London Underground and Rail innovation
Innovation has always been a hallmark of London Underground. We opened as the world’s first metropolitan railway in 1863, and ever since, our pioneering approach has kept London moving.

From electrification in the early 1900s to automatic train operation in the 1960s to open data policies today, London Underground has been a leader in the use of new technologies to provide faster, more reliable and more comfortable journeys. Metros around the world today continue to look to our network for inspiration and expertise.

Of course, our customers aren’t the only ones benefiting from our innovation. The growth of modern London itself follows the growth of our transport network. Where the Tube has gone, residential developments and jobs have followed. Economic revitalisation in areas like Canary Wharf has been a success because of the reliable transport links we provide. Londoners depend on us to get to work every day — and that’s not a responsibility we take lightly.

We are currently in the middle of the largest investment programme in our history. We’re modernising stations to meet the demands of London’s increasing population and making our trains faster and more reliable with new signalling and new train stock. We’re transforming customer service with more available staff, contactless payments, and all-night running on weekends. All of these improvements contribute to the continuing growth of our local and national economies, supporting jobs in research, manufacturing and further technology. And ultimately, it helps provide world-class transport for a world-class city.

Mike Brown MVO
Managing Director, London Underground and London Rail
**Introduction**

With London’s population growing rapidly, it’s not surprising that there is a greater demand on the Underground, Overground, Docklands Light Railway and tram networks. We have an ambitious investment programme to provide the best possible service, so we’re overhauling all parts of our rail network to increase capacity and make journeys faster, more comfortable, reliable and accessible. We’re also responding to the rising expectations our customers have of our staff, stations, information and ticketing. Only through innovation can we meet the challenge of delivering this massive programme on the world’s oldest metro, while still ensuring the millions of people who rely on our services each day get to where they need to go.

**Reliability and safety**

Across the organisation we have a common focus – to provide a reliable service for our customers and ensure they get around safely every day. In the past few years, we have cut delays by 40 per cent and are on target to reduce them by a further 30 per cent by the end of 2015. Our commitment to innovation has led to London Underground being recognised as one of the safest metros in the world. Crime on our network has fallen by 36 per cent as a result of partnerships with the British Transport Police, and accidents, illegal activity and suicide are also at their lowest levels.

**Track retrieval**

Items dropped on Tube tracks led to delays totalling 195,000 hours in 2014. At the same time we’ve seen a rise in the number of passengers risking their lives by venturing on to tracks to retrieve belongings – an increase in incidents of 62 per cent between 2009/10 and 2012/13.

Our new track retrieval device – designed, built and tested by London Underground staff – is being used at every Tube station to pick up small, high-value items such as mobile phones and tablets. The tool can be used without having to turn off the track power supply and staff do not have to step down on to the track, making it much safer and ensuring trains are not delayed.

**Predict and prevent**

We have transformed the way we monitor and manage our network. New methods are allowing us to assess risks to the reliability of the train service from our assets, operations and customers. This ‘predict and prevent’ approach enables us to adapt our plans for both the running and maintenance of the railway, improving the reliability and availability of our services.

For instance, on the Victoria line, we use remote track circuit monitoring that provides live information to the signalling system. Developed in-house, the technology flags faults so they can be resolved before they develop into full signal failures. Its use has resulted in a dramatic fall in signal-related delays and, based on current performance, we estimate it has saved 50,000 lost customer hours in the past year.
Maximising capacity of the existing network

To cope with the unprecedented demand on our services, a massive investment programme is under way to increase network capacity. We’re installing new signalling to increase the frequency of trains, meaning we can carry more passengers every hour. We’re also modernising our stations to make journeys faster.

Automatic train operation
London Underground has always led the way in automatic train operation, opening the world’s first automatic railway – the Victoria line – in 1969. We began introducing ‘one person operation’ in 1984 using CCTV, which allows train operators to see when trains are ready to leave the platform, removing the need for guards.

Today, we continue to provide faster, more reliable services and have increased capacity through state-of-the-art automatic signalling.

These systems, which rely on the telecommunications between the train and track equipment, more accurately identify the position of a train than traditional signalling methods. They offer a more efficient and safer way to manage the railway traffic and enable us to run trains more frequently while reducing the scope for human error.

In the 1990s we introduced automatic signalling to the Central line and more recently on the Jubilee, Victoria and Northern lines, which are three of our busiest. On the Jubilee line, we can now carry 12,500 more passengers every hour on a service that’s 50 per cent more reliable. On the Victoria line, we’re running 34 trains an hour – one of the highest frequency services in Europe. The recently completed re-signalling of the Northern line adds 20 per cent more capacity and makes journeys 18 per cent faster. Best of all, modern signalling will allow us to push the frequencies on these lines even higher over the next few years.

Growing the network

With London’s population expected to exceed 10 million by 2031, our rail network needs to expand to relieve the burden on existing routes and open up areas for development, new homes and jobs.

London Overground
Since taking over part of the Capital’s overground rail services in 2007, we have significantly increased capacity and connectivity, particularly between areas outside central London. London Overground is one of our biggest success stories, carrying a record 136 million passengers in 2013/14 and achieving one of the highest levels of customer satisfaction of any UK railway.

Our vision for the service relied on us doing things that had never been done before. Firstly, we had to make the case for part of the National Rail network to be transferred from central government to TfL, a devolved regional body. We worked to ensure that the 2005 Railways Act allowed for this, which enabled the transfer to take place.

Secondly, we knew that the Overground’s potential lay in creating a fully orbital network that could help reduce pressure on busy links to and from central London and provide better access to and between town centres. To achieve this we had to integrate our plans to improve the routes not yet under our control (the North and West London lines) with the separate proposals to renovate and extend London Underground’s East London line.

And finally, we developed a new way of appointing and managing a train operator to run the service on our behalf. We introduced strict performance measures with clear incentives. Because our operator receives a set fee, it can focus entirely on operating the best service possible, rather than having to predict and respond to variations in fares revenue – which in London is driven by factors such as employment levels.

The resulting success means we can now take the Overground model forward to lines in the Lea Valley. The same principles will also be applied to Crossrail services when they begin later this decade.
Customer service

We want to improve all aspects of our customers’ journeys. London Underground was the first metro outside Asia to introduce smartcard ticketing. Tube customers have benefited from Oyster since 2003, our contactless smartcard that holds pay as you go credit or season tickets. Passengers touch their Oyster cards on an electronic reader when entering and leaving our stations, then the system calculates and deducts the best possible fare. Oyster is now accepted on all TfL services and most National Rail services within the Capital and more than 80 per cent of all public transport journeys in London are paid for using the card.

In September 2014, we launched contactless payments across the London Underground and rail network. The system operates in the same way as Oyster, charging customers a pay-as-you-go fare when they touch their debit, credit or pre-paid cards on readers at the start and end of every trip. However, contactless payments make journeys even easier, as customers no longer have to exchange their currency (pounds and pence) for ours (Oyster and tickets).

Open data
We are committed to providing open data for web developers. We have led the way in this area and have 30 data feeds available, and more than 5,000 developers registered. Hundreds of apps have been created that enable customers to see when their next train is due or decide which journey to take. Apps are also replacing paper-based products used by our staff, such as our fares table, allowing them to access information at the touch of a button.

Open data allows developers to place TfL and London Underground widgets on their websites. Examples include Journey Planner, departure boards and the Tube map. Our goal is to ensure that any person needing travel information when in the Capital can get it wherever and whenever they wish, in any way they want.

Keeping our customers comfortable
Rising temperatures on the Tube mean we have to find new ways of keeping customers cool. We are continuing our programme of upgrading ventilation fans and installing other cooling equipment to manage temperatures on the Underground. We’ve also developed a computer model that predicts what the temperatures will be on certain lines after they are upgraded. Upgrades mean more trains and higher speeds, which leads to an increase in the amount of heat generated. By assessing the power use and characteristics of new trains, our tunnel ventilation models can accurately predict future temperature changes. This information allows us to evaluate how best to manage this, whether through energy efficiency methods such as regenerative braking or heat extraction equipment such as chilled water systems.

Using internally developed models and resources we are able to target when and where capital investment in cooling infrastructure should be made as part of a line upgrade. These have been particularly useful as we work on pushing frequency on the Victoria line to up to 36 trains an hour. An innovative chilled air system housed in a ventilation shaft is managing the temperatures at the north end of the line, while several other energy efficiency measures have been put in place.

Improving accessibility

London has one of the most accessible transport networks in the UK. While major schemes are under way to provide step-free access, we are focused on innovative projects to make our network accessible in other ways.

Manual boarding ramps
A familiar sight on National Rail services for many years, these ramps were previously considered unsuitable for the Tube owing to the frequency of our services and the short stopping times at stations. While preparing for the 2012 Games we recognised that finding a way to enable these ramps to be used was essential to significantly improve the service for disabled people. In fact, they could actually reduce the delays that occur if a wheelchair user tries to board a train without assistance.

Improving accessibility
The ramps were initially installed at 16 stations that were crucial during the Games. Now, they are in place at more than 40 locations and their use continues to increase.

In 2014 we developed a new ramp that could be used when the level of the train is lower than the platform and these are benefiting passengers at Kilburn, Stanmore, Wembley Park, Wembley Central, Woodside Park and Harrow & Wealdstone. Platforms with a step down to the train are unique to the Underground.

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Providing value for money and driving efficiency

All of our income pays for the operation of services and helps to improve the network. Alongside our suppliers, we are working hard to get the best value for every pound we spend. Innovation in how we procure our equipment and services has allowed us to achieve much more for less.

Innovative contractor engagement

Every day almost 350,000 people use Bank station in the heart of the City. However, this level of demand means we often have to hold customers outside the station to prevent overcrowding. We recently contracted a massive project to overhaul the station – to reduce congestion, improve journey times and provide step-free access to the Northern line and Docklands Light Railway.

As with everything we do, the upgrade had to be cost effective and minimise disruption to our customers and neighbours. To achieve these aims, a concept called ‘innovative contractor engagement’ was introduced. We developed a ‘base case scheme’ for the upgrade, but rather than asking bidders to quote on this, we asked them to improve on it, focusing on things that were of value to us.

We gave bidders a clear and detailed overview of the requirements, then innovations could be discussed and developed together. We contributed to the cost of this dialogue and had the right to buy ideas from unsuccessful bidders.

The result is a commercial environment in which contractors have an incentive to invest in innovation and develop solutions as part of the bidding process.

STAKE

This new supplier system was first used to contract work for a £330m programme to make vital stations fit for the next decade. It ensures best value, encourages innovation and minimises disruption.

Under the STAKE model, London Underground engages directly with trades contractors, rather than through our main supplier, so overall cost is reduced. Communication, workforce engagement and quality is improved as London Underground is closer to the people carrying out the work. Contractors have an incentive to bid for future work, which is conditional on supplier performance.

As a result of STAKE, customers experience fewer planned and unplanned station closures for remedial work. London Underground is working with the successful suppliers to establish craft academies that will provide craft skills training and frontline leadership practices so supervisors and construction managers can deliver the programme efficiently.

Building Information Modelling (BIM)

Modernising, expanding and adding step-free access to our stations – many of which are in densely populated and confined areas – is a huge challenge. We use BIM 3D modelling in our station design to give us a clear view of the works required when carrying out a spatially complex project. This enables good decision making and minimises construction waste. Successful examples include upgrade works at Victoria and Bank stations, which were early adopters to BIM.

BIM also provides a consistent, collaborative approach to the production, use and management of data and information. All data about our station projects is electronic, and can be exchanged both internally and with our suppliers to support decision making.
Access to our tracks is limited to between three and four hours a night when our trains are in service. Within this short timeframe, we have a team of experts who take tools and materials to each site and replace and renew our tracks, before cleaning up ready for the first morning train.

Efficient use of time is critical and we’re always looking for ways to make the most of these engineering hours.

**Ballasted track replacement**

We have a continuing programme of track replacement and renewal that ensures journeys are safe, reliable and smooth. But this presents challenges – the London Underground network was constructed to weave around all parts of the Capital, resulting in some of the tightest railway curvatures in the world.

Traditionally we’ve used longer weekend or block closures for track replacement and renewal work owing to the difficulty of mobilising the heavy equipment required. With improved ways of working and new tools and machinery, we can now carry out this challenging work during engineering hours. In just two to three hours a night, we can replace sleepers, ballast and rails, and as we improve our methods we’ve been able to achieve even more. A year ago, we could complete two to three metres of track replacement a night – now we can manage up to 20.

Working with our partner, Balfour Beatty, we’re leading innovation in this area. For example, we’re bringing in mechanised rail movement, using little robots that move rail into place. These are much safer and twice as fast as traditional methods.

**Delivering materials quickly**

An innovative solution to the challenge of delivering materials to a site quickly and safely was found in a long redundant ventilation shaft at St. Paul’s station on the Central line.

A hub, serving 10 worksites, was created by constructing an industrial lift system within the shaft, giving direct access from the street to the disused passenger walkways below. Equipment, materials and spoil can be moved quickly and safely behind the scenes without risk of injury, damage or disruption. The hub is completely independent of the passenger service and can be accessed 24 hours a day.

Before the day’s passenger services draw to a close, bagged concrete, shingle, sleepers and tools are moved from their storage area to the platform using motorised pallet trucks. These are loaded on to a conveyer belt leading to the fully operational Central line platform.

Once passenger services stop running and the platform is clear, the materials are taken to the centre of the platform and unloaded ready for the gangs to use once they arrive. Track trolleys, pulled by electronic powered carts, are then loaded up and driven down the track to support sites 4km away, east and west from the hub.

At the same time, waste materials such as rubble, sleepers and plant are continuously taken from the work sites back to the hub.

This process has significantly reduced the risk of injury to people working on the tracks and has enabled us to be more productive within the few hours available.
Enabling innovation

Our web-based Innovation Portal, available at tfl.gov.uk/innovation, is helping us develop new technology and approaches to the challenges we face in four categories – reliability, value, sustainability plus customers and delivery. It allows staff, suppliers, the public, academia and small and medium enterprises to share their ideas as we continue to upgrade the Tube and transport network. All ideas submitted are assessed for relevance then reviewed by in-house experts.

Advanced on-train and signalling telemetry
Our assets work extremely hard as they are responsible for moving millions of people each day. Constant monitoring and making intelligent use of the available data can greatly improve the service our customers receive. Using a ‘predict and prevent’ approach, technicians can monitor the ‘health’ of a train in real time, providing assurances to operators and controllers that it is in good condition, or allowing a controlled exit from service before causing a disruption.

A train contains thousands of software signals (telemetry) that provide detailed data about its condition. We are currently running a ‘proof of concept’ to access and stream this information via WiFi. Trains will automatically upload data when at a station, allowing us to take ‘predict and prevent’ on the Underground to the next level.

Introducing aerospace materials to rail
One of the ideas that has been developed through our Innovations Portal is the use of aerospace materials in our train design.

A consortium led by London Underground and including Atkins Aerospace, the National Composites Centre, Wabtec Rail and University College London has developed a commercially feasible, lightweight train door using state-of-the-art composite materials and manufacturing processes.

The reduced weight means larger doors can be installed on trains, reducing the time needed at stations for passengers to get on and off. This leads to shorter overall journey times and increases capacity on the line.

The future

With a rapidly growing population, London needs a Tube and rail network that can not only meet increased demand, but also continue driving growth.

Only through innovation will we be able to deliver our challenging investment programme. We need to make use of new technology to monitor, manage and improve every aspect of our network’s operation. We must continue to develop new, more efficient and reliable ways of working. Finally, we must keep looking for opportunities to collaborate with our industry partners and suppliers to build on our pioneering legacy for London’s future generations.