commuting: considering factors such as journey time, the value of time, fare, crowding levels, ease of using the network, service reliability, user functionality and so on. This reflects the efficiency and speed with which a journey can be undertaken in a given city, capturing the knock-on effects on productivity. Investing in transport to reduce this cost would bring benefits for commuters and business, drive productivity and stimulate new economic activity as a city becomes better connected and more attractive.

To put a value on the economic benefits referred to above,

Figure 1: Percentage change in the volume of peak commuters on public transport (present - 2030)



the study analyses the performance of transport networks of 35 commercially important centres across six continents, both now and in 2030. We consider 2030, since due to the lead times of major transport projects, this is a reasonable timescale for cities to address their challenges, and attempt to unlock the benefits highlighted. The benefits identified for 2030 take into account existing investment plans. Therefore they represent the potential benefits available to cities through investment beyond their existing plans. However, to consider the benefits individual transport projects can bring, we have attempted to assess the impact of a selected number of planned transport investments. Details of the examples, which are purely indicative in nature, can be found in appendix 1.

To reflect different levels of wealth and development, we assess cities in three categories: 'well-established cities,' 'high density compact centres' and 'emerging cities'. Comparing cities to the leading examples in their categories, we determine the economic cost of sub-optimal transport and consequently the economic uplift if cities were to improve transport to the levels of the leading examples. The economic uplift includes benefits to public transport commuters, road users, businesses, and the wider economic impact in terms of increased productivity and new economic activity. To help urban authorities identify how they might access this uplift, we provide in-depth case studies from global cities, as well as key pointers for investment strategies.

This study focuses solely on public transport. While pedestrian, bicycle and car infrastructure are also important, public transport is a key part of the solution to the mobility challenge and thus merits a specific focus. In our analysis the transport network includes all forms of mass transit in a city such as bus, rail and light rail. For the most part the city population is typically that of the metropolitan area, with a few exceptions where we used the population of the "city proper" as this more closely represents the area served by the transport network. Data are drawn from a wide range of publicly available sources, using a single source for each metric where possible and using proprietary research where published data sets were unavailable. The economic modeling used to quantify the costs and benefits has been verified by an independent third party, Connected Economics.

Key findings

Cities that invest in transport will reduce economic costs and drive economic growth.
The potential impact from investment is clear: cities with plans in place will see the economic cost of transport fall, as well as drive economic growth. For example Paris' large scale investment in 200km of new metro line will help to drive down its economic cost of transport by roughly one percentage point of GDP per capita and generate annual economic benefits including wider economic impacts of $2.7bn. With this level of potential economic benefit, it would take roughly 13 years to pay back the estimated investment cost of $36bn, and in addition generate an economic value add of $46bn over the estimated 30 year life of the project. And yet, even for those cities with strong future plans, there are still further opportunities to gain economic benefits from investments in transport improvements.

The economic costs of transport range from 9% to 28% of GDP per capita – and will generally rise by 2030
Current costs of transport range from about 9% of GDP per capita in Copenhagen to about 28% in Lagos. For many cities, the economic cost of transport is forecast to increase by 2030. Where cities have not already put plans in place to react to increased demand by 2030, or where current plans are insufficient, transport costs will consume an increasingly large portion of economic output. For instance, taking into account known investments, the cost of transport in New York is forecast to increase from 15% to 18% GDP per capita. Conversely Paris, which, as seen above, has clear plans in place, will see the economic cost of its transport decrease.

Greater transport efficiency across the 35 cities in our study would boost GDP already today by $119bn, and by circa $238bn annually by 2030
Our analysis suggests that if all the cities in the study invested to make their transport networks as efficient as the relevant 'best in class', the current economic benefit would be worth $119bn annually. The cities that stand the most to gain in absolute terms today are Tokyo ($15.4bn), Moscow ($14.1bn), London ($11.9bn), Paris ($10.6bn) and New York ($9.8bn) on an annual basis. Rising populations, labour force engagement and wealth will increase the gain, and so by 2030, the economic benefit will be worth $238bn annually (in current prices).

The potential economic opportunity from investing in transport in cities globally could be as much as $800bn, or around 1% of global GDP
Extrapolating to all relevant cities globally suggests an economic opportunity of almost $800bn – equivalent to almost 1% of global GDP – on top of which would come further social and environmental benefits (see figure 2). Without investment in their transport networks, cities will be unable to unlock this opportunity cost, and face being left behind in the competition for growth. The investment needed to address the future mobility challenge will often be high, but some cities have found relatively low cost ways of improving their transport systems. Furthermore, the benefit of improvement is a permanent increase in GDP. When discounted over a 30 year period the global benefits could be almost $15trn, making the case for investment in transport highly compelling.

Copenhagen is the best-performing city overall; Singapore and Santiago top their respective categories
Copenhagen's transport network is the most cost-efficient of the cities in this study. Its performance is driven by the capacity of its network and the strength of its plans, which include adding two new metro lines. These rigorous plans will help ensure that the cost of transport does not rise by 2030, even with increased demand.

Among high density compact centre cities, Singapore's system is the best in class (see figure 3), particularly due to its strong governance and high capacity. Santiago is the best performer within the emerging cities category. Over the past twenty years, it has expanded its metro to meet the changing demands of its population, modernised its ageing bus network, and created a modern, integrated mass-transit network.

Figure 2: Economic opportunity through investment in transport

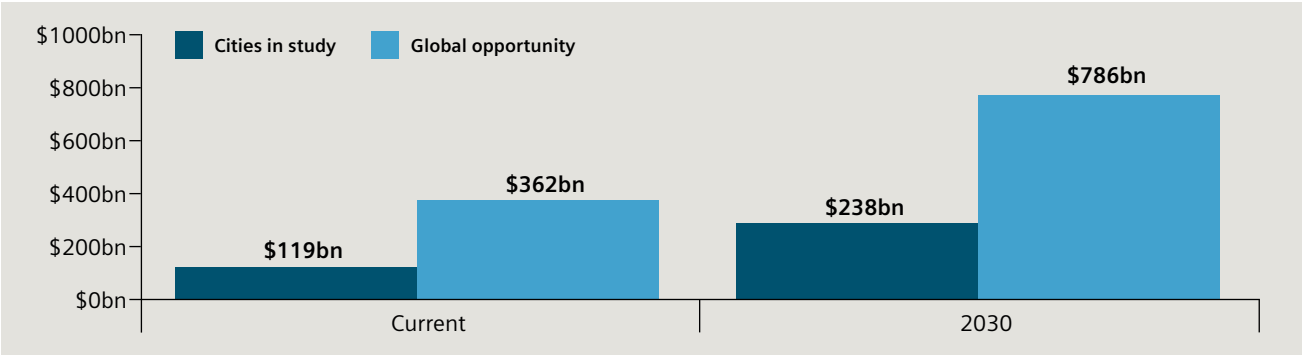


Figure 3: Leading cities by present economic cost of transport (percentage of GDP per commuter)

Well-established cities		High density compact centres		Emerging cities	
Copenhagen	8.6%	Singapore	8.9%	Santiago	10.8%
Madrid	8.7%	Hong Kong	9.2%	Mexico City	12.2%
Vienna	9.7%	Beijing	11.0%	Bangkok	12.6%
Range	9-19%	Range	9-16%	Range	11-28%

Leading cities share efficiency, broad coverage, integration and clear planning

The best networks minimise the time passengers spend travelling and optimise their daily lives. The leading cities in our study – like Copenhagen and Singapore – show common attributes. They provide efficient transport networks with sufficient capacity to minimise crowding, and broad coverage to ensure convenience. Modern rolling stock and infrastructure helps to provide a reliable and frequent service. Fully integrated networks mean passengers can make multimodal journeys using the same payment system, planned through joined-up journey planners. They also have clear plans to address future demand.

Pointers for investment strategies

As all cities are likely to require investment across a range of areas, rather than make specific recommendations – which must be tailored to a particular city's requirements, potential economic benefits, and ability to invest – we propose a number of pointers.

The scale of economic benefits should dictate the level of investment

In larger, wealthier cities, the cost of inefficient transport is higher, and so large-scale, high-value projects can be justified – like the estimated $36bn that Paris plans to invest in its metro network. For less wealthy cities, investment should focus on incremental improvements and other low-cost options to maximise existing capacity – for example Sao Paulo integrated fares and introduced priority measures for buses.

Using technology to improve quality may be the best route to economic uplift

Investing purely in new capacity may not be the most efficient way to realise benefits. Certainly, in cities like Cairo where capacity is a major constraint, adding new lines and increasing seats should be the focus. However, in cities like Stockholm or Berlin capacity is adequate and it would be better to invest in quality. Technology can maximise the potential of existing systems. This might include modern communications-based train control (CBTC) signalling to increase reliability and train frequency, or integrating technology such as shared payment systems to encourage customers to use multiple modes and so ease the burden on high congestion routes. Technology can also improve the customer experience, e.g. introducing WiFi, helping to drive increased public transport usage.

Urban rail networks are a key way to meet demand for larger cities which can afford them

Although urban rail development requires significant investment, it forms the basis of all of the most cost-efficient systems in our study, such as Copenhagen, Santiago, and Singapore, and is a key feature of those cities with strongest future plans, such as Riyadh. Despite the outlay, the economic benefits can be significant, particularly for larger or wealthier cities, or those facing more major capacity challenges.

Governance should be effectively integrated to create successful plans and bring them to fruition

Cities with effective transport networks (such as Singapore) and those that have been able to plan clearly for the future (such as London) have integrated governance and planning capability. For example, Singapore's 2013 Master Plan updates a previous long-term plan from 2008, and lays out clear plans to 2030 across all modes of transport, whilst the Mayor's Transport Strategy sets out plans for London as far as 2031.

Cities should act now

The benefits of investment appear clear, but the timescales for major transport projects must be considered. Unless cities act to address the inefficiencies in their transport networks, the economic costs of transport will rise by 2030 as highlighted. Cities can invest in their transport networks in a range of ways and should not be afraid of the upfront investment cost, since the economic benefit is likely to repay that investment many times over.

“The cities in the study have different histories and geographies and face different challenges. But whilst every city is unique, it is in direct competition in a single global market.”

2. How the study was conducted

Scope of study

In this review we assess the transport networks of 35 cities, representing some of the world's key commercial centres. These cities cover populations from 750,000 to over 20 million, and a broad range of settings, wealth and transport infrastructure, so our conclusions will be applicable globally. Figure 4 shows the cities and their categorisation.

The cities in the study have different histories and geographies and face different challenges. But whilst every city is unique, it is in direct competition in a single global market. We have grouped the cities into three categories, enabling us to reflect their uniqueness whilst allowing benchmarking between competitors, as well as realistically evaluating the level of efficiency to which cities' transport networks can aspire:

- **'Well-established cities' such as New York or Berlin**
  These cities typically have well-established layouts and developed transport systems, which may be facing capacity constraints.

- **'High density compact centres' such as Singapore or Dubai**
  These are more modern cities that have experienced recent or ongoing expansion, with high population density in the centres. Transport networks may be less developed than in well-established cities.

- **'Emerging cities' such as Jakarta or Cairo**
  These cities are typically less wealthy than those in the other categories, with large and growing populations, and typically underdeveloped transport infrastructure.

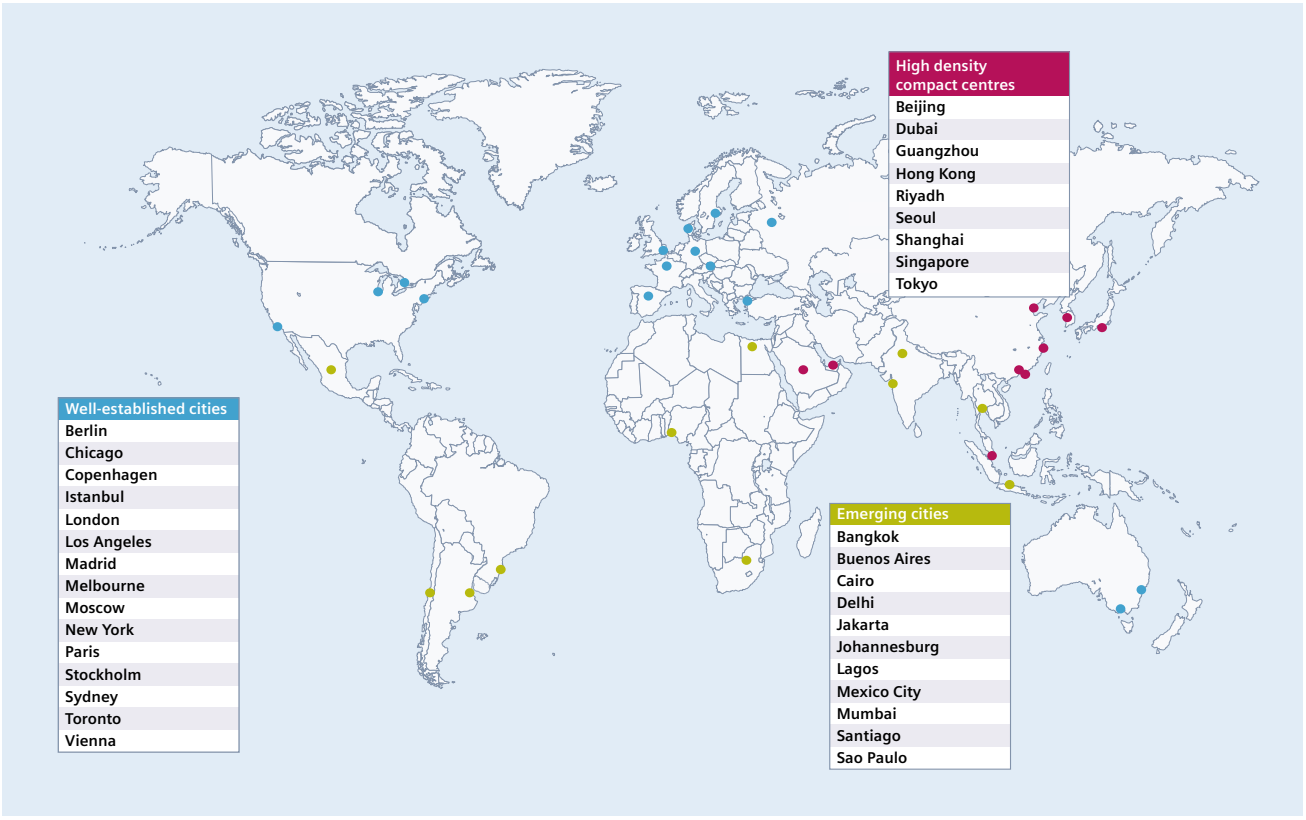
The true cost of transport

All transport activity has a cost – both the financial cost of making the journey, and the economic cost of the time spent making the journey. This economic cost depends not only on how long the journey takes, but on how productive and enjoyable the experience is. The total cost of a journey, in terms both of financial cost and broader economic costs, is known as the generalised cost. Minimising this cost – through an efficient transport network that is affordable and rapid, but also of high quality to enable people to productively or enjoyably use the time spent travelling – should be a priority for cities.

To calculate the true journey cost, we modify the actual journey time in line with multiplier effects that affect how a user perceives the time of the journey. The multipliers used are explained in the technical appendix. The generalised journey time is multiplied by the value of time in that city, to give a picture of the true cost of a single journey to a commuter.

This generalised journey cost framework assesses the

Figure 4: Cities included in the mobility opportunity study



economic cost of transport journeys for each individual, and therefore in aggregate the total economic cost for the commuting population of the city. By comparing the aggregate cost across cities, on a normalised basis, we can see how efficient cities can be: what is the economic cost of the most efficient systems? What, then, is the economic benefit available to cities, if they invest to reduce their transport costs to the level of the most efficient systems?

High-level approach

Our approach to this study is based on an extensive data set which we have built from a combination of published data, proprietary research and extensive analysis and normalisation. This data set is the foundation for our analysis, from which we have carried out economic modelling in line with best practice, which subsequently informs our recommendations.

For more detail on the theoretical basis of the economic modelling and a detailed description of methodology, see appendix 3.

Economic audit

Credo has been commissioned by Siemens to analyse the economic opportunities arising from addressing the future urban mobility challenge in major cities around the world. Connected Economics Limited has been asked by Credo to independently review the approach taken to this analysis.

In our view:

- The broad structure of the approach is suitable for assessing impacts on the economic output of the cities selected;
- A suitable range of factors have been considered in the analysis;
- The evidence which has been applied to reflect transport behaviour and valuations is reasonable; and
- A suitable approach has been taken to benchmarking between peer groups of cities.

We conclude that the findings are directionally reasonable and that a suitable set of sensitivity tests has been undertaken to provide additional confidence in the results.

Dominic Walley, Connected Economics.
For full details, please see appendix 4.

Figure 5: High-level overview of approach

3. The economic opportunity

Cost and the size of the prize today

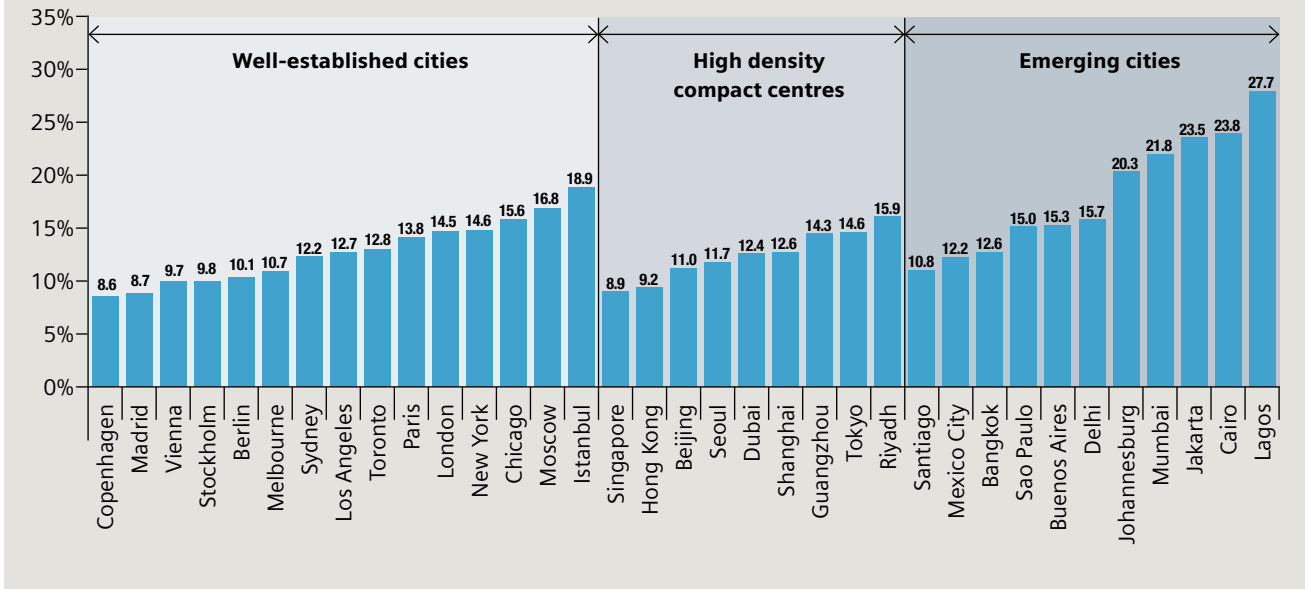
Transport cost ranges from 9% to 28% of GDP per capita
Current costs of transport range from about 9% of GDP per capita in Copenhagen to about 28% in Lagos. So for an average individual commuter in Copenhagen, the total annual cost of transport for that individual would be 9% of GDP per capita. We show the cost on an individual basis, as a percentage of GDP per capita, to enable easy comparison between cities – showing the total cost of transport to all commuters as a percentage of city GDP would be a false comparison, distorted by varying number of commuters between cities.

Relative to GDP, cities such as Jakarta, Moscow and Cairo have the greatest opportunity from investment
We assume that the most cost-efficient system possible for a given city is that of the leading city in its class. So, for instance, transport in the most cost-efficient system for a well-established city would cost 9% of GDP per capita for each commuter annually, in line with Copenhagen. In practice, even these 'best in class' cities can find incremental improvements through investment, but using them as a benchmark allows for a realistic view of the improvement available.

The economic opportunity of investment is made up of three parts: in addition to the direct benefit to commuters from eliminating the cost of inefficiency by improving transport to best in class, there are also the related direct impacts of investment in transport on road users and non-commuting business travel, as well as the wider economic impacts of investment.

The value of the total economic uplift available is driven not only by the current level of inefficiency within a city's transport network, but also the proportion of the city's residents who use public transport to commute. Relative to GDP, cities such as Jakarta, Moscow and Cairo have the greatest opportunities.

Figure 6: Present annual cost of public transport to an individual commuter as a percentage of GDP per capita



The 35 cities in our study could realise benefits of $119bn annually from improving transport

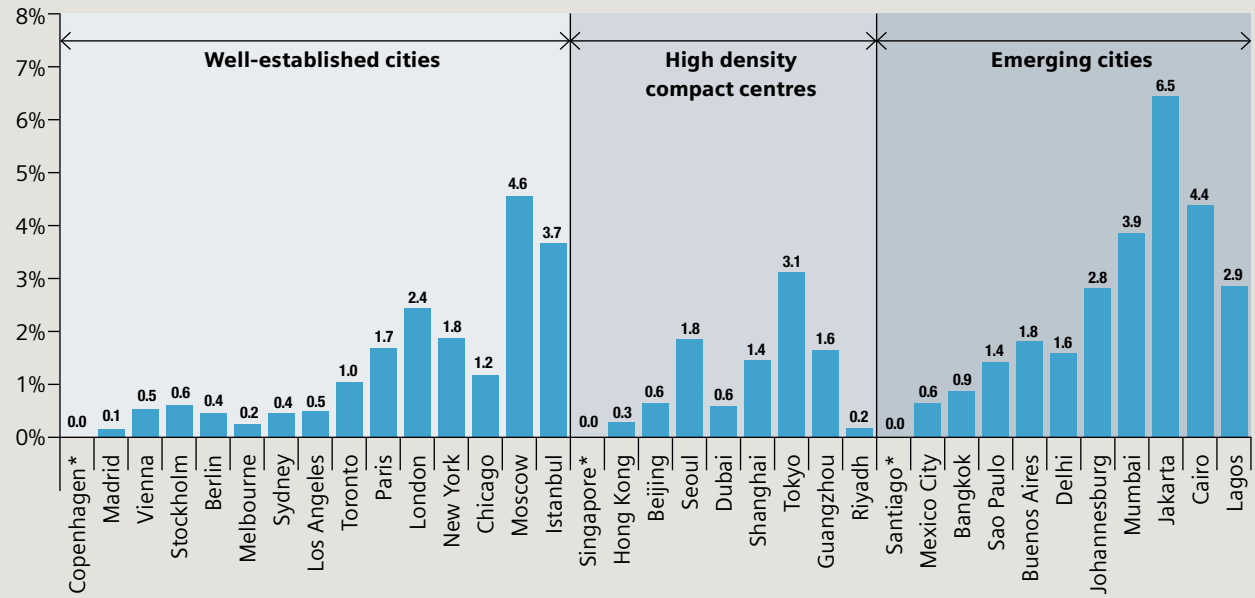
When converting the economic opportunity to a dollar value, the wealth of the city becomes important; the more valuable time is to commuters, the greater the cost of time lost through inefficient transport. Hence, large, wealthy cities such as Moscow, London or Tokyo, which have lower opportunities in percentage terms than Istanbul, have higher opportunities in absolute terms. Turning Istanbul's potential uplift of 4% of GDP into a dollar value suggests an annual cost of inefficient transport, and therefore opportunity through investment, of about $5.5bn.

Our analysis demonstrates that, in these 35 cities alone, the cost of inefficient transport is $67bn, and the economic benefit (allowing for the wider economic impacts of improved transport) that would arise from fixing it would be $119bn. As shown in figure 8, this benefit is spread among all cities, although unevenly.

The biggest opportunity is in wealthy developed cities with insufficient transport systems

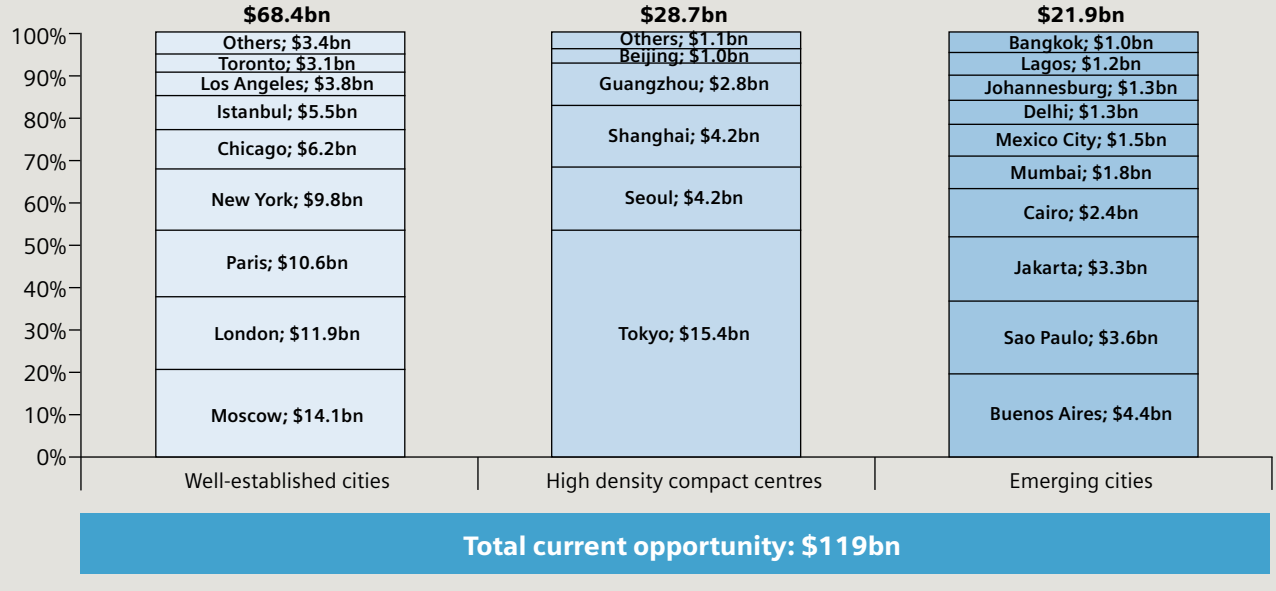
Moscow, London and Tokyo stand out as cities that have the most to gain. For less wealthy cities, such as those in the emerging cities group, or other cities with more effective current systems, the absolute benefit of investment is smaller. However, it is important to note that the values shown above reflect the annual cost of inefficiency. Given the lifespan of transport project, the benefit of investment would be felt over many years.

Figure 7: Current total economic opportunity as a percentage of city GDP, by city



* The potential uplift is estimated by benchmarking against the best-in-class cities. While the methodology precludes us from establishing a potential uplift for these cities, they are still likely to benefit from transport investments

Figure 8: Current total annual economic opportunity from addressing mobility challenge



How cost and opportunity will change by 2030

The cost of transport is set to rise

In the future, social and demographic changes will raise demand for cities' transport networks, increasing the potential economic benefit of investment.

- Population growth and urbanisation will be most prevalent in (although not exclusive to) developing cities. For instance, in Istanbul the number of commuters will increase by 50% by 2030.
- Increased labour force engagement (especially among women) will raise the number of people actively employed for a given working age.
- The challenge of an ageing population and the need for people to work longer before retirement will widen the working age, so that there is more working population for a total city population.
- The increased affluence of a growing middle class, and the ability to be more productive during travel, is likely to increase distance travelled and the number of people relying on transport to commute to their place of work. Teleworking will not fully allay the rise in demand or the growing expectations of that demand.

Overall, the growth in demand that we forecast ranges from 0% in Berlin (labour force engagement will remain flat) to growth of 165% for Lagos. At the same time rising income levels will increase the value of time – especially in the rapidly developing nations – and therefore increase the economic cost of poor transport.

Transport costs will range from 9% to 32% of GDP per capita by 2030

Based on the anticipated changes in demand and the anticipated impacts of investment already announced, we forecast that costs in 2030 will range from about 9% of GDP per capita in Copenhagen to about 32% in Lagos, as shown in figure 9.

Cities that invest can reduce the economic cost of transport, as well as drive economic growth

Whilst the economic cost of transport is forecast to increase in almost every city by 2030, there are some cities where the cost will decrease; figure 10 shows the change in economic cost between now and 2030. Paris' large-scale investment in metro capacity will help drive a roughly one percentage point fall in the cost of its transport system relative to GDP, whilst in Riyadh it is forecast to fall by nearly four percentage points of GDP per capita, driven by substantial investment. Conversely, even taking into account known investments, the cost of transport in New York is forecast to increase by almost four percentage points of GDP per capita. This shows that cities with sufficient plans in place to react to increased demand by 2030 will see the economic cost of transport fall,

Figure 9: 2030 annual cost of public transport to an individual commuter as a percentage of GDP per capita

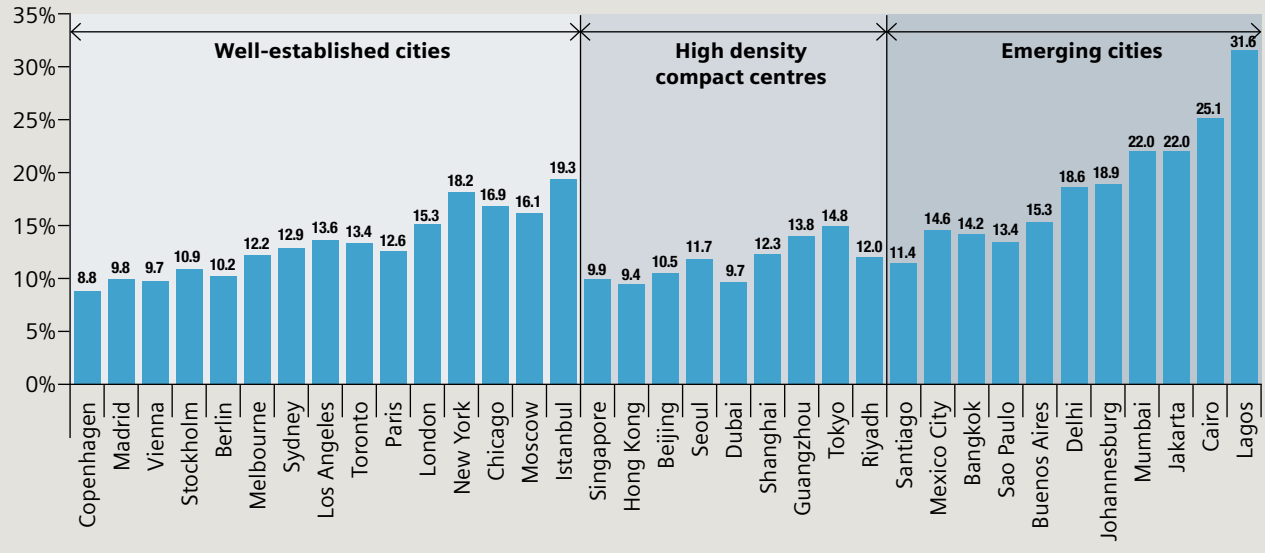
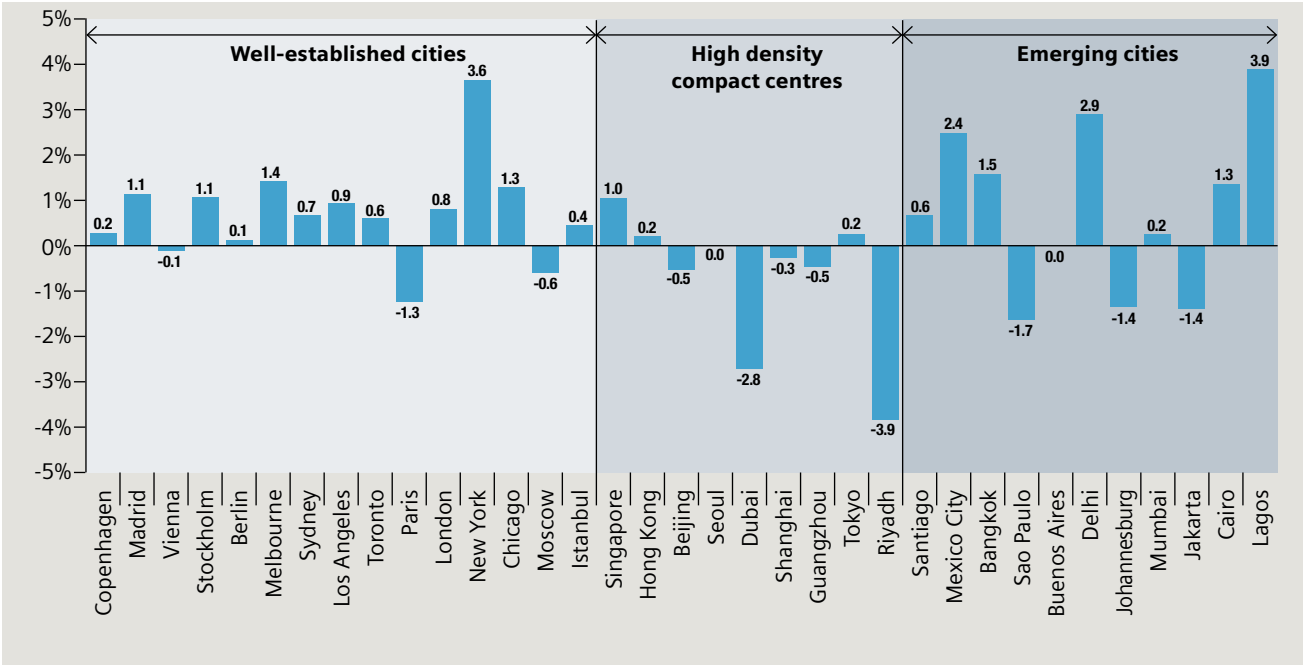


Figure 10: Change in annual cost of public transport as percentage of GDP per capita, current vs. 2030



whereas cities with insufficient plans will see transport costs consume an increasingly large portion of economic output. Yet, even for those cities with strong future plans, there are still further opportunities to gain economic benefits from investments.

In addition to helping cities lower the economic cost of transport, investing in transport improvements can also generate economic benefits. While the economic opportunity we refer to is that beyond known investment plans, to illustrate the level of benefits transport investments can bring, we have attempted to assess the impacts of some known planned investments. The examples, which are indicative in nature, range from low cost to options such as bus rapid transit to higher cost rail-based projects, details of which can be found in appendix 1. If we consider Paris' $36bn planned metro expansion, in addition to reducing its economic cost of transport, we estimate that it will generate annual economic benefits, including wider economic benefits of $2.7bn. With this level of potential benefit, it would take roughly 13 years to pay back the investment costs and in addition generate an economic value add of $46bn over the estimated 30 year life of the project. Similarly Johannesburg's phase 1C will add a further 20km of trunk roads and 240 new buses to its bus rapid transit network. The lower cost of bus rapid transit will see its $290m investment paid back in just four years, and generate additional economic benefits of $2bn over the project's lifetime. Both projects will increase capacity, quality, reliability and reduce journey times, thereby helping to lower economic cost of transport in 2030.

The economic opportunity will rise to $238bn by 2030

We estimate that by 2030, the total economic cost of poor transport across our cities will be $140bn. Meanwhile, given higher demand, the opportunity available from resolving this poor provision will have increased to $238bn, taking into account the wider economic benefits of investment (see figure 11).

The continental balance will also change, with the opportunity within Asia growing rapidly as cities there expand and modernise. As today, the absolute benefits will be greatest in those cities with the highest level of income. However, the relative benefits for emerging market cities will be even greater than today, driven by economic growth and fast population growth, rising from $22bn today to $65bn in 2030.

Figure 11: Annual economic opportunity within assessed cities, current vs. 2030

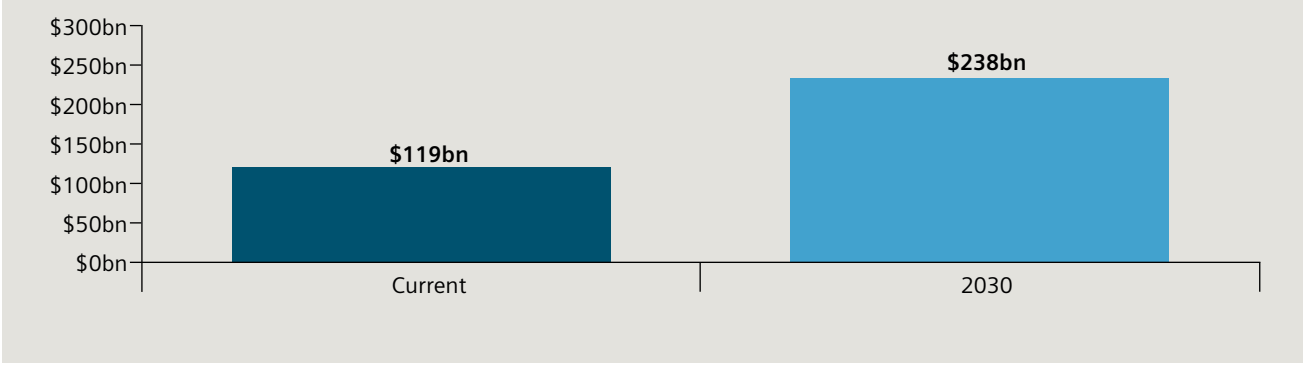
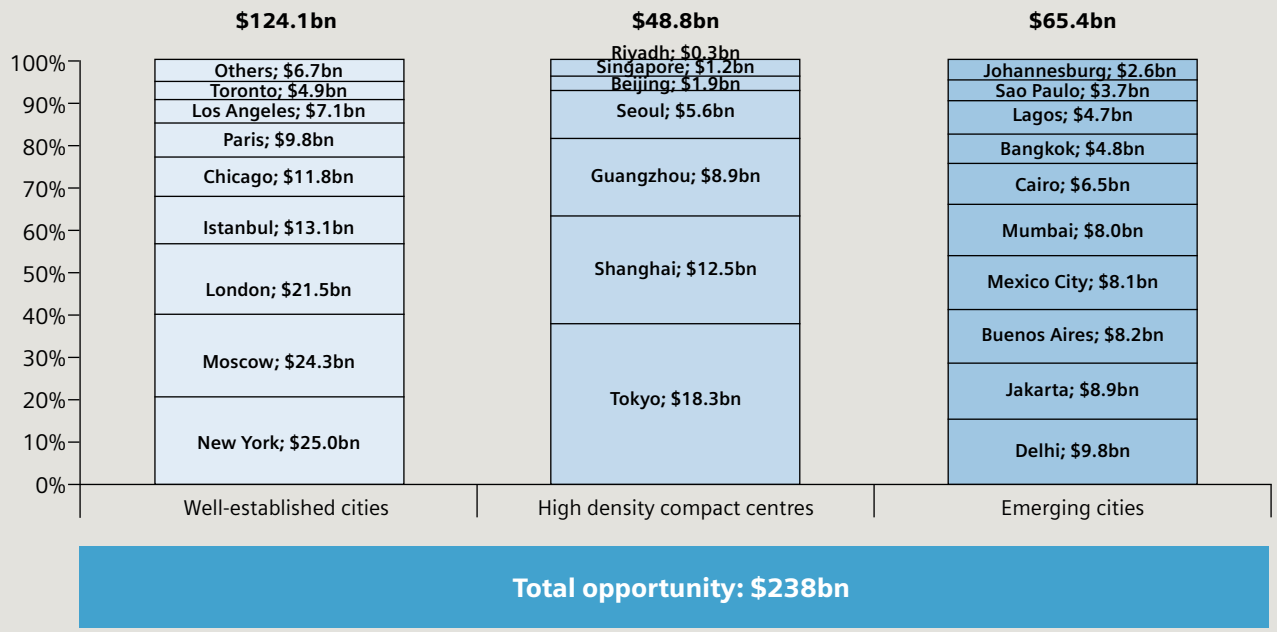


Figure 12: 2030 annual economic opportunity from addressing the mobility challenge

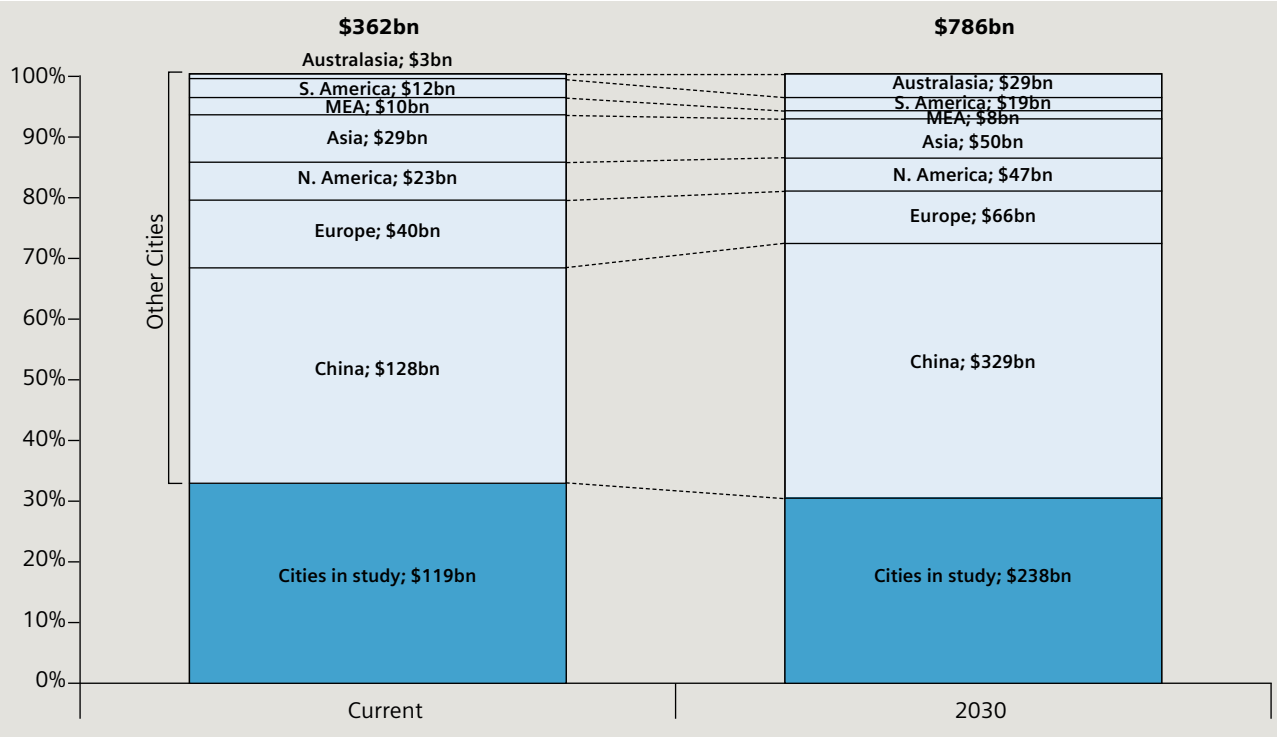


The global economic opportunity could reach almost $800bn annually by 2030

The challenges faced by the 35 cities in this study are not unique and nor is the value of improved transport. By 2030, some 60% of the world's population is forecast to live in cities. By extrapolating our analysis, we estimate that the total cost of poor mobility on economic growth in the approximately 470 cities with populations of at least 750,000 people could be around $465bn by 2030, with the full economic benefits from addressing these issues potentially reaching almost $800bn. China's opportunity is especially significant, with over 120 applicable cities, and a total potential economic opportunity of some $330bn by 2030.

Importantly, this is a single year total, and the benefits will be experienced every year that the transport investment is delivering benefit. In the case of capital investment, this could be over 30 years. If all these cities were to develop their transport networks to the efficiency level of the best cities of their type, the total potential benefit to the global economy (in present value terms, over 30 years) could reach some $15trn.

Figure 13: Total value of potential economic opportunity, cities above 750,000 population, current vs. 2030



“As cities see their economies grow, the cost of not acting to improve transport systems will rise as well, making earlier investment all the more important.”

4. How cities compare

Well-established cities

Within the well-established cities group, and overall, Copenhagen is the best performing city
Copenhagen's performance is driven in no small part by the capacity of its network and the strength of its plans, which include adding two new metro lines, one of which will be a City Circle line. These rigorous plans will help ensure that the cost of transport does not rise by 2030, even with increased demand.

Other cities would do well to learn from Copenhagen's example – even though it is currently a leading city, it is continuing to invest to maintain the efficiency of its network and meet future demand. Copenhagen's experience highlights the economic potential from incremental investment even in the absence of capacity constraints. Although it is smaller in population terms than a number of the cities in its class, others can learn from how it has successfully developed a cost-efficient transport network.

COPENHAGEN: KEY STATISTICS	
Relevant population	**1.2m**
City GDP	**$63bn**
Peak AM public transport commuters	**150k**
Light rail & metro share	**15%**
Suburban rail share	**26%**
Bus share	**59%**

SUCCESS FACTORS

- High-capacity system to meet demand
- Strong plans to accommodate future demand
- Continual investment to enhance quality

Istanbul and Moscow could benefit most from investment among the well-established cities group
Istanbul has the world's second oldest metro line, but policies favouring road and bus transport have led to chronic traffic congestion. Investment in expanding its metro network from 140km now to 400km by 2019 will ensure that costs remain broadly constant by 2030 in the face of increasing demand, but there is clear opportunity for further benefit, as costs are currently approximately twice the level of the best in class.

In Moscow, increasing capacity appears to be the biggest opportunity, but there is also a case for investing in technology such as Copenhagen's CBTC based signalling systems, or Paris' automated trains, in order to maximise the impact of capacity additions. As cities like Moscow see their economies grow, the cost of not acting to improve transport systems will rise as well, making earlier investment all the more important.

High density compact centres

Singapore is the 'best in class' in the high density compact centres group
Singapore's system is the best in class, particularly due to its strong governance and high capacity. Hong Kong also scores highly, thanks to its impressive connectivity, and the ability of its future plans to accommodate growth. Even within these developed systems, there are further incremental opportunities, for example, installing WiFi in Singapore to increase productive time on transport. However, despite its leading position for system efficiency today, it will likely slip to third by 2030 because it is not forecast to invest enough to maintain its lead.

SINGAPORE: KEY STATISTICS	
Relevant population	**5.2m**
City GDP	**$276bn**
Peak AM public transport commuters	**1.0m**
Light rail & metro share	**37%**
Bus share	**63%**

SUCCESS FACTORS

- High-capacity system to meet demand
- Strong governance integrating land and transport planning
- High levels of user functionality

Many high density compact centre cities have seriously underdeveloped systems

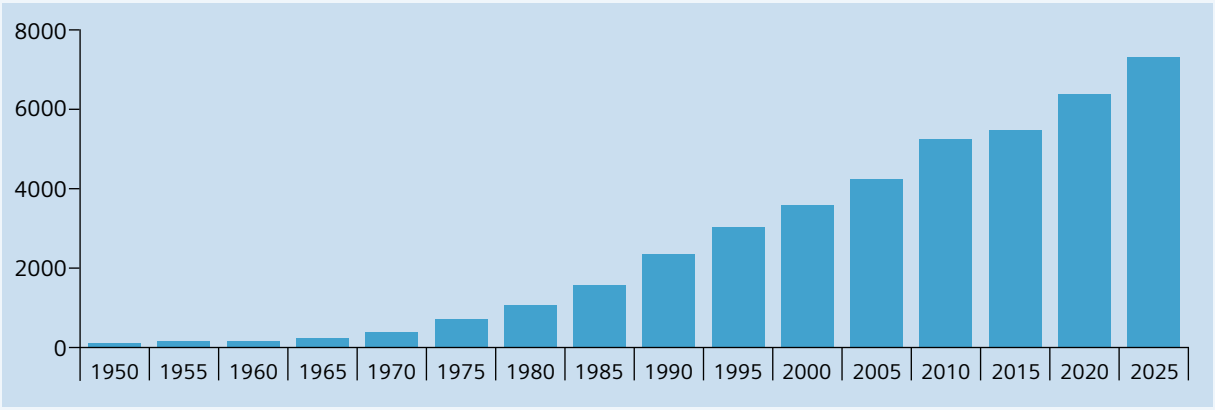
Beyond Singapore and Hong Kong, many cities in this group have underdeveloped systems with massive potential for economic benefit through widespread investment – most notably Riyadh and Guangzhou. In both, investment is ongoing. For example, Riyadh is currently investing $22bn in a new metro network with six new lines, and this should see real benefits by 2030 in terms of a reduced cost of transport for users. Other cities within this group – such as Shanghai or Tokyo – have established networks that face severe capacity pressure which are currently insufficiently addressed by future plans.

Case Study: Riyadh - developing an entire public transport network

OVERVIEW & ISSUES

Riyadh has expanded almost beyond recognition over the past century, from just 83,000 inhabitants in 1949 to nearly six million residents today, and is set to grow to over eight million people by 2030. Yet the city has a suffered from a lack of investment in its transport network. Thanks to this, and the second-cheapest petrol in the world (at around $0.50 a gallon), only 2% of commuter journeys are carried out by public transport. However, roads are increasingly congested. The city has realised that it cannot compete with the likes of Dubai or Abu Dhabi to be a leading business city in the region without an effective transport network.

Population of Riyadh, 1950-2025, thousands (Source UN)



SOLUTIONS

Riyadh is investing in a city-wide mass transit system, composed of a new six-line metro network, and a three-line bus rapid transit system. The metro will feature 176km of lines and 85 stations, and will open by 2019. The city is also investing in technology to maximise the potential of its system – automation train control (ATC) and communication based train control (CBTC) systems, for instance. This will help to maximise capacity – for example through greater train frequency – and drive generally higher service levels.

Integration will also be a key feature – all metro stations will be integrated with BRT stations, and there will be integrated payment systems across both networks. Similarly, technology will be used to maintain flows on road networks, with ITS and traffic management operated from a traffic control centre to ensure that the various modes, including car transport, work effectively as a whole.

> *"The Riyadh Public Transport Project will be a major driver of employment and economic development. It will also help to reduce traffic congestion and improve air quality,"*
>
> Ibrahim Al-Sultan, President of Arriyadh Development Authority

KEY LESSONS

- Given the lead times of major transport projects, it is important to plan for future demand today. Without this investment in capacity in Riyadh today, the lack of mobility in future would make it less attractive to residents, and in as competitive an area as the Middle East, less able to act as a major city in the region.
- Intelligently maximising capacity with high-specification technology (e.g. ATC and CBTC systems) and user functionality such as air conditioning to ensure the service is attractive and reliable.

Emerging cities

Santiago is the 'best in class' among emerging cities
Over the past twenty years, Santiago has expanded its metro to meet the changing demands of its population, modernised its ageing bus network, and created a modern, integrated mass transit network. Those cities where the economic opportunity for improvement is greatest (in terms of percentage of GDP) are typically less wealthy – for instance, Cairo and Lagos. This suggests that they may consider it more realistic to focus on low-cost options like bus rapid transit to add capacity or or incremental investments - for example technology, to maximise the benefit of existing infrastructure. However, the long-term benefits of major transport investment mean that there is still a case for cities to take a bolder approach to investment.

"Those cities where the economic opportunity is greatest are typically less wealthy so they may consider it more realistic to focus on low-cost options to add capacity and technology solutions to maximise the benefit of existing infrastructure."

SANTIAGO: KEY STATISTICS	
Relevant population	**6.0m**
City GDP	**$88bn**
Peak AM public transport commuters	**590k**
Light rail & metro share	**43%**
Bus share	**57%**

SUCCESS FACTORS

- Continued investment in network in response to demand
- Integrated approach to urban planning and transport development
- Integrating bus and metro to maximise capacity and coverage

Case study : Santiago - Creating efficient systems in emerging cities through investment in metro and the formalisation of outdated bus networks

OVERVIEW & ISSUES

In 2005, Santiago's transport network consisted of an efficient metro network, albeit with poor network density, and unmodernised, unreliable bus services with poor quality levels. The metro had opened in 1975, and despite extensions, did not serve large areas of the city. The bus network was run by thousands of private operators, typically using old, uncomfortable vehicles on congested roads. Service reliability was poor and there were many accidents. Bus stops were chaotic as each bus operator competed for business. Air pollution from ageing vehicles was a major issue.

SOLUTIONS

Santiago's metro system has been undergoing expansion since 2005. The new No 4 line was opened in 2005/6, and the existing four lines were extended over the following five years. Over the next three years, two more lines will be added. The replacement of ageing trains will improve quality.

However, the major innovation has been the modernisation of the bus network and its integration with the metro, under the Transantiago programme which commenced in 2005. This entailed a consolidation of routes, with a huge reduction in the number of operators, and the introduction of a bus rapid transit network. Bus priority measures have increased service reliability, and the introduction of over 4,000 new buses has improved the journey quality for passengers.

The introduction of the Bip! payment card has helped integrate bus and metro networks. Major implementation issues in the first couple of years have largely been resolved, to leave a more modern, efficient system. Although there is no robust data to compare before and after the reforms, bus travel has grown steadily since 2007, the average age of buses fell from eight years in 2007 to five years in 2011, and the number of accidents involving buses more than halved between 2005 and 2010.

KEY LESSONS

- Modernising bus networks and effectively integrating bus with metro networks can expand network density. Other cities which rely heavily on outdated buses operated by large numbers of private operators may consider Santiago's strategy of operator and route consolidation, and the introduction of BRT (but should be aware of the difficulties it faced in agreeing effective commercial terms).

- However, implementing major operational changes such as these is difficult. The issues faced over the first two years of the Transantiago programme showed the importance of coherent planning and having infrastructure (e.g. bus priority systems) in place in advance of operational changes.

5. Pointers for investment strategies

How can cities realise the economic benefits from improving their transport systems? Given their differing circumstances – in terms of development, population challenges, availability of funding – the solution will vary. We have identified some key pointers:

The scale of the opportunity should dictate the level of investment

Investment can drive economic uplift, but it is not the case that any level of investment is justified for any city. In less wealthy cities, although it may be possible to significantly reduce transport costs as a percentage of GDP, the absolute gain may be too small to justify large-scale investment. In richer economies though, the size of the benefit can justify major investment, as with the Crossrail project in London. However, this does not just apply to the wealthiest cities – the likes of Mumbai, Mexico City or Jakarta also have significant potential benefits that appear to justify large-scale investment.

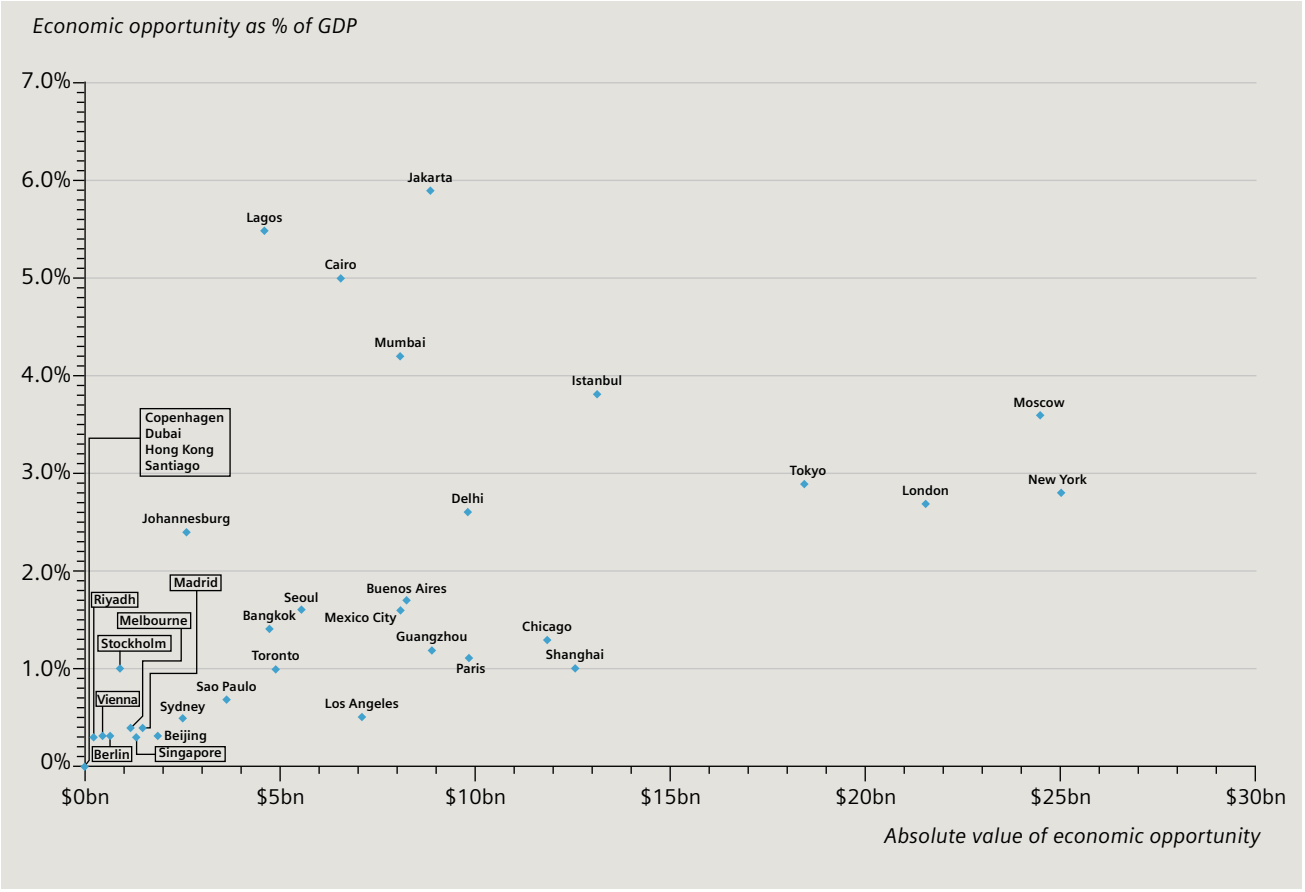
Lower levels of benefit do not rule out investing in capacity. What they may do is rule out investing in expensive ways of expanding capacity. Investing in new lines, extending networks and adding stations is likely to be expensive, but there are cheaper options – for instance bus rapid transit (along with the technology and traffic management to optimise its efficiency). Similarly, there are various ways of improving quality that require different levels of investment – from renewing rolling stock, to improving signalling, upgrading traffic management systems or installing air conditioning on existing fleet. So whilst the level of benefit should dictate the level of investment, it should not automatically dictate the type of investment.

Of course, there may be challenges in securing upfront funding for projects. But this should not prevent cities from investing in the infrastructure that they require. Innovative approaches are possible – for instance Hong Kong combines transport projects with property development to help financing.

Where the scale of the economic benefit is more limited, the focus should be on incremental investment

For the majority of cities, principally those on the left of figure 14, the relatively small absolute size of the benefit may mean focusing on low-cost investment options and incremental improvements. For instance, the TransMilenio project in Bogotá has demonstrated the potential of an integrated rapid transit bus network, and other cities such as Bangkok are now following similar paths. However, getting full value from this type of investment requires innovative

Figure 14: Comparison of percentage and absolute economic opportunities, 2030



approaches – for example using modern technology to make buses run more efficiently, or active traffic management to help ensure reliability (see next pointer).

For wealthier cities with larger benefits, large-scale investment can be justified

The absolute economic opportunity is higher in the largest, wealthiest cities. They can focus on large investment programmes in the knowledge that the economic benefit can justify the investment. For instance, Paris is investing $36bn to build 200km of new orbital automatic metro lines by 2030, as well as modernising existing lines – which will help to drive down its economic cost of transport by roughly one percentage point of GDP per capita and generate annual economic benefits including wider economic impacts of $2.7bn. With this level of potential economic benefit, it would take roughly 13 years to pay back the estimated investment cost of $36bn, and in addition generate an economic value add of $46bn over the estimated 30 year life of the project. In this case, the scale of the benefits shows that large scale investment, if executed effectively, can achieve economic uplift.

Cities with relatively high GDP and relatively poor levels of transport such as Moscow or Istanbul have the largest absolute opportunity from investing on a large scale. The impacts of city-wide investment in metro networks have already been seen in many Chinese cities such as Shanghai, and explain why these cities are well positioned for future economic growth. Such is the level of investment in China that there will be 3,000km of urban rail by 2015, and this will have doubled five years later. A similar model is being replicated in the Middle East where, building on the success of the Dubai metro, cities are committing to major public transport networks to drive mobility. Riyadh's investment into the development of a public transport network will allow it to accommodate anticipated demand growth of c. 300% between now and 2030 whilst reducing the economic cost of its transport network by around 4% of GDP per capita.

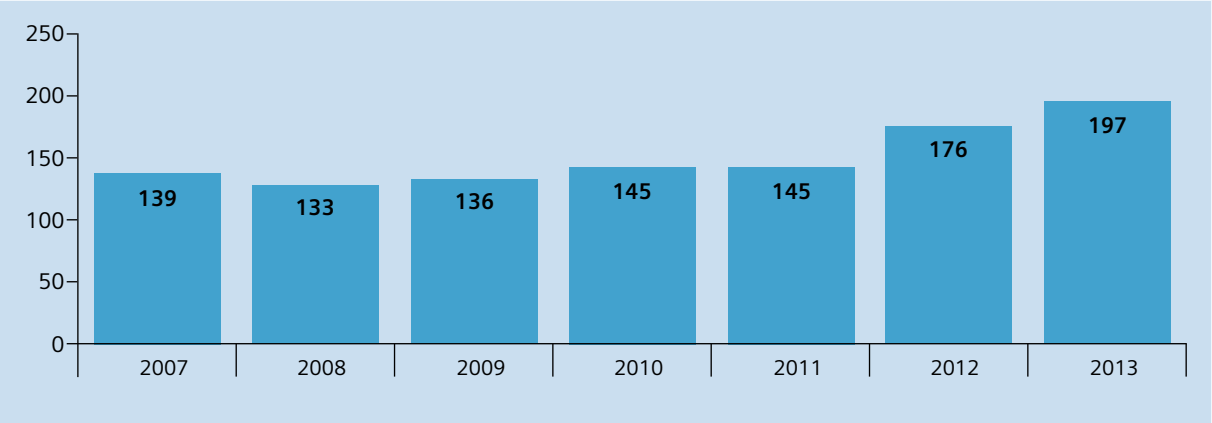
Case study: Bangkok - Raising efficiency ahead of expansion plans

OVERVIEW & ISSUES

As Bangkok's growth has outpaced the development of its transport network, it has become heavily reliant on a congested road system. Roads occupy c. 4% of the city's area, compared to 10-20% in similar cities; but since increasing road capacity is not possible, Bangkok has had to focus on utilising existing infrastructure more effectively ahead of the delivery of expansion plans.

The network currently consists principally of metro (SkyTrain, MRT), bus rapid transit (BRT), and conventional buses. Buses are the most popular, accounting for 65% of peak commuting journeys. Whilst there is sufficient capacity, congested roads mean that reliability is poor. Capacity on the SkyTrain and MRT networks is under more pressure, while the rail network's poor density means much of the city's population is unable to access the system easily.

Sky Train annual ridership, 2007-2013 (millions of passengers)



SOLUTIONS

The current Master Plan addresses capacity and network density issues, with major extensions to rail and BRT networks planned by 2030. However, given the lead times for these projects, the city has sensibly looked to maximise existing infrastructure through a range of lower cost investments that are likely to realise benefits in a shorter timescale.

A key investment has been traffic management technology to improve traffic flow on roads. The Area Traffic Control system, introduced between 2009 and 2012, offers active traffic management, such as traffic signal timing systems which automatically respond to traffic density. Traffic controls for the whole city have been integrated in one location.

User functionality on public transport has been improved by the introduction of the Rabbit Card electronic payment system in 2012. The Rabbit Card works across SkyTrain and BRT networks, and will be extended to the MRT. This has helped integrate the different modes of transport for customers. Other measures, such as real-time information and online multimodal journey planners, have also made the public transport system easier to navigate. This should help to drive public transport volumes and ease congestion on roads.

The rail network has seen a number of investments as well. CBTC signalling was installed to increase train frequency, and investment in new carriages for the SkyTrains commenced in 2012 with the extension of three car trains to four car trains. This, coupled with the introduction of the Rabbit Card, has increased usage of the rail network.

KEY LESSONS

- Even where major investment is required, cities should not ignore the potential for improvement through lower-cost, shorter lead time opportunities - for instance, technology to increase rail frequency, or new carriages to add capacity, or investing in integrated payment systems.

- Where road capacity is constrained and it is not possible to build more roads, as is the case in many cities, investing in high-tech traffic management can help optimise traffic flow and ensure that existing capacity is used as efficiently as possible.

Using technology to improve quality may be the best route to economic uplift

For some cities, investing in increased capacity is the best way to improve a system. However, where capacity is sufficient, the best route to realising economic benefits is likely to be through improving quality – reliability, functionality, usability. A balanced approach to assessing the mobility solution is crucial – examining both the quantity and quality of transport networks shows where improvement is needed. Figure 15 compares cities for quantity and quality of transport (in terms of congestion, comfort and ease of use).

Cities such as Cairo, Buenos Aires or Mumbai should add new capacity.
How to add capacity will depend on existing geography and the level of investment available – for instance, investing in bus rapid transit systems is likely to be more realistic in Cairo, whereas richer cities may be able to increase rail capacity. The economic impact of sufficient capacity is clear: cities such as Santiago, Copenhagen, and Singapore which have invested in this area are amongst the most cost-efficient in our study.

Cities such as Mexico City and Santiago should focus on improving the quality of their existing systems.
The immediate priority for these cities should be areas such as new fleet that includes modern technologies to offer a better user experience (for instance Santiago is buying 58 new trains to replace some of its forty-year-old stock), or improving reliability and punctuality. Areas of spend such as traffic management, signalling, or integrating technologies will be more efficient in capturing economic gain than new capacity. For instance, Beijing's use of the Yikatong system-wide electronic payment card (which can even be used in taxis) and its roll-out of real-time information across more than 100 bus routes have created a user-friendly, cost-efficient network. Although Sao Paulo's physical transport capacity is severely constrained, it has invested in technology to optimise current networks, such as latest-generation CBTC signalling systems on the metro, and the Interligado bus network's use of optimised routes, integrated fares, and extensive bus priority measures.

Integrating technologies can offer important incremental improvements.
At its most advanced, integrated technology can spread demand throughout the system to use existing capacity efficiently, through integrated journey planners based on real-time information. Technology can also improve network reliability, through advanced signalling on rail networks or traffic management on bus systems. Cities such as Sao Paulo and Bangkok have shown the benefits that innovative technological approaches can bring to lower-cost solutions such as bus networks, through integrated fare systems and payment cards and improved traffic management. Cities

Figure 15: Comparison of current transport attractiveness and capacity

such as London and Berlin have shown how a user-friendly experience can improve the quality of a system and bring real benefits. We therefore highlight two key areas for integration:

- First, using technology to strengthen operational efficiency - improving service reliability, allowing increased frequency of services, and therefore higher effective capacity.
  - Investment can focus on traffic management, bus priority systems, signalling, or automation of train networks.
  - Integrated ticketing - either across modes as with London's Oyster card, or across different bus operators, as with Sao Paulo's Interligado system - can improve the way passengers use a system, and help to drive volume.

- Second, capitalising on that technology to provide more information and flexibility to passengers in planning integrated journeys across modes. Journey planners informed by real-time information systems, such as in Berlin, are especially useful.
  - Investing in the technology to integrate different modes across the network can really benefit the customer. This is likely to require an integrated platform to allow integrated electronic ticketing, joined-up journey planning, and real-time information across the network.

Customer-facing technology is key to some of the most efficient systems

Our assessment of transport networks included the use of passenger-facing technology, taking into account the presence, and level of cross-mode integration, electronic payment systems, online journey planners, real-time information and public-facing live traffic information. Those cities which had invested in this technology typically experienced a lower cost of transport. In Madrid an integrated public transport card can be used to pay all modes, supported by a multi-mode journey planner which can recommend optimum routes based on different criteria (e.g. fastest or fewest transfers), with real-time information integrated with popular apps. This offers a truly integrated passenger experience, and shows how cities can use technology to integrate their networks, gain incremental benefits and promote intermodal shifts.

Urban rail networks are a key way for larger cities to meet capacity demand

A common feature of the most efficient networks is a focus on urban rail capacity. Copenhagen, Santiago, and Singapore have all invested significantly in metro or light rail capacity, and now run the most cost-efficient networks in each of their classes. Similarly, those cities whose networks appear best placed to face the demands of 2030 have ambitious rail investment plans – for example Riyadh, Paris and Copenhagen.

Rail may be high-cost, but the economic benefits can be significantly greater

The business case for London's Crossrail project showed a benefit-to-cost ratio of 2.8:1, even before consideration of wider economic impacts. Similarly, rail's ability to add significant capacity to existing systems appears a key driver of cost efficiency. Whilst smaller or less wealthy cities may be better off focusing on lower-cost capacity additions, larger cities should aim higher to maximise economic gain. Large projects require not only the ability to invest, but also the strength of governance to plan on a grand scale to meet the challenges the world's largest cities will face over the next 20 years and beyond.

London's answer to future capacity challenges has been to invest in urban rail (with Crossrail) and this is also a feature of major investment elsewhere. London's ageing transport network has seen underinvestment for some time; since it was built, the population has grown exponentially, and the economic cost of not investing has necessitated projects on the scale of Crossrail. The investment in Crossrail will not on its own bring London's transport network in line with the 'best in class', but it will enable it to keep pace with future demand growth better than, for example, adding bus capacity. The value of large-scale investment can also be seen in Dubai, where major investment in expanding its driverless train network from 75km currently to around 320km by 2020 will bring down the cost of transport by around 3% of GDP per capita by 2030.

Investing in new lines is not the only way to improve rail networks. New trains can offer increased capacity – as with the new S7 and S8 stock on the London Underground. They can also improve quality, such as air conditioning on the new London Underground trains, which may make users more productive and comfortable, and so help drive increased usage.

Case study: London - Major investment in infrastructure to capture wider economic impacts

OVERVIEW & ISSUES

Much of London's rail infrastructure was initially built in the first half of the last century and is now increasingly under pressure because of age and increased demand. Whilst the population of London is roughly the same as in 1950, the number of tube journeys has almost doubled. Yet, aside from addition of the Victoria Line in the late 1960s and the Jubilee Line in 1979 (extended in 1999), the Underground infrastructure is largely unchanged. In addition, the city is now a different shape, with densely populated areas such as Battersea poorly served. Underinvestment had led to a congested and ageing network.

SOLUTIONS

Crossrail is a major £15bn investment, creating a direct link across the centre of London from east to west, and adding capacity for a further 200k passengers at peak times by 2026. Whilst the investment is significant, the benefits are expected to far outweigh the cost – with a direct benefits ratio of 2.8-1, and between 4 and 7.7:1 once wider economic impacts are included.

The city has also kick-started the Thameslink programme, a £5.5bn scheme to extend and add capacity to the suburban rail line which had been discussed since 2000. Further rail expansion projects are being considered – a Northern Line Extension to serve Battersea, and a second phase of Crossrail, which would run from the southwest to the northeast of the city. These plans show an acknowledgment of the need to add capacity to meet future demand, and an acceptance of the benefits that rail projects can bring despite the initial outlay.

Crossrail: key project details	
Cost	**£15bn**
Length of lines (total)	**118km**
Length of lines (in London)	**c.45km**
Number of stations	**40 (incl. nine new central London stations)**
Capacity	**200m passengers p.a.**
Increase to rail capacity in London	**10%**

KEY LESSONS

- When faced with capacity challenges and a congested road network, new rail capacity is likely to be the only way to effectively meet demand growth. Many developed cities faces congestion across both public transport and roads, and given the need for a step change in capacity, new rail lines are the best option.

- Although the initial investment required can be large, the direct benefits are likely to exceed the costs even before the consideration of the wider economic benefits; and in more economically developed cities, these can be significant, particularly if transport investment is used to regenerate areas.

Integrated governance is crucial in planning and operating an efficient network

Investing in transport is important, but does not guarantee that the schemes will be effective. Cities need an integrated transport network with the appropriate governance and oversight to maximise the value of investment and ensure that the network continues to evolve.

Integrated governance has been a key factor in enabling major investment in transport networks to meet the challenges of future demand. For example, in London, the introduction of the mayoral system has led to more integrated governance across different modes of transport and a more integrated network. This helped to make the most of existing infrastructure even before the large investment in Crossrail. The city has been able to lay out clear plans under the Mayor's Transport Strategy, developed alongside a broader London Economic Development Strategy. These are effectively cascaded into sub-regional plans by mode of transport, and with government support for key projects. Effective governance helps to create clear, resilient, and suitable future planning.

This is a key area where cities can learn from each other. Across South East Asia, for example, Singapore has become a model for how effective governance can ensure an effective transport network and drive down cost.

Integration between transport authorities and broader governmental authorities (e.g. planning at a regional or national level) can also be important in creating successful transport systems. Such integration has enabled Santiago to react to changing population patterns, extending the metro to meet new demand and creating a more efficient transport network. Similarly, in Copenhagen, the 2011 Municipal Plan covers all aspects of city planning to 2025, as well as integrating with a broader National Transport Infrastructure plan. This helps to make Copenhagen's future plans seemingly some of the most effective in our study at positioning the city for future growth.

Case study: Singapore - Ensuring appropriate governance to drive benefit from transport

OVERVIEW & ISSUES

Singapore has one of the most cost-efficient transport networks in our study, with large capacity and high quality services across its mass rapid transit (MRT) rail network and bus services. However, the city's constricted geography has created its own challenges as the population has grown from around three million in 1990 to over five million today. This, coupled with increasing wealth and expectations from its residents, has placed its transport network under pressure.

SOLUTIONS

Established in 1995, the Land Transport Authority (LTA) is responsible for overseeing the infrastructure for land transportation within Singapore. Integrated governance has allowed a holistic approach to planning across all modes – from the MRT and bus networks, to private travel by car, bicycle and foot, including the development of a unified payment system across all bus and transport operators, enhancing the attractiveness of its public transport.

The LTA has taken a long term view – first publishing a Master Plan in 2008, and updating it in 2013. The current Master Plan covers the next twenty years, and addresses the challenges of increasing population, economy and expectations across all modes of transport. It focuses on increasing public transport usage to manage future road congestion, by increasing capacity, network density and integration.

The combined 2008 and 2013 plans will see four new MRT lines built, and five extended by 2030 so that 80% of homes will be within a 10 minute walk of a train station. Connections to the rail network on foot will be improved with sheltered walkways, and the off-road cycle network will be expanded. Bus services will be improved by adding new bus priority measures and introducing a new bus fleet management system which will include real-time information for passengers. Integration across modes will be improved by adding a further seven hubs linking MRT and bus networks to the existing six by 2023.

KEY LESSONS

- Integrated governance across all modes can help to create a network that meets evolving demands in the face of a growing population and land capacity constraints. Large-scale networks are likely to use multiple modes of transport, and their integration is crucial for an effective system.

- Given the timescales required to develop major transport projects, long-term planning is necessary to meet future demands. This does not rule out adaptability – as shown by the way the LTA has built on its 2008 Master Plan with the updated 2013 version.

Singapore plans by mode	
Metro (MRT)	• Four lines to be added & five extended, taking network length from 138km in 2008 to 360km by 2030 • Eight out of 10 homes to be within 10 minutes' walk of MRT station by 2030
Bus	• Over 40 new bus services, with a 20% increase to fleet
Cycle	• 90km of cycling paths to be added to bring total off-road network to 190km by 2020
Walking	• Adding sheltered walkways between bus and MRT and trip-generating hubs
Integration	• Seven new hubs to integrate MRT & bus by 2023

Cities should act now

Cities can invest in their transport networks in a range of ways. Even 'best-in-class' cities have opportunities for further improvement; indeed if any city were to stand still and not maintain investment in their transport network, their cost of transport would rise by 2030. However, cities have differing needs and differing levels of potential benefit: for some the focus is on capacity, for others it is service quality. For some cities, the scale of benefits justifies large-scale investments, whereas in others the focus must be on low-cost improvements. But cities should not be afraid of the upfront costs of investment, since the economic benefit from improving their transport systems is likely to repay that investment many times over.

Appendix 1: Selected investment cases

To consider the benefits of individual projects and how transport investment can pay off, we have attempted to assess the impacts of a selected number of planned transport projects. The examples vary by geography and by scale of investment: from low cost projects such as bus rapid transit to higher cost rail-based projects. For each case we give a short summary about the planned investment, its anticipated benefits – such as the direct benefits to commuters and other transport users and the indirect benefits from the wider economic impact. Based on the anticipated benefits, we can estimate the number years it takes for a project to pay back, as well as the benefits it is expected to generate over an estimated lifetime of 30 years. It is important to note that the exercise is indicative in nature and that all figures are estimates, including the investment costs, which are based on publicly available data. In addition to the quantitative assessment, we make a qualitative assessment of how the project will affect crowding, reliability, quality, and journey times, all of which were included in the metrics to assess the effectiveness of a city's transport network. According to our methodology, these elements would impact a city's economic cost of transport and in each example our projections show that the economic cost of transport will fall in 2030.

The featured cases include:

- **Johannesburg** bus rapid transit extension
- **Moscow** metro extension
- **Paris** metro extension
- **Sao Paulo** monorail extension

JOHANNESBURG

Investment in bus rapid transit is expected to pay off in shorter timescales than major metro investment

- The Rea Vaya bus rapid transit system in Johannesburg currently comprises 48 stations and 59km of trunk roads
- Phase 1C, which commenced construction in March 2014 and will be completed by 2017, adds a further c. 20km of trunk roads and 240 buses to the fleet
- The lower cost of BRT vs. rail is expected to see investment paid back in a shorter timeframe than larger investments

Qualitative Assessment

Crowding	↓	• Bus capacity will increase by 30%, helping to reduce crowding levels
Reliability	↑↑	• Dedicated BRT lanes improve reliability vs. regular buses currently in place on many routes
Quality	↑	• New fleet will improve user experience and service quality
Journey time	↓↓	• Journey times likely to reduce thanks to dedicated bus lanes

Sources: Rea Vaya website, UN Urbanisation Statistics, World Bank, Credo research & analysis

Quantitative Assessment

Investment (Current $)	~$290m
Timescale	Now - 2017
Change in economic cost of transport (% GDP per capita until 2030)	20.3% →20.1%
Annual value of benefit - Direct **Annual value of benefit** - Wider economic impact (by 2030)	$50m $25m
Years to pay back (Including wider economic impact)	~4
Economic value add (Value over life post payback)	$2bn

MOSCOW

Putting the metro in walking distance of 90% of Moscow's citizens

- Investment addressed includes 120km of metro line extensions, including 57 stations to be added by 2020
- These schemes will increase the capacity of the Moscow metro by around 40% (in terms of passenger km)
- Network density will be improved, with 90% of Moscow's citizens in walking distance of a metro station by the end of the programme
- 150 construction sites, 20 complex tunnel developments and 40,000 workers over the construction period

Qualitative Assessment

Crowding	↓↓	• New capacity will help alleviate crowding and extend metro network
Reliability	↑	• On new lines with new rolling stock
Quality	↑	• Focus on capacity over information and interoperability
Journey time	↓↓↓	• Point to point journey times between suburbs and to outlying business districts reduced

Sources: Moscow Department of Transport, UN Urbanisation Statistics, World Bank, Credo research & analysis

Quantitative Assessment

Investment (Current $)	~$13.5bn
Timescale	Now-2020
Change in economic cost of transport (% GDP per capita until 2030)	16.8% →16.5%
Annual value of benefit - Direct	$0.6bn
Annual value of benefit - Wider economic impact (by 2030)	$0.3bn
Years to pay back (Including wider economic impact)	~15
Economic value add (Value over life post payback)	$14bn

PARIS

Grand Paris Express metro extension is expected to realise material economic benefit

- 200km of new metro line focused on connecting the outer suburbs by 2030
- The investment will construct four new orbital metro lines (Lines 15, 16, 17, & 18)
- The investment will increase capacity on the metro network by around 20% (in terms of passenger km)
- Paris is also investing to improve the quality of existing metro and RER lines, although we have excluded this investment from our analysis

Qualitative Assessment

Crowding	↓↓	• Extra capacity in outer rings takes passengers off main metro
Reliability	↑↑↑	• New rolling stock and lines highly reliable plus improvements to existing routes
Quality	↑↑	• Interoperability, information systems and WiFi
Journey time	↓	• Point to point journey times between suburbs and to outlying business districts greatly reduced

Sources: Railway Gazette, Railway Technology, UN Urbanisation Statistics, World Bank, Credo research & analysis

Quantitative Assessment

Investment (Current $)	~$36bn
Timescale	2015-2030
Change in economic cost of transport (% GDP per capita until 2030)	13.8% →12.6%
Annual value of benefit - Direct **Annual value of benefit** - Wider economic impact (by 2030)	$1.6bn $1.1bn
Years to pay back (Including wider economic impact)a	~13
Economic value add (Value over life post payback)	$46bn

SAO PAULO

Extensions to monorail are expected to pay back investment within five years

- Sao Paulo has a wide range of investment plans in place; we assess the plans to extend its monorail network
- The lines we assess are the 24km Expresso Tiradente, which is expected to be completed by the end of this year, and the 18km extension to Line 17 (Gold) line
- The city is also investing in its network in a number of other areas, such as through new fleet, but this investment is excluded from our analysis

Qualitative Assessment

Crowding	↓	• 15% growth in capacity across monorail will reduce crowding
Reliability	↑↑	• Automatic train operation and vehicle management systems likely to improve reliability
Quality	↑	• New rolling stock will improve user experience
Journey time	↓	• Journey times will reduce as passengers are able to avoid using congested road network

Sources: Railway Technology, UN Urbanisation Statistics, World Bank, Credo research & analysis

Quantitative Assessment

Investment (Current $)	~$3bn
Timescale	2013 - 2014
Change in economic cost of transport (% GDP per capita until 2030)	15.0% →14.6%
Annual value of benefit - Direct	$0.4bn
Annual value of benefit - Wider economic impact (by 2030)	$0.2bn
Years to pay back (Including wider economic impact)	~5
Economic value add (Value over life post payback)	$15bn

“The opportunity highlighted in 2030 takes into account known investment plans; as such the benefit we show is incremental beyond investments already announced”

Appendix 2: City profiles

This section gives a snapshot view of each city featured in the study, detailing the potential economic uplift each could experience by improving public transport services to the levels of the best-in-class city in its respective category. The opportunity highlighted in 2030 takes into account existing investment plans; as such, the benefit we show is incremental beyond investments already announced. In all cases, this value is an annual benefit; this should be considered in light of the lifespan of transport projects, and the extended period over which benefits are likely to be realized.

Based on the data collected for each city, we outline their strengths and weaknesses and offer some high-level recommendations on how the featured city could potentially access the economic uplift highlighted. For a full explanation on how this value was derived please refer to the methodology in appendix 3.

This economic uplift was identified based on the current performance of a city's public transport. The metrics used in compiling this performance are detailed in the urban mobility metrics table in the methodology. When it comes to interpreting a city's public transport performance, it is worthwhile to note that some results are based on a relative benchmarking against the other cities featured in the study and therefore may differ to conventional perceptions of the transport performance of a particular city. Relative scoring is used for the following metrics 'current congestion and crowding,' 'sufficient capacity to accommodate growth,' 'affordability,' 'density of network,' and 'connectivity to other major cities'. Relative metrics help us to convert analytical output into intelligible scores and compare performance across networks; however, this may mean in some categories (e.g. affordability, network density), one or two high performers can make other cities score relatively low by comparison. The other metrics are scored against a set criteria, and as such, are not relative. For further details please refer to the methodology.

The city population assessed is typically that of the metropolitan area with a few exceptions where we have taken the population of the "city proper" as this more closely represents the area served by the transport network. Where this is the case, we have noted it on the city profile. GDP is assessed in line with the relevant population we have included in our study. Where possible we have used the same data source for all metrics to ensure that the results are consistent. Where published data sets were unavailable, we have used proprietary research.

BANGKOK

CURRENT GDP: $109bn[1]
POPULATION: 8.4m[1]
CITY TYPE: Emerging

Bangkok's network has reasonable capacity, and clear plans to accommodate future growth, but without investment in quality, the full benefits of its system won't be realised

STRENGTHS

- Investment in bus network has created a system with a reasonable level of capacity
- Use of integrated electronic ticketing (through the Rabbit card), real-time information systems and live traffic information improves usability of system
- Clear and resilient plans, linked with broader city development plans, bode well for the future

CHALLENGES

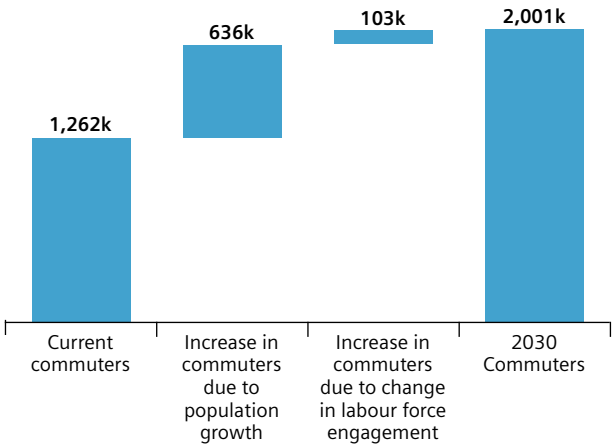
- The low network density score reflects poor public transport coverage within the city
- Lack of connectivity to other cities means that Bangkok may be poorly positioned to maximise the wider economic benefits of future transport investment
- An ageing fleet on the network and a lack of connectivity (for instance WiFi) mean that travel time is typically unproductive for users
- Cancellation of majority of bus rapid transit lines has reduced future capacity and efficiency gains

RECOMMENDATIONS

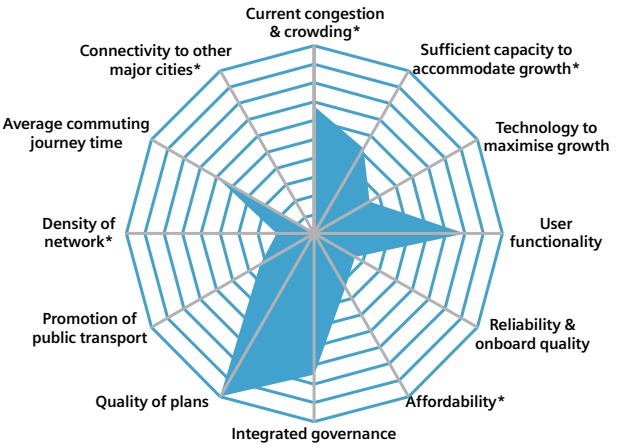
- Focus on incremental investment to improve quality of current system (e.g. new fleet, WiFi), and on optimising efficiency of current infrastructure

SCALE OF THE CHALLENGE

Volume of peak AM commuters

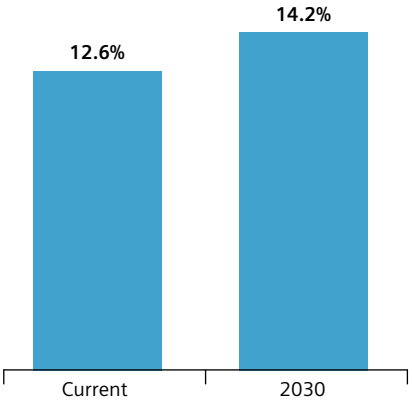


CURRENT PUBLIC TRANSPORT PERFORMANCE



Note: *Metrics scored out of ten; shading further from centre indicates higher score.*
**Indicates metric scored relatively; all other metrics are absolute*

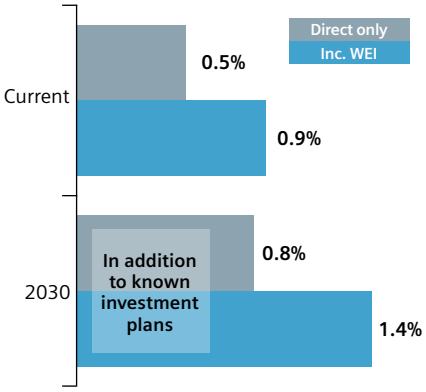
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

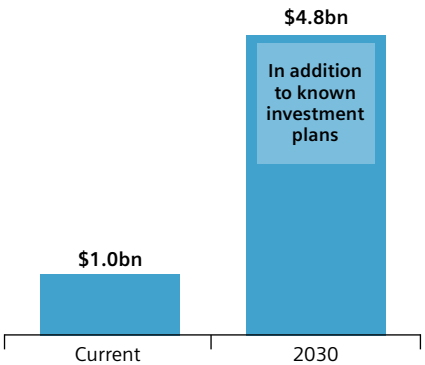
OPPORTUNITIES

Size of the opportunity (% of GDP)



Note: *The **WEI** includes the wider economic impacts of transport investment, rather than the direct impact to transport users alone*

Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

BEIJING

CURRENT GDP: $159bn[1]
POPULATION: 11.5m[1]
CITY TYPE: High density compact centre

Beijing offers a high quality, affordable service to its users, but population growth appears likely to exacerbate current capacity issues

STRENGTHS

- A highly user friendly network, thanks to the system-wide Yikatong payment card, and ongoing roll-out of real-time information across the bus network
- Extensive use of bus priority measures, traffic management and modern signalling technology maximise the potential of existing capacity
- High levels of affordability for users

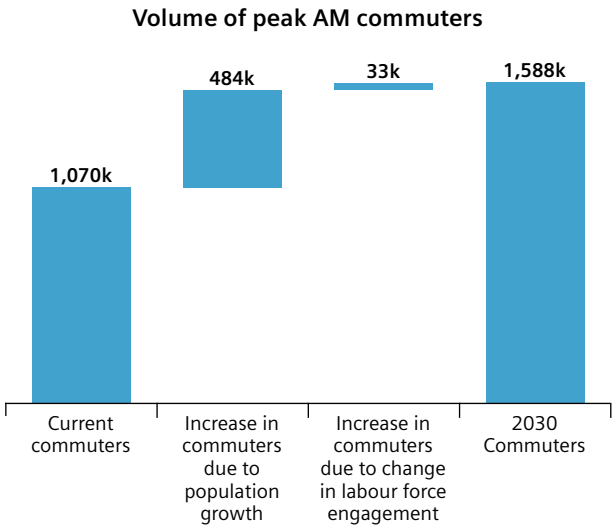
CHALLENGES

- The current capacity issues in Beijing's transport network are likely to be exacerbated as the population increases to 2030
- Capacity issues appear most acute on the metro network (although expansion plans are in place), whilst bus capacity appears less constrained
- A lack of clarity in terms of governance (between local and national agencies) and funding restricts the city's ability to plan for the future

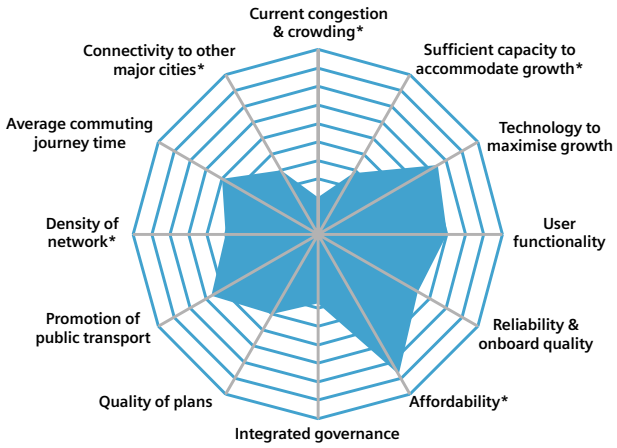
RECOMMENDATIONS

- Create clear and resilient plans for future
- Focus on investment to increase capacity, and consider whether existing metro expansion plans are sufficient

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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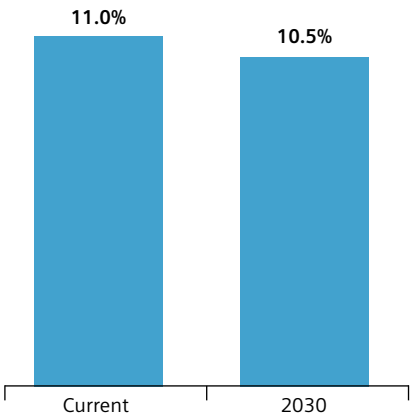
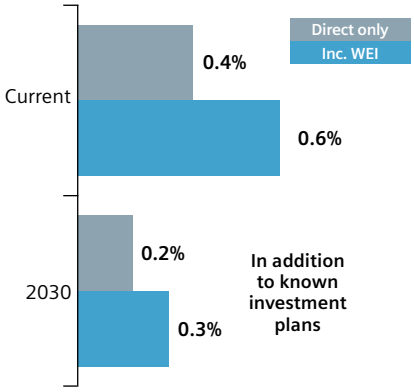
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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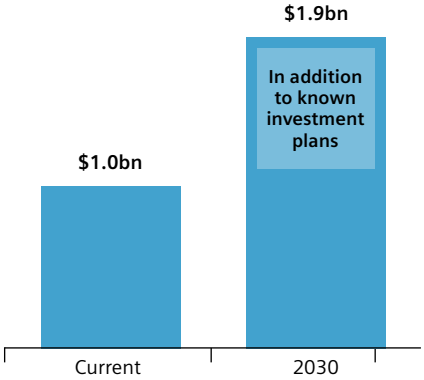
Annual value of the opportunity (US$)



Note: [1] City population based on 'city proper", taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

BERLIN

CURRENT GDP: $118bn[1]
POPULATION: 3.5m[1]
CITY TYPE: Well-established

Berlin operates a high capacity system with good user functionality; future investment should focus on improving service quality, particular on the bus network

STRENGTHS

- Network capacity is sufficient for current demand across all modes
- Strong governance through Department for Urban Development has enabled development plans to 2025 to be clear and detailed
- High levels of user functionality thanks to integrated customer facing systems for journey planning and live travel information

CHALLENGES

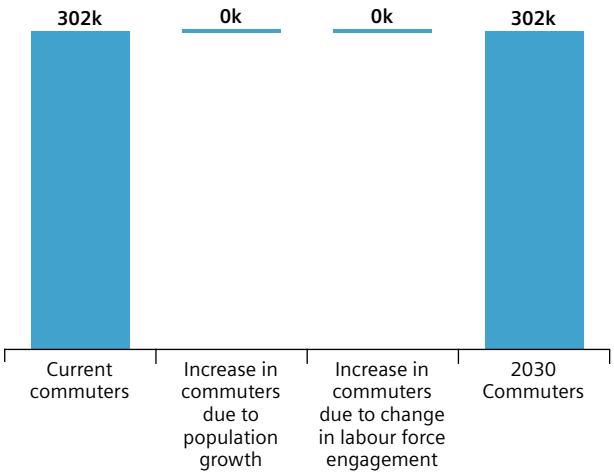
- Although capacity is sufficient, the network is relatively low-tech, with an ageing fleet on the metro
- Payment technology appears outdated, and is not fully integrated across modes
- Although there is a mobile network on the U-Bahn, a lack of WiFi means productive time whilst travelling is restricted
- Reliability on the bus network is relatively poor, with 85% of buses on time (compared to 97% of all U-Bahn trains)

RECOMMENDATIONS

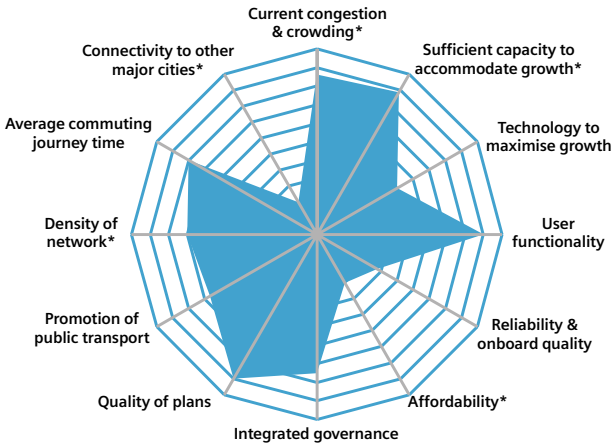
- Expand network to meet growing demand from suburbs
- Maintain quality of rail infrastructure and focus on incremental quality-driven investments to enhance user experience or technology
- Targeted investments to relieve bottlenecks on rail network
- Improve reliability of services on bus network

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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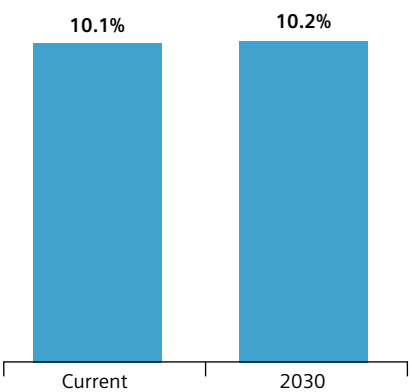
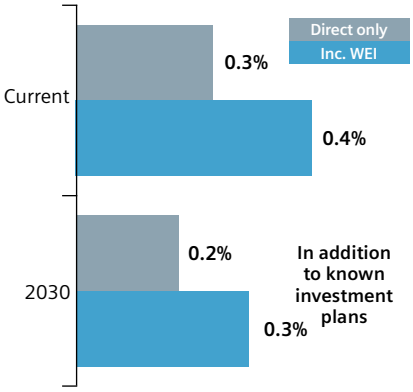
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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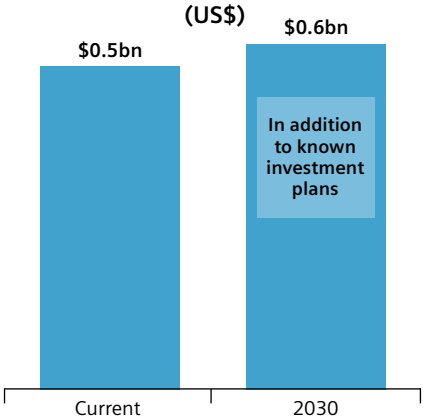
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

BUENOS AIRES

CURRENT GDP: $244bn[1]
POPULATION: 13.5m[1]
CITY TYPE: Emerging

Buenos Aires faces major capacity challenges, and although investment in metro is planned, more is likely to be required to realise the full potential benefits

STRENGTHS

- Addition of three new metro lines will go some way to easing current capacity constraints by increasing length of metro line by around a third
- SUBE card integrated payment system, WiFi on metro, and effective journey planning systems create a relatively user-friendly experience
- Recent introduction of bus rapid transit system likely to improve network efficiency

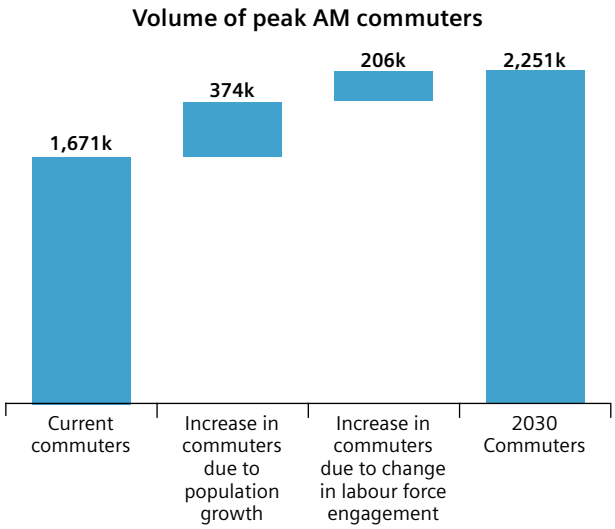
CHALLENGES

- Future capacity on suburban rail and bus networks appears constrained, with the latter particularly important given its high share of journeys
- Metro rolling stock is currently amongst the oldest in the world at c.50 years (although 800 new cars will arrive over the next two years)
- The lack of capacity on the network is made worse by a lack of infrastructure optimisation (e.g. through traffic management)

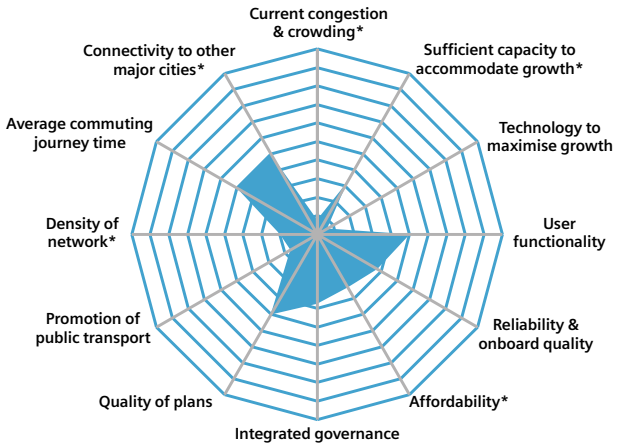
RECOMMENDATIONS

- Invest in expanding capacity further – either at low cost through extending BRT and by adding metro capacity
- Invest in innovative technology to find incremental improvement opportunities e.g. traffic management

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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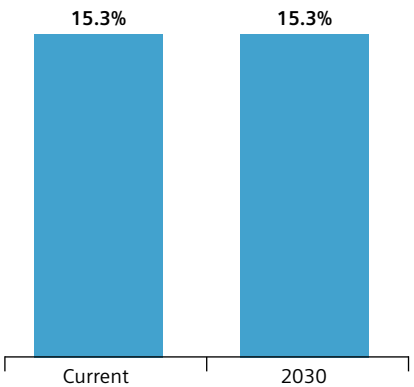
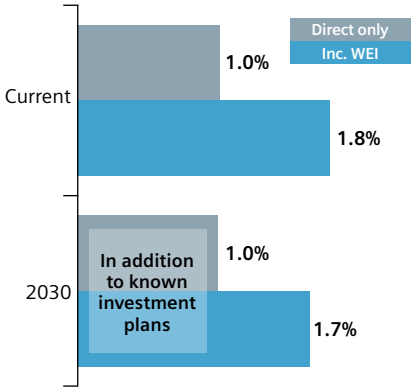
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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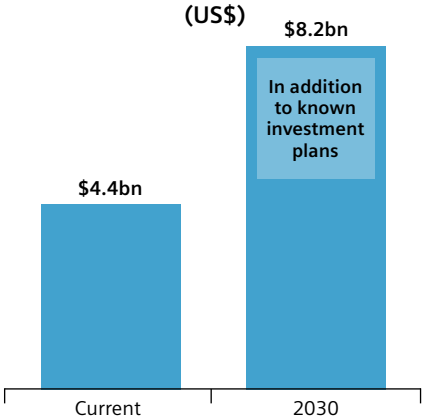
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

CAIRO

CURRENT GDP: $55bn[1]
POPULATION: 11.2m[1]
CITY TYPE: Emerging

Cairo faces challenges across a range of metrics, and requires a clear long term investment strategy to unlock the potential economic benefits of transport

STRENGTHS

- Cairo's transport system is one of the most affordable to users of the 35 cities in our study
- The city's high levels of connectivity to other cities means it is likely to be able to capture the full benefit of the wider economic impacts of investment
- Two new metro lines by 2020, from Nasr to Port Said St and from Shubra to Maadi, will go some way to easing current capacity issues

CHALLENGES

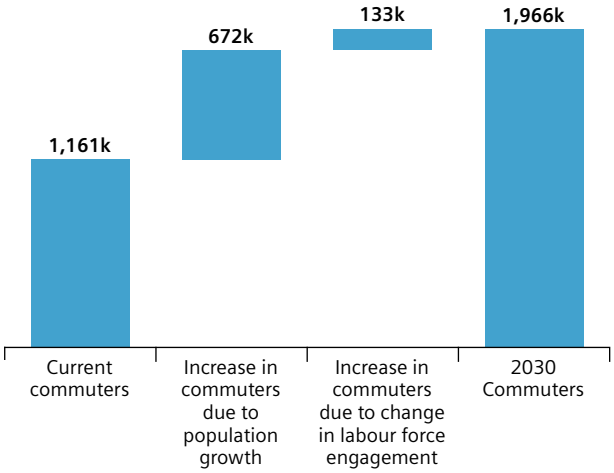
- Current capacity across both bus and metro is severely constrained, and current expansion plans are not expected to materially alleviate this
- Current service reliability levels are low, and high levels of road congestion driven by low public transport usage exacerbate this
- Public transport lacks user functionality – with very limited integration, journey planning or real-time information
- Similarly, technology has not been exploited to improve service levels

RECOMMENDATIONS

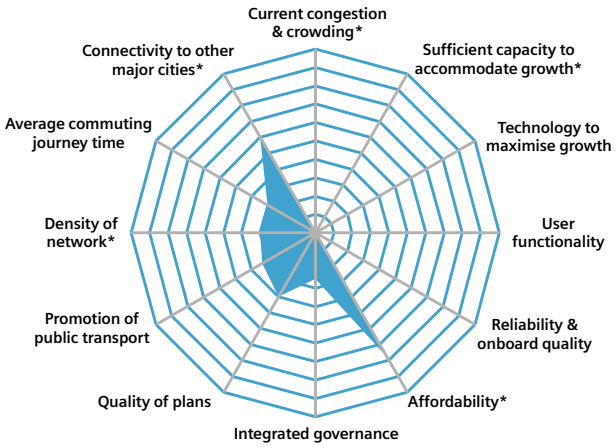
- Increasing capacity and reducing road congestion are key – the size of the benefit by 2030 suggests investment in bus rapid transit or light rail could be justified

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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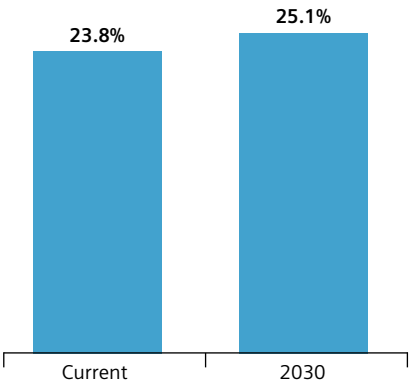
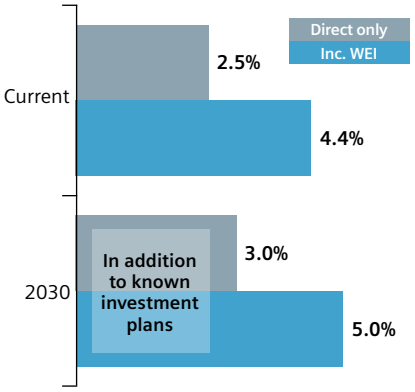
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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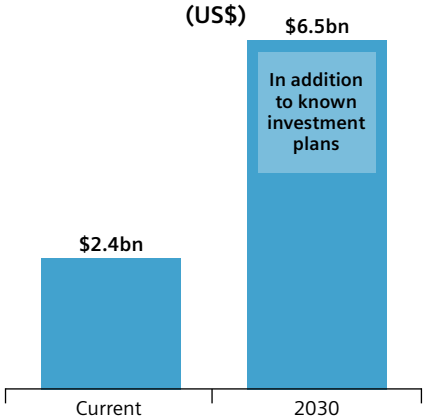
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

CHICAGO

CURRENT GDP: $532bn[1]
POPULATION: 9.7m[1]
CITY TYPE: Well-established

Chicago's ongoing investment programme will improve quality, but the scale of the benefits mean that large scale investment in capacity may also be justified

STRENGTHS

- Impressive user functionality, including integrated electronic payment systems (despite implementation issues), multi modal journey planning and real-time information
- Plans are in place to address capacity constraints with new circle metro line, and increased train speed limits
- Ongoing investment plans worth $4bn will improve the quality of trains and stations

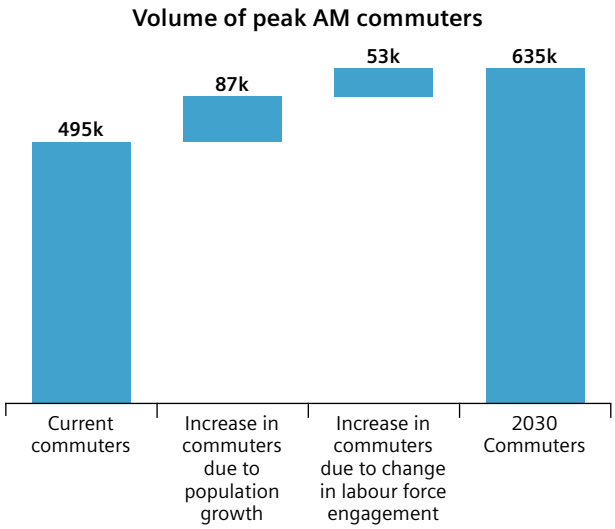
CHALLENGES

- Both current and future capacity appears severely constrained across buses and metro
- The majority of the metro fleet is over 20 years old, with the bus fleet over five years old, although we note this is being addressed
- For a city of its size, the density of the network is low, making the network less appealing to passengers
- Investment in technology has been limited thus far – signalling systems are outdated for instance – so the existing network is not optimised

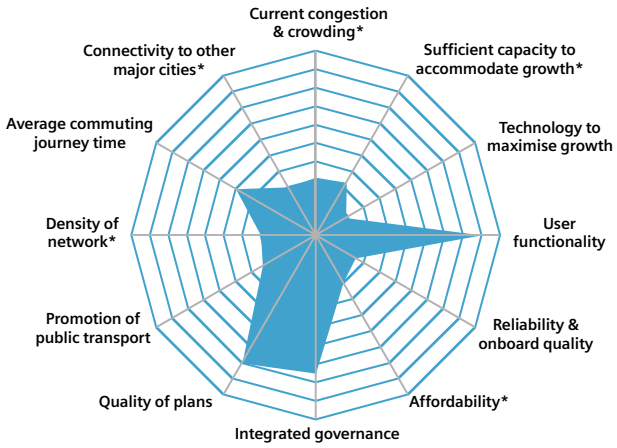
RECOMMENDATIONS

- Major investment in capacity such as new metro lines is required, and can be justified by the scale of the economic benefit
- Additionally, further investment in technology may help optimise the system

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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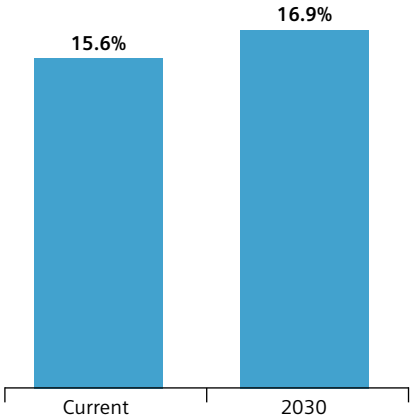
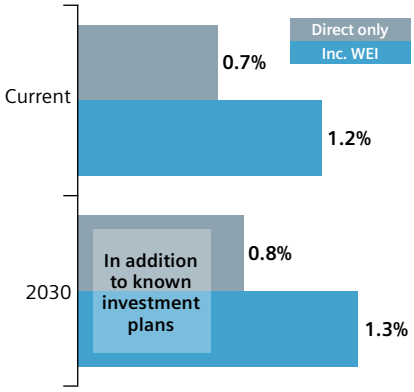


Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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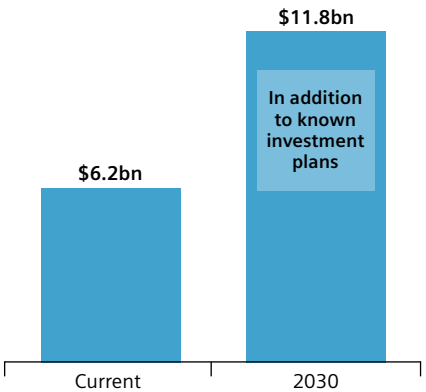
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

COPENHAGEN

CURRENT GDP: $63bn[1]
POPULATION: 1.2m[1]
CITY TYPE: Well-established

Copenhagen has the most economically efficient system in our study, thanks to its ongoing investment in capacity and the user-friendly nature of the network

STRENGTHS

- Use of automated trains on all metro services has helped drive reliability and service quality
- Network offers a high level of user functionality, for example through Rejsekort electronic payment system
- Investment in cycle infrastructure and integration has encouraged modal shift, with the aim of reaching a 50% modal share of cycling by 2015
- This has eased demand on the public transport network, which already has excellent capacity thanks to investment in metro
- Future demand challenges will be met thanks to clear plans to add metro capacity, for example through city circle line

CHALLENGES

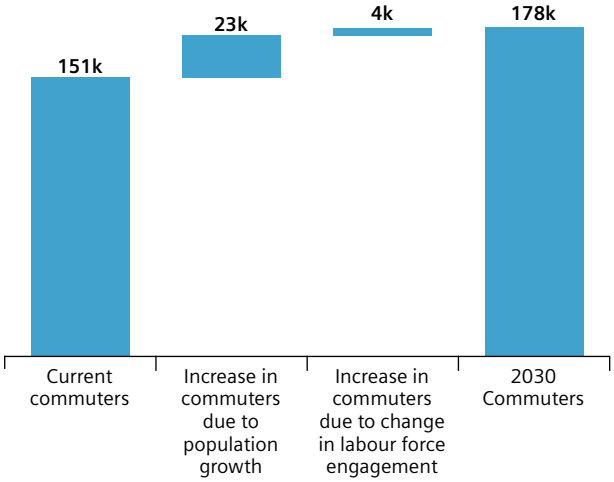
- The price of public transport is high, with buses in particular appearing relatively more expensive than in other cities
- There is potential for further promotion of the public transport network – for example through congestion charging

RECOMMENDATIONS

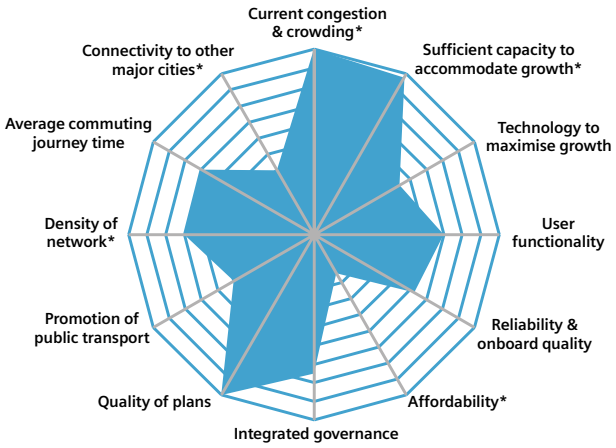
- Copenhagen has the leading transport system in our study; as such, its focus should be on delivering its future plans and incremental improvements such as technology

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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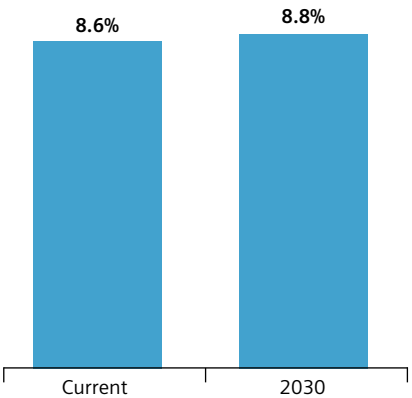
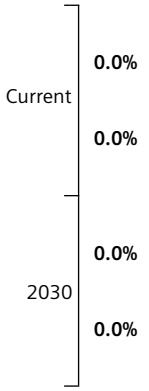
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

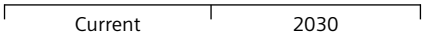
OPPORTUNITIES

Size of the opportunity (% of GDP)



Note: *The **WEI** includes the wider economic impacts of transport investment, rather than the direct impact to transport users alone*

Annual value of the opportunity (US$)



- Copenhagen is the best in class within the well-established cities group, but there are opportunities for further efficiencies through incremental investment

Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

DELHI

CURRENT GDP: $84bn[1]
POPULATION: 22.7m[1]
CITY TYPE: Emerging

Rapid population growth will challenge Delhi to increase capacity in its network, but it should not ignore the opportunities to improve efficiency through technology

STRENGTHS

- Good levels of user functionality thanks to multimode, point to point journey planning and live traffic information systems
- Clear transport development plan to 2021, including bus rapid transit and metro expansion, effectively integrated with broader city development
- Given challenges of congestion within the city, service reliability appears reasonable

CHALLENGES

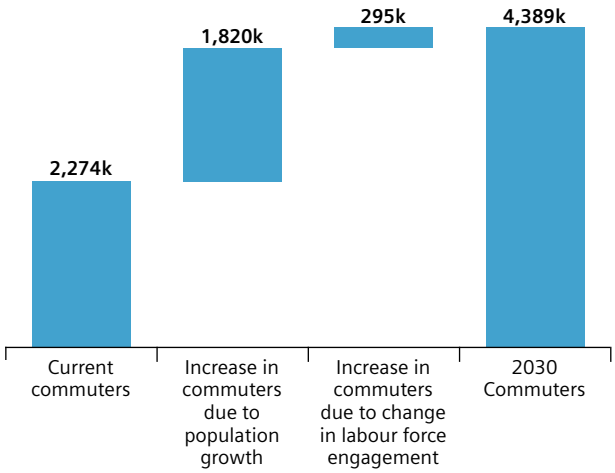
- Current capacity is under pressure across all modes, and rapid population growth to 2030 will exacerbate this issue
- A lack of investment means current capacity is not as efficiently utilised as possible – for example, traffic management systems are lacking
- Although there is a bus rapid transit system, accessing the platforms in the middle of roads is dangerous and it covers only a short distance
- Governance structures lack integration

RECOMMENDATIONS

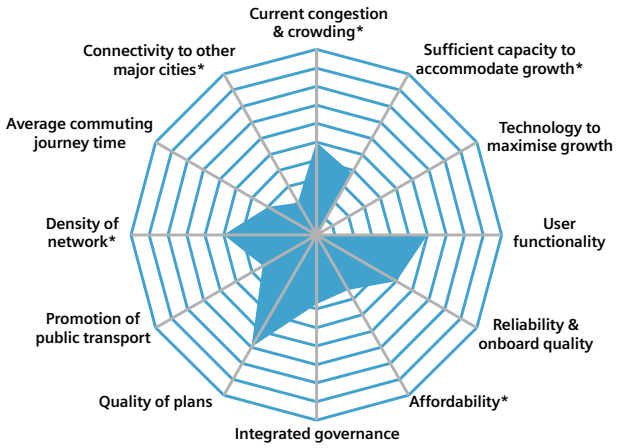
- Population growth will create material benefits by 2030 which can justify major investment
- Given the level of population growth, investment should focus on building capacity – for instance by expanding the BRT network

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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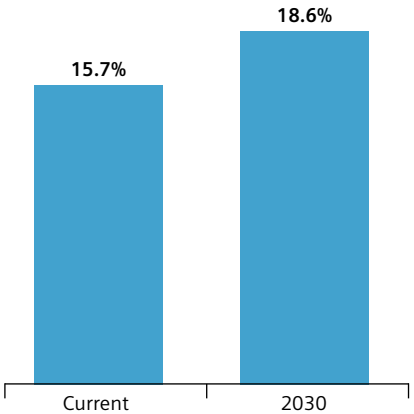
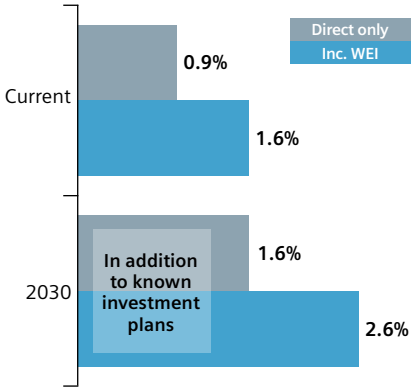
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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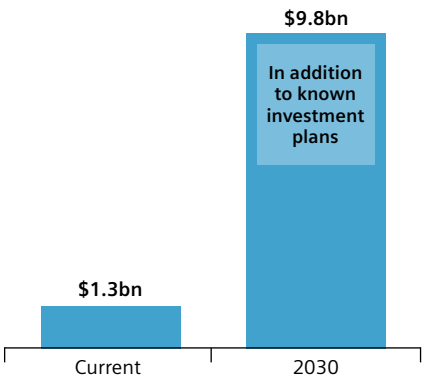
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

DUBAI

CURRENT GDP: $34bn[1]
POPULATION: 1.8m[1]
CITY TYPE: High density compact centre

Dubai's ongoing investment in a modern, high-tech metro system appears set to create one of the best systems in its class by 2030

STRENGTHS

- Significant expansion of metro (from 75km currently to 320km by 2020) expected to address current capacity issues and meet future demand
- Fully integrated governance under the Roads & Transport Authority has created clear plans to meet future demand
- Transport network will be highly specified once current investment is complete – featuring driverless trains, CBTC signalling, and user-friendly features such as integrated electronic payment systems

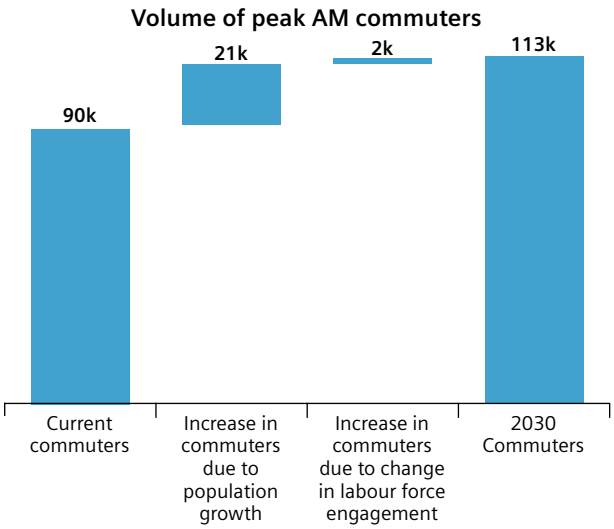
CHALLENGES

- Current metro system is under severe capacity pressure (although as noted above, current expansion plans address this)
- A lack of promotion of public transport threatens to restrict the impact of future capacity additions
- Roads are currently severely congested; demand management may need to be considered if public transport capacity additions do not encourage modal shifts

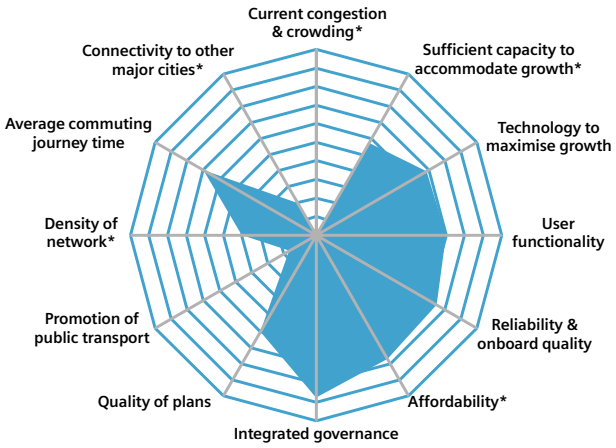
RECOMMENDATIONS

- Focus on delivering current expansion plans effectively
- Successful future promotion of public transport likely to be key to reducing congestion and maximising potential of ongoing investments

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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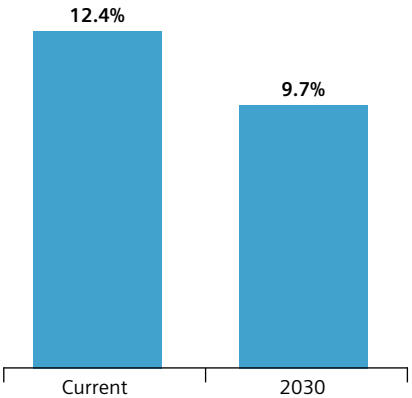
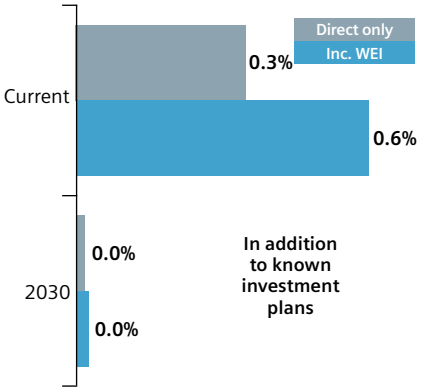
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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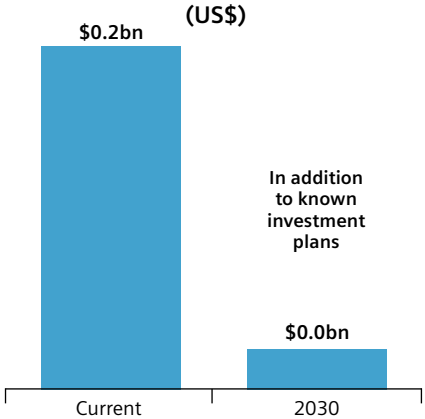
Annual value of the opportunity (US$)



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GUANGZHOU

CURRENT GDP: $172bn[1]
POPULATION: 10.8m[1]
CITY TYPE: High density compact centre

Rapid population growth has meant that in Guangzhou, the focus has been (and continues to be) on adding capacity

STRENGTHS

- Plans are in place to address current capacity issues, with six new metro lines under construction and a further 12 proposed
- High tech SIG signalling and automatic train operating systems installed on metro network
- High levels of connectivity to other major cities will enable Guangzhou to maximise the wider economic impact of transport investment

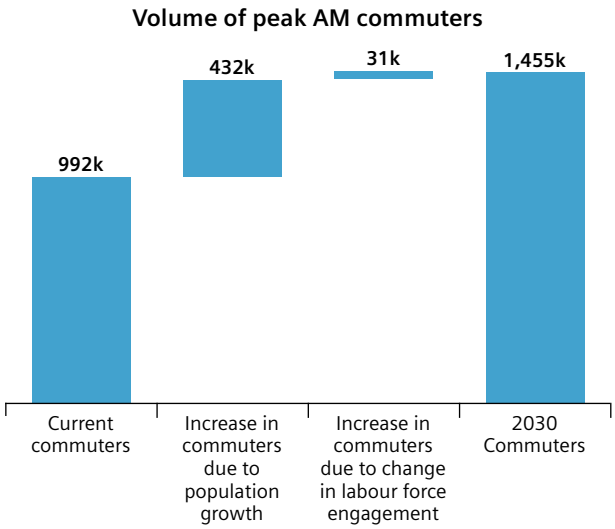
CHALLENGES

- Current capacity is under pressure on both bus and metro networks, and despite expansion plans, will require further expansion to meet demand by 2030
- Increasing numbers of car users are also placing more strain on the road network
- As with other Chinese cities, shared governance between local and national authorities is likely to make transport planning more difficult

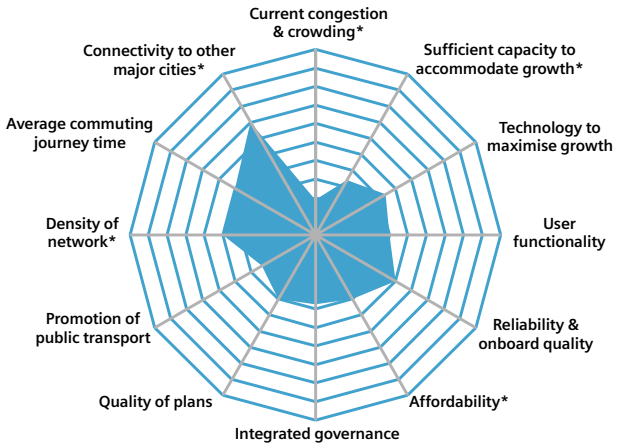
RECOMMENDATIONS

- Investing to meet future capacity demands is critical; without it transport may act as a constraint on Guangzhou's growth potential

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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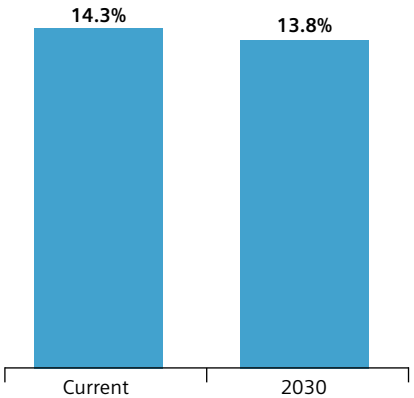
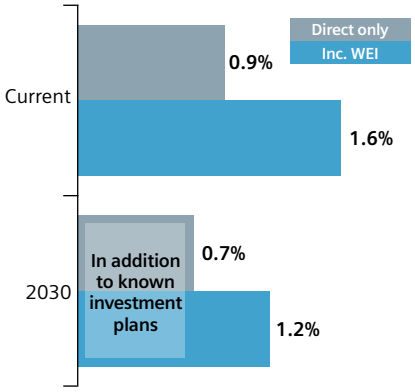
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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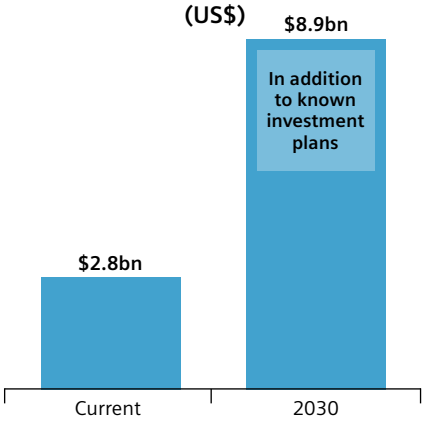
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

HONG KONG

CURRENT GDP: $250bn[1]
POPULATION: 7.1m[1]
CITY TYPE: High density compact centre

Combining property development with transport projects has enabled Hong Kong to create a highly efficient system, and it is positioned well to meet future challenges

STRENGTHS

- Hong Kong has raised funds for investment in its metro network by combining property development with transport projects
- This has created a network that offers large capacity, and high levels of user functionality
- Future plans are clear and sufficient to meet demand, with extensions to existing metro lines and new additions planned
- The city's investment plans will mean that by 2030, it has realised the most cost efficient network in its class, having unlocked the economic benefits of transport through investment

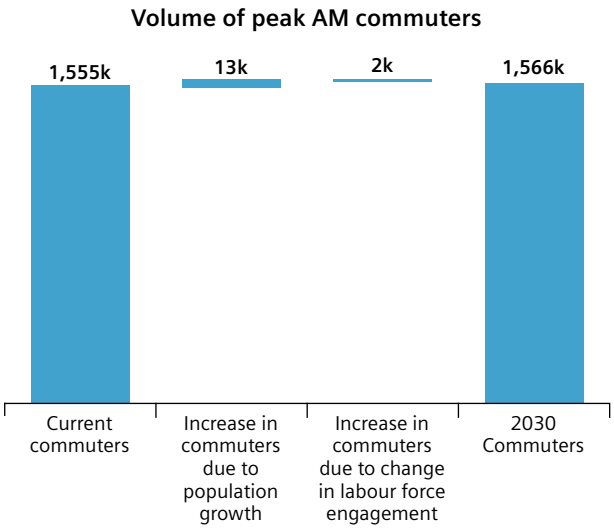
CHALLENGES

- Despite the success of its public transport network, roads in Hong Kong remain highly congested
- The fleet across both metro and bus networks is ageing, and in need of renewal to improve the quality of journeys for passengers

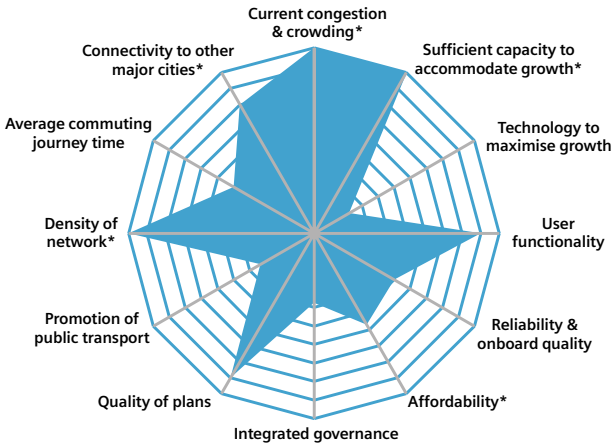
RECOMMENDATIONS

- Focus on delivering current plans efficiently and additional opportunities for investment to drive improvements in on-board quality

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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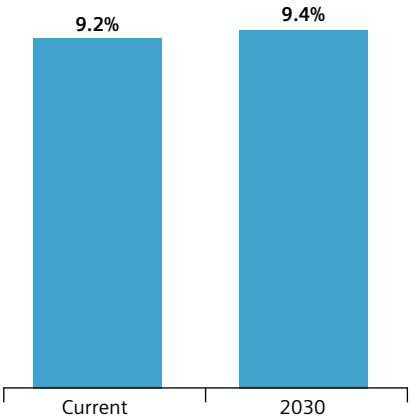
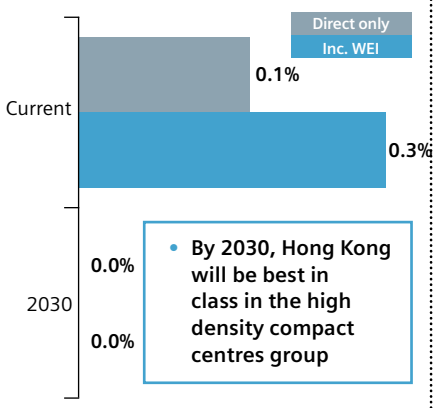
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

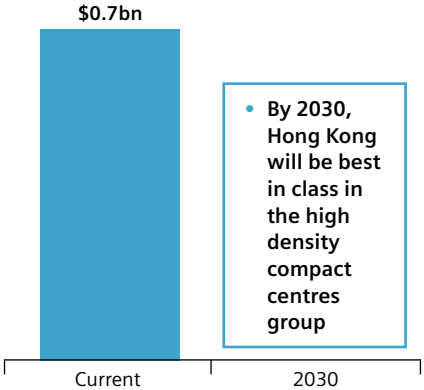
Size of the opportunity (% of GDP)



- By 2030, Hong Kong will be best in class in the high density compact centres group

Note: *The **WEI** includes the wider economic impacts of transport investment, rather than the direct impact to transport users alone*

Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

ISTANBUL

CURRENT GDP: $149bn[1]
POPULATION: 11.3m[1]
CITY TYPE: Well-established

Istanbul's planned investment in metro over the next 10 years will go some way to addressing the issues caused by a historical focus on road transport

STRENGTHS

- Although the transport network is not currently fit for purpose, there are clear plans for expansion across modes to increase capacity
- Investment in metro network is ongoing, with the first line on the Asian side of the city opened in 2012, with 260km of new lines to be added by 2020

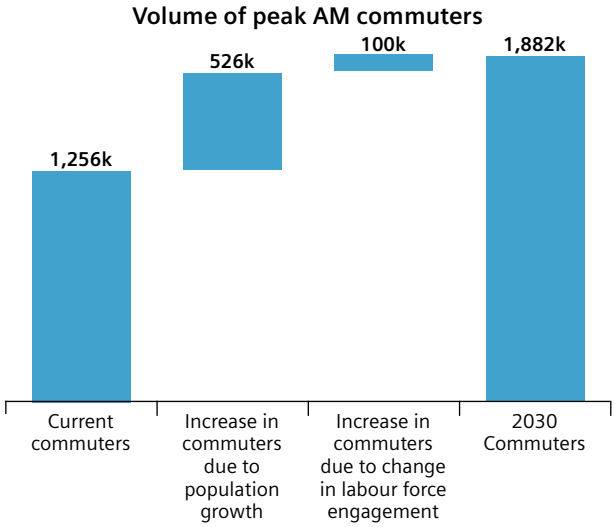
CHALLENGES

- Istanbul is home to the world's second oldest metro line and the ageing infrastructure is in need of expansion and renewal
- Current capacity is severely under pressure across all modes
- Despite a historical focus within transport policy on roads, traffic throughout the city is still highly congested
- Aside from capacity constraints, there has been limited investment in optimising the existing system

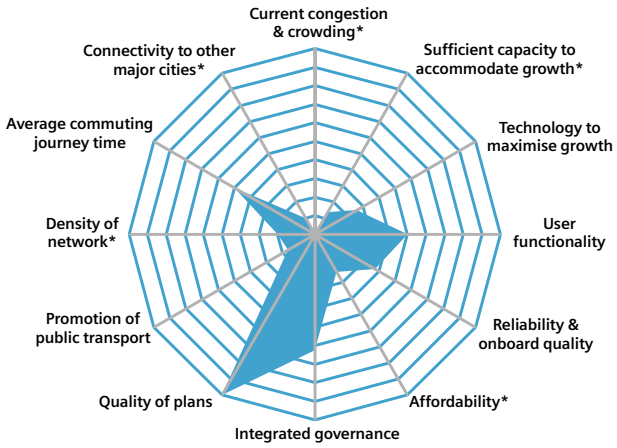
RECOMMENDATIONS

- Delivering currently planned expansions is critical, but further capacity additions will be required, and are justified by the benefit in 2030

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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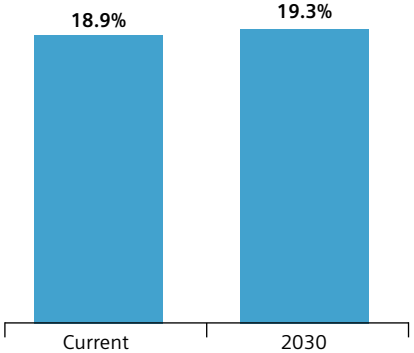
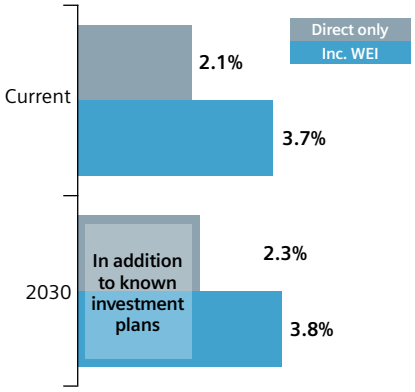
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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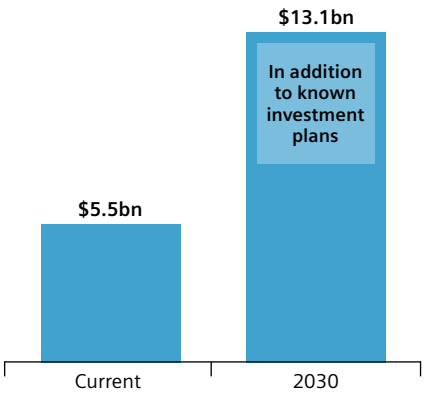
Annual value of the opportunity (US$)



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JAKARTA

CURRENT GDP: $52bn[1]
POPULATION: 9.8m[1]
CITY TYPE: Emerging

Jakarta has suffered through a historical lack of investment in its network; whilst investment in rail is forthcoming, there is a need for clear future plans to meet demand

STRENGTHS

- Although it has historically not confronted the transport challenges it faces, there are signs that Jakarta is addressing its transport issues
- It is building a 110km rapid rail transit system, which is expected to be complete by 2024-7
- It has invested in a bus rapid transit network, in an attempt to build low cost capacity (although we note that this currently comprises a small portion of the network)

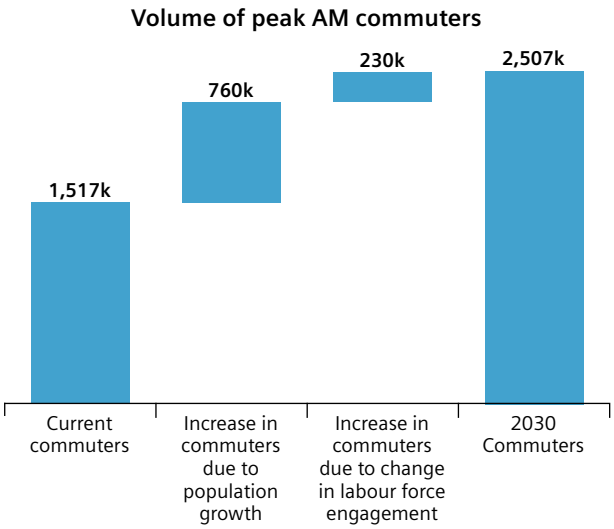
CHALLENGES

- The historical lack of metro or light rail has led to a highly congested road network, with a bus system running at full capacity
- Service quality across the network is low, with ageing buses and poor levels of reliability
- There is a lack of user functionality, which is likely to further discourage users from taking public transport
- The city has not had a culture historically of creating long term plans for transport (although we note it is currently in the process of creating a plan for 2025 to fill this gap)

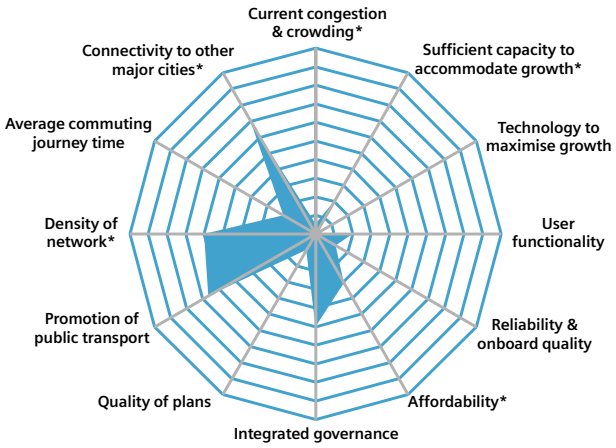
RECOMMENDATIONS

- Create firm future investment plans to address capacity issues, integrated with broader city planning, and cascaded to modal management

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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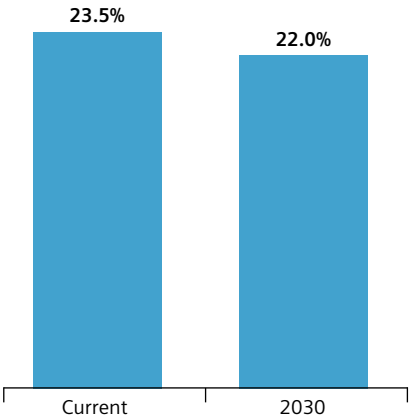
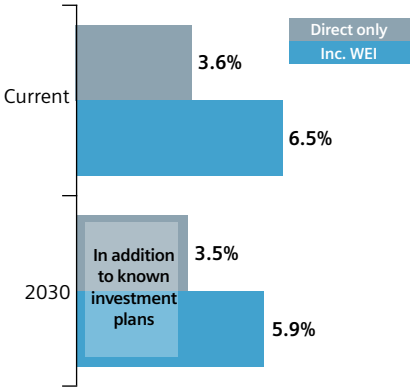
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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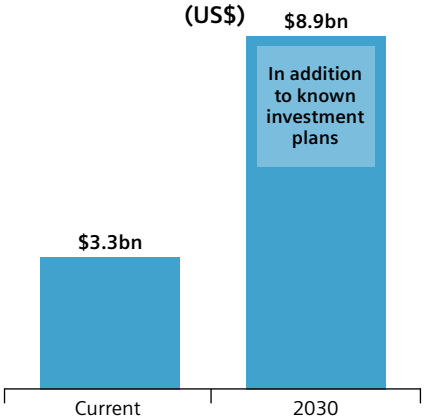
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

JOHANNESBURG

CURRENT GDP: $45bn[1]
POPULATION: 3.9m[1]
CITY TYPE: Emerging

Adding low cost capacity, potentially through extended bus rapid transit, appears the best strategy for Johannesburg to realise the economic benefit available

STRENGTHS

- Introduction of Rea Vaya bus rapid transit (BRT) system in 2009 increased capacity and mobility, but has not solved capacity issues fully
- Use of Metrobus prepaid tags enable use of multiple buses for journeys within two hours of initial use, helping integrate different routes
- Gautrain suburban rail network, introduced in 2011, links to Pretoria and is well integrated with other modes

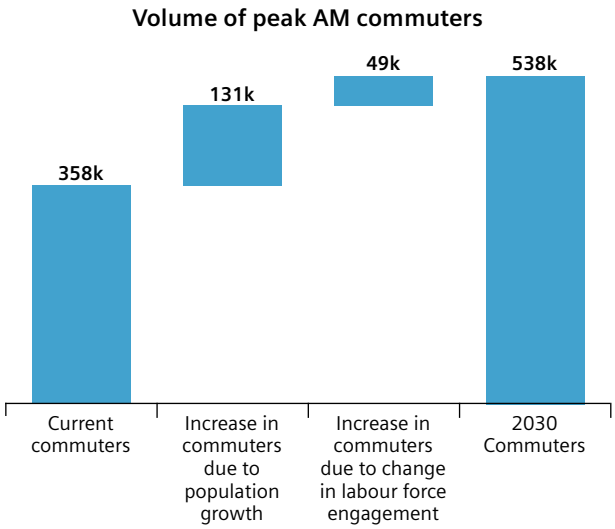
CHALLENGES

- Despite introduction of Rea Vaya BRT and Gautrain, capacity is still severely limited, and levels of road congestion are high
- Service levels are low; there is no punctuality KPI on the bus network and only 85% of rail services are on time
- Aside from Rea Vaya BRT fleet, bus fleet is ageing and low in quality
- Bus priority measures only apply to the BRT, and as such are limited in impact

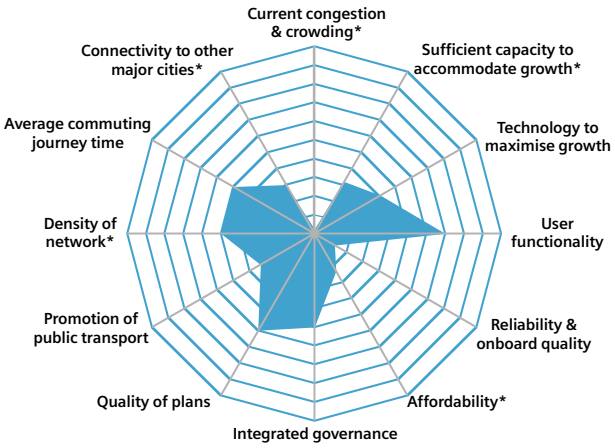
RECOMMENDATIONS

- Investment in capacity appears important – given scale of economic benefit, the most appropriate approach appears to be extension of BRT
- Increased use of traffic management and bus priority systems may also realise incremental benefits

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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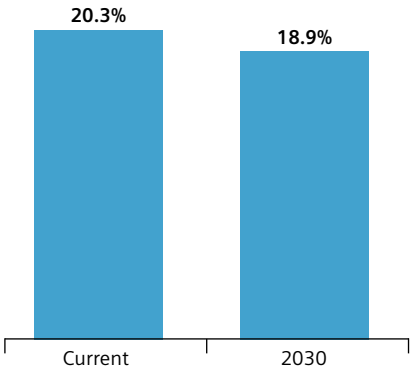
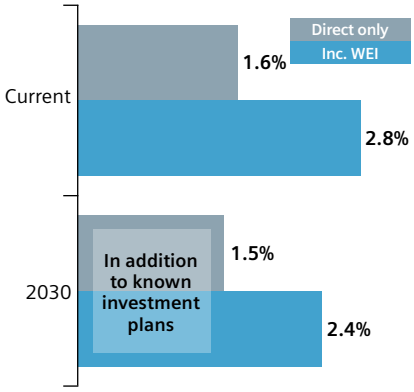
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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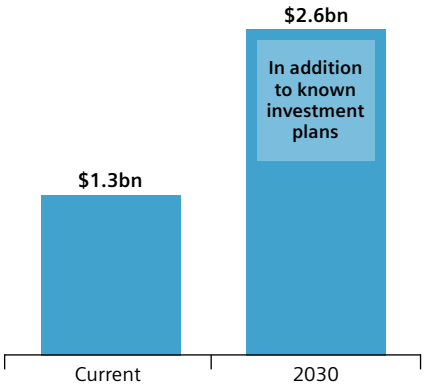
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

LAGOS

CURRENT GDP: $44bn[1]
POPULATION: 11.2m[1]
CITY TYPE: Emerging

Lagos theoretically has sufficient capacity to meet demand, but this may not be the case in practice, and rapid population growth will exacerbate any capacity issues

STRENGTHS

- Although Lagos' system is entirely based on bus journeys, there is sufficient capacity on paper to meet demand (although this may not translate to practical capacity – see below)
- Planned investment in a new seven line light rail system appears to position it well to meet future demand
- Integrated transport governance with close links to regional governments has enabled large scale future plans to be created

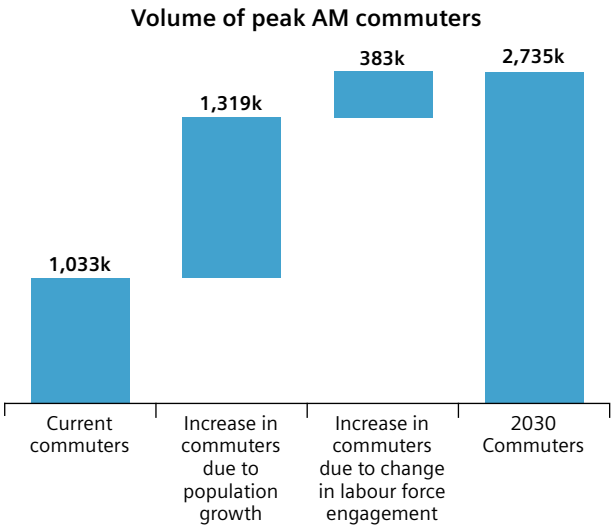
CHALLENGES

- The system's current reliance on bus transport means that roads are heavily congested
- Despite apparently high capacity, service levels are low, with long queues for buses amid suggestions that many are not in use
- The quality of the bus fleet is low, typically old, and with features such as air conditioning or stop request buttons not functioning
- A lack of systems to optimise bus network – e.g. traffic management, priority lanes (outside of limited BRT network) – constrain quality of service

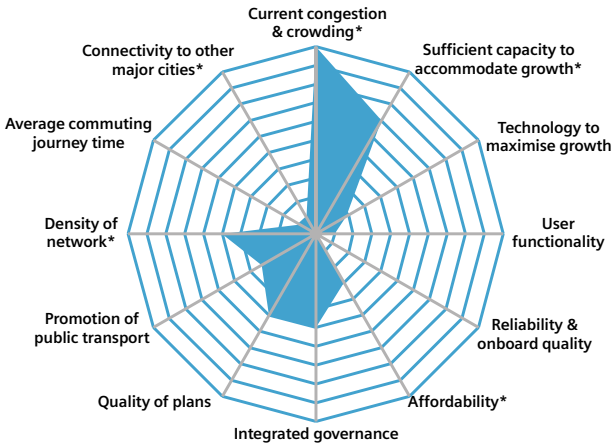
RECOMMENDATIONS

- The planned light rail work must be delivered as cost efficiently and quickly as possible
- Improving reliability of existing bus capacity – through fleet investments or bus priority measures – should be considered in the short term

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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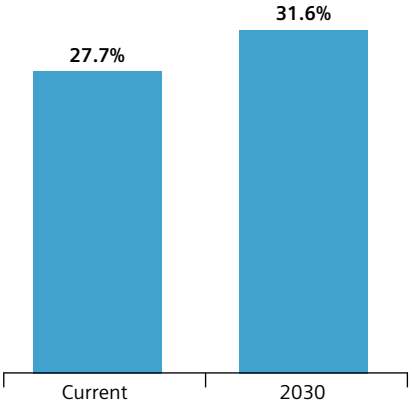
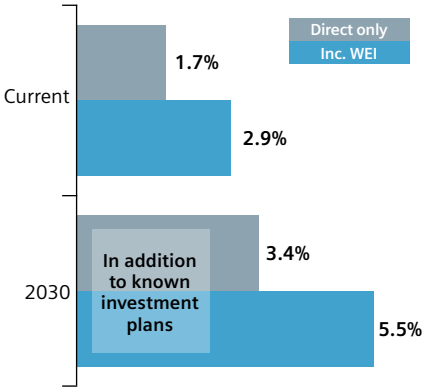
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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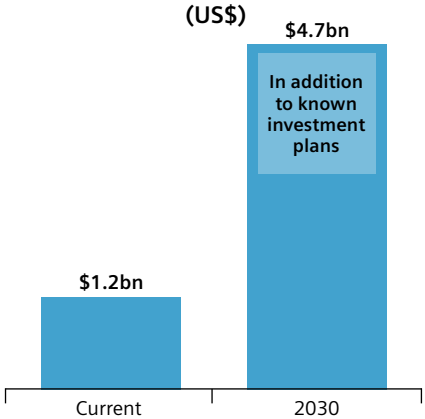
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

LONDON

CURRENT GDP: $489bn[1]
POPULATION: 9.0m[1]
CITY TYPE: Well-established

London has a developed but congested transport network; its rail expansion plans go some way to addressing capacity issues, but more may be required by 2030

STRENGTHS

- Comprehensive network serves whole of city and has been subject to ongoing expansion
- Has secured strong funding and modal shift from effective road user charging scheme
- Planning for the future with the development of Crossrail, Thameslink and Crossrail 2 and other upgrades to existing Tube network
- World leading integrated ticketing and electronic payment systems

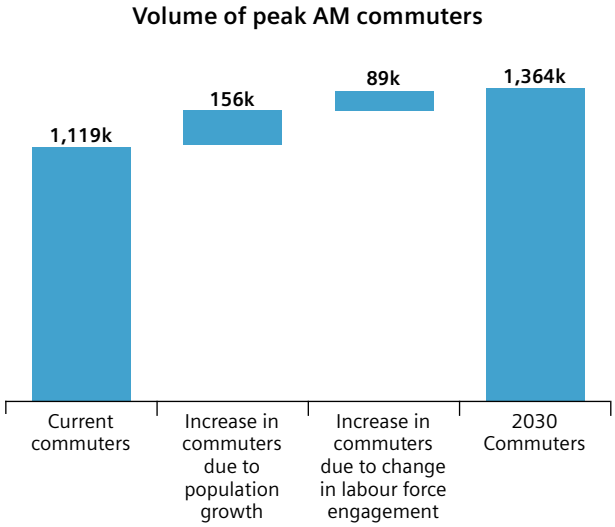
CHALLENGES

- Continuing population growth but shortage of housing creating longer distance commuters
- Ageing infrastructure unable to cope with current passenger volumes and requiring upgrades on some parts of network
- High crowding levels in the peak – especially on the Underground and National Rail network
- High fares becoming an increasingly political issue
- Bus network appears increasingly under capacity pressure

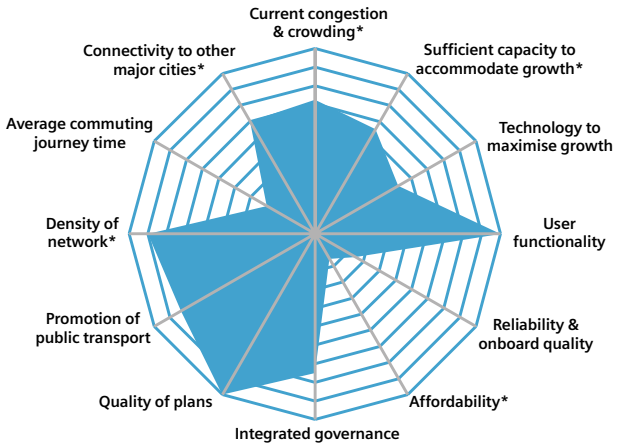
RECOMMENDATIONS

- Confirm and commence plans for Crossrail 2 as soon as possible
- Further capacity expansions, particularly in bus network, may be required to meet demand by 2030

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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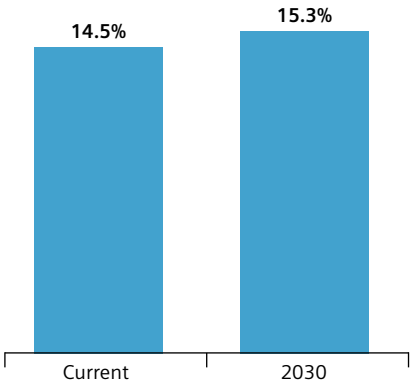
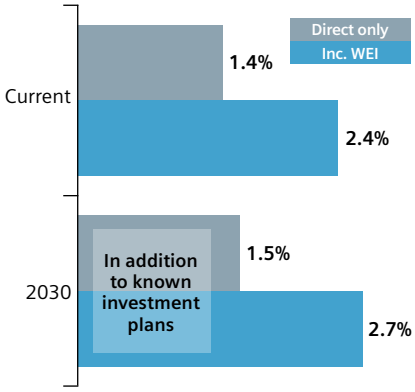
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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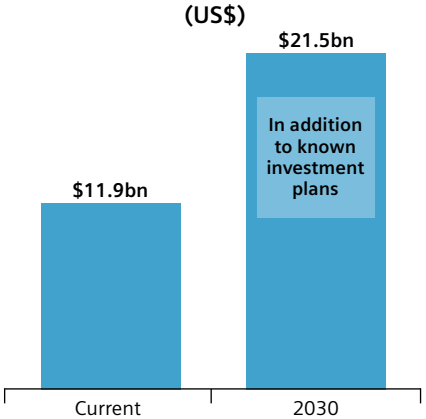
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

LOS ANGELES

CURRENT GDP: $809bn[1]
POPULATION: 13.4m[1]
CITY TYPE: Well-established

Addressing road congestion in Los Angeles would realise benefits through increased service levels on its highly utilised bus network as well as for private car users

STRENGTHS

- Capacity across light rail and subway systems appears sufficient, with future expansion plans in place to meet growing demand
- The network uses customer-facing technology effectively, including:
  - Systemwide electronic payment system (TAP card)
  - Multimodal, point to point journey planning
  - Live traffic information systems

CHALLENGES

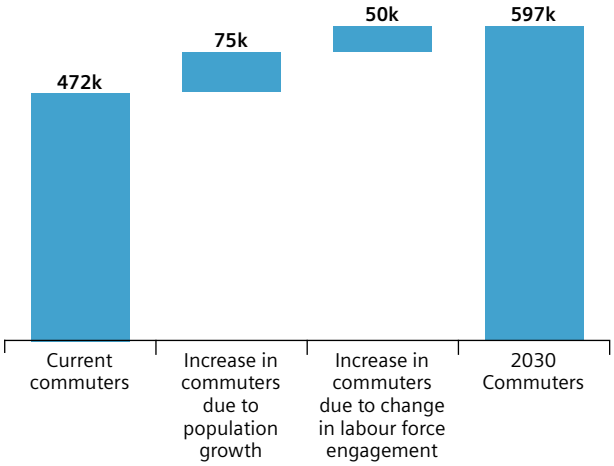
- Road congestion is a major issue for the city, and given the 82% share of public transport journeys undertaken by bus, this has major consequences for system performance
- Given this, punctuality is poor, with only 63% of buses running on time
- Although there are some high occupancy vehicle priority lanes in place, the lack of extensive bus priority measures is a weakness
- A lack of promotion of public transport means a high volume of journeys taken by private vehicle

RECOMMENDATIONS

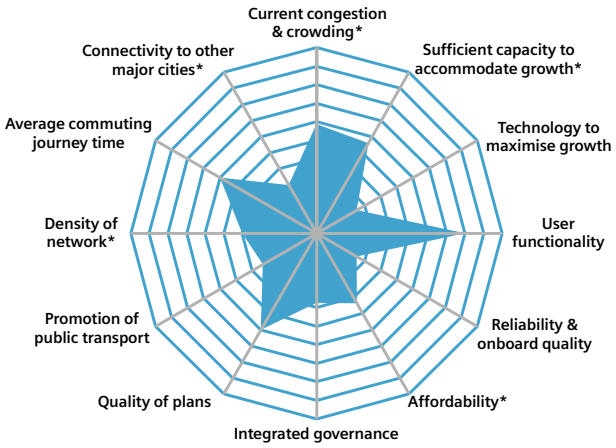
- Focus on optimising existing road network and promoting public transport usage – consider demand management and bus priority measures

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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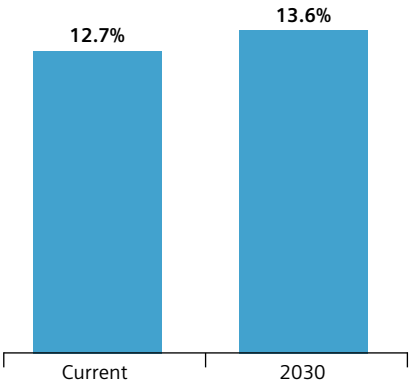
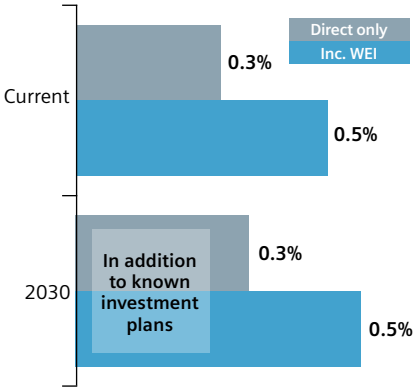
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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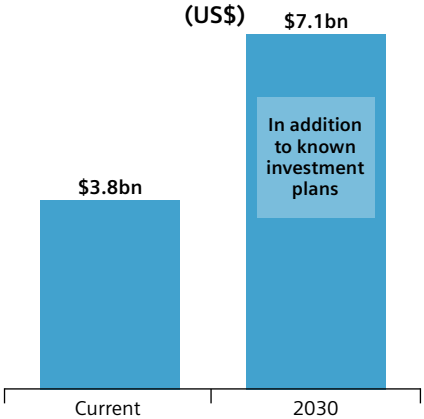
Annual value of the opportunity (US$)



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MADRID

CURRENT GDP: $229bn[1]
POPULATION: 6.4m[1]
CITY TYPE: Well-established

Madrid operates a user-friendly network with high capacity, but a lack of clear future planning may threaten its ability to invest to maintain performance levels

STRENGTHS

- High levels of passenger-facing integration using systemwide electronic payment cards, real-time information, and journey planners linked to popular mapping apps
- Capacity across all modes appears sufficient to meet demand, and there are further plans to expand the metro with three new lines
- Decent network density helps reduce total commuting times, improving usability of network

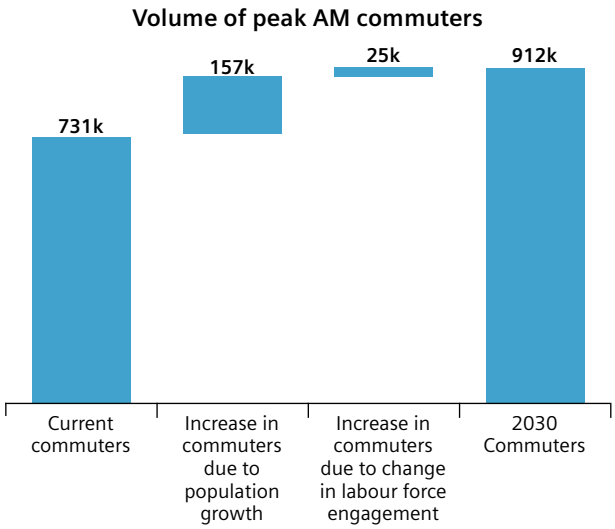
CHALLENGES

- Despite current effectiveness of the transport, the absence of a clear long-term plan may threaten the city's ability to respond to future demands
- The cost of travel is an ongoing concern
- A lack of WiFi or 3G/4G across whole network reduces potential productive activity whilst travelling

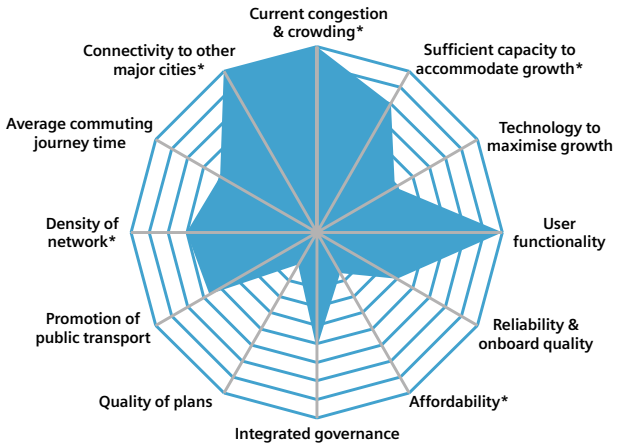
RECOMMENDATIONS

- Creating a clear long-term plan will enable Madrid to ensure it can meet future demands and maintain efficiency levels
- Investment in technology may be required to maintain service and quality levels (e.g. extending signalling upgrades across whole network)

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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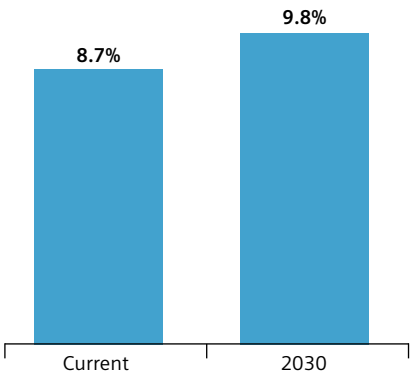
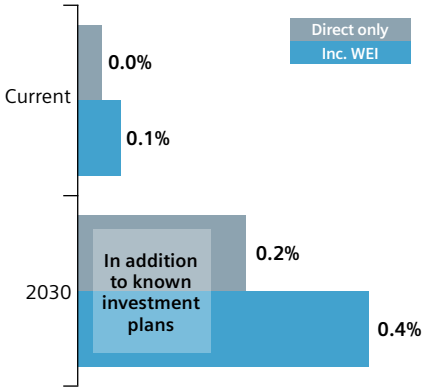
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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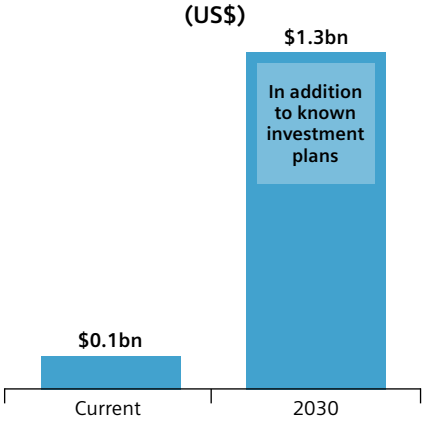
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

MELBOURNE

CURRENT GDP: $242bn[1]
POPULATION: 3.9m[1]
CITY TYPE: Well-established

Whilst Melbourne's network is relatively efficient, there are incremental opportunities for investment to improve its attractiveness over private transport

STRENGTHS

- Integrated governance and funding ensures effective planning, as shown by the clarity of the Transport Strategy to 2030, which is effectively broken into modal plans
- High levels of user functionality on public transport, with electronic payment systems, real-time information and multimodal journey planners
- Reliability is typically good, with over 94% of buses on time according to recent figures

CHALLENGES

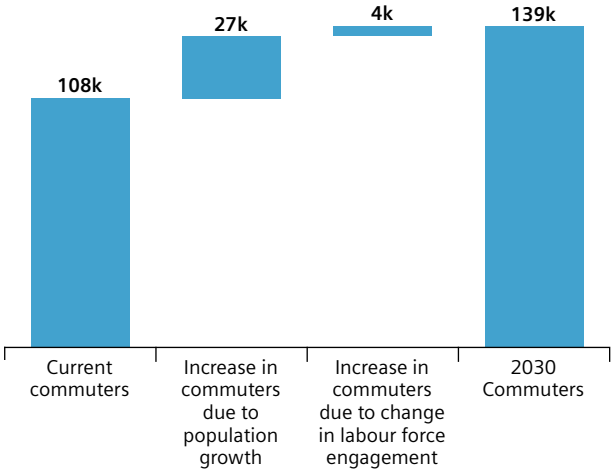
- The cost of public transport makes it uncompetitive with car travel
- Both public transport networks and road systems are increasingly congested
- Investment in the East West road link project appears to have been prioritised over public transport investment
- The rail fleet in particular is in need of renewal, with most trains around 30 years old

RECOMMENDATIONS

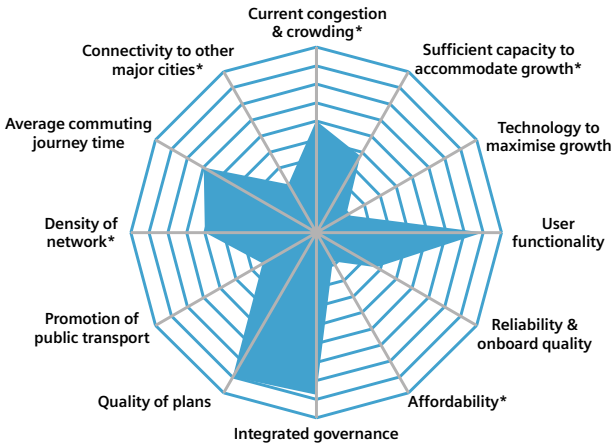
- Consider demand management for car use such as congestion charging; invest in technology and process to improve attractiveness of public transport

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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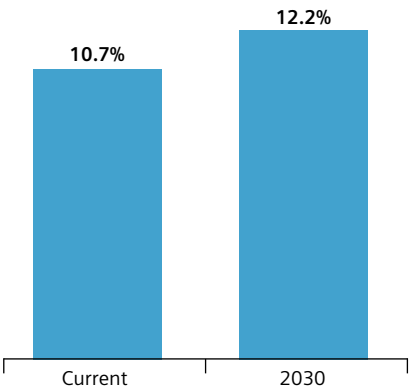
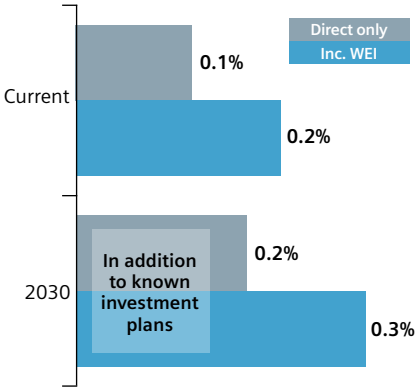
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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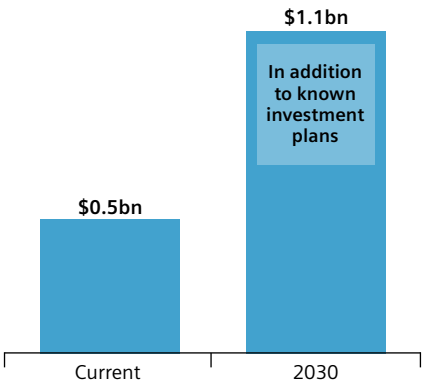
Annual value of the opportunity (US$)



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MEXICO CITY

CURRENT GDP: $238bn[1]
POPULATION: 20.4m[1]
CITY TYPE: Emerging

Improving network density and service quality should be the key strategies for Mexico City to realise the economic benefits available

STRENGTHS

- High capacity metro system is the second largest in North America (after New York)
- Use of multimodal TDF electronic payment card helps integrate modes, as does multimodal journey planner
- Metro stations are physically integrated effectively with Metrobus and Light Rail systems

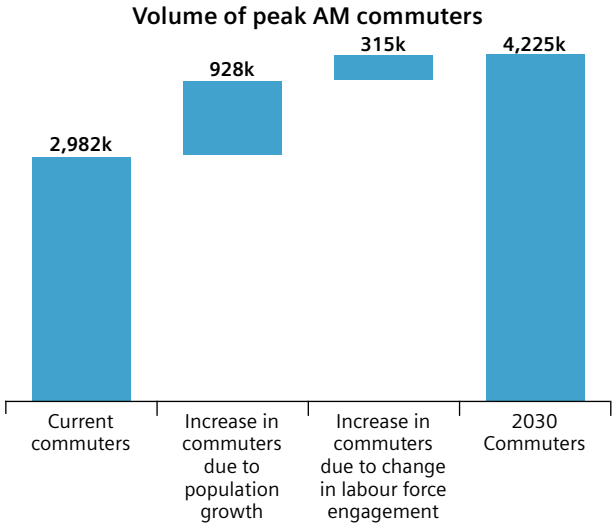
CHALLENGES

- Although metro network has a high capacity, it is relatively low density, making it harder to access for some users
- The metro is low in quality – reflecting the age of a network, most trains are now old, and don't offer modern features such as WiFi
- In general, the system does not utilise technology effectively with outdated signalling on metro and no use of traffic management or bus priority measures

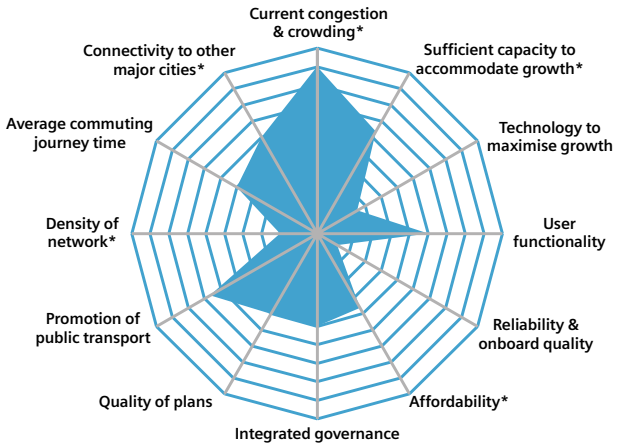
RECOMMENDATIONS

- Given current capacity, investment should focus on improving quality and the productivity of passengers
- Attempt to address network density issues

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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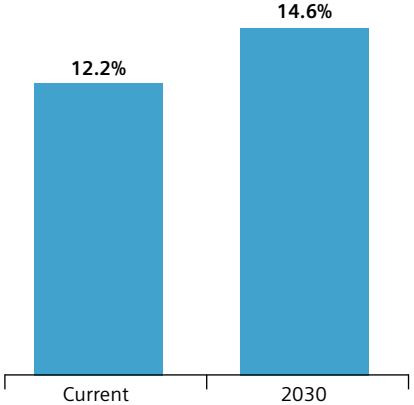
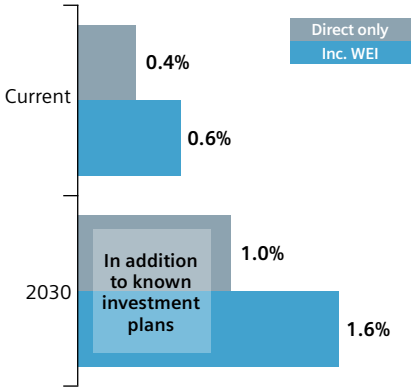
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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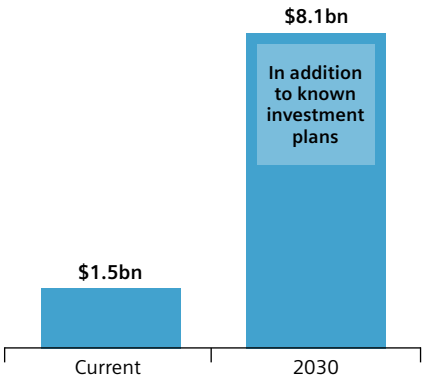
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

MOSCOW

CURRENT GDP: $311bn[1]
POPULATION: 11.6m[1]
CITY TYPE: Well-established

Moscow's investment plans go some way to improving capacity and quality, but given the scale of benefit available, there appears to be opportunity to go further

STRENGTHS

- Clear future plans will increase capacity on Metro (250km new track by 2018, including 79 new stations), and double capacity on suburban rail
- Future plans include replacing existing ageing rolling stock on metro system
- System features a good range of user functionality, including Troika integrated payment system, as well as effective journey planning and traffic information applications

CHALLENGES

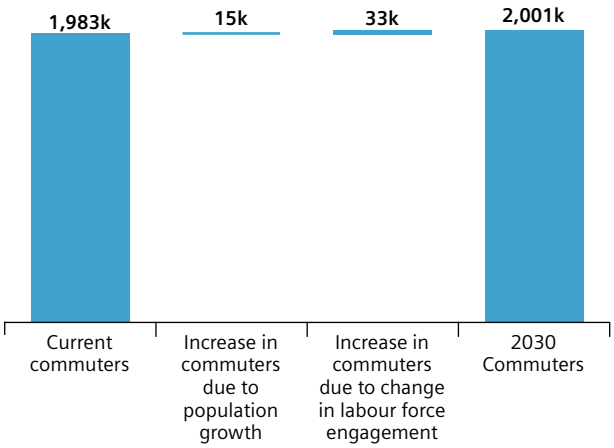
- Current metro capacity is under pressure, although there are plans in place to address this
- The system relies largely on ageing infrastructure such as outdated signalling technology and old rolling stock
- Even given the relatively low quality of the network, using public transport is expensive
- In general, governance lacks a single overarching authority (although funding is integrated)
- There is no long term transport plan in place beyond 2020, and transport planning is not integrated with urban development

RECOMMENDATIONS

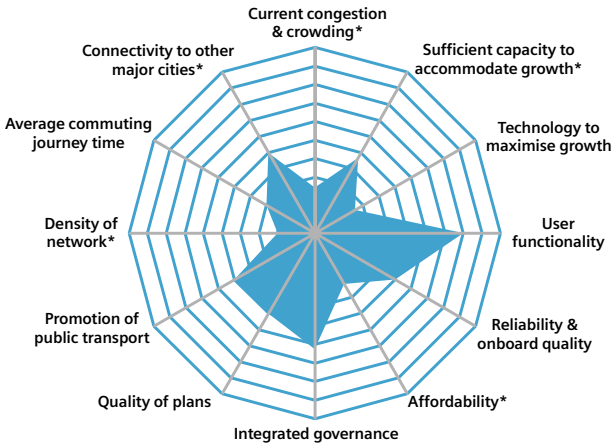
- Given the scale of economic benefits available, investment should focus both on increasing capacity and network density, as well as quality

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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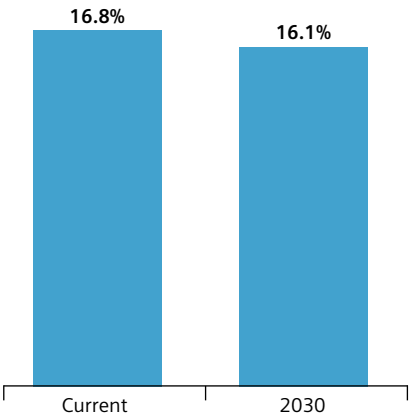
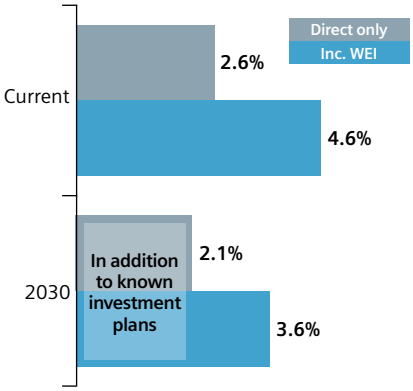
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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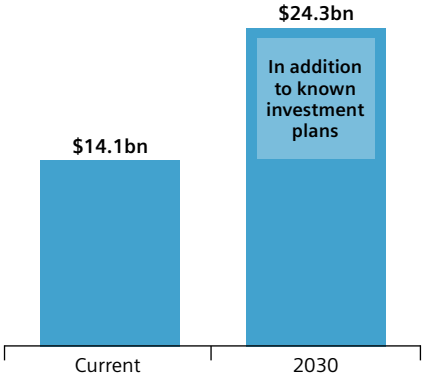
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

MUMBAI

CURRENT GDP: $46bn[1]
POPULATION: 19.7m[1]
CITY TYPE: Emerging

The current capacity challenge faced by Mumbai will be exacerbated by rapid population growth; a low cost solution to increase capacity is required

STRENGTHS

- Transport in Mumbai is the most user affordable of any city in our study
- The long term transport plan (to 2025) is integrated into the broader urban development plan covering the same period
- The city has invested in a live traffic information system with integrated journey planner

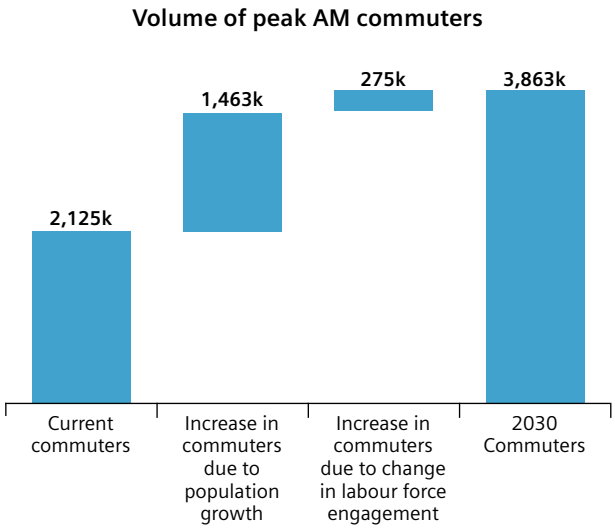
CHALLENGES

- The city is confronted by a major capacity issue currently, and given forecast population growth, this will only be exacerbated by increased urbanisation by 2030
- Roads are highly congested, which given the high modal share of buses, has severe impacts on service levels
- Whilst the Mumbai Urban Transport Project has invested in new trains, the bus fleet varies more in terms of age and could benefit from investment
- Traffic management systems are only in place in South Mumbai currently, and rolling this out across the rest of the city would offer benefits

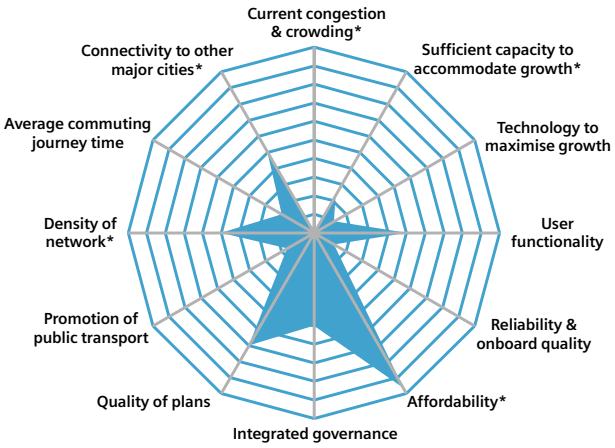
RECOMMENDATIONS

- Investing in capacity is the key challenge; addressing this should be a priority
- Alongside improving public transport capacity, further promotion of public transport will be required to address congestion issues

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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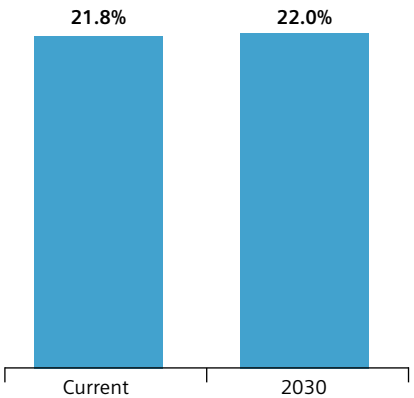
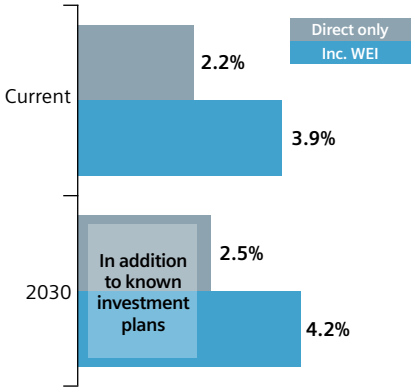
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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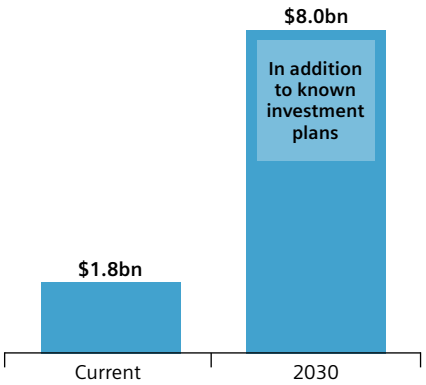
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

NEW YORK

CURRENT GDP: $531bn[1]
POPULATION: 8.4m[1]
CITY TYPE: Well-established

Whilst New York has an extensive transport network, its ageing infrastructure is in need of renewal and expansion if it is to realise the potential benefits available

STRENGTHS

- The subway system is one of the largest in the world, and its 24 hour operations offer round the clock mobility
- The Metrocard payment system has integrated payment across subway and bus networks
- High levels of usability thanks to effective journey planning and real-time information systems
- The 2nd Avenue subways and 7 line extensions will increase capacity

CHALLENGES

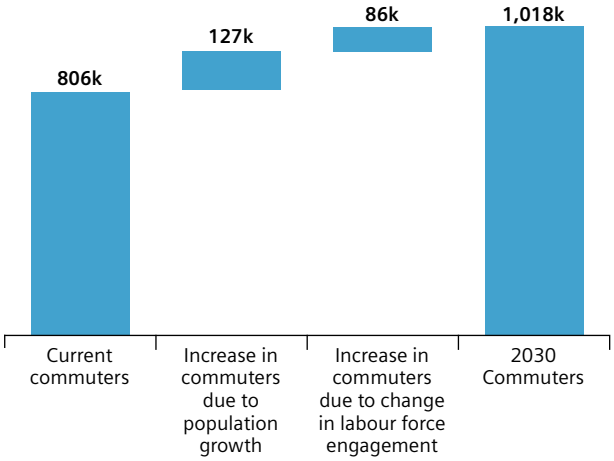
- In general, the subway network is suffering from its age and in need of modernisation
- Roads are highly congested, and plans for active traffic management and congestion charging have not been implemented due to political opposition
- Limited availability of WiFi in the subway reduces productive travel time

RECOMMENDATIONS

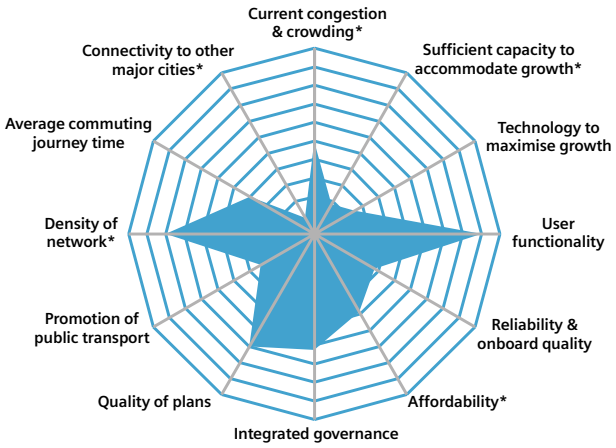
- Given the scale of economic benefit available, large-scale investment focusing on both capacity and service quality is justified

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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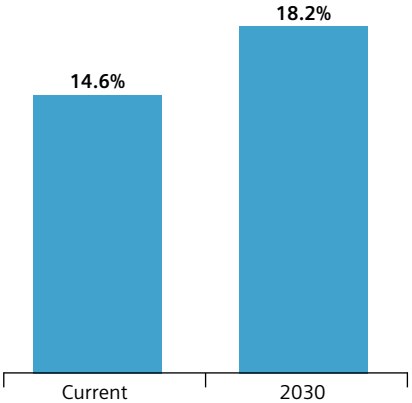
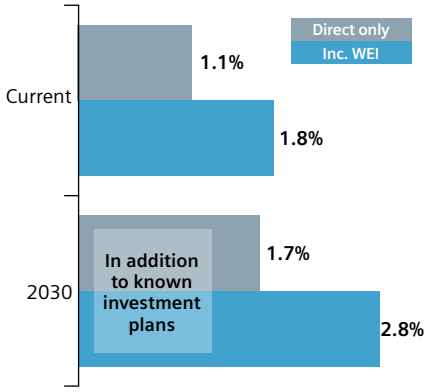
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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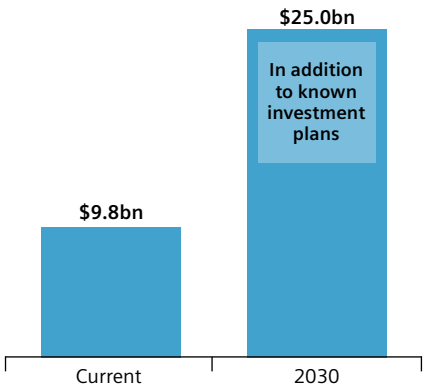
Annual value of the opportunity (US$)



Note: [1] City population based on 'city proper', taken from US Census. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; US Census; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

PARIS

CURRENT GDP: $630bn[1]
POPULATION: 10.6m[1]
CITY TYPE: Well-established

Large scale investment in Paris' ageing network is expected to enable it to meet future demand challenges and realise economic benefits

STRENGTHS

- Clear plans to expand capacity by investing €27bn to add 200km of orbital metro lines and modernising existing network
- Highly useable network featuring integrated Navigo payment system, journey planning and real-time travel information apps
- Extensive use of bus priority measures
- Punctuality levels are high (99%) on metro system
- Autolib and Velib schemes help to discourage use of private cars

CHALLENGES

- Majority of network – both in terms of infrastructure and fleet – is ageing and in need of investment
- Current capacity is under pressure, particularly on bus network, and roads are typically congested
- Cost to use public transport is relatively high
- WiFi availability is limited to 48 stations across the whole network, and as such limits productivity during travel
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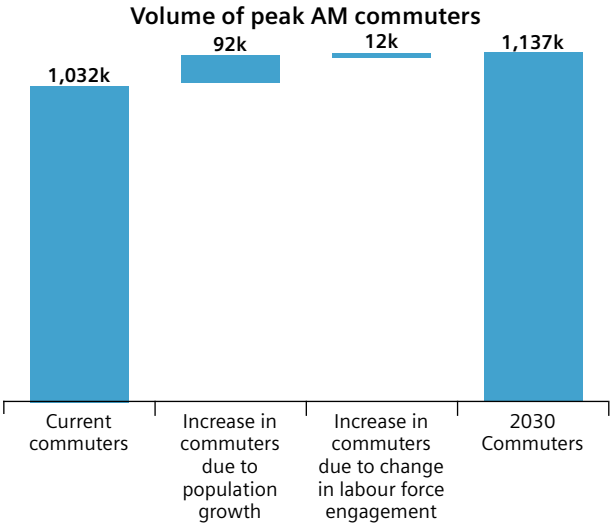
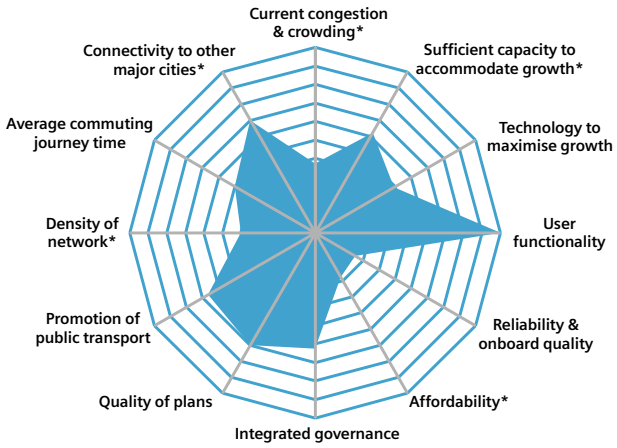
RECOMMENDATIONS

- Successful delivery of current plans will realise material economic benefit
- Beyond this, the focus should be on incremental quality improvements or increasing bus capacity

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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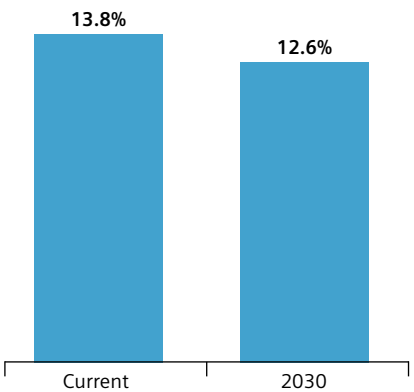
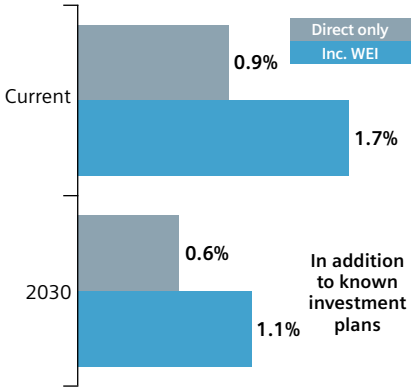
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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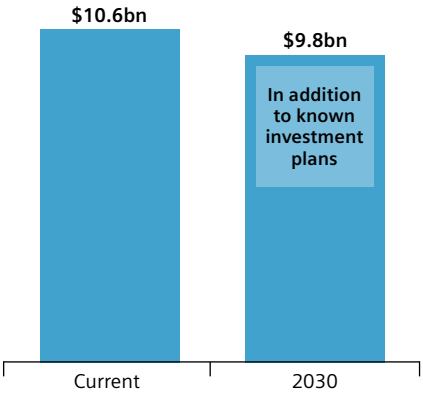


Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

RIYADH

CURRENT GDP: $98bn[1]
POPULATION: 5.5m[1]
CITY TYPE: High density compact centre

The scale of Riyadh's metro and BRT plans appear to address a historical lack of investment and position it well to meet future demand challenges

STRENGTHS

- Current investment plans will create a high quality network with sufficient capacity to meet future demand
- Ongoing investment includes new 176km metro network with 85 stations and 69 new automated trains and three line bus rapid transit system
- New metro and BRT networks will be fully integrated through shared stations

CHALLENGES

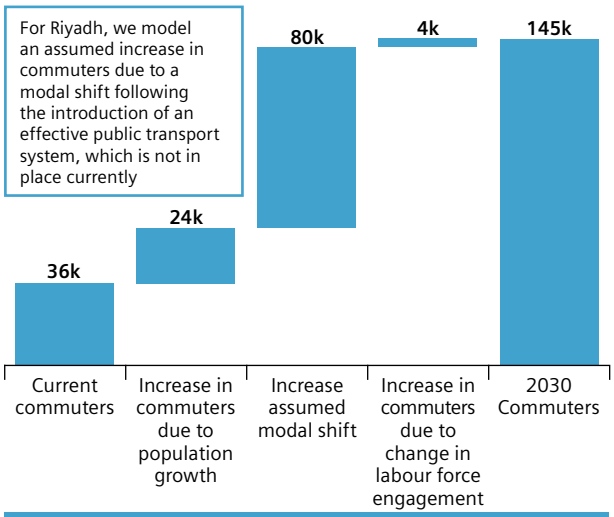
- Current system is insufficient to meet future demand, and experiences very low levels of usage – c.2% of journeys are undertaken on public transport
- Delivering investment on this scale brings its own challenges, and delivering the plans effectively will be essential to realising the economic benefit on offer
- There is a lack of promotion of public transport currently, which may constrain the benefit realised if not addressed following completion of new networks

RECOMMENDATIONS

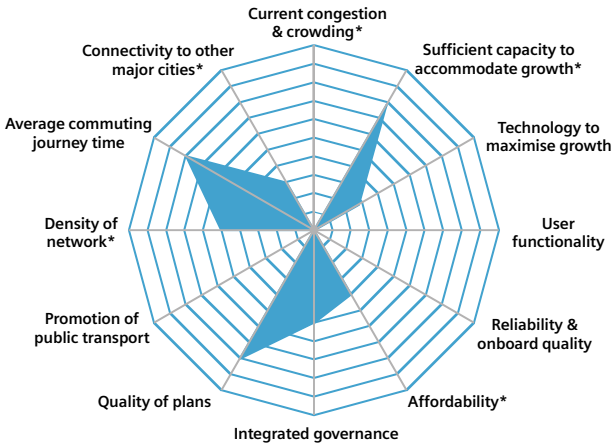
- Focus on delivering current investment plans
- Monitor growth to ensure future demand will be met by planned network

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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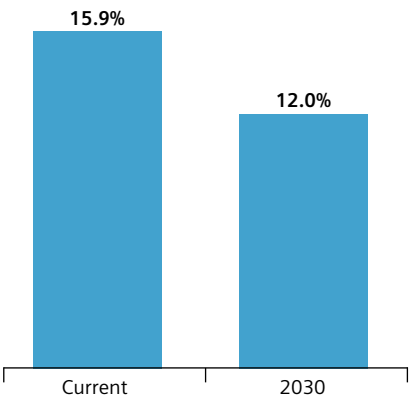
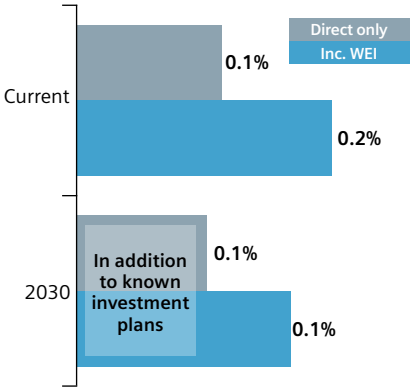
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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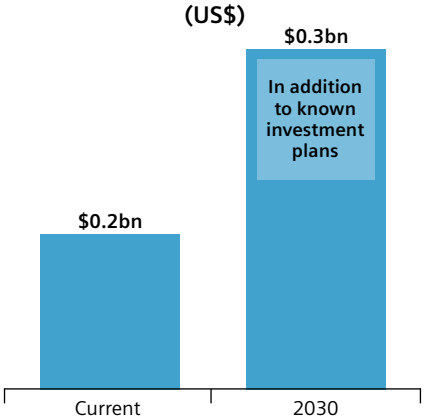
Annual value of the opportunity (US$)



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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

SANTIAGO

CURRENT GDP: $88bn[1]
POPULATION: 6.0m[1]
CITY TYPE: Emerging

Santiago's investment in its metro network has created a cost-efficient, high capacity network. Future investment should focus on improving the level of quality and usability

STRENGTHS

- Well developed metro system which has been expanded over last 20 years to provide good capacity as the city has grown
- Clear future plans to expand metro with new lines and help meet future demand and improvements to signalling technology
- Bip! payment card integrates bus and metro and offers two free transfers within two hours
- Quality of current system will be improved to some extent by investment in 185 new trains in 2015

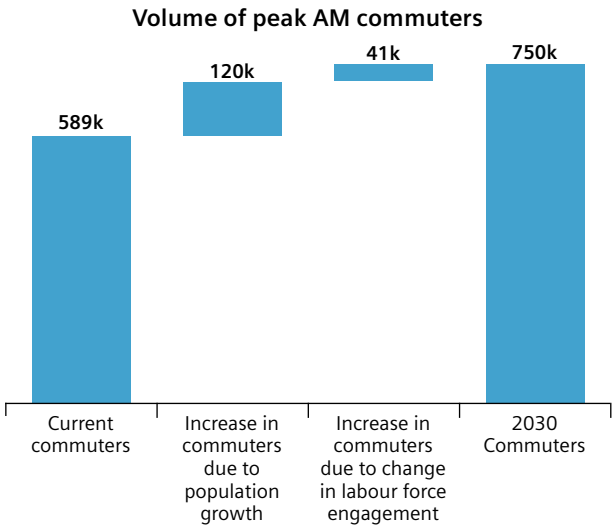
CHALLENGES

- The lack of WiFi connectivity on the metro network constrains productivity during journey time
- The absence of real-time information and live traffic information affects the usability of the network
- Much of the rolling stock is now old, dating from before 1990, and the planned additions will only go some way to addressing this

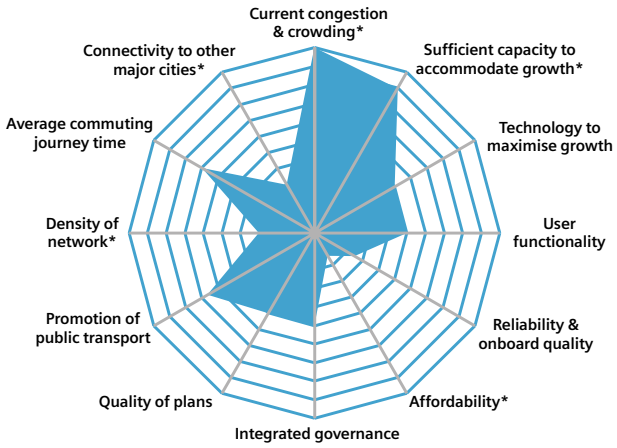
RECOMMENDATIONS

- Additional investment should focus on improving quality (e.g. new rolling stock, improved information systems), although costs must be contained to avoid increasing the existing cost of fares

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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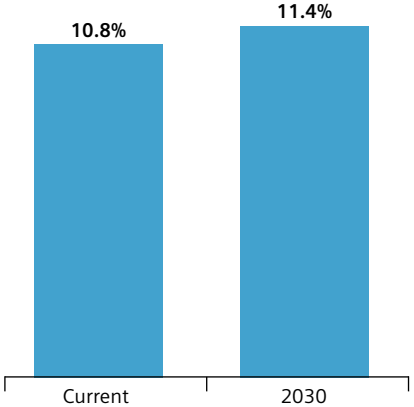
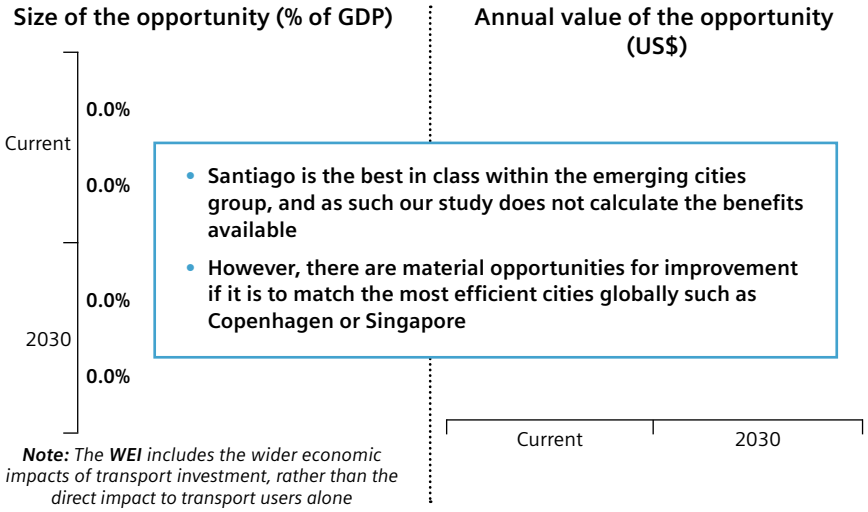
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES



- Santiago is the best in class within the emerging cities group, and as such our study does not calculate the benefits available
- However, there are material opportunities for improvement if it is to match the most efficient cities globally such as Copenhagen or Singapore

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Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

SAO PAULO

CURRENT GDP: $258bn[1]
POPULATION: 11.2m[1]
CITY TYPE: Emerging

Sao Paulo has attempted to optimise its existing network, but capacity on both rail and roads remains a key challenge in urgent need of attention

STRENGTHS

- Impressively integrated Interligado bus system with shared payment system allowing transfers between buses
- Extensive use of priority lanes to improve service quality
- Recently upgraded signalling systems on metro to improve reliability of ageing network
- Bus fleet is renewed every five years to ensure quality levels are maintained

CHALLENGES

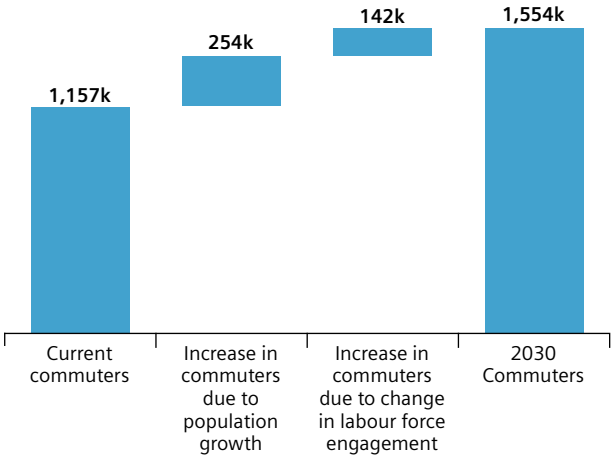
- Capacity on existing network is under severe pressure, and the city lacks plans to increase capacity to meet future demand
- Road congestion is a serious problem for the city, with traffic jams of up to 100km frequently occurring
- Affordability is an issue, as has been shown by fare protests over the past 12 months

RECOMMENDATIONS

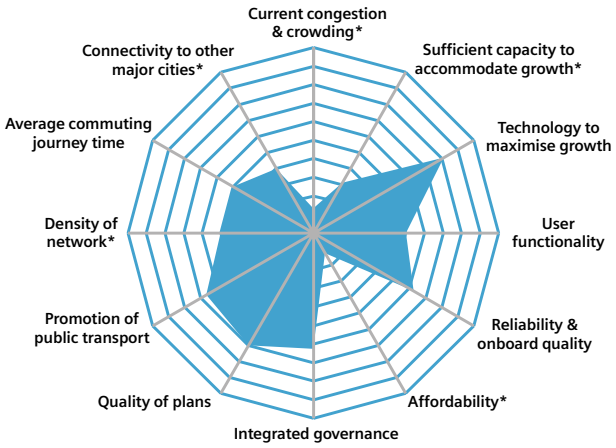
- Increasing capacity should be the main focus of investment; given road congestion, this is likely to require investment in rail
- Demand management on road network should also be considered to attempt to ease congestion

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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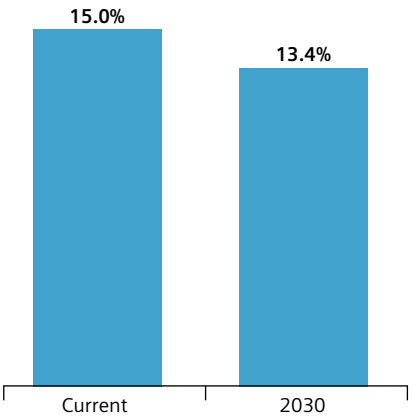
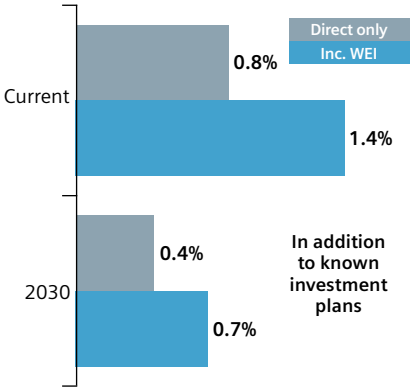
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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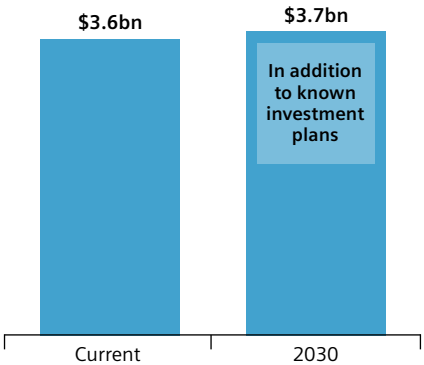


Note: [1] City population based on urban area, taken from Sao Paulo Census. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Sau Paulo Census; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

SEOUL

CURRENT GDP: $230bn[1]
POPULATION: 9.7m[1]
CITY TYPE: High density compact centre

Seoul's current investment plans focus on improving the network density of its high tech subway system; however, the capacity challenge must also be addressed

STRENGTHS

- Subway system is the most widely used rapid rail transit system in the world, with 286km of rail and 291 stations
- Subway offers a full suite of user-facing functionality, including journey planners and information systems
- Many trains also offer air conditioning, heated seats and TVs
- Proposed expansion plans with 10 new lines to increase network density and improve connectivity

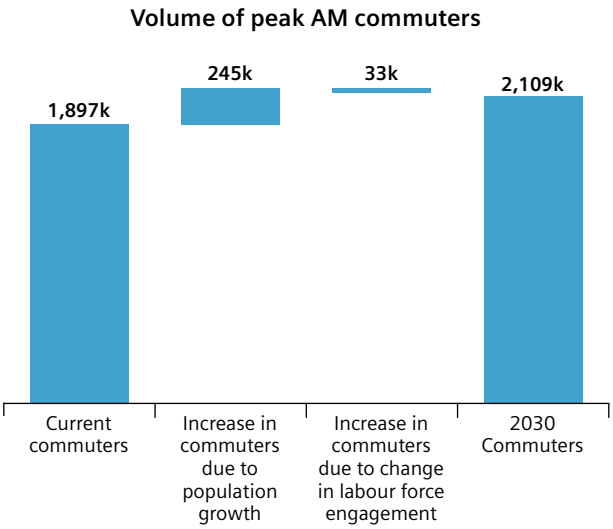
CHALLENGES

- Capacity on the subway appears under pressure; since new lines are focused on increasing network density rather than capacity, this will remain an issue
- Low network density means that some areas of the city are poorly served (although this will be addressed if all proposed lines go ahead)
- Signalling technology across the network is underdeveloped, with only 18km using CBTC technology

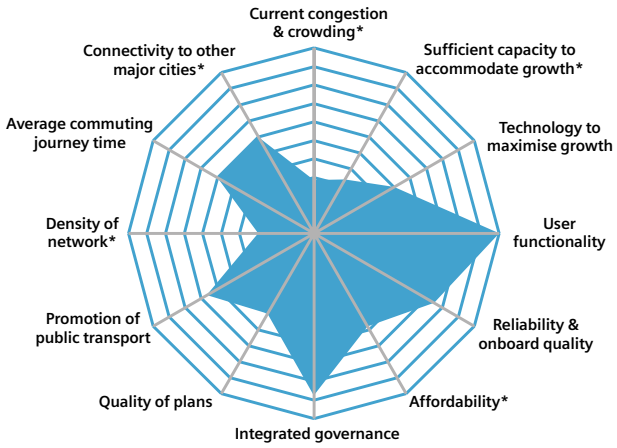
RECOMMENDATIONS

- Encouraging modal shift to less utilised bus network or increasing integration between modes, would ease capacity issues
- Investing in technology could enable increased capacity on existing subway lines

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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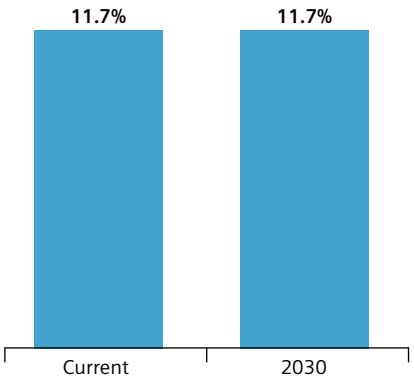
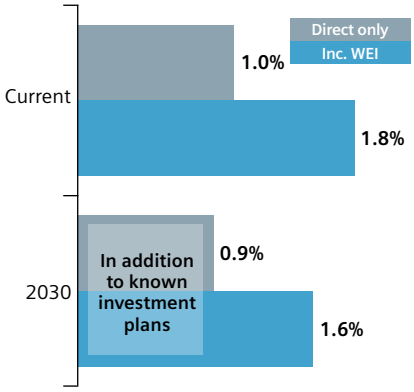
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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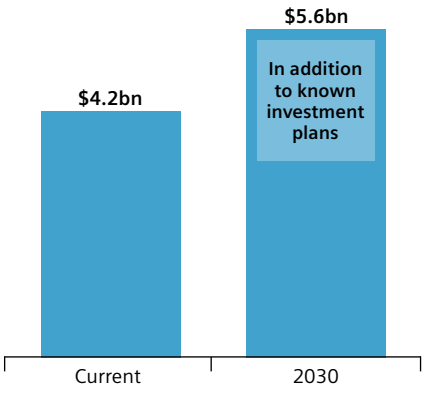

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SHANGHAI

CURRENT GDP: $290bn[1]
POPULATION: 20.2m[1]
CITY TYPE: High density compact centre

The scale of economic benefits available to Shanghai can justify the large scale investment required to meet the growing capacity challenge it faces

STRENGTHS

- Extensive use of modern technology to enhance capacity, such as CBTC signalling on metro network
- Active use of traffic management and live traffic information systems to manage demand across all modes of transport
- High service levels across metro and light rail with 99% of trains on time
- Strong focus on increasing share of public transport in future

CHALLENGES

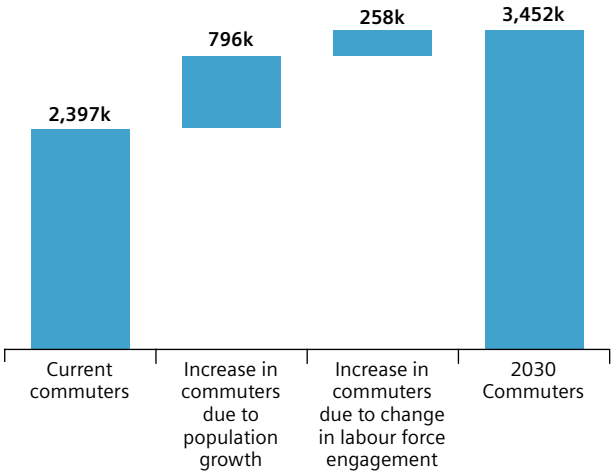
- Current capacity is under pressure, and despite increasing the length of the metro from c. 400km currently to 820km by 2020, this will remain an issue
- Given the rate of population growth, current levels of road congestion are unlikely to be alleviated even if the city reaches its target of a 50/50 public/private transport split
- User-facing technology (e.g. journey planning) appears rudimentary currently

RECOMMENDATIONS

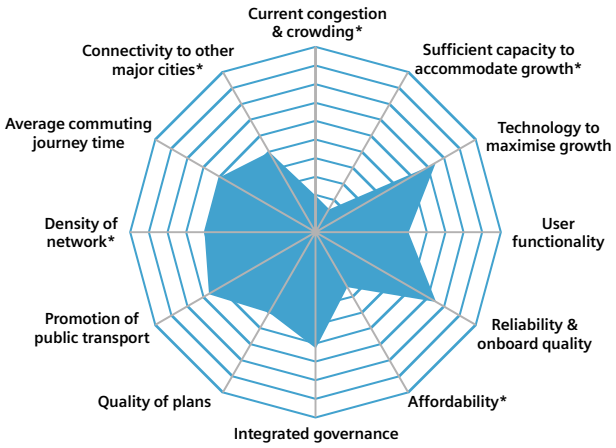
- Investing in capacity to meet future demand appears the key challenge, but the scale of benefits in 2030 suggest large scale investment is justified

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



Note: *Metrics scored out of ten; shading further from centre indicates higher score.*
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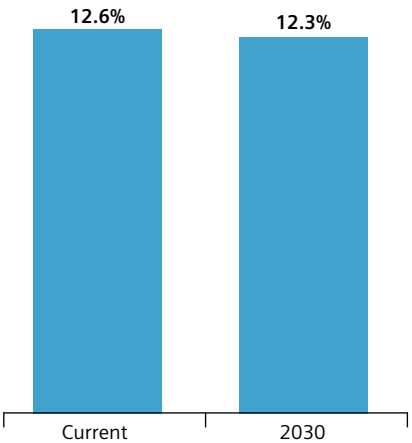
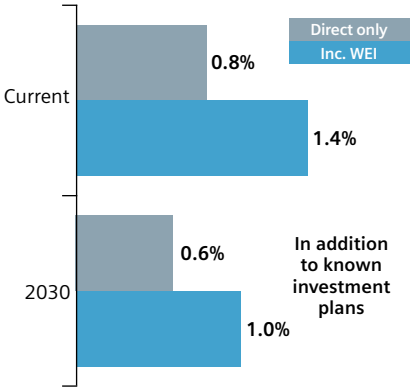
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

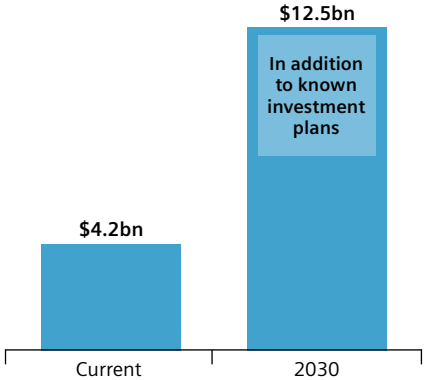
OPPORTUNITIES

Size of the opportunity (% of GDP)



Note: *The **WEI** includes the wider economic impacts of transport investment, rather than the direct impact to transport users alone*

Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

SINGAPORE

CURRENT GDP: $276bn[1]
POPULATION: 5.2m[1]
CITY TYPE: High density compact centre

Singapore has one of the most efficient systems in our study, with high capacity and user functionality. Its current investment plans position it well to meet future demand

STRENGTHS

- High capacity system able to meet current demand with minimal crowding across both bus and metro networks
- Highly integrated governance has helped to develop the current system and create sufficient plans to meet future demand
- 40km fully automatic Downtown line first addition to be complete by 2017
- High levels of user functionality - including EZ link integrated payment system, effective journey planners and real-time information for rail and road traffic
- Reliability and punctuality levels are high
- Air conditioning (important due to climate) across almost 100% of metro and 85% of buses

CHALLENGES

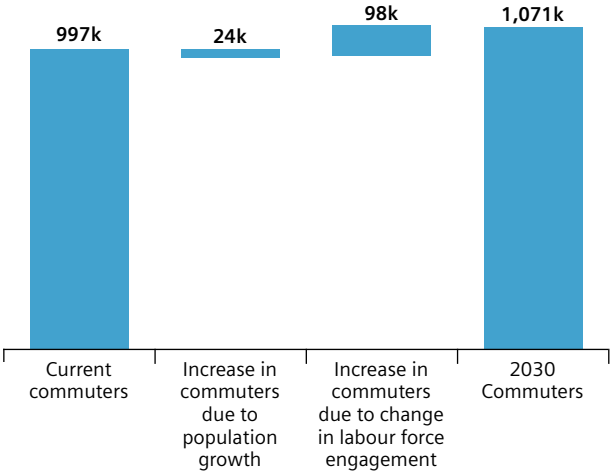
- Relatively low network density leaves some areas poorly connected
- Some of bus fleet appears to be ageing, potentially harming quality

RECOMMENDATIONS

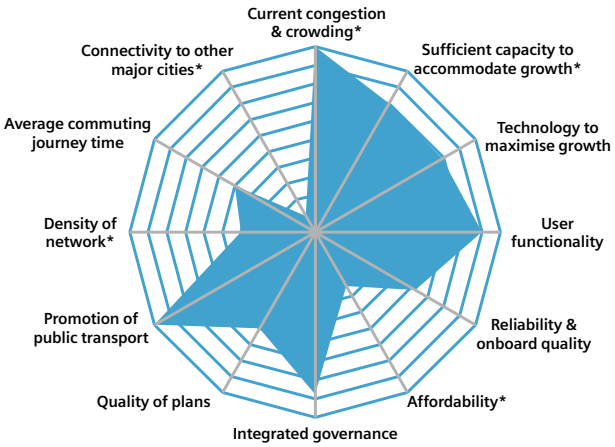
- Current investment plans to 2030 appear effective at dealing with future demand; there may be an opportunity for further investment to improve network density
- Some level of continuous investment will be required to maintain standards

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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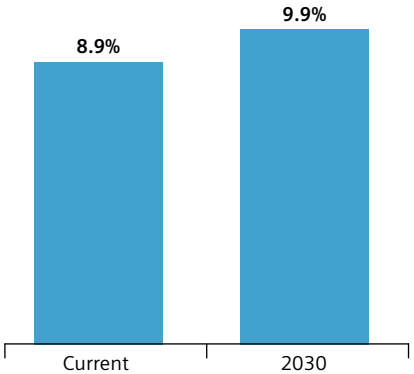
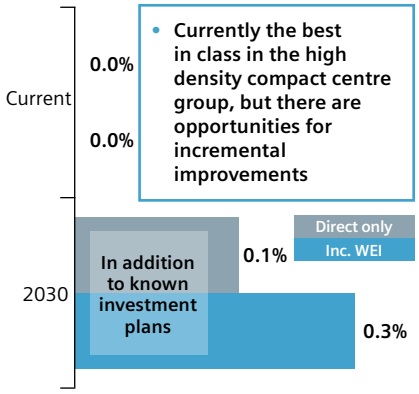


Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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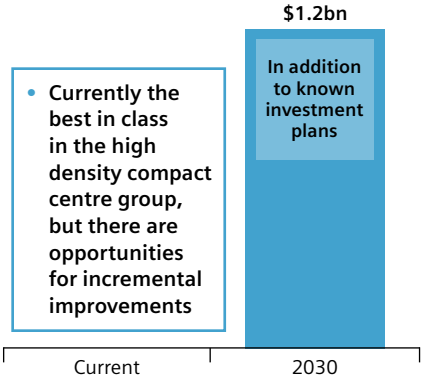


Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

STOCKHOLM

CURRENT GDP: $94bn[1]
POPULATION: 1.4m[1]
CITY TYPE: Well-established

Stockholm's network performs well across a range of metrics, notably capacity and network density, but is expensive to use

STRENGTHS

- High network density ensures that the whole of the city is effectively connected
- Existing capacity is sufficient to meet current and future demand across all modes
- Access payment card works across all modes; integration of network also shown by multimodal journey planner
- Age of current fleet is being addressed through modernisation programmes – e.g. new fleet on Red Metro Line
- Service is reliable - 95% of journeys across network are on time

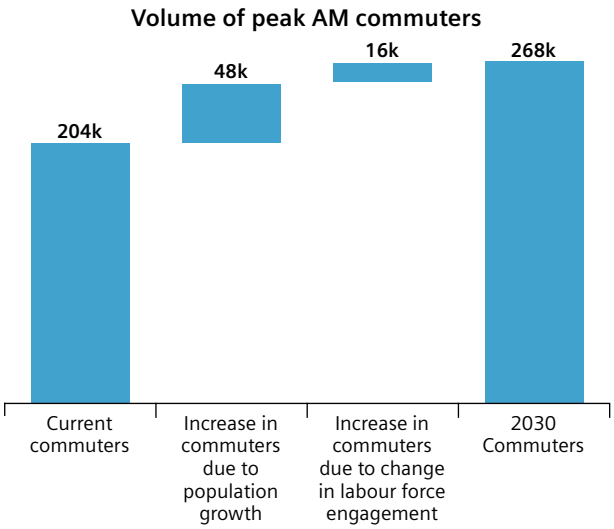
CHALLENGES

- Majority of fleet is now ageing; rail stock ranges from 10 to 40 years old (although we note that plans are in place to renew this)
- Similarly, some infrastructure such as signalling is now out of date
- By some measures, Stockholm has the most expensive urban transport fares in the world
- The greatest challenge is to keep up with strong population growth and catch up from decades of low investments in network expansion.

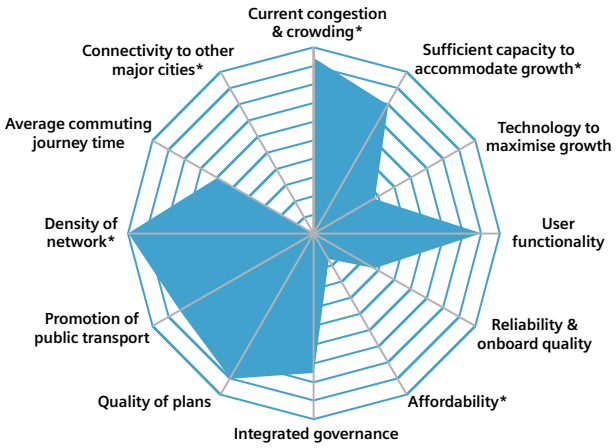
RECOMMENDATIONS

- Focus on incremental investment to renew ageing components of network, whilst attempting to control cost to users

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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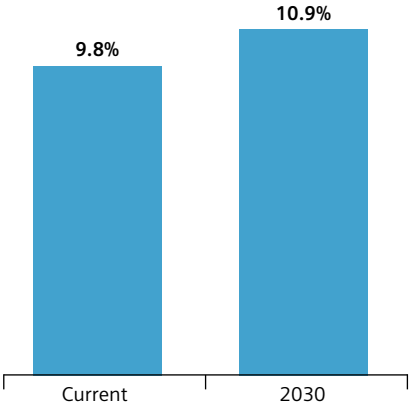
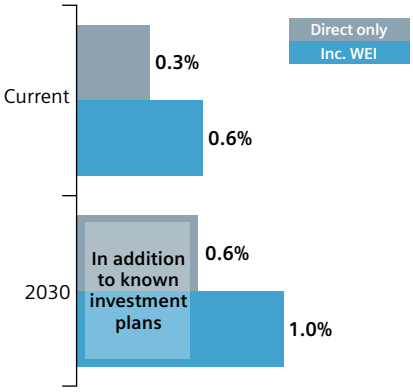
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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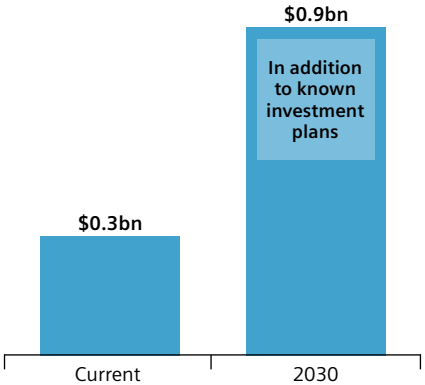

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Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

SYDNEY

CURRENT GDP: $306bn[1]
POPULATION: 4.5m[1]
CITY TYPE: Well-established

Sydney's network performs well in general, but there are opportunities to realise economic benefits through improving quality

STRENGTHS

- Multimodal system with good levels of capacity across bus, boat and light rail
- Single point of governance and source of funding within New South Wales enables joined up planning
- Plans to add light rail line in 2015 and North West Rail link in 2020 will help meet future demand
- Integrated real-time information and journey planning systems improved usability
- Payment systems integrated across modes

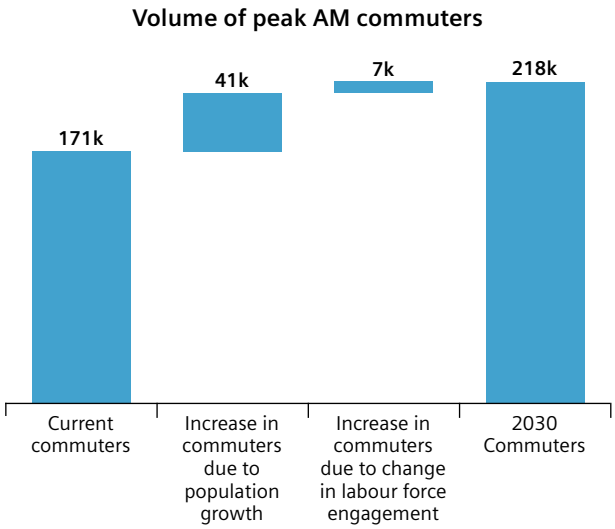
CHALLENGES

- Capacity on suburban rail appears challenged, and this will become more material by 2030
- Current payment systems are based on magnetic strip cards, and whilst previous attempts to introduce smart card technology (with the Tcard) failed, the Opal card is being rolled out soon
- Both bus and rail fleets appear in need of renewal
- Relatively low network density makes private transport more attractive for many

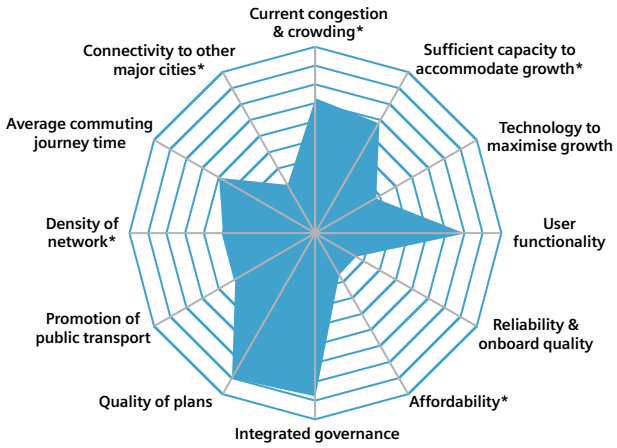
RECOMMENDATIONS

- Focus of investment should be on improving quality, for instance through new fleet or using technology to offer a better service

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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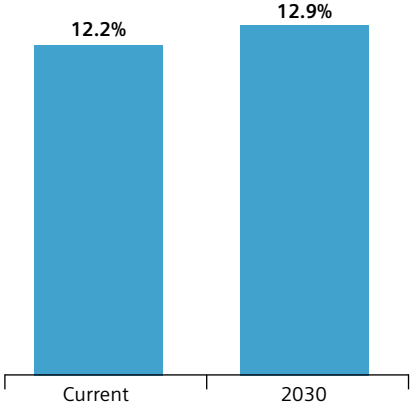
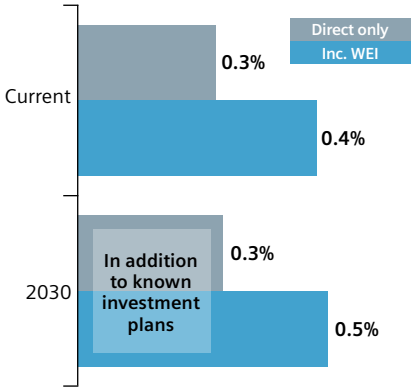
ECONOMIC COST OF TRANSPORT



Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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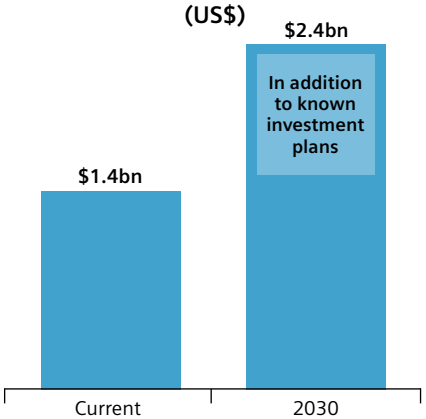
Annual value of the opportunity (US$)



Note: [1] City population based on urban area, taken from UN statistics. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

TOKYO

CURRENT GDP: $492bn[1]
POPULATION: 9.0m[1]
CITY TYPE: High density compact centre

Tokyo's rail-focused network offers impressive network density, and thus addressing its capacity challenge will required optimising existing networks rather than new lines

STRENGTHS

- Tokyo is home to the world's most extensive urban rail network, and it has impressively high network density with 0.61 commuter rail stations per square mile
- PASMO and Suica payment cards offers integration across both rail and bus operators in Tokyo and nationwide, and allows payments in shops and vending machines
- Service levels are high, with delays of more than a minute viewed as unacceptable

CHALLENGES

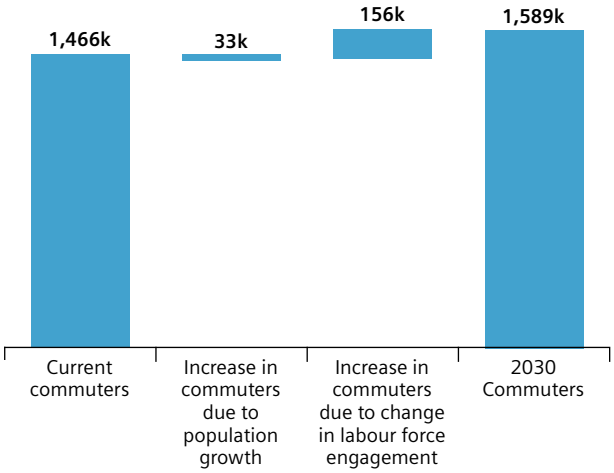
- Capacity on rail network, which carries c.90% of commuters, is severely challenged at peak times
- Much of Tokyo's infrastructure – both fleet and network – is ageing and in need of renewal
- Whilst there is a single point of governance, the presence of numerous private operators throughout the network makes coherent future planning more difficult

RECOMMENDATIONS

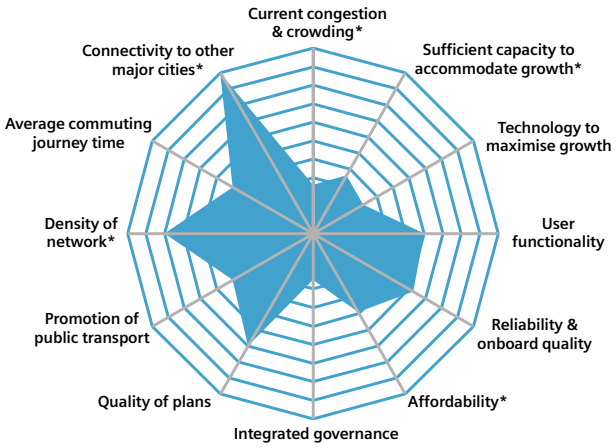
- Attempt to drive increased capacity through rail system – network density is impressive currently, so this is likely to rely on additional carriages and more frequent services

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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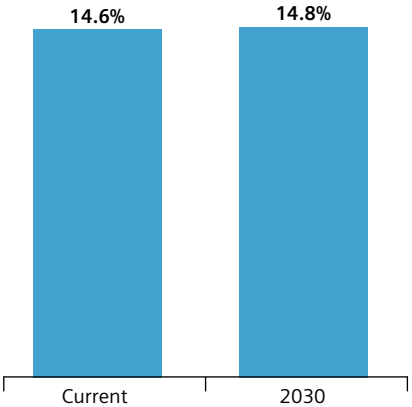
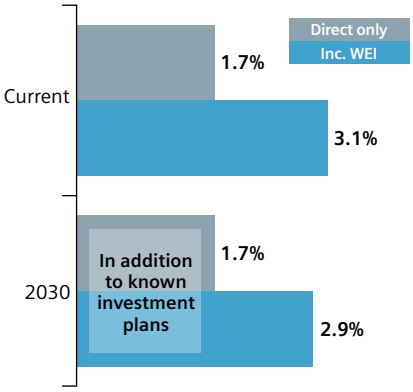


Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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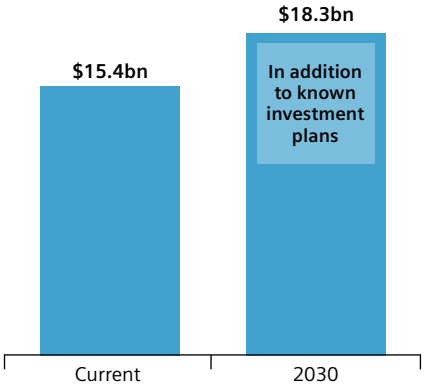


Note: [1] City population based on 'city proper', taken from Tokyo Census. City GDP derived from population and GDP per capita as stated by Brookings Institution
Sources: UN; Tokyo Census; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

TORONTO

CURRENT GDP: $296bn[1]
POPULATION: 5.6m[1]
CITY TYPE: Well-established

Toronto's network is user friendly, and has sufficient capacity at a high level. However, key routes to downtown areas are facing rapidly increasing demand

STRENGTHS

- Current capacity across bus and metro systems is good, although some routes such as Yonge line face pressures
- A number of extensions to the metro are planned, including to the Yellow line and Sheppard line, which will help meet future demand
- High occupancy vehicle lanes are used across a small portion of the network currently, but plans are in place to roll them out more extensively

CHALLENGES

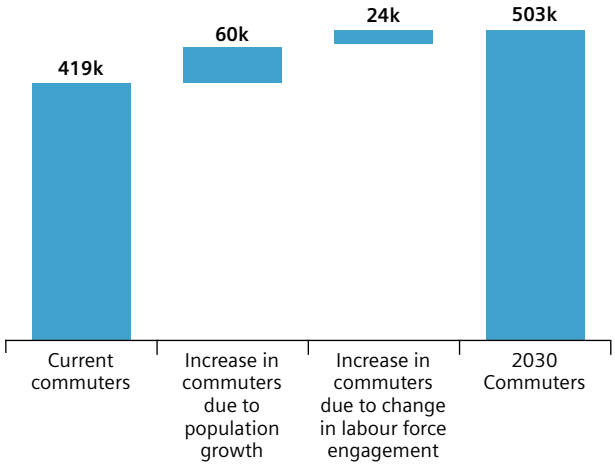
- The low density of Toronto's transport network means that some areas are poorly served
- The metro network is not effectively aligned with areas of high population and employment density, leading to capacity issues on some routes (e.g. to downtown)
- Service quality is respectable, but not on a par with leading systems
- There is significant potential to improve the quality of services – through fleet modernisation, and or adding modern functionality like WiFi

RECOMMENDATIONS

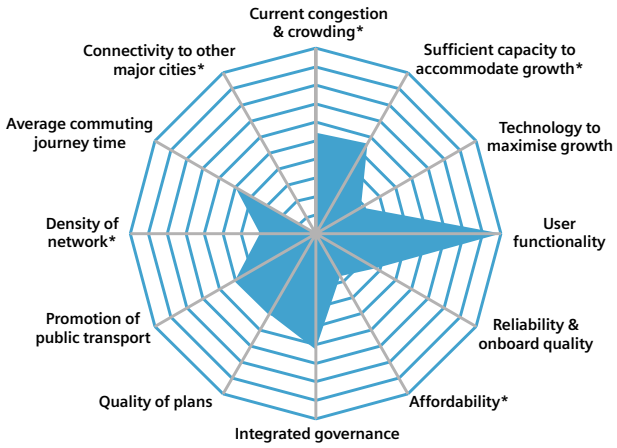
- Focus on incremental improvements to quality, for example new fleet or technology
- Invest to improve network density, and more closely align transport networks to changing population density

SCALE OF THE CHALLENGE

Volume of peak AM commuters



CURRENT PUBLIC TRANSPORT PERFORMANCE



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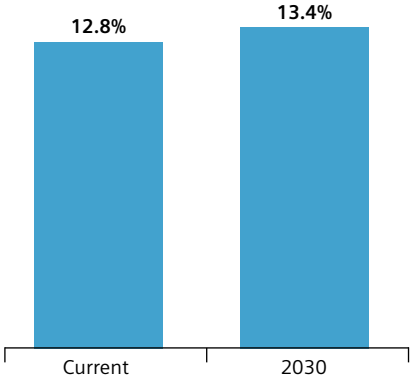
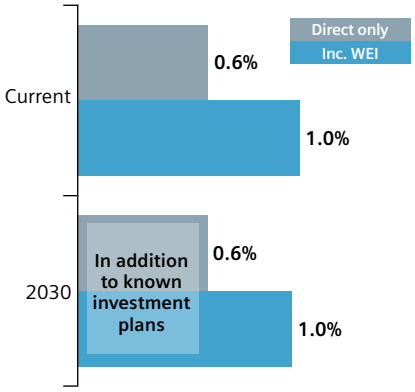


Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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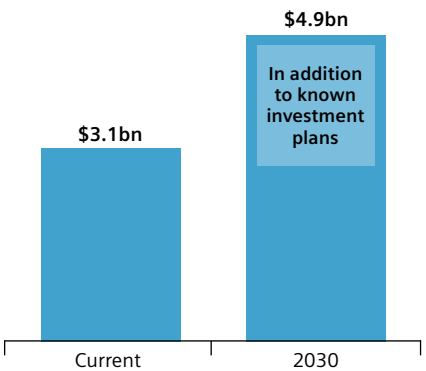

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VIENNA

CURRENT GDP: $87bn[1]
POPULATION: 1.7m[1]
CITY TYPE: Well-established

Vienna has a high capacity, user-friendly network. Investment opportunities should be focused on maintaining current high service levels

STRENGTHS

- High network density makes network convenient for users, with combination of modes well integrated
- Continuous investment in growing metro capacity in four phases since 1980 has ensured current capacity is sufficient to meet demand
- Multimodal, point to point journey planner with embedded live traffic information offers high functionality

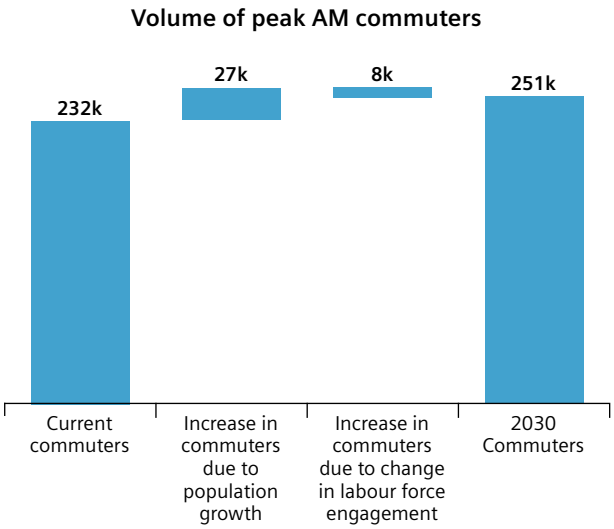
CHALLENGES

- Ticketing technology in need of updating – tickets are manually checked in random inspections, although smartcards have been piloted
- Some of the metro rolling stock has been in use for 40 years, although we note that 44 new six-car train sets will go some way to addressing this
- Older rolling stock (e.g. trams) lack air conditioning
- Although mobile networks are available on much of the metro, a lack of WiFi connectivity reduces productivity

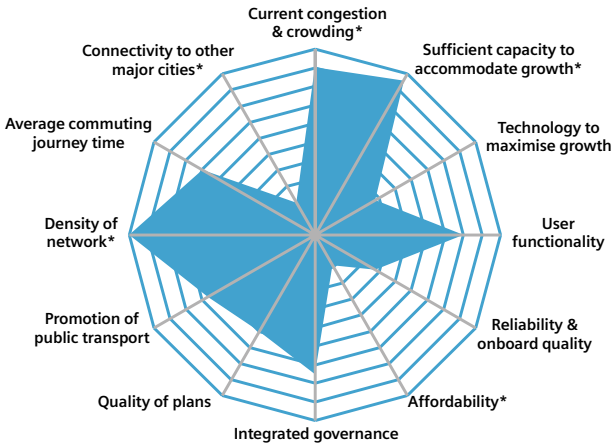
RECOMMENDATIONS

- Continue programme of incremental investment to maintain standards (e.g. fleet renewal, signalling improvements)
- Consider opportunities to improve quality (e.g. WiFi)

SCALE OF THE CHALLENGE



CURRENT PUBLIC TRANSPORT PERFORMANCE



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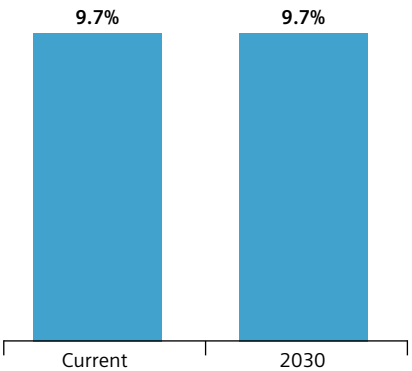
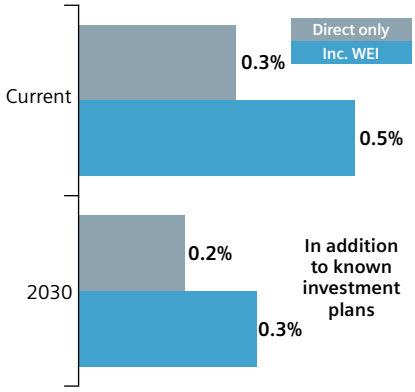


Economic cost of transport to individual commuter as % of GDP per capita

OPPORTUNITIES

Size of the opportunity (% of GDP)



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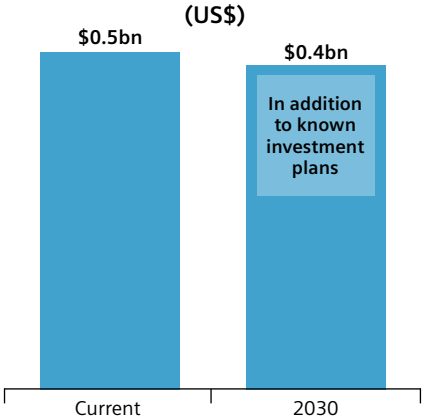

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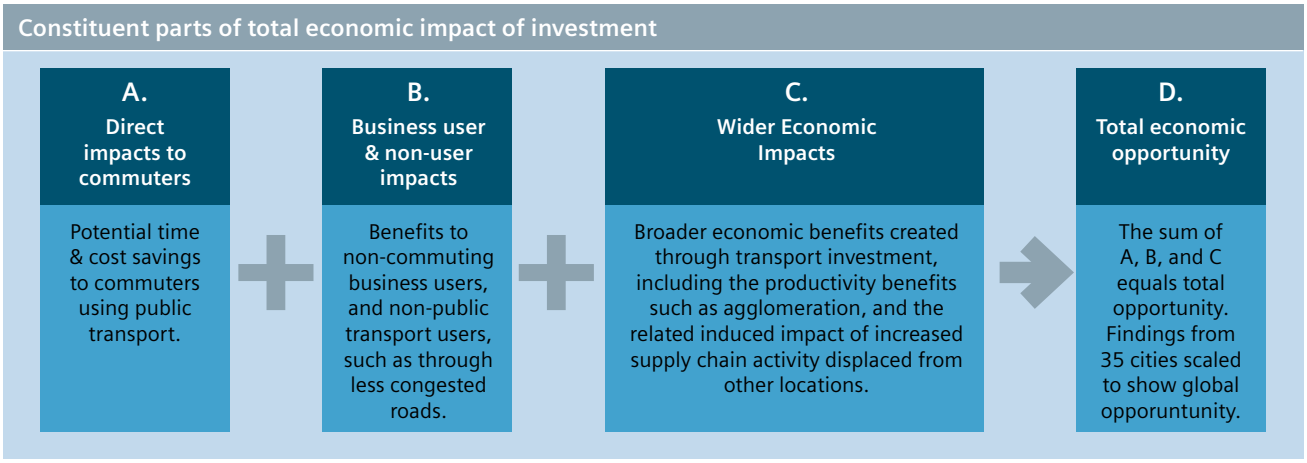
Sources: UN; Brookings Institution; Jane's Urban Transport Systems; Credo research & analysis

Appendix 3: Methodology

Overview of approach

Our modelling approach is based on four steps to understand: the cost of transport within each city, both currently and in 2030; the cost differential between each city and the best in its class; and the broader scale of economic benefit that may be realised through investment. The approach breaks the impact into a number of parts: the direct impacts to commuters (step A below), the direct impacts to non-commuting business users and non-public transport users (step B), and the wider economic impacts which transport investment brings (step C). The sum of these makes up the total economic opportunity and we then scale the findings from the 35 cities in order to show the global opportunity (step D).



A1 Generalised journey time

- The generalised journey time is the average length of the commute, adjusted for quality factors that affect a user's perception of the length of their journey (in line with accepted transport economics practice).

A2. Cost of transport to individual

- The cost of transport to an individual consists of two parts: first, the value of the time taken to travel (based on the generalised journey time), and second, the cost of the fare – which is an average across modes, weighted in proportion to their modal shares. We aggregate this to an annual value by multiplying for the average number of commutes per year.

A3. Overall cost of commuting transport

- The overall cost of commuter travel is then the cost to an individual, multiplied by the number of commuters.

A4. Economic cost of sub-optimal transport networks for commuters

- We then assess the cost of commuter travel for an individual within each city, normalised for the variation between cities in terms of commuting population by comparing as a percentage of GDP per capita.
- The potential economic benefit to commuters from investment is then the difference in terms of transport cost as a percentage of GDP per capita with the 'best in class' city, multiplied by the volume of commuters.

B. Opportunity for non-commuter business travel & non-public transport users

- To assess the value of the opportunity within each city we then include business travel outside of peak commuting hours and non-public transport by applying multiplier factors based on known urban transport projects globally.

C. Wider economic impact (WEI) of investment

- Finally, we model the broader impact of investment by applying multipliers (again, based on known urban transport projects) to reflect the typical uplift from the wider economic impact and induced effects of transport. We adjust the wider economic impact multiplier in relation to how well connected each city is to other cities, in order to reflect how well placed a city is to capture the benefits of more attractive transport networks. For 2030, we adjust the level of wider economic impact to reflect the level of governance of a city. We assume that cities with strong integrated governance are more likely to achieve the full benefit of investment.

D. Total value of opportunity from investment

a. To calculate the total economic opportunity available to cities, we therefore add the direct and indirect effects from each city to create the total potential uplift

b. In order to assess the global opportunity – in all cities over 750,000 inhabitants currently, rather than just the 35 cities in our study – we scale the opportunity from the 35 cities in our study in line with economic output.

Key principles

Base data points
Our economic modelling builds on over 70 separate data sets, which we have collected from a wide range of published data (e.g. UN, World Bank, Brookings Institution), as well as through proprietary research.

Whilst the more quantitative data has been used as direct inputs in our modelling, we have also developed a number of metrics, which enable our modelling to take account of all the key drivers of transport systems' performance.

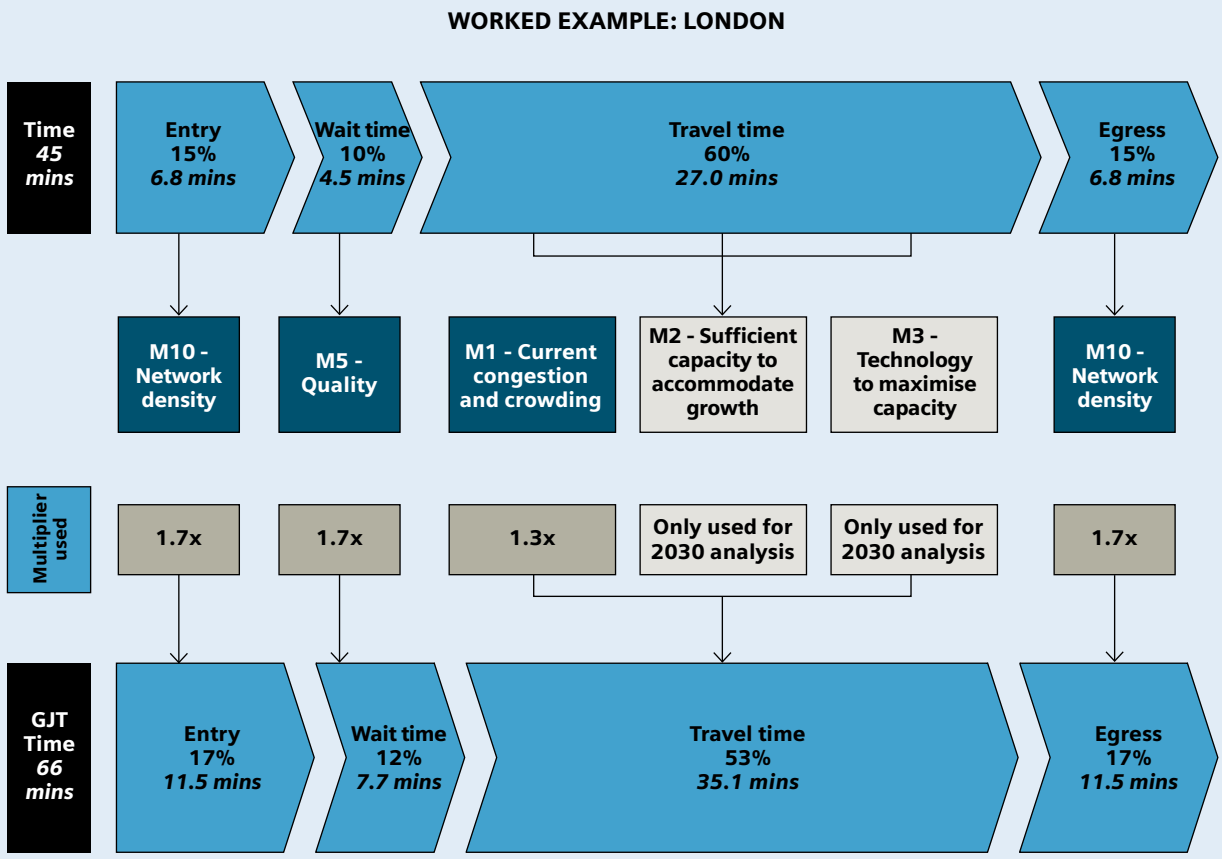
Urban mobility metrics
These twelve metrics are based on a wide range of data sources, and represent a quantitative assessment of a city's public transport network. For some of the metrics (M1, M2, M6, M9) the scoring system is based on the relative performance of cities; other metrics are scored against a defined set of criteria. Where cities partially met a criterion (e.g. CBTC signalling on a small part of the network rather than the majority), partial marks were awarded at a sub-metric level. Some metrics are only applied to our 2030 assessment, as shown right.

Value of time
To assess the economic impact of travel efficiency, the model attributes a monetary value to travel time, calculated using the established methodology in the UK's Passenger Demand Forecasting Handbook. This produces a cost for each minute of travel time. This cost is adjusted using GDP per capita to account for differences in value of time between cities.

Generalised journey time
To give a true cost of commuting journeys for each city, above the base fare, the model uses a 'generalised journey time' (GJT), unique to each city. GJT works on the principle that perceived travel time varies depending on a number of factors. Broadly speaking, travelling in conditions less comfortable and conducive to productivity leads to longer perceived journey times, and therefore a higher perceived journey cost. The model assumes the proportion of each journey that is spent travelling to the point of departure, waiting for the vehicle to arrive, travelling in the vehicle and travelling from the arrival station to the final destination. These proportions are then adjusted based on each city's specific urban mobility metrics scores.

Application of general journey time modifiers

Application of general journey time modifiers



Urban mobility metrics		
Area	**Metric**	**Details**
Capacity & Crowding	**M1 – Current capacity & crowding** *(Current only)*	Score calculated based on current capacity vs. peak AM demand, by mode, with the overall score weighted by modal share.
	M2 –Sufficient capacity to accommodate growth *(2030 only)*	As per M1, but taking into account planned extensions for which data is available, and future demand modelled in line with population growth and changing labour force engagement.
	M3 – Technology to maximise growth *(2030 only)*	Score based on use of four categories of technology which are likely to drive improved efficiency: 1) Automated trains 2) CBTC signalling & moving block technology on rail networks 3) Bus priority measures 4) Traffic management technology
Attractiveness	**M4 – User functionality**	Score based on use of technology to improve customer experience and usability of network, across all modes: 1) Integrated electronic payment systems 2) Effectiveness and functionality of journey planning software 3) Use of real-time information 4) CCTV coverage of network 5) Availability of live traffic information
	M5 – Reliability and on-board quality	Score to reflect reliability of services, and on-board quality, including: 1) Age of fleet (top scoring required average age of buses under five years, and average age of trains under 10 years) 2) Reliability of services (top scoring required >95% of services to run within five minutes of scheduled time) 3) Presence of air conditioning across network 4) Connectivity – presence of WiFi or 3G/4G connectivity
	M6 – Affordability	Relative score based on the average fare within a city across bus and rail transport. Modal fares were weighted in proportion to share to create a compound average fare, this was then expressed as a proportion of GDP per capita, and scores out of 10 were allocated on this basis.
Governance	**M7 – Integrated governance**	Cities were scored on four areas of governance, with a maximum score requiring all of the following elements: 1) Single point of control for all transport modes 2) Single funding source for all transport modes 3) Consistency of customer experience across modes 4) Integration with broader national bodies (e.g. national government, planning)
	M8 – Quality of plans *(2030 only)*	Future plans were rated based on quality according to the following factors: 1) A clearly articulated long term plan to 2030 2) Plan clearly cascaded into supporting plans across all modes 3) Clear linkage of transport plan to broader development plans of city 4) Level of risk management incorporated into plan 5) Overall effectiveness of plan
	M9 – Promotion of public transport *(2030 only)*	A compound score based on: 1) City performance in Green Cities Index (a report focused on environmental performance of cities) 2) Promotion of efficient use of road network – for instance using high occupancy vehicle lanes 3) Use of congestion charging to manage demand
Connectivity	**M10 – Density of network**	Relative score based on comparison of network length (across all modes) compared to city area.
	M11 – Average commuting time	Average commuting time by city.
	M12 – Connectivity to other major cities	Score based on the proportion of population within region (considered to be 600km from city) which is connected to the city – either by one hour or less by plane, or by three hours or less by high speed train.

'Best in class' comparison

The model takes into account these two components (base fare and generalised journey time cost) to give a total perceived cost of a single commute. This number is then adjusted for the number of such journeys made per year to give the annual cost of commuting for one passenger. We then take this number as a percentage of total GDP per capita.

The city where the annual cost of commuting is lowest as a percentage of GDP per capita is defined as 'best in class'. The potential economic benefit available to each city is calculated by comparing the 'best in class' percentage of total GDP per capita spent on commuting with the same percentage for each city. This difference is converted to a cash cost, and adjusted for the number of commuters to give a total economic benefit available.

City types

We have sorted cities into three 'peer groups', broadly defined by geographic features, population density, and level of development. These groupings are not intended to be definitive, but instead are used to aid comparison between cities, and offer a realistic view of the potential improvements available. At a high level, we define the cities as follows:

'Well-established cities'

These cities typically have well-established layouts and developed transport systems, which may be facing capacity constraints.

'High density compact centres'

These are more modern cities that have experienced recent or ongoing expansion, with high population density in the centres. Transport networks may be less developed than in well-established cities.

'Emerging cities'

These cities are typically less wealthy than those in the other categories, with large and growing populations, and typically underdeveloped transport infrastructure. Whilst the centres of these cities may be well-established, in general terms the layout may be less defined than that of 'well-established' cities. The list of cities by 'city type' is shown below:

CITY TYPES		
Well-established cities	**High density compact centres**	**Emerging cities**
Berlin	Beijing	Bangkok
Chicago	Dubai	Buenos Aires
Copenhagen	Guangzhou	Cairo
Istanbul	Hong Kong	Delhi
London	Riyadh	Jakarta
Los Angeles	Seoul	Johannesburg
Madrid	Shanghai	Lagos
Melbourne	Singapore	Mexico City
Moscow	Tokyo	Mumbai
New York		Santiago
Paris		Sao Paulo
Stockholm		
Sydney		
Toronto		
Vienna		

Wider economic impact and induced impacts

A specific WEI and induced impact multiplier is calculated for each city by taking into account each city's 'connectivity to other major cities' score. Increased connectivity is likely to make the city in question better placed to capture the benefits of an improved transport network, so a well-connected city receives a higher adjusted multiplier. This multiplier is applied to the economic benefit available to estimate the total economic benefit achieved by matching the 'best-in-class' comparator. Finally, for the 2030 view of networks, we adjust this total using each city's 'governance' score, as cities with poor governance structures are less likely to achieve the full benefit.

Appendix 4: Technical audit

The economic opportunities of addressing the urban mobility challenge

Findings from technical audit

Summary

Credo has been commissioned by Siemens Infrastructure & Cities to analyse the economic opportunities arising from addressing the future urban mobility challenge in major cities around the world. Connected Economics Limited has been asked by Credo to independently review the approach taken to this analysis.

In our view:

- The broad structure of the approach is suitable for assessing impacts on the economic output of the cities selected;
- A suitable range of factors have been considered in the analysis;
- The evidence which has been applied to reflect transport behaviour and valuations is reasonable; and
- A suitable approach has been taken to benchmarking between peer groups of cities.

We conclude that the findings are directionally reasonable and that a suitable set of sensitivity tests has been undertaken to provide additional confidence in the results.

Structure of the approach

Credo's approach begins by assessing the likely impact of improvements in transport supply on commuters within a city. At a city level, improved commuter transportation will affect the wage bargain and enable employers to offer lower wages as journeys get easier. This translates into productivity impacts for firms and will therefore affect Gross Domestic Product (GDP)[1]. Credo builds these commuter impacts up from:

- Data which describes existing commuter public transport journeys within the selected cities;
- Evidence of how these journey characteristics are valued by commuters; and
- Forecasts of how they are likely to change over time.

These building blocks follow the structure of, and are consistent with, standard transport appraisal practice. While standard appraisal techniques are usually used to assess a defined transport investment proposition, there are no reasons why it should not be applied to a more broadly defined policy or programme of improvements with given transport outcomes (such as increasing network

[1] There is some debate about the extent to which commuter benefits could instead be reflected in land use changes as commuters choose to spend similar amounts of time travelling but to move further outward from the city core. Translating commuter time savings into GDP must therefore assume that significant changes in city land use (specifically further urban sprawl) will not be brought about by improvements in commuter journeys.

coverage or reducing unreliability). Credo has therefore applied established practice in an innovative new way.

The analysis then continues to estimate further economic impacts (such as impacts on business travel within the cities, and multiplier effects) in order to provide a more complete view of likely impacts on city GDP. The approach taken reflects findings of comparable investments in similar cities around the world and is a reasonable approach to building out to this more complete view.

The potential economic benefits available are examined using a benchmarking exercise. This effectively creates a hypothetical investment case situation in which the characteristics of different transport systems were brought up to 'best in class' standards. Strengths and weaknesses of this benchmarking approach are discussed further below.

Range of factors considered

There are a very large number of factors which affect how people perceive the difficulty of a journey. However, some of these are consistently found to be more significant than others and these are the features that are usually reflected in transport modelling and analysis. The most important factors are: in-vehicle journey time; service frequency (which affects the time spent waiting); ease or difficulty of accessing the public transport network; and fares. In addition to these, crowding, reliability and service quality (capturing aspects such as cleanliness, ride quality, facilities and information provision) are sometimes also modelled.[2] Credo's analysis captures all of these elements and we therefore conclude that the range of coverage of the analysis of commuter impacts is good and reflects best practice in transport appraisal.

We note that the analysis is based on data reflecting the transport characteristics of the different cities (such as average commute time, crowding levels and fares). Connected Economics has not been asked to review this underlying data.

Applicability of evidence

A key challenge in transport analysis is the applicability of behavioural evidence to different contexts. It must be recognised that the evidence base of the impacts of transport change is disproportionately from the developed nations, and the evidence that Credo has drawn on has mainly been derived from the UK in particular. However, this challenge is not unique to Credo's work and in our view the best use has been made of the evidence that is available.

In general the evidence is only suitable where changes in overall generalised costs are relatively small and caution should be exercised where changes in generalised costs exceed around 20 or 30 per cent. For many cities, the changes in transport provision to match the 'best in class' cities fall within this range, although some would require very significant changes in generalised cost in order to achieve 'best in class' status. These changes could be expected to lead to significant behavioural and land use change impacts within these cities. This issue should not bias the results in a particular direction and Credo's results are therefore a reasonable central case. However, modelled economic benefits in the worse performing cities are therefore subject to additional uncertainty.

[2] The benefits that can arise from having a choice of different route options are sometimes captured within a more complex modelling framework in which route choice algorithms are used.

Approach to benchmarking and determining 'best in class'

Credo's approach reflects the economic opportunity of raising performance to that of a 'best in class' comparator. It does this by first considering the average annualised commuter journey costs as a share of GDP per capita.

The 'best in class' approach poses some challenges. First, this methodology does not admit of improvement in the city which is currently performing the best, although in some cases improvements are clearly possible. This is a feature of any benchmarking methodology and means that the findings must be interpreted carefully and not in the more naïve sense of reflecting the maximum economic benefit might be possible in a given city. A related practical concern is that investments brought forward in a given city may not serve to improve the aspects of transport that would bring them up to 'best in class' levels. For example, a fast growing city with chronic crowding problems may see persistent crowding issues while developing its network coverage, frequency and reliability to levels which are better than the current 'best in class'. This is not so much a methodological weakness as a requirement for caution when interpreting the findings.

Second, the sample size for such a study is inevitably limited and the study findings are sensitive to the cities chosen for analysis. If for example a different city was added to the analysis which performed better than the current 'best in class' city, the economic benefits for achieving 'best in class' performance would rise for all cities. There is no way around this problem within available data constraints. That said, the cities selected do cover a wide range of different city types, sizes and global locations ensuring a wide range of transport systems and characteristics.

Third, the method used to establish 'best in class' is to establish cities with the lowest average generalised costs of commuter travel. This will be affected by considerations of geography, planning and existing land use. It could be expected to favour cities which are small and compact and which have relatively short existing commute times. However, Credo has addressed this concern in two ways: first, by grouping cities into thematic groups of similar city types and comparing within these; and second, by sensitivity testing. The sensitivity testing has shown that the results are robust to changes in the overall length of commuting journeys. This allays the fear that land use differences could be responsible for the results and provides confidence in the benchmarking approach.

Finally, the sample size provides some grounds for caution if the results are extrapolated to other cities or to whole national or international economies. Smaller towns, for example, may exhibit very different transport characteristics from the megacities examined in Credo's analysis.

Conclusions

Credo have taken an approach which is based on current appraisal practice, and innovatively applied it to an international benchmarking and forecasting study between cities. We consider the method to be reasonable, proportionate and based on the best available evidence, although some caution is urged in the interpretation of findings and in extrapolating them more widely.

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