Intelligent traffic management: How Big Data can keep Smart Cities moving

Powered by a diverse network of partnerships and data sources, TomTom's traffic solutions shape smart cities, optimize business operations and keep traffic flowing in the right direction.

FROST & SULLIVAN WHITEPAPER

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1. Introduction: Smart Cities in 2024 and beyond

1.1 Goals and success factors of Smart Cities

"A city is a machine with innumerable parts that never stop moving". These words, widely attributed to Writer, Photographer, and Art Historian Teju Cole, encapsulate the chaos of large, densely populated urban environments that offer citizens so much opportunity, entertainment, and vibrancy.

But what if the "machine" of a city could work in a more efficient way? A way that reduces transportation congestion and environmental pollution, while enhancing public safety and social inclusion. Those are exactly the aims of the leaders of smart cities, where they invest in information and communication technologies, data analytics, and intelligent infrastructure to improve the quality of life for all residents.

Enabling a smart city relies on five broad components that must operate symbiotically for the city to enjoy their benefits. These are data collection, strong communication networks that act as the city's central nervous system, an integrated command and analytics platform, an applications layer to host the smart city's services, and robust cybersecurity defenses to protect the city's digital assets.[1] If each of these components is adequately sourced, integrated, managed, and maintained, then cities have a chance to alleviate some of their pain points. For instance, even a small reduction in the average time that drivers spend sitting in traffic could have an impressive impact on the environment, economic productivity, and happiness of citizens.

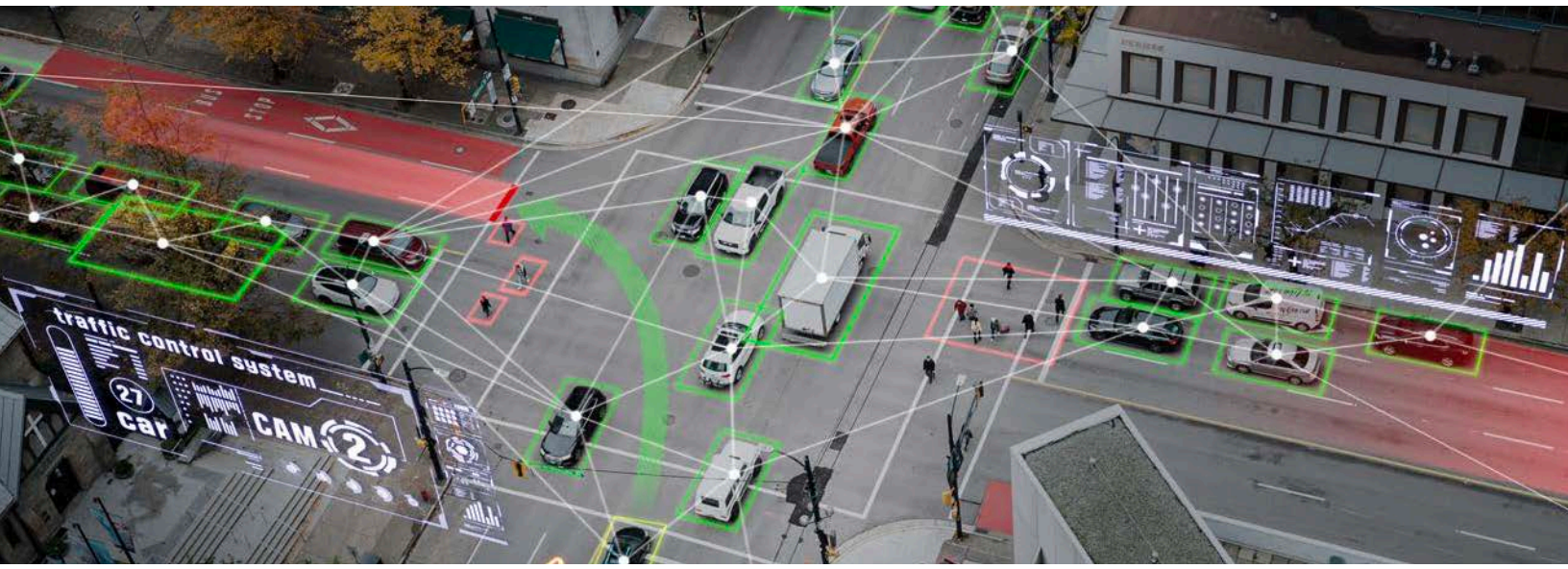
It is for this reason that tech-savvy city leaders have become so keen to monitor metrics that point to the overall efficiency and running of their urban environments through the data points that smart cities produce.

1.2 Growth drivers and restraints of Smart Cities

The origin of the term smart city is a matter of debate, as is the identity of who first coined it, but what is clear today is that the impetus behind the concept is as strong as ever. According to the World Bank, nearly 7 in 10 people will live in cities by 2050—a large increase from the estimated 56 percent that do so today.[2] In a more urbanized world, it is of paramount importance that cities operate with minimized resource consumption and environmental impact. To that end, the United Nations champions goals to make cities and human settlements inclusive, safe, resilient, and sustainable through its 2030 Agenda for Sustainable Development.[3]

From the perspective of elected officials and city leaders, creating a well-functioning city that people enjoy living in and visiting is a prerequisite for attracting investment, fostering innovation, and creating prosperity—the city must be a source of pride and prestige. For this reason, mature, world-class cities, such as London, Berlin, and Paris, are pursuing smart city initiatives backed by large, allocated public and private funds. In turn, citizens' quality of life improves, governments run better, and social equity and cohesion increase. When it comes to city-level infrastructure, investing in intelligent transportation systems allows smoother traffic flow, more effective vehicle routing, and a more diverse mix of mobility options.

While the allure of smart cities is hard to resist, the truth is that they require large-scale, up-front investments. For cities of all shapes and sizes, and at different levels of technological maturity, other competing imperatives, such as affordable housing, public health, and education services, can instead get a quick bump up the priority list—a reality that suffers from unpredictable political cycles that dictate where and



how public money is spent. This complexity increases even more due to the lack of (literally) ground-breaking regulations necessary at the national and supranational level to pave the way for smart cities in areas such as data privacy and security, spectrum allocation, wireless infrastructure, and autonomous vehicles. Despite policymakers' best intentions to protect all stakeholders against security breaches and information misuse, cyberattacks are impossible to prevent completely, and smart cities are particularly exposed due to the numerous attack surfaces of IoT devices.

In that sense, when city planners and architects design new cities in China and the Arabian Gulf, they do not use the blueprints of centuries-old European urban environments. Legacy cities contain legacy infrastructure with outdated transportation networks that do not easily integrate with smart technologies. Starting with a near-blank slate like the city of Shenzhen did—going from a rural village to the world's largest megalopolis in a matter of 50 years—is far less complex than shoehorning new technology into roads that have evolved through centuries.[4]

1.3 Transport and infrastructure landscape in Smart Cities

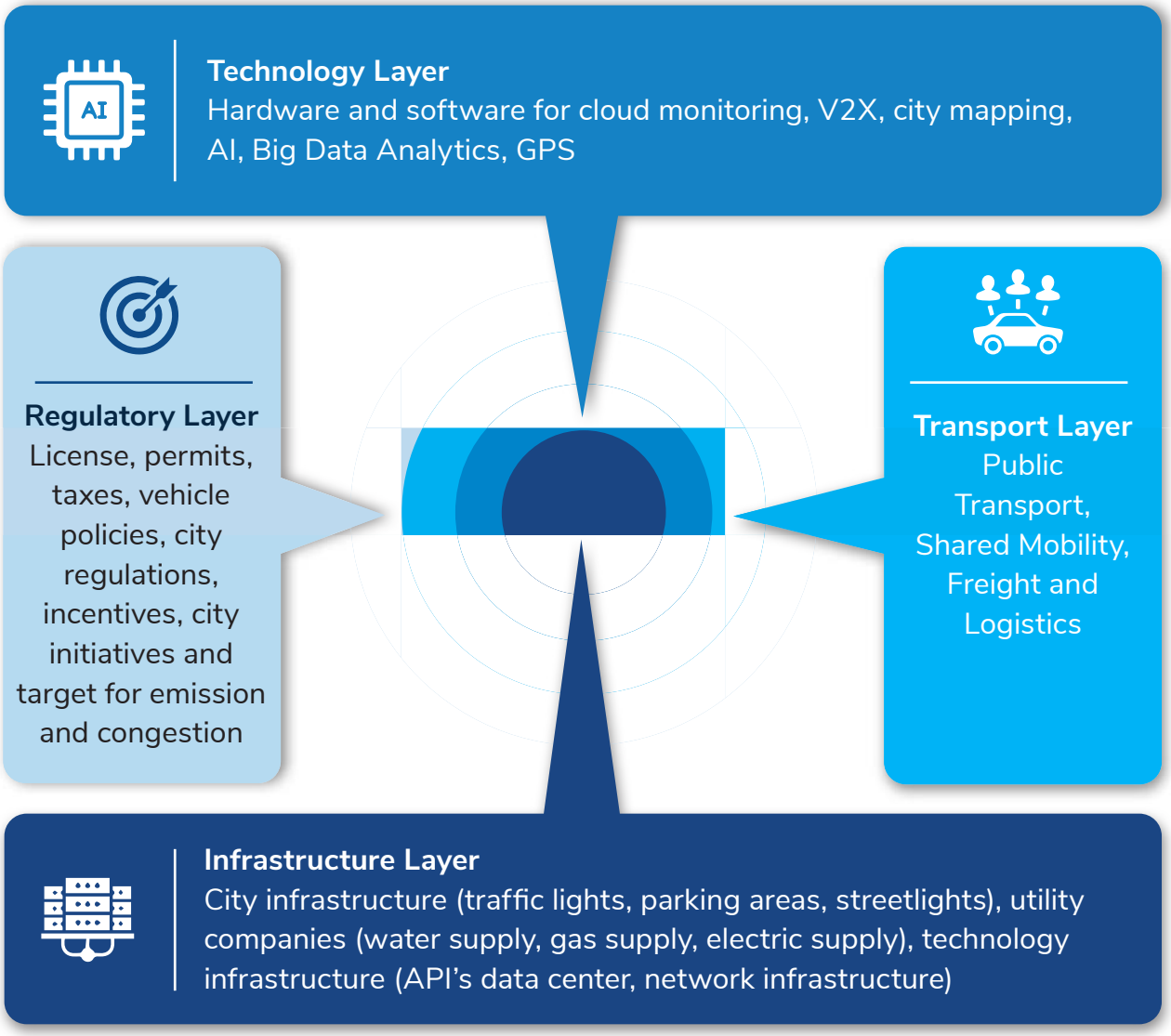
Not all of us are inside the futuristic world of new city planning. You could be forgiven for thinking that Saudi Arabia's ambitious goal to create a 170-kilometer-long, linear megacity, with a height of 500 meters and enough capacity to accommodate 9 million people is the only ongoing project that is completely re-imagining the make-up of an urban environment.[5] Beyond the media coverage that has been devoted to NEOM's The Line, there are other exciting projects in progress, such as Telosa in the United States, BiodiverCity in Malaysia, and Amaravati in India.[6]

The smart-city operating systems of each of these cities (and indeed those of legacy cities with the ambition to embrace technology) are split into 4 main layers, a future-proofed framework to support operational modes of mobility for passengers and freight, shown in the image below.

The role of the stakeholders in each of these layers blurs as cities demand intelligent solutions for centralized operations that can integrate, interconnect, and manage information and processes at a city level.[7] In the next section, we will focus on how smart cities are planning for current and future operational modes of mobility for passengers and freight.

Smart city systems: Key layers of Smart City mobility systems

EXHIBIT 1: Image from Frost & Sullivan Smart City Solution Growth Opportunities Report (2022)



2. Traffic, congestion, and emissions management within Smart Cities

2.1 Size of the problem

In his 2016 book, The Road Taken: The History and Future of America's Infrastructure, acclaimed Engineer and Historian Henry Petroski asserted that traffic congestion and delays cost the US economy more than $120 billion annually.[8] This figure has almost certainly increased since then, with road usage rebounding strongly since the global pandemic. Despite work-from-home trends, a large proportion of workers in developed and developing countries continue to rely on their vehicles to get to work. This is most pronounced in the car-obsessed United States where 73 percent of American commuters use their car to move between home and workplace.[9]

The density of vehicles on the road leads to reduced work productivity for those who must spend time in traffic jams and increased economic costs for vehicle owners, who must pay more for fueling/charging and maintaining vehicles. The table below shows the cities with the worst congestion in the world and the impacts they have on productivity and cost to the driver.

The transportation mix of a city also has a detrimental effect on the environment and the health of citizens. The United Nations' Intergovernmental Panel on Climate Change claims that urban areas are responsible for 70% of global CO2 emissions, with transport and buildings being among the largest contributors, although the per-head emissions of city dwellers are significantly lower than those living in less dense rural/semi-rural environments without public transport options.[10] Traffic and congestion are

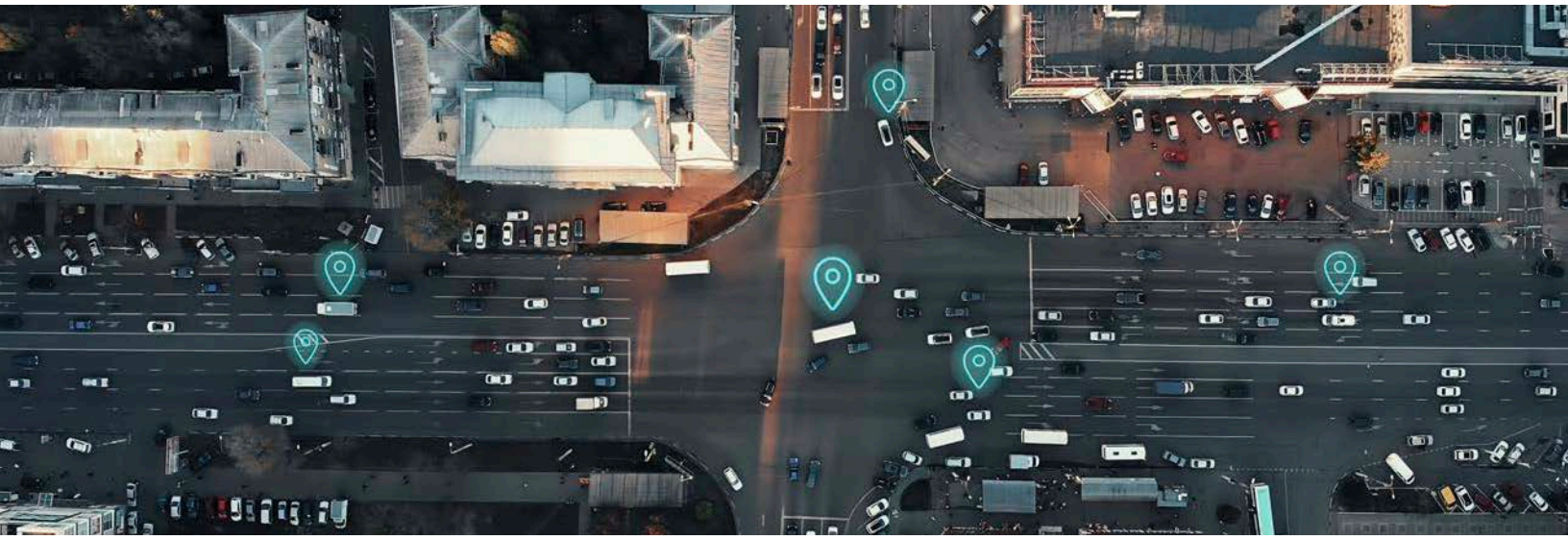
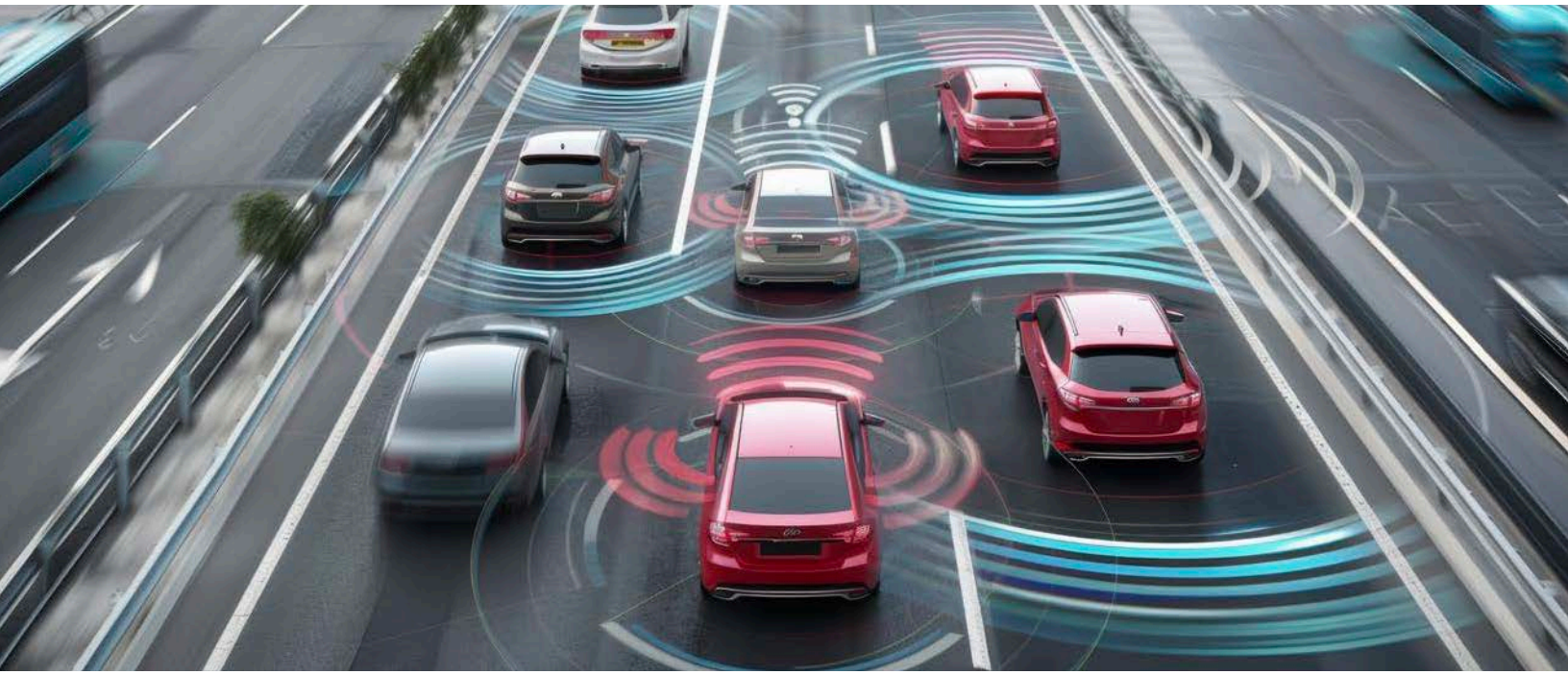


EXHIBIT 2: TomTom's Traffic Index—Ranking based on the average time it takes to travel 10 km in each city

World rank	City	Average travel time per 10 km	Change from 2022	Congestion level	Time lost per year at rush hours	Average speed in rush hour
1	**London** United Kingdom	**37 min 20 s**	+ 1 min	45%	148 hours	14 km/h
2	**Dublin** Ireland	**29 min 30 s**	+ 1 min	66%	158 hours	16 km/h
3	**Toronto** Canada	**29 min**	+ 50 s	42%	98 hours	18 km/h
4	**Milan** Italy	**28 min 50 s**	+ 20 s	45%	137 hours	17 km/h
5	**Lima** Peru	**28 min 30 s**	+ 1 min 20s	61%	157 hours	17 km/h

core factors behind these alarming figures because they lead to harmful practices, such as vehicle idling, stop-and-start driving, and circling areas for parking spaces. Aside from the impact on air quality, vehicles also contribute to other negative environmental consequences. These range from water pollution (for instance, rainwater can wash motor oil and brake dust into rivers) to habitat disruption that reduces biodiversity. Traffic's impact on noise pollution and mental health are also factors to consider, despite being harder to track.

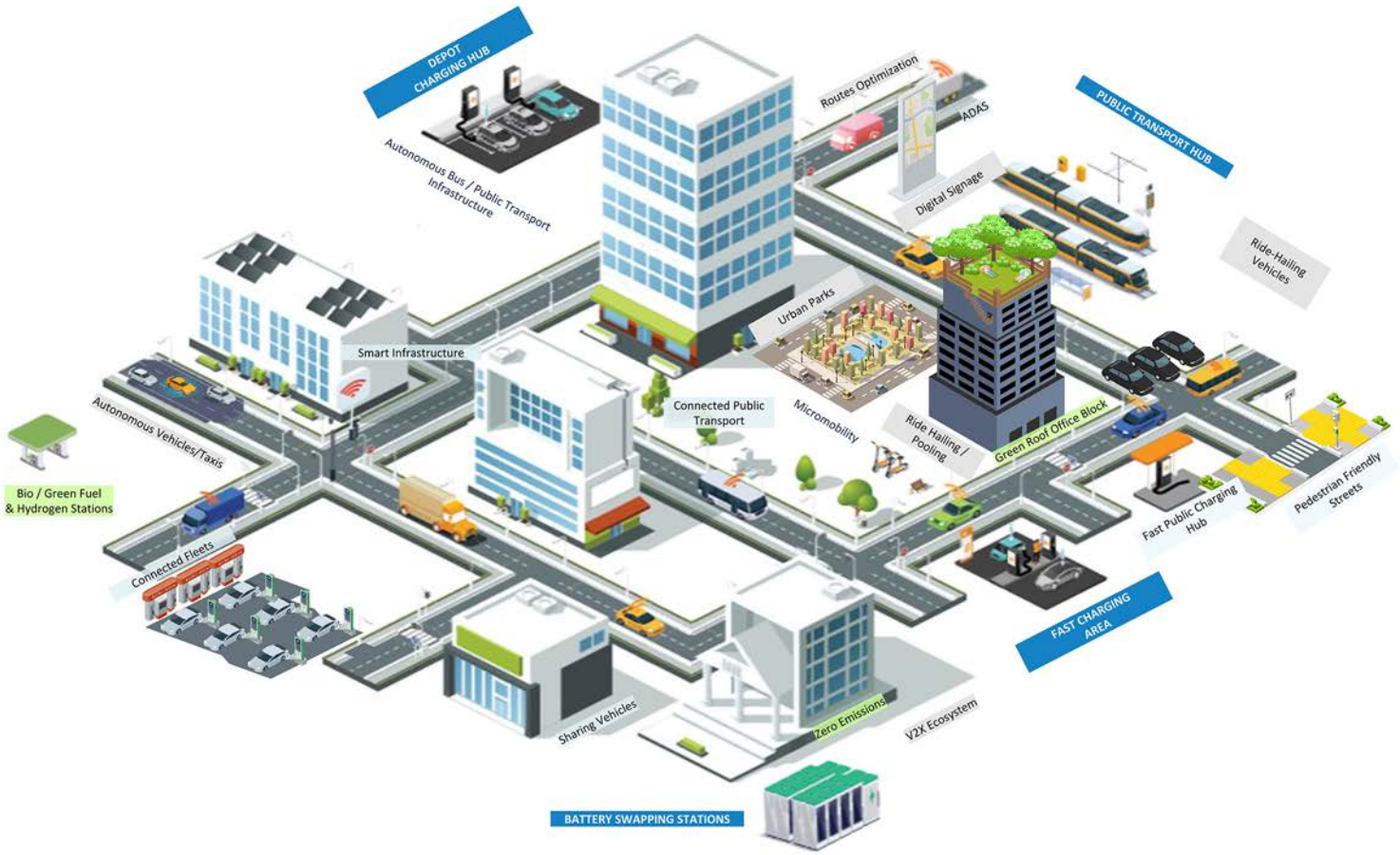


2.2 A vision for Smart Cities

Apart from the brand-new cities built from the ground up (as described in previous sections), legacy cities around the world are at different stages of progress in each focus area that will make mobility smoother, cleaner, and cheaper.

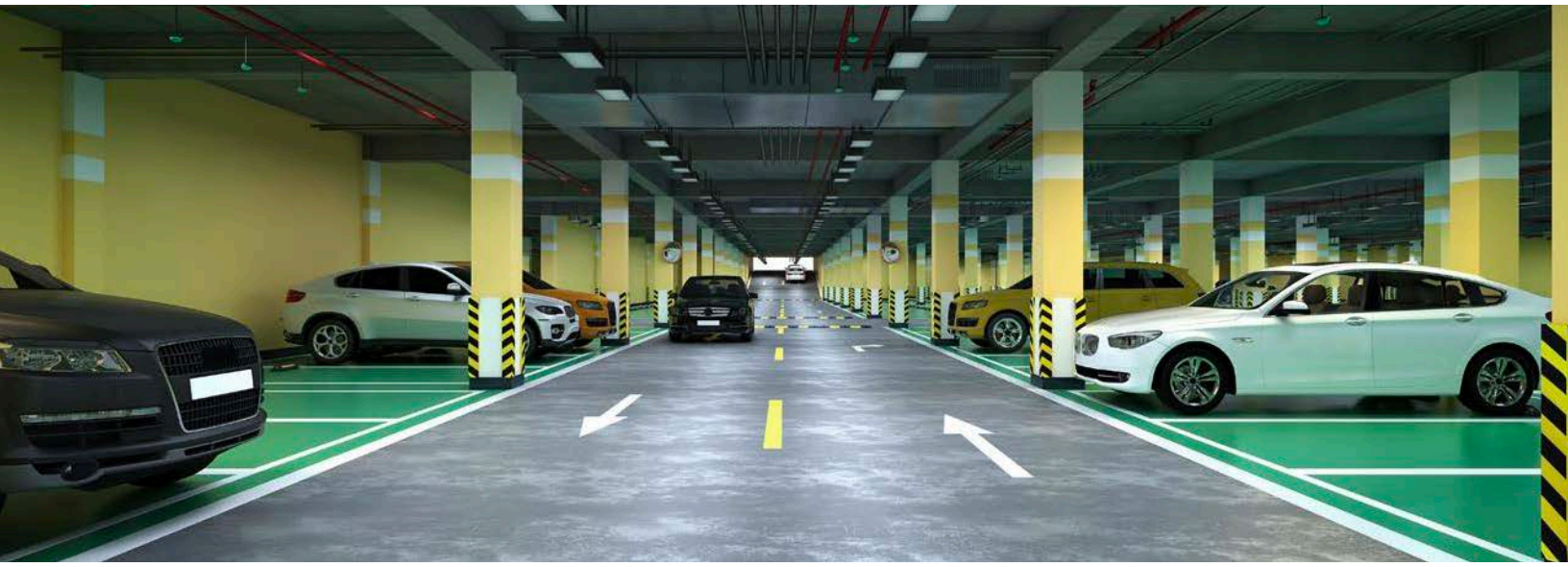
In the image below, we have envisioned what the transportation infrastructure of a future smart city could look like. Investments in smart infrastructure may bring assets such as intelligent streetlights that adjust their brightness to pedestrians and traffic, government policies could see the reallocation of road space and parking spots for more green space (as seen in Paris), and multi-modal transit and local commercial hubs where a range of transport options accessed in one place could deliver on mobility's end of the bargain for the concept of the 15-minute city.[11]

EXHIBIT 3: Frost & Sullivan's vision for the future of smart cities



Even the most efficient city authorities cannot ensure that the new initiatives explained above roll out at the same time. Here are four examples of cities that are taking the lead in four distinct areas of mobility policy:

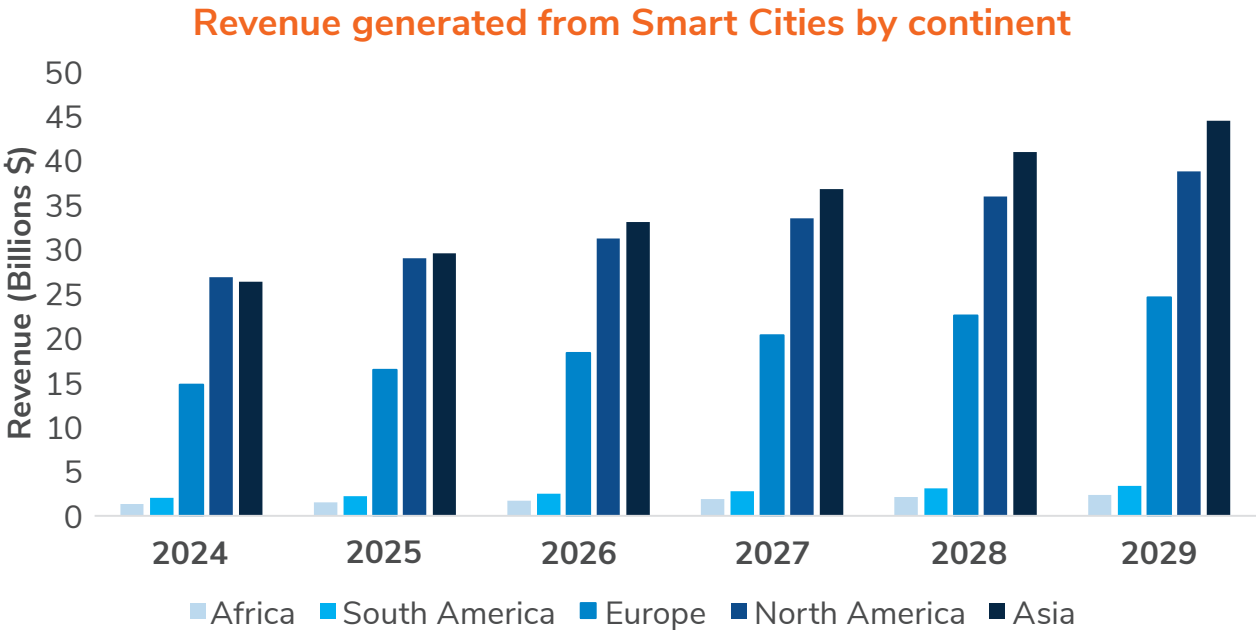
1. *Intelligent traffic management in Amsterdam:* The city has invested in the infrastructure necessary to monitor traffic flow in real time. To reduce journeys into the downtown area, it has instituted roadblocks, most notably around the Central Railway Station. It can track changes in traffic behavior by observing floating car data that TomTom provides.[12]
2. *Congestion pricing in New York City:* From mid-June 2024, the city, via an electronic toll collection system, has charged an additional $15 to enter Manhattan at 61st Street and below, while trucks could be charged between $24 and $36, depending on size.[13] This has reduced traffic density in the area and is projected to earn the city millions of dollars a year that can be directed to transportation upgrades.
3. *Integrated public transit system in Singapore*: The city's Mass Rapid Transit network integrates ridesharing, bike-sharing, and micromobility services to give users easy and transparent access to transportation.[14] This is one of the factors that sees Singapore consistently ranked in the top 5 of the world's smartest cities by the International Institute for Management Development, a business school.[15]
4. *Electric vehicle adoption in Oslo*: Norway's strong uptake of EVs is laudable, and its capital city is setting the pace for the whole country. By 2021, the number of EVs entering Oslo's toll ring exceeded the number of petrol cars.[16] The city achieved this impressive feat through consumer incentives to purchase EVs and supportive infrastructure developments, such as the construction of charging points and the imposition of zero-emission zones and priority access for EV drivers for parking.[17]



2.3 Market opportunity for traffic management solutions

To deliver on the vision of more efficient traffic management in smart cities, urban environments need a portfolio of digital solutions. Toward the end of the decade, growth in revenues accrued from smart city connections will be strongest in Asia and North America, followed by Europe. The graph below shows the revenue that companies are projected to generate through the sale of smart city solutions such as hardware, platforms, connectivity, and the services needed to integrate and install such components. The projected values represent more than just transport and traffic management solutions.

EXHIBIT 4: Revenue generated from smart cities by continent.
Source: Statista's Smart Cities Outlook Research (2024)



The key applications and use cases that constitute this portfolio will grow toward 2030 as more cities turn to digital solutions to get a much-needed edge on analyzing and managing traffic, congestion, and emissions, but most importantly, reducing them and their associated externalities.

Better traffic management functionalities within smart cities rely on the following types of solutions:

- Traffic signal optimization
  - Junction analysis
  - Route monitoring
  - Live traffic
  - Traffic stats

- Road safety
  - Junction analysis
  - Hazards
  - Jam tail warning (Advanced driver assistance systems [ADAS])
- Environmental impact assessment
  - Historic traffic
  - Live traffic
  - CO2 emissions
  - EV
- Project cost-benefit analysis
  - Historic traffic
  - Live traffic
  - CO2 emissions
  - Traffic index

2.4 The change makers—system integrators and Smart City developers

The stakeholders that can make the most difference in the quickly developing technology and infrastructure layers of modern cities are system integrators and smart city developers.

Systems integrators, such as Siemens, Cisco, and SWARCO, are specialists that combine hardware and software components to create cohesive and functional systems. They provide networking solutions, traffic and transportation management, and data analytics and insights. TomTom has partnered with the Austrian traffic technology company SWARCO to provide floating car data that can better manage urban mobility scenarios through SWARCO's management suite, MyCity.[18]

Smart city developers include urban planners and technologists who work with system integrators to implement technologies that enhance the sustainability, connectivity, and quality of life within future city environments, fostering innovation and efficiency. StreetLight Data, for example, is a company that helps megacities allocate their multi-billion-dollar infrastructure budgets. To make this process even more data-driven, TomTom has partnered with StreetLight Data to grant it access to its historic and real-time traffic data, which will enhance StreetLight Data's analytics solutions.[19]

3. TomTom holds the key to enabling the world's Smart Cities of the future

3.1 Cities speak, TomTom translates

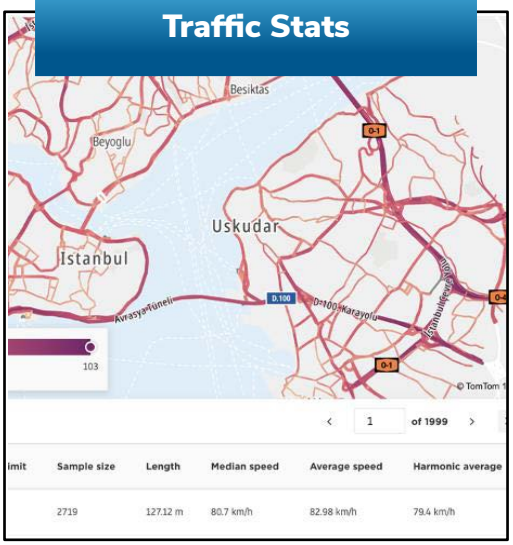
TomTom has built its road traffic management solutions upon its 30-year heritage in the location intelligence industry. Alongside its focus on mapping and routing, TomTom offers tailored scalable solutions that provide historic and real-time traffic data as a service for standalone use or combined with other datasets and infrastructure networks. One in five vehicles on the road worldwide contributes to TomTom's traffic data, which covers 83 countries. This powers TomTom's Traffic Index, a global report used by city planners, governments, policymakers, businesses, and automakers to measure the costs, time, and environmental impact of traffic to feed into their strategic decision-making for smart cities and mobility.

3.2 Traffic analytics as the key to unlocking smoother mobility

As discussed throughout this white paper, reducing congestion to improve mobility is an integral goal of running a smarter city. TomTom Traffic Analytics products, which are accessible through the TomTom MOVE portal or an API, provide high-quality historic and live GPS data to help clients understand, anticipate, and respond to real road conditions.

The products in the TomTom Traffic Analytics portfolio look like this:

Traffic Stats

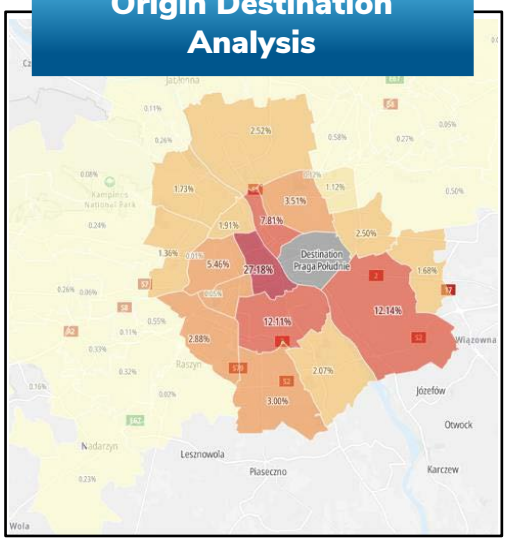


Tap into the industry's largest historic traffic archive, with insights on road speeds, travel times and traffic density.

- Gain insights into local traffic situation
- Create customized queries for a dedicated area or route
- Specify days and time periods of interest
- Results can be viewed in a detailed report or downloaded

Historic Traffic

Origin Destination Analysis



Access detailed information about trip dynamics and drivers' preferred routes for smarter decision making.

- Leverages trillions of GPS measurements
- Trip based analysis
- Origins, destinations, via-points
- Measure movement between areas, or through selected road connections

Historic Traffic

Route Monitoring

Track traffic on key routes in real time and connect to Virtual Message Sign (VMS) displays to keep drivers informed.

- 24/7 measurements of pre-defined routes
- Tracks current route travel and delay times
- Times are compared to free-flow traffic
- Enables local traffic managers to take proactive measures towards improving mobility

Real-Time Traffic

Junction Analytics

Get a clear view of traffic movements at intersections and optimize performance to reduce congestion and emissions.

- Reduce jams at intersections
- Optimize traffic lights
- Get info on current delays and jam length at the junction
- Number of stops and turn ratios

Real-Time Traffic

3.3 TomTom's partner success stories

Whether stakeholders seek to identify mobility problems, evaluate investments, or set policy based on traffic trends, TomTom has helped a range of public and private clients to make road data and analytics actionable. Examples include:

City authorities:

- The Wisconsin Department of Transportation (DoT) monitors the impact of road works and uses TomTom Route Monitoring to measure the delays that they cause in real time. TomTom's solution means that sensors and cameras are no longer required to measure travel times around areas affected by road maintenance, saving the DoT money.
- On the 1st of January 2024, the city of Amsterdam changed its speed limit from 50 km/h to 30 km/h to make the city more livable, safer, and less polluted. The city used TomTom Traffic Stats to assess how the traffic behaved before and after the change, which helped the city address the questions people might have about the change and show them its impact.

System integrators:

- The highway authority for the Paris metropolitan region, the Direction des Routes d'Île-de-France (DiRIF), depends on clear and accurate insights into the traffic situation of the nearly 1,300 kilometers of roads in its network. Since 2023, this is exactly what real-time traffic management technology from PTV Group, powered by TomTom Traffic data, has provided. Alongside DiRIF's roadside sensors, this solution has significantly enhanced the reliability of live traffic updates, informing road users about current traffic conditions, congestion, and road closures in the city.[20]

Smart City developers:

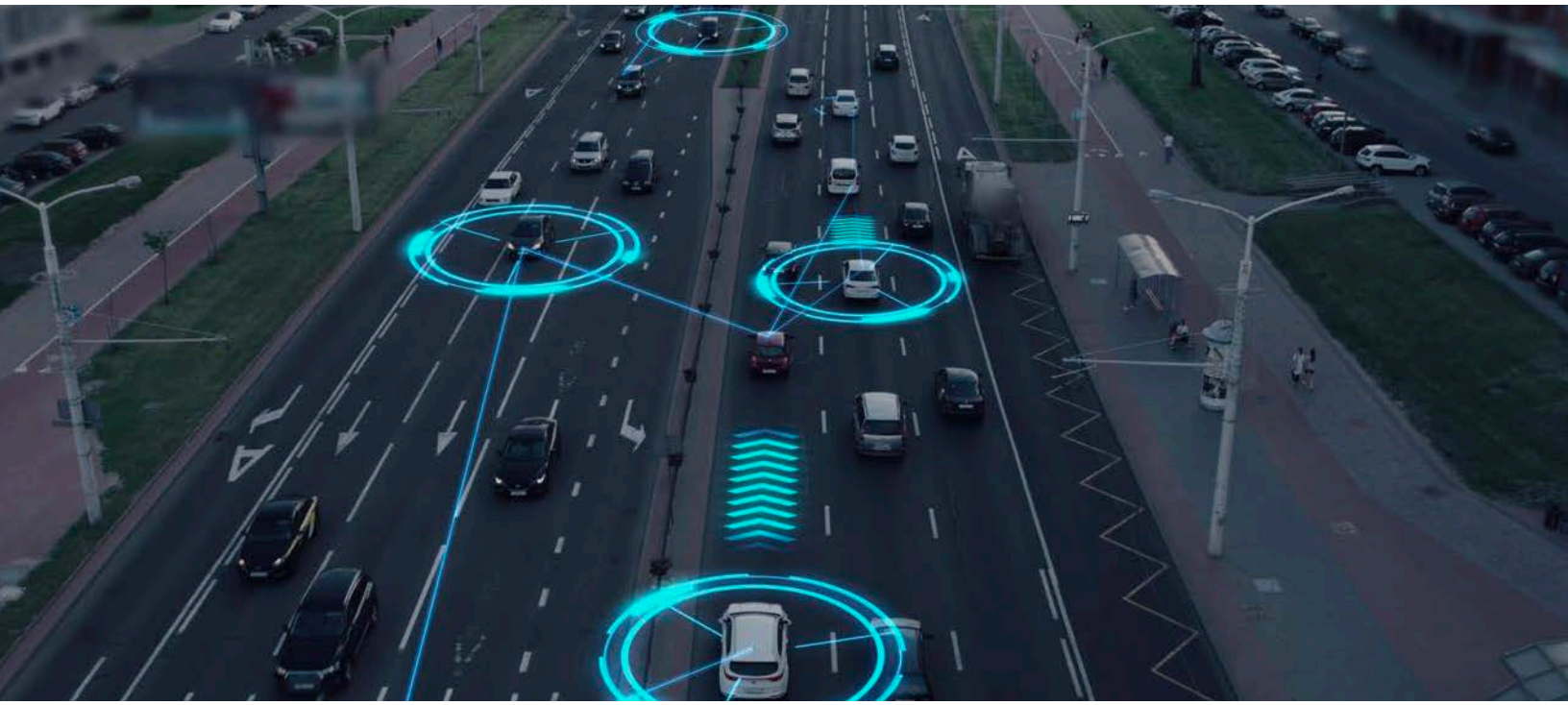
- StreetLight Data applies proprietary machine-learning algorithms and vast data processing resources to measure the travel patterns of vehicles, bicycles, and pedestrians, which it makes available through its InSight® software platform. Following a partnership with TomTom, StreetLight Data can offer highly detailed and accurate travel and traffic information to its client base of traffic planners, municipalities, and other transportation professionals. With TomTom's data covering 3.5 billion kilometers of roads globally, it has opened the door for StreetLight Data to expand into new markets beyond its home market, the United States.[21]

4. Final thoughts

4.1 Floating car data to the rescue of the world's busiest cities

Traffic and congestion are never going to be eradicated from cities. People and activity are the lifeblood of cities, two things that were sorely missed during the worst of the 2020 COVID-19 lockdowns when global congestion levels were down by an average of 26 percent during rush hour.[22] Thankfully, the world is on the other side of the global pandemic. Through smart traffic management, cities can achieve positive impacts across key metrics such as productivity, the environment, and people's health—three unintended benefits of lower congestion levels due to lockdowns. Unlike hardware-heavy smart city investments, TomTom's Traffic Analytics portfolio is one of the easiest and most cost-effective infrastructure solutions that can be implemented.

The 61 billion GPS data points that TomTom collects globally each day increase the quality and accuracy of transportation insights so that traffic managers can keep cities running as smoothly as possible. This can help create different outcomes. For instance, it can generate higher vehicle utilization rates through ride-hailing instead of car ownership and minimal usage; or it can enhance delivery vehicle efficiency and capacity through more accurate expected time of arrivals and routing instead of private car trips that block the system.



4.2 Future outlook for Smart Cities & TomTom's solutions

The smart city of today will not be the smart city of tomorrow. The journey of mature megacities leads toward greater pedestrianization, better and more diverse public transportation options, fewer cars and fewer parking spots, and more flexible and responsive transport options.

We expect traffic data and traffic analytics products like those of TomTom to play an important role in enabling cities to plan and prepare to respond to a wider range of scenarios as a result of climate change, population growth, migration, emissions management and events. For example, for events such as a marathon or a parade, a section of the city might need to be fully car-free. Using traffic pattern insights, TomTom can provide a basis of evidence for city authorities so that they can understand and react to the pressure that this will put on their transportation network. This might result in making more commuter trains available or increasing the capacity of park-and-ride schemes. TomTom has products ready to provide these insights—such as its Traffic Stats solution and its Origin Destination Analysis. In the scenario described above, city planners can enable the desired outcomes through TomTom's archive of road speeds, travel times, and traffic density, as well as the billions of trips that have been made in the past. By studying what has happened before, TomTom can help shape future mobility objectives.

Whatever the transportation goal, TomTom works alongside and shares its mobility data with system integrators and smart city developers to keep a city moving seamlessly. Traffic is the heartbeat of a city and TomTom can help authorities monitor and respond to it.

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