Siemens has been at the centre of thinking on the urban mobility challenge and the use of traffic management to drive cities’ competitiveness for the last 30 years. Continuing this tradition, Siemens has commissioned Credo – a leading strategy consultancy – to carry out this independent report to review the current use of traffic management in Regional and National Capitals (RNCs), defined as cities in Europe and the US with 200,000 to 1m people. This report also identifies how RNCs and the broader traffic management industry can learn from some of the world’s megacities on the best ways to harness traffic management to drive competitiveness and mobility. The research was carried out with the support of Rijwiel en Auto Industrie (RAI), organizer of the Intertraffic international trade fair for infrastructure, ITS traffic management, safety and parking.

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1. Executive summary

1.1 Background

As the world economy recovers after the global financial crisis, Regional and National Capitals (RNCs) are having to adjust to the new economic landscape. Fierce competition for a limited number of growth opportunities, the companies and investment to drive those opportunities, and the skilled but highly mobile workforce to capitalize on that investment is no longer focused between megacities but all cities. The ability to travel to and around cities is a key factor impacting their competitiveness.

Urban mobility and its link to a city’s competitiveness is a key theme that Siemens has been exploring. For the RNCs of Europe and North America, the ability to reduce congestion to speed and facilitate the flow of traffic around the city is one of the key drivers of overall mobility. In many RNCs, further expansion of the road network is not possible due to the difficulty and expense of such projects. Instead RNCs need to maximize the capacity of their existing road infrastructure by capitalizing on the opportunities afforded by new technology. RNCs of Europe and North America, the ability to reduce congestion to speed and facilitate the flow of traffic is not possible due to the difficulty and expense of such projects. Instead RNCs need to maximize the capacity of their existing road infrastructure by capitalizing on the opportunities afforded by new technology. RNCs will be able to do this most successfully by taking key learnings from megacities who have already established themselves as leaders in traffic management.

In many RNCs, further expansion of the road network is not possible due to the difficulty and expense of such projects. Instead RNCs need to maximize the capacity of their existing road infrastructure by capitalizing on the opportunities afforded by new technology. RNCs will be able to do this most successfully by taking key learnings from megacities who have already established themselves as leaders in traffic management.

1.2 Key findings

From our audit of current traffic management usage, we have found significant variation in how traffic management is understood, used and funded across the RNCs of Europe and North America. However, the overriding picture is one in which the benefits of traffic management are not fully understood or exploited:

- Only 40% of cities state that they have been very effective in their use of traffic management;
- One quarter of cities do not have a clear vision and supporting plans to deploy traffic management;
- Where cities are looking to invest in traffic management, there is often an underlying conservatism in how it is used, with nearly a third of cities looking to simply replace existing technology and less than 35% seeing traffic management as a way to better accommodate existing traffic demand;
- Perhaps because of this, in the next 5 years less than 40% of cities expect their traffic management spending to increase.

Based on this audit, we have created a categorisation of cities according to the scale of their ambition for traffic management and their goals and funding commitments in this area. We found that less than half of the RNCs have the “strategic ambition” combining the right goals and funding for traffic management, with the majority of cities at risk from a vicious cycle whereby a lack of ambition means that the benefits of traffic management are neither understood nor attained, thereby reducing available funding.

Megacities face similar challenges to RNCs when competing in the global market place and our survey respondents pointed to some of these same cities as examples of global best practice in traffic management. In this White Paper we have analyzed these examples, highlighting what can be achieved and the potential opportunities which the majority of RNCs are forgoing. We therefore propose a four stage ‘way forward’ to help RNCs establish the right framework to avoid this cycle and capitalize on the opportunities afforded by traffic management (Figure 1), and use examples of best practice in traffic management to illustrate how this can be done and the benefits that can be achieved.

2. State of play

2.1 Creating a baseline of traffic management in RNCs

Working with RAI, Credo invited over 2,000 traffic management stakeholders to participate in a survey to build a complete picture of the current use of traffic management technology. This online survey was supplemented with telephone interviews with traffic managers and city leaders to understand the senior executive view of traffic management and compare it with the views “on the front line.”

As shown in Figure 2, the survey focused on three different elements of the use of traffic management: the vision and plans cities had for traffic management; the goals they were seeking to achieve through traffic management; and their future plans for spending. The results of this survey are discussed below.

2.2 Vision and plans

A quarter of RNCs do not have a clear vision and plan to manage traffic flows in cities.

We found that one in four of cities do not have a clear vision and defined set of priorities to manage traffic flow in cities, and even among those cities that do state they have a clear vision, not all believe that this is successfully translated into initiatives to manage traffic flows (Figure 3). Overall, nearly a quarter of RNCs do not believe that they have the vision and initiatives to manage traffic flows in the city.
Our research has highlighted three key factors which differentiate those cities which do have a clear vision and initiative.

- A stable political environment: In one European city, that has a stable administration with strong policy preferences, a Traffic Manager explained the positive impact of this stability, “There is a clear manifesto and good political stability which allows us to have a clear, consistent vision.”
- A clear planning process for what traffic management can achieve: A good example of this is in an American city where the Transport Director proudly claimed, “We have had a planning process since 1962 which has evolved and become more and more sophisticated.”
- An understanding of the potential for traffic management: A European Traffic Manager explained her city’s positive approach to traffic management projects, “We have a number of initiatives and schemes to drive improvements. We are a creative city and are always willing to try new things.”

Those cities which have the clearest vision and have used traffic management most effectively combine these three factors to create a self-reinforcing cycle to maximize the benefits of traffic management (Figure 4).

Only 40% of cities state that they are effective in using traffic management

Even among those RNCs that do have a clear vision and initiatives, there is frustration. Overall, only 40% of cities state that they have been very effective in benefiting from traffic management over the last three years, and almost a quarter have found that they have not been very effective at all (Figure 5).

We have identified three key barriers to the effective use of traffic management

- A lack of funding: 40% of cities cited “a lack of funding” as the principal reason why they were not more effective. In some cases the lack of funding has limited the breadth of traffic management solutions such as in one European city where the Chief Transport Executive explained that a lack of funds forced a narrow focus, “We did a lot of work three years ago but since then we have focused on implementing our congestion charge system. There are insufficient resources to do much else.”
- A lack of resource: In addition cities complained about a lack of experts and HR resource. One European City Leader who explained, “We did have an excellent traffic management expert, but he left and it wasn’t a management priority to replace him.”

2.3 Goals and objectives

Only 35% of cities are looking to traffic management to prioritize accommodating demand...

Enhanced traffic management technologies offer cities the chance to accommodate demand and support growth through speeding traffic flows through key junctions and suggesting alternative routes to avoid bottlenecks, rather than just deter car use to manage congestion. The cities at the forefront of traffic management deployment appreciate this. As one Traffic Manager explained, “We want to make it easier for everyone.” There was a strong belief that this promotion of more efficient transport would be of economic benefit to the city. Another European Traffic Manager, commented, “We don’t want to restrict the use of cars because we want to make it easier for everyone to access our city, which will drive economic growth.”

However, cities that have such an ambitious mindset for traffic management are sadly in the minority with only 35% of cities looking to use traffic management to better accommodate demand (Figure 6). In contrast 50% of cities state reducing car use as the key ambition of their traffic management policy. One European Traffic Manager said, “We want to avoid traffic through the city and encourage people to use the public transport system instead.”

Even among the 15% of cities who had other objectives, reducing the number of car trips and increasing public transport usage is still seen as a key priority.
RNCs that look to use traffic management to "better accommodate demand" are not only in the minority, they tend to perceive themselves as having been less effective than those cities which have achieved more modest ambition (Figure 7). This is perhaps not surprising given that they have set themselves more ambitious targets, but further illustrates that RNCs are not, as a whole, capitalizing on the benefits offered by traffic management systems.

30% of cities are looking to invest simply to stand still As with all IT and Communication based technology, the capability of traffic management is developing quickly. These technology enhancements should allow cities to better accommodate demand and ensure that management of car use, rather than simple deterrence, can become a key part of RNCs’ mobility strategy.

About 70% of cities who are planning investment recognize this, and are looking to implement new solutions which have more advanced and innovative solutions (Figure 8), with wireless technology and smart car solutions seen as key opportunities. For the cities that understand this, the ambition and potential is clear to see. For example, in one European city which has decided to invest in enhanced capability the Chief Transport Executive stated, “We are going to make a step change. Our new ITS will help the city prioritize types of traffic and make better use of road capacity.”

However, three in ten cities do not share this investment focused mindset or ambition, and are looking to maintain similar technology during their next investment round. As articulated by one North American Traffic Manager, “We look to balance between extending our current system and general maintenance.” In addition to funding pressures, the other most commonly cited reason for this was a view that the new solutions offered little benefit and were unnecessary – suggesting a real challenge for suppliers to determine how they can better articulate the benefits of their products. This confirms that cities need funding and an understanding of the true potential of traffic management before they will be able to switch their mindset from a focus on costs to a focus on investment.

It is noticeable that those cities that understand the potential of new technology and are looking to invest to improve are also more likely to be those cities that see the potential of traffic management to better manage demand. Cities that have such an ambition for traffic management are more likely to be looking to invest to upgrade those cities, compared with those who saw traffic management as a way to deter car usage (Figure 9).

Motivation versus investment

<table>
<thead>
<tr>
<th>A. What is your main motivation in modernizing and enhancing your existing traffic management system?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. How effective do you think your city has been in the last three years in benefiting from the opportunities offered by traffic management?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment focus</th>
<th>Very effective</th>
<th>Somewhat effective</th>
<th>Not very effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better accommodating demand</td>
<td>Reducing car usage (via modal shift)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementing new solutions with more advanced and innovative features</td>
<td>71%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacing existing technology with similar functions</td>
<td>29%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7: Motivation for enhancing traffic management systems

Figure 8: Effectiveness of traffic management by main motivation

2.4 Spending

Less than 40% of cities expect to spend more on traffic management in the next five years.

The pressure on public funding as a result of the financial crisis is well documented and the majority of authorities are having to make cuts and plan for a period of austerity. The majority of Traffic Managers clearly expect this to have impacts on their budget, with less than 40% of cities expecting to spend more on traffic management in the next five years and almost a third expecting the amount to go down (Figure 10).

Maybe the biggest area of concern is that traffic management is seen as less deserving of a limited transport budget than other forms of transport. For example one European city explained, “The main priority is to invest in public transport. The only investment in traffic management will be where it is required for health and safety.” This creates a real risk of a downward spiral where a lack of ambition and success in traffic management causes the funding to dry up and therefore prevents cities from capitalizing on their own budgets. But if traffic management is seen as an opportunity to drive economic growth through investment, rather than a cost, it may help unlock more generous funding.
2.5 Summarizing the state of play in RNCs

Creating a framework for analysing the performance of cities...

In order to understand the overall state of play in the use and ambition for traffic management in RNCs, we have created a framework to evaluate cities. Based on the responses we received in our surveys, we have assessed cities on their governance and the priority afforded to traffic management and the scale of their ambition for the use of traffic management in improving mobility, accommodating demand and driving economic growth.

We have grouped cities into four different categories:

- **Strategic ambition** – those cities which have appropriate governance for traffic management and have high levels of ambition for what traffic management can achieve
- **Advocates with limitations** – those cities that have high ambitions for traffic management but do not have the appropriate governance, policies and structures to capitalize on this ambition
- **Informed conservatism** – those cities which have some knowledge and structure around traffic management, but have made an informed decision not to capitalize on these opportunities.
- **Unaware and unambitious** – cities that have a limited knowledge about the options for traffic management and very limited ambition to use it to accommodate demand

... shows that less than half of RNCs have strategic ambitious plans for traffic management

As shown in Figure 12, this analysis demonstrates that less than 50% of the RNCs in Europe and North America have both the governance and ambition to capitalize on the benefits of traffic management. Nearly 10% are both unaware and unambitious in their plans for traffic management, whilst over 40% lack either the ambition or the governance and priorities to capitalize on the opportunities afforded by traffic management.

Indeed those cities which have the most ambition seem to be those that are getting the most funding and are likely to achieve the greatest success. Cities which are more positive about funding tend to be more ambitious and focused on implementing new solutions. Funding and ambition are therefore key enablers for switching a city’s mindset from a focus on costs to a focus on investment. This impact of available funding is further confirmed by the fact that while a number of cities mentioned plans for new technology, they expressed concerns that these plans were dependent on successful funding bids. Almost 15% more cities who expect their traffic management budget to go up are looking at using that budget to implement advanced and innovative solutions, as opposed to those cities where spending is expected to go down where there is a higher propensity to invest only to stand still (Figure 11).

Those cities with ambitious plans for traffic management are pushing hard for new funding, whilst those looking to stand still do not have the ability to make a strong case for new funding – as best shown by the contrasting attitudes of one city with strong plans and a proactive search for funding, “We need new technology – our current system was installed 20 years ago. We have an investment plan...

We are petitioning the government for support,” with another example city where a lack of budget and ambition go hand in hand “We are just looking to hang on to what we have with minor developments.”

Whilst further research is required to fully understand the cause and effect of this phenomenon, it does appear to support the case that those cities with plans and ambition are those most likely to make a strong case for robust funding.

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**Figure 12: Traffic management evaluation matrix results**

![Traffic management evaluation matrix results](image_url)

- **Governance & priority**
  - **High**
    - Informed conservatism: 21%
    - Strategic ambition: 47%
  - **Low**
    - Unaware and unambitious: 9%
    - Advocates with limitations: 24%

- **Ambition**
  - **High**
  - **Low**

**Notes:**
- The darker the shade of blue the greater the number of cities in that category
- Figures do not sum to 100% due to rounding

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**Figure 11: Funding environment versus investment focus**

![Funding environment versus investment focus](image_url)

- **What do you anticipate will happen to this level of spending in the next 5 years in absolute terms?**
  - Go down: 0%
  - Stay about the same: 100%
  - Go up: 0%

- **Funding view**
  - Replacing existing technology with similar functions
  - Implementing new solutions with more advanced and innovative features
3. A way forward to transform the approach to traffic management

3.1 Creating a way for transformation

Our analysis has shown a disappointing picture for the use of traffic management technology in the RNCs of North America and Europe. What our research highlights is not that traffic management could not deliver step changes in urban mobility, but that the majority of RNCs did not have the tools, resources, knowledge and ambition to capitalize on the opportunities:

- A lack of knowledge about global best practice is limiting ambition
- Concerns about funding are limiting ambition, and a lack of ambition means cities are unable to create a compelling case to secure funding
- A limited appreciation of how traffic management can accommodate traffic flows is forcing cities to set modest ambitions and view traffic management as a tool to deter car use and by extension a less deserving cause for increasingly limited funding than public transport

Whilst these issues present significant challenges, they are not insurmountable. There are a number of success stories of how traffic management has been deployed – especially in some of the largest cities in the world.

As part of our research we asked respondents to highlight those cities that they saw as case studies of best practice, and we have since spoken to leaders in those cities to capture the lessons from their experience. Based on these learnings, we have identified a four stage "way forward" to make the most of the opportunities afforded by traffic management and overcome many of the challenges we found cities facing in our audit.

This format is shown in below (Figure 13), and then the different stages – including examples of how large cities have successfully capitalized on these stages – are discussed in turn in the following sections.

![Figure 13: A way forward to capitalize on traffic management opportunities](https://example.com/figure13.png)

### 3.2 Stage one: Be bold

Cities need to be ambitious and "Be bold" in order to maximize the opportunities offered by traffic management. This ambition is important both to produce a compelling case for new funding to develop schemes, but also to implement radical solutions to capitalize on the benefits offered by traffic management.

In order to "Be bold", cities need to implement a strong foundation of strategic planning to develop clear traffic management visions and initiatives. As discussed, strategic planning requires collaboration with other partners, as well as a clear governance process to ensure that the initiatives introduced are complementary and promote mobility across the whole network. Such a strategic approach to planning will help cities to implement their traffic management solutions more effectively making them more likely to be successful. This success will then in turn fuel a positive cycle of increased confidence and ambition.

Perhaps the best case study which demonstrates the requirements for bold decision making, and the benefits which this can achieve, is the success London had in the introduction of the congestion charge.

When cities can harness this knowledge, it can be very powerful – even if the city was already at the forefront of traffic management. This has been shown in the ongoing development of intelligent transportation systems in Hong Kong, where a constant receptiveness to new ideas, reviews of international best practice and an open partnership with suppliers has led to continued improvements in mobility.

Despite being considered a leader in traffic management, prior to 2001 the ITS in Hong Kong were limited and the city was in need of a more comprehensive ITS strategy that truly exploited ITS capability. Hong Kong was able to develop a stretching yet achievable ITS strategy by engaging a wide range of stakeholders. Potential ITS applications were evaluated by key ITS stakeholders in the government and two panels were formed; a local advisory panel of members from local industries and tertiary institutions to provide advice to the evaluation and an expert panel formed by ITS government officials from around the world to provide independent reviews on the proposed final strategy.

### 3.3 Stage two: Be knowledgeable

Whilst London was the first city to implement such a city wide congestion charge scheme, it has become the model for a number of other cities including Singapore and Stockholm. This is a key example of how the success of traffic management in one city can be replicated in other cities, and the imperative of traffic managers and RNCs in different cities to keep abreast of global best practice.

During our survey, we found a very limited awareness of global best practice – less than half of traffic managers we spoke to could highlight cities across different categories where they felt traffic management was effective. Most knowledge that we did find was through personal networks rather than through formal knowledge sharing.

However, this represents a tremendous waste. Last year, over €5bn was spent globally on traffic management systems, and each of these systems offers potential learnings for other cities including options to inform the development of strategy and evidence to support the development of a compelling case for public funding.

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![Please find more details in our case study “London – Congestion charging”](https://example.com/case_study_london.png)

![Please find more details in our case study “Hong Kong – Integrated intelligent transport system strategy”](https://example.com/case_study_hong_kong.png)
3.4 Stage three: Be creative

Our research highlighted a number of obstacles across RNCs that were limiting their ability to deploy traffic management or secure funding for new systems. In such a scenario, it is easy for cities to perceive barriers to implementation and create a vicious cycle whereby they scale back their ambition, in turn making it harder to secure funding and deliver transformational benefits.

However, there are many cities around the world that have overcome such barriers. The key is to use a range of creative solutions to overcome problems as they arise. This can be done through three key channels.

Look at how emerging technology can provide new solutions to long standing solutions

As technology develops, so the role traffic management can play in helping mobility in a city increases. The key role that traffic management or secure funding for new systems. In such a scenario, it is easy for cities to perceive barriers to implementation and create a vicious cycle whereby they scale back their ambition, in turn making it harder to secure funding and deliver transformational benefits.

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Look at how emerging technology can provide new solutions to long standing solutions

As technology develops, so the role traffic management can play in helping mobility in a city increases. The key role that traffic management plays in helping mobility in cities can be done through three key channels.

1. Use real-time data to traffic centres which is possible the key current technology update that will step-change traffic management in a city. It allows cities to maximise their existing road capacity by allowing more efficient responses to congestion or incidents. In particular, the integration of monitoring technology and response technology can allow pre-determined responses to be designed increasing the reliability and repeatability of a response to the build-up of congestion.

2. Use the use of emerging technology to provide new solutions should not just be limited to the promotion of traffic flows within a city. Interactivity traffic flow is also key to the economic competitiveness of a city. In the Netherlands cities have made creative use of traffic management to accommodate both the demand of flows within cities and between neighbouring urban centres, in particular through the use of tunnels loaded with the latest technology to make use of limited space and maximise traffic flow.

For example in the city of Utrecht, the Leidsche Rijn Tunnel was built below the development of the Leidsche Rijn Centre to minimize the impact of increased traffic into the area on noise pollution. A safety system was installed based on camera and video surveillance as well as an integrated automatic incident detection system which identified not only traffic jams but also smoke formation. This allows the better monitoring of incidents, enabling quicker responses and a more reliable flow of traffic through the tunnel. In addition in the Province of Noord-Holland a bypass route was built for the N201 highway. Part of this bypass comprises the 800 meter long Waterwolf tunnel. A traffic control centre monitors and controls all operations and traffic systems. And in Zeeland city authorities overlaid technology on their existing lock infrastructure to ease operation of the locks. Previously locks in Zeeland were controlled individually so the new technology was introduced to link several locks and enable them to be centrally controlled and monitored.

Such creative and integrated used of the existing road space also delivers significant benefits for smaller scale projects. For example, in Amsterdam, city authorities found that it was easier to drive bicycle modal shift when the use of cars was actively discouraged through increases in parking costs and more 30 kmph areas. Amsterdam also introduced special traffic lights that give cyclists priority over cars and display the seconds until the green light, and by making cyclists feel safer further encouraged the uptake of cycling.

Look at how third parties can bridge the funding gap

As noted above, more than 60% of RNCs expect funding to come under pressure over the next five years, and as a result many are limiting their ambition for traffic management. However, these cities that have had the most success around the world have not been constrained by current funding packages, but rather looked at alternative sources of funding to support further development. Often, this has focused on user charging. For example, congestion charges are highly effective as part of a “carrot and stick” approach to traffic management. People are creatures of habit and expansions and improvements in public transport alone do not necessarily reduce car usage.

This was demonstrated by the successful introduction of the congestion tax in Stockholm. Public transport was improved in 2005 but significant reduction in congestion was not seen until the introduction of the congestion tax in 2006.


A similar situation was seen in San Francisco where the public supported and voted for a number of capital proj-
ects in 1998 and then again in 2004. However the intro-
duction of congestion pricing in 2010 on the Bay Bridge
led to confusion over the purpose of the charge. In particu-
lar the $2.50 charge to carpoolers (previously free) was seen
as new charge rather than a discount, influencing a 26% re-
duction in the number of carpool lane users on the bridge.

On a smaller scale, user charging on specific routes can
also offer major benefits. The dual purpose of charges for
both revenue generation and to manage vehicle flows
directly makes them a highly effective traffic management
tool. Cities often focus on revenue generation and the
management of congestion via large scale capital projects
to increase road or public transport capacity.

However the congestion pricing on the Bay Bridge in
San Francisco shows how effective congestion pricing
can be as a traffic deterrent to manage congestion.
Even the small differential changes in peak and off-peak
tolls on the Bay Bridge led to peak spreading with drivers
choosing to travel before or after the peak periods.

It is not just larger cities using creative solutions. Another
smaller scale example of user charging is the introduction of
a workplace parking levy in Nottingham in 2012.

Employers with 11 or more parking spaces have to pay
a fee of currently £362 per year per space under the levy.
The council expects the scheme to generate an average
of £14m a year which will be used to pay for transport
infrastructure.

As with San Francisco, this type of charging is now
increasingly being used by cities as a way of managing the
violation of parking, the scale of the city’s limited available
parking and the resulting impact of the city’s congestion.

For example Lisbon, Portugal was facing challenges over
its limited available parking and the resulting impact of
drivers restricting traffic flow by parking in the city’s nar-
row lanes. While parking enforcement officers were in
place to manage the violations of parking, the scale of the
task limited their efficiency. The city decided to pilot
new technology to increase the efficiency of the parking
enforcement officers and consequently improve traffic
flows through the city. Mobile ANPR cameras were assem-
bled on parking enforcement vehicles, which were able to
detect licence plates and automatically notify the parking
enforcement officers of vehicles in violation of the parking
regulations. The parking enforcement officers were also
provided with four handheld devices that linked to a cen-
tral database containing permit holder information allow-
ing quick verification of vehicles in violation. This pilot was
successful at driving efficiency of parking regulation rein-
forcement and demonstrates how this approach to traffic
management can be simple yet effective.

Look at using efficiency savings to fund investments

Cites with limited budgets should look to simple initiatives
to drive efficiency savings. One such example is the
replacement of traditional light bulbs in traffic lights with
LED technology. The savings in energy costs and from
reduced maintenance requirements can fund the installa-
tion of the technology and future savings can be used to
fund new traffic management investments. For example
Montebelo, California had the challenge of refurbishing
2,900 traffic lights on a limited budget and with reduced
numbers of staff. The city decided to replace the light
bulbs with LED technology and used a self-funding model
which leveraged the savings from using this technology to
fund the labour required to refurbish the lights. The sav-
ings were sufficient to expand the scope of the project
to include an additional 800 lights and the future savings
from the lights will be used to fund additional projects.

Look at using technology to increase funds raised from
enforcement activity

In many cities, pressure on the existing infrastructure can
increasingly be driven by users not following traffic man-
agement restrictions or regulation. Emerging technology
can be used to promote greater enforcement of these reg-
ulations and ensure more efficient use of the infras-
structure.

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forcement and demonstrates how this approach to traffic
management can be simple yet effective.

3.5 Stage four: be accountable

Cities need to be empowered and accountable for driving
city mobility through traffic management. In order to
do this effectively, cities need to set targets that they can
measure their performance against and track progress.
Cities that can demonstrate improved performance will
have greater confidence in the potential of traffic manage-
ment and increased ambition for the implementation of
further solutions. As seen from the results of our research,
this greater ambition and understanding of traffic manage-
ment will instigate a positive cycle where this ambition
leads to improved governance and available funding as
cities evolve in purpose and support the fierce
competition for funding.

Targets should be set in the context of the entire
transport network

The establishment of these targets requires cities to have
a clear traffic management governance structure which
offers a robust repeatable decision framework. This govern-
ance structure needs to identify specific and measurable
key performance indicators which they can then set achiev-
able but ambitious performance targets against. To ensure
these targets drive overall city mobility, targets need to be
set in the context of the entire transport network. This will
encourage all traffic management stakeholders to view the
transport network in its entirety and ensure that any new
solutions will complement the existing transport network.
This approach has the added benefit that by adopting an
integrated view, cities can also identify synergies and link
otherwise isolated initiatives for greater mobility
improvements.

In the same way targets should be set in the context of
the entire transport network, the measured outputs should
also consider the rest of the network. In particular it impor-
tant for cities to compare the return on investment from
traffic management with the return from other transport
spending. This will help cities to identify the most effective
solutions for improving city mobility and prioritize future
investment spend. This is particularly important for cities
where traffic managers and city leaders have expressed
their frustrations at the priority given to public transport
investments at the expense of traffic management. These
return on investment measurements will allow city leaders
to have sensible discussions based on data rather than
assumptions or emotion.
4. Conclusion

Regional and National Capitals are increasingly being drawn into the global marketplace, and this means competition for economic growth opportunities. This comes at a time of continuing austerity in public budgets. But developments in technology and the emergence of the cloud provide opportunities for cities to deliver improvements in traffic management, and not just manage its maintenance. This has the potential to bring more people into the labour market and facilitate more connections between businesses.

However, our research found that the majority of RNCs do not have the tools, resources, knowledge and ambition to capitalize on the opportunities offered by traffic management. This White Paper therefore identified how RNCs can learn from some of the world’s megacities on the best ways to harness traffic management to promote traffic mobility and reduce congestion. Analysis of these best in class megacities shows that they have achieved their success by being bold, knowledgeable and creative. If cities adopt this mindset, and make themselves accountable for delivery, they can deliver a true step change in traffic management.

As with all communication technology, the capability of traffic management is developing rapidly. Therefore in order to harness the true potential of traffic management solutions, cities need to invest.

The financial burden on RNCs is showing no sign of easing, meaning traffic management has to fight even harder for its share of transport budget to invest. In order to do this, cities must have a strong foundation of strategic planning, from which they can clearly communicate the benefits of their proposed solution, and strong ambition so that they can to continue to fight for funding despite the challenging environment. Cities also need to be creative in the solutions they implement to overcome the challenge of funding.

Cities need to evaluate potential solutions against their traffic management strategy. It is important that each RNC chooses the most appropriate solution for their city. RNCs should learn from examples of best practice in the world but ensure any adopted solution is tailored to its city’s specific congestion challenges. While solutions can be implemented in isolation, megacities are demonstrating that the true potential of traffic management will only be realized through the integration of systems. RNCs need to integrate their technology systems as much as possible and should look to justify the necessary investment by demonstrating the efficiencies and the additional capability an integrated system will deliver over isolated systems.

Some cities have shown the way forward and while each city is different many of these learnings are transferable to RNCs. We hope that this White Paper helps to provide international context on best practice, and can encourages cities to pursue ambitious plans for effective traffic management.

Traffic Management Transformed – Moving cities forward

Safeguarding mobility is one of the big challenges in our society. To ensure our mobility in future, we need networked transportation and information systems. And we will only meet these mobility requirements through efficient coordination and automation of individual and public transportation – for attractive, liveable and competitive cities and regions.

Please find more details on intelligent traffic management solutions described in the following case studies:

- London – Congestion charging
- Hong Kong – Integrated intelligent transport system strategy
- New York – Midtown in Motion project
- Bogotá – Implementation of a BRT system
- Stockholm – Congestion tax
- San Francisco – Use of tolls on bridges

Figure 14: A way forward to capitalize on traffic management opportunities

The way forward

- Be bold
  - Set ambitious targets
  - Let the goals dictate the funding
  - Create the governance framework to innovate

- Be knowledgeable
  - Monitor global trends
  - Learn from best practice

- Be creative
  - Capitalize on new technology
  - Develop new approaches
  - Leverage new sources of funding

- Be accountable
  - Set targets and measure outcomes
  - Compare return against other transport spending
  - Global benchmarking

Case studies
levels of hazardous car emissions by reducing car usage in
stone wanted to tackle this level of congestion and reduce
delays of 2.3 min/km in the zone. New mayor Ken Living-
zone was 1.9 min/km, meaning typical congestion and
However the uncongested travel rate for the charging
average travel rate for the charging zone was 4.2 min/km. In 2002, prior to the congestion charge, the
modate the number of motorists commuting into the city
With its compact city centre London struggled to accom-
Case study
Challenge
London Congestion charging
With its compact city centre London struggled to accom-
modate the number of motorists commuting into the city
each day. In 2002, prior to the congestion charge, the
average travel rate for the charging zone was 4.2 min/km. However the uncongested travel rate for the charging
zone was 1.9 min/km, meaning typical congestion and
delays of 2.3 min/km in the zone. New mayor Ken Living-
stone wanted to tackle this level of congestion and reduce
levels of hazardous car emissions by reducing car usage in
the centre and encouraging the use of public transport.

Solution
The congestion charge scheme was introduced in 2003
and charged motorists a levy for driving in the charge
zone (Figure A). To help reduce harmful emissions,
discounts were offered to those with more efficient
vehicles.
After the initial success Ken Livingstone extended the
charge zone to the west of London. This was perceived
by the public as purely a revenue generating scheme
and was highly unpopular, leading to Mayor Boris Johnson
confirming its cancellation in 2010, "The long desired
eradication of the western extension is my Christmas
present to the people who live, work and shop in west
London".
By law the revenue from the congestion charge has
to be used to improve transport in London. To encourage
the use of public transport, approximately 80 % of opera-
tional revenue was spent on bus network improvements
including new vehicles, garages and shelters.

Results
The congestion charge was initially successful with an
18 % reduction in the number of charged vehicle trips
by 2007 and a 21.1 % reduction in the overall vehicle kms
in central London (2011 vs. 2000). In contrast, overall
vehicle kms in outer London only decreased by 8.4 %.

Figure B shows that average speed in central London
increased by 8 % after the congestion charge (2000 –
2006). However after 2006, the average speed decreased
and is now lower than before the charge. TfL has attri-
buted this to changes in road space allocation to other
public transport users. Arguably the situation would be
worse if these space allocation changes had occurred
without the scheme.

Between 2002 and 2012, London observed significant
modal shift with a 53 % reduction in car usage, a 61 %
increase in bus usage and a 208 % increase in cycling. The
increased bus usage and cycling broadly mirrors the pat-
tern across London and is consistent with the London-
wide investment in both modes of transport. This sug-
gests that the congestion charge supported rather than
directly caused this modal shift. The congestion charge
however did contribute to this modal shift through fund-
ing. In 2007 82 % (£101m) of the scheme’s operational
revenue was spent on bus improvements.

London congestion charge key facts
The congestion charge covers an eight mile zone of central London.
• When: The charge applies between 07:00 and 18:00 Monday-Friday excluding public holidays
• Cost: When introduced in 2003 the cost was £5 per car. This was increased to £8 in July 2005 and
then £10 in January 2011. Consultations are taking place currently over proposed further increases.
• Fine: Drivers can pay in advance or on the day of travel. If drivers have not paid by midnight on
the charging day they receive a penalty charge notice of £130
• Payment method: Drivers can pay over the phone, online or register with CC Auto Pay. Drivers registered for Auto Pay pay a reduced charge (£9 per day) and receive a monthly bill

London average traffic speeds at the morning peak

Figure A
Figure B

Learnings for other cities
The implementation of a congestion charge scheme
requires clear governance with a decision-making
framework that is robust. The establishment of TfL in
2000 provided a focused body aligned to the new mayoral
system that could implement strategic projects that
affected both the public transport and road networks.
This solution can be applied to all cities regardless of size
but will be harder in cities with fragmented governing
bodies.

A congestion charge requires public support as demon-
strated by the failure of the west end extension. TfL is
discussing whether to raise the congestion charge by
a further 15 %, causing the public to question whether
the focus has moved to revenue generation. Further
controversy has been generated by the fact that freed-
up road capacity has primarily been reallocated to public
transport users, benefiting these users rather than the
motorists funding the scheme. Cities where there is
greater public support for investment in infrastructure
will face less controversy over the revenue-generating
aspect of a congestion charge scheme.

Cities need to accompany changes with improvements
in alternative methods of transport. In this case study
the revenue was used to fund improvements in the bus
network, making the use of buses more efficient. This
helps maintain public support for the scheme by not
pricing motorists off the roads and forcing them to
compromise on the efficiency of their travel.

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Results
140
120
100
80
60
40
20
0
Traffic Speed (index to 2000–2002)
Inner ring AM peak
Central zone AM peak
Outer ring AM peak

Learnings for other cities
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Performance of the existing transport system. Find solutions that maximize capacity and enhance such projects. Instead the government has sought to expensive and environmentally unfriendly to implement travel demand but it is becoming more difficult, more road and railway infrastructure to cope with increasing the world. The government has been expanding the Challenge

Hong Kong
Integrated intelligent transport system strategy

Challenge
Hong Kong’s roads are amongst the heaviest used in the world. The government has been expanding the road and railway infrastructure to cope with increasing travel demand but it is becoming more difficult, more expensive and environmentally unfriendly to implement such projects. Instead the government has sought to find solutions that maximize capacity and enhance performance of the existing transport system.

Solution
Having observed the journey time and road capacity benefits of large-scale Intelligent Transport Systems in other countries and smaller scale ITS such as AutoToll in Hong Kong, the government decided to review its ITS strategy in 2001. The government took a collaborative approach to developing the strategy and action plan. Twenty potential ITS applications were evaluated using a questionnaire among ITS stakeholders in the government, transport sector and other related industries. Two key objectives, “A Smart way to Travel” and “A Smart Way for Safety and Efficiency” were identified.

Under the “A Smart Way to Travel” objective, it was decided to establish a Transport Information System (TIS). This centralised data warehouse would be used for the collection and processing of comprehensive transport information to support the provision of real time traffic information.

In order to do this, Hong Kong needed to increase its ability to collect traffic data. The small-scale Area Traffic Control systems and Traffic Control and Surveillance systems were extended and in 2004 were integrated into a new Traffic Management and Information centre (TMIC). The TMIC now serves as a major source of real-time traffic information for the TIS and as of 2011 the TIS provided four key services, which are summarised in Figure B.

Results
The establishment of the TIS was able to increase the capacity of the current road network by enabling commuters to choose less congested routes or take an alternative public transport option. This helped to even the distribution of traffic flow around the city.

The Hong Kong eRouting and Hong Kong eTransport services are extensively used and the Transport Department decided to release them as smartphone applications (Figure A). Assistant Commissioner Mr Leung Tak-fai commented that this would, “help travellers search for suitable transport routes while on the move anytime, anywhere”. Figure C shows that there was a five-fold increase in usage since the launch of the eRouting app in 2013. The TIS also provides data free of charge and there are more than 700,000 data downloads every day to support many, private mobile applications disseminating traffic information.

Providing commuters with real-time road traffic information and public transport status helps to evenly distribute traffic flow across the city. While ITS systems can be implemented separately with single purposes, the provision of comprehensive real-time data requires the integration of systems, such as in this case through the establishment of a traffic management and information centre. This requires investment and can therefore be less feasible for cities with restricted finances. Cities need to justify this investment by demonstrating the efficiencies and the additional capability the integrated system will deliver over isolated ITS systems.

Learnings for other cities
The development of an ITS strategy requires the clear identification of focused traffic management objectives in order to evaluate possible solutions accordingly. Evaluation of solutions is most effective when city governments work in collaboration with academic and professional institutions and the private sector to gain alternative perspectives. Key learnings should be taken from examples of best practice from other cities, including global locations. No two cities are identical so solutions successfully implemented in other cities shouldn’t be adopted without first being adapted to address specific local transport challenges.

Key initiatives by objective
A smart way to travel:
2. Hong Kong eRouting – to provide users with an optimum driving route search service
3. Hong Kong eTransport – provides users with a one-stop portal for a multi-modal public transport route search service
4. Intelligent Road Network (IRN) – provides up-to-date information on traffic for private value-added service providers to use

Growth of eRouting downloads

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Challenge
Approximately one million vehicles enter and leave New York on a daily basis. This volume of traffic places considerable strain on the city’s infrastructure, in particular in the central business district, where demand often exceeds capacity in the grid environment. In 2011 resulting traffic congestion was estimated to cost New York City $13 billion in revenue. To help combat increasing congestion the New York City Department of Transportation (NYCDOT) completed a programme of ITS investment including the installation of a modern traffic management centre in Queens, the introduction of a wireless communications network and the upgrading of intersection traffic signal controllers. This gave the city a strong infrastructure platform from which to implement new technologies with the aim of step-changing traffic management.

Solution
NYCDOT implemented Midtown in Motion (MiM), a congestion management system designed to enable city traffic engineers to identify and respond to traffic conditions in real time. Mohammad Talas, NYCDOT’s deputy director for systems engineering explained, “The underlying strategy was to use key ITS deployed, including city-wide wireless connections between the TMC and advanced signal controllers”. The first phase of the programme went live in August 2011 covering a 110 block zone from 57th to 42nd street and from Second to Sixth Avenue. By already having an effective wireless network, NYCDOT were able to install monitoring and control technology on existing street poles without additional infrastructure. The sensor network summarised in Figure A was used to measure traffic speeds. This real time-data was then passed wirelessly to a traffic control centre in Queens where remote adjustments to signalling were made through networked advanced solid state traffic controllers. Prior to the MiM system going live, data from the sensors was used for analysis of traffic flow to create a database of traffic data which was then used to generate a two level response strategy. At the first level an “algorithm of adaptive control” would respond to the real time traffic data and adjust green-time signal phasing to anticipate build ups of congestion. At the second level traffic management centre operators would respond to discrete incidents by the activation of pre-determined signal phasing.

Results
Results after the first phase of the programme showed an overall 10% improvement in travel times on the avenues in the zone. Figure B shows how the average travel speed in the zone increased from 10.5 kmph to 11.6 kmph between 8 a.m. and 8 p.m. which was additionally confirmed by Taxi GPS data. It was therefore decided to expand the area covered by the system to more than 270 square blocks.

The system has won many awards, with then Mayor Bloomberg commenting: “We are now using the most sophisticated system of its kind in the nation ... to clear up Midtown jams at the touch of a button.”

Learnings for other cities
The use of real-time data can significantly step-change traffic management by allowing more efficient responses to congestion or incidents. In addition the use of pre-determined signal phasing also increases the reliability and repeatability of the response. NYCDOT also made the data freely available to motorists to further ease congestion and more evenly distribute traffic by helping motorists choose alternative routes.

This project also demonstrates the opportunities a strong ITS platform can offer for managing congestion by allowing new technology to be installed without additional infrastructure. This depends on a strong ITS platform and is therefore only feasible for cities with a similar existing ITS infrastructure. However cities without this can aim to introduce more pre-determined responses to any ITS they do have, in order to increase the reliability and repeatability of their traffic management responses, as well as emphasise the ease of overlaying additional technology as a key benefit when constructing business cases for the development of an integrated ITS platform.
Challenge

Increasing urban migration to Bogotá from neighboring rural areas placed increasing strain on the city’s road infrastructure, resulting in severe traffic congestion. Prior to 2001, the roads were congested with 21,500 buses, operated by 600 official and 300 unofficial bus operators transporting 70 % of the population, and 850,000 private cars. Plans to build a subway to address congestion had been in discussion since the 1970s but were eventually deemed financially unviable. In 1998 Mayor Enrique Peñalosa implemented a new approach to transport, deemed financially unviable. In 1998 Mayor Enrique Peñalosa implemented a new approach to transport, making it much cheaper to build per mile than a metro system. The infrastructure investment for a metro in Bogotá was estimated at more than double the cost of the BRT system, $4bn versus $1.97bn. A BRT system is also able to serve a much larger proportion of the population. Bogotá’s TransMilenio serves 1.8 million riders per day and covers 85 % of the city whereas it was estimated a metro system would cover only 8 %. This solution is not dependent on city size, however is easier to implement in cities with wider roads to avoid the costs of road-widening.

Solution

The TransMilenio Bus Rapid Transit system (Figure A) was introduced in 2001 after a two year construction period. The city commandeered lanes in the middle of major boulevards to create double lane right of ways. The double lanes allowed buses to overtake each other, meaning local (service stops at all stations) and express services could operate on the same trunk lane. Stations were constructed in the centre islands and just like in a subway, buses were designed with multiple doors that slide open level with the platform, allowing easy and quick access for passengers.

Increasing taxes on car drivers and banning cars from the city centre were some of the initiatives that were introduced to discourage car use. 46 % of the financial resources for the implementation of the BRT system came from a fuel tax, which was increased from 14 % to 25 %. Half of this tax is now used for the continued expansion of the system. Parking costs were also increased by 100 % and one third of street parking was removed to make way for the TransMilenio. Bogotá introduced two schemes that involved banning cars from the city centre, including a car-free day on Sundays which involved the closing of 150 km of Bogotá’s main roads to traffic, and the Pico y Place system, which stipulates the times that cars are not allowed in the city on specific work days based on the last digit of their license plate number.

Results

The TransMilenio system had a strong positive impact on congestion with a up to 32 % reduction in travel times. Figure B shows that before implementation, speed on some of the routes were as low as 12 kmph but have now increased to 21 kmph (local service) and 32 kmph (express service). Surveys show that 83 % of users perceive the increase in speed as the main reason to use the TransMilenio. There have also been positive effects on the environment. Removing 7,000 private buses from its roads led to a 59 % reduction of emissions, resulting in the TransMilenio becoming the only large transportation project approved by the United Nations to generate and sell carbon credit in 2008.

However the TransMilenio system was introduced 13 years ago and in recent years, demand on the system has risen faster than its own capacity with the number of buses being used remaining relatively constant. This situation is made worse by the fact that the planned construction of phase 3 to add 20 kilometers of BRT lanes along with 250 more buses to the entire network has been delayed until 2015/2016. Former Deputy General for TransMilenio, Dario Hidalgo explained “The big problem we’re facing now is nobody is talking about these system expansions, it’s like this plan has been abandoned.”

Learnings for other cities

A mass transit and less polluting metropolitan transport system is achievable even for cities with funding limitations. A BRT system utilises current road infrastructure, making it much cheaper to build per mile than a metro system. The infrastructure investment for a metro in Bogotá was estimated at more than double the cost of the BRT system, $4bn versus $1.97bn. A BRT system is also able to serve a much larger proportion of the population. Bogotá’s TransMilenio serves 1.8 million riders per day and covers 85 % of the city whereas it was estimated a metro system would cover only 8 %. This solution is not dependent on city size, however is easier to implement in cities with wider roads to avoid the costs of road-widening. Strong leadership and stakeholder engagement enabled the implementation of the BRT system. A co-ordinated plan engaged key stakeholders such as bus operators early on in the planning and established large marketing campaigns to enable the re-branding of negative stereotypes about bus travel to the public.
Stockholm

Congestion tax

Challenge

With more than half a million cars travelling into the city on weekdays, Stockholm faced significant congestion and a need for better road infrastructure. A solution was needed that would reduce congestion and the negative environmental impact of traffic.

Solution

In order to achieve these objectives, Stockholm introduced a trial for a variable pricing congestion tax, where higher charges were used at peak times to evenly distribute the flow of traffic around the city (Figure A). The full-scale seven-month trial was operated from January to July 2006, with a referendum over its permanent implementation held in September 2006. 51% supported the scheme.

The congestion tax was complemented with the introduction of IT systems to monitor traffic flows and provide real-time information on congestion for commuters. Improvements to the public transport network were also made prior to the trial, with improved cycle lanes, 197 new buses, 16 new bus lines into the inner city and 2,800 new parking places in park and ride facilities.

Other positive impacts observed during the trial included:
- 50% reduction of queuing times on access roads to the city
- 14 – 18% reduction of carbon emissions in the inner city
- 23% increase in cars in park and ride facilities
- 4.5% increase in public transport usage

Until 2009 clean cars that used alternative fuels were exempt from the charges. This led to a 12% increase in clean cars from 2006 to 2008, and in 2008 a third of cars sold in Stockholm were clean cars.

The congestion tax has also provided economic benefit to Stockholm. Analysis at the beginning of the scheme estimated a payback time of four years and an annual operating profit of €50m to be invested in road infrastructure. Finally a key success was the change in public opinion from a 51% preference for keeping the charge at the referendum to a 70% preference in 2011.

Results

The congestion tax was highly successful, with the positive impacts observed during the trial maintained when the scheme was made permanent. Figure B shows how the traffic reduction of 18% in 2006 has been maintained. The public have adapted to the charge by changing destinations and decreasing trip frequencies. Analysis at the time of the trial found that 24% of commuters switched trips by car disappeared, with only 1% of drivers switching route to avoid the area. There was only a small amount of peak spreading, with most drivers maintaining their departure time within the same 15 minute period before and after the trial.

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- 50% reduction of queuing times on access roads to the city
- 14 – 18% reduction of carbon emissions in the inner city
- 23% increase in cars in park and ride facilities
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Stockholm congestion charge key facts

The congestion charge covers the entire city centre.

- **When**: The charge applies weekdays 6:30 a.m. to 6:30 p.m.
- **How it works**: Charges are collected upon entering or exiting the zone at 18 barrier-free control points with cameras encircling the city centre
- **Cost**: The cost on weekdays is €2 during peak hours, €1.50 30 minutes before and after each peak period and €1 during the rest of the charging hours, €1.50 30 minutes before and after each peak period and €1 during the rest of the charging period. Drivers are charged each time they pass through a control point. There is a daily maximum charge of €6
- **Payment method**: A monthly invoice is sent to the registered address of the vehicle through automatic number plate recognition

Learnings for other cities

This case study in Stockholm shows the effectiveness of a “carrot and stick” approach to traffic management. Public transport improvements were made in autumn 2005 but significant reductions in congestion were not seen until the introduction of the congestion tax.

However, improving the accessibility of alternative options is important to reduce the negative impact of the charge, encouraging adaption to a new behaviour rather than coercion into it. Surveys in Stockholm suggest this adaptation was achieved with people gradually travelling less at peak times without the majority acknowledging any change in their behaviour.

The success of a congestion charge relies on public support, and the use of trials is particularly influential for this. Prior to the trial, Stockholm officials conducted extensive public consultations. However it was the use of the seven month trial and the referendum that had most influence by reassuring individuals of their freedom to experiment with the charge without committing to a permanent change and encouraging them to be more open to the benefits achieved. Congestion charges are an effective but often controversial way for the majority of cities to manage congestion. Opposition can be mitigated by first using trials to build public support.

Finally this case study shows the importance of learning from examples of best practice in the world but tailoring any adopted solutions based on the specific local congestion challenges. It would have been easy for Stockholm to simply duplicate London’s successful congestion pricing system, however by tailoring the solution Stockholm was able to address specific challenges in the city, achieve its objectives and win public support.

Stockholm congestion reduction graph

- **Reduction in traffic volumes compared to reference**
- **Adjusted for seasonal variation**

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**Figure A**

**Figure B**

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Challenge

Due to the central location of the San Francisco Bay, transport in the area requires crossing one of eight bridges across the bay. The limited number of bridges means that congestion often builds creating a need for increased bridge capacity and better management of traffic flows.

Solution

The Bay Area Toll Authority (BATA) was established in 1997 to manage and invest revenues from all tolls levied on the seven state-owned toll bridges. Since 1998 public ballots have voted for toll charge increases to generate revenue for capital projects. These included a seismic retrofit programme, Regional Measure 1, which included a number of major toll bridge congestion relief projects such as the building of the new Benicia-Martinez bridge, and Regional Measure 2, which allocates funding for a further 36 capital projects and operating funds for 14 transit routes. The approximately $655m annual revenue from tolls is split as shown in Figure A.

BATA have used the tolls themselves to manage traffic flow as well as to generate funds for capital projects. In 2010, BATA introduced peak hour congestion pricing on the San Francisco-Oakland Bridge, where on weekdays drivers had to pay a premium of $6 during peak commuter periods (5–10 a.m. and 3–7 p.m.), which then decreased to $4 off peak. High-occupancy vehicles such as carpools were offered a 50 % reduction during the peak periods.

Results

The introduction of congestion pricing on the bridge successfully reduced congestion with the occurrence of peak spreading. Figure B shows there was a 20 % increase in volume during the 4–5 a.m. hour before the toll increase, and a steep 12 % reduction during the 5 to 6 a.m. hour when the toll increases to $6. Similar peak spreading was seen before and after the p.m. peak period.

Travel times in the cash and FasTrak lanes also decreased with the exception of an increase for FasTrak customers from 7 to 8 a.m., likely to be caused by drivers switching to FasTrak. Times in the carpool lanes remained relatively unchanged.

Since 2011 congestion has remained reduced despite an overall increase in the number of vehicles crossing per day. The BATA Transport Director explained that, "congestion has worsened on the other larger bridges in San Francisco as the total number of vehicles crossing has increased." This therefore demonstrates the effectiveness of encouraging peak spreading for managing congestion.

Learnings for other cities

Tolls are an effective traffic management tool due to their dual purpose, being used both for revenue generation and to manage vehicle flows directly. Cities often focus on revenue generation and large scale capital projects. However, this case study shows how effective congestion pricing can be, as only small differential changes in peak and off-peak tolls can lead to significant behavioural changes that are maintained over a long period of time. Not all traffic management solutions need to be large-scale and smaller cities with fewer resources need to be creative and identify similar solutions.

Using tolls requires support from the public. Regional measure 1 and 2 were approved following public votes in 1998 and 2004 respectively and the infrastructure changes showed clearly the investment output. However a focus group study by the University of California revealed a general "resigned acceptance" of the congestion pricing on the Bay Bridge and a lack of understanding as to why the tolls were increased. The $2.50 charge to carpools (previously free) was seen as a new charge rather than a discount, influencing a 26 % reduction in the number of carpool lane users on the bridge. Tolls are a solution which can be easily applied to most cities. However schemes to implement tolls or congestion charges often meet with great controversy by the public and therefore require extensive programmes of engagement and clear communication of potential benefits.