

# London Underground Simulates Passenger Movements on Major Subterranean Station Upgrade

Bentley's LEGION<sup>®</sup> Software Facilitated Assessment and Improvement of the Bank-Monument Station Upgrade Planning, Design, and Operation



## UPGRADING AN URBAN UNDERGROUND STATION

Located in London, the Bank-Monument station is one of the most complex subterranean railway stations in the world. It is a major gateway to the area, used by more than 52 million passengers each year, and is of strategic importance to London and the United Kingdom's economy. In the past 10 years, the number of passengers that use Bank-Monument station has risen by 50%, totalling just under 400,000 each weekday. Demand continues to rise, and if nothing is done, there will be an increase in temporary station closures for crowd control and some trains will run through Bank-Monument station without stopping. These steps would inconvenience passengers and cause disruption to other parts of the London Underground.

Improving Bank-Monument station is also a key step toward enabling future frequency increases on the Northern line. Therefore, in 2013, London Underground Limited decided to upgrade Bank-Monument station to improve and maintain access to the city of London, the rest of the London Underground, and the Docklands Light Railway network. The Bank-Monument Station Capacity Upgrade project will improve passenger access, circulation, and interchange, providing an additional 45% capacity during peak hours. London Underground Limited's station modeling and public transportation service planning team was tasked with assessing the benefits, operational impacts, and strategies for the improved capacity upgrade. The team needed to increase capacity, improve pedestrian traffic flow, and make the station more accessible.

## OVERCOMING A COMPLEX DESIGN CHALLENGE

Incorporated in 1985, London Underground Limited provides passenger rail services, and refurbishment and maintenance of parts of the rail network in Greater London. The organization manages all the stations in the London Underground. Bank-Monument station's configuration is complex, containing five London Underground lines with a terminating line, as well as a Docklands Light Railway terminus, three ticket halls, 10 platforms, 15 escalators, and two 300-foot moving walkways. The maze of complex routes within the station hampers wayfinding and increases conflict between opposing flows.

Around 50% of all journeys during peak periods are passengers interchanging between the six lines, and the complex and often indirect routes result in crossflow, confusion, and crowding. These issues make the station challenging to manage. To address these challenges, the team needed to provide design and validation throughout the project, shaping the emerging scheme and measuring its performance.

## SIMULATING TO MEET CORE REQUIREMENTS

London Underground Limited developed a design for this station upgrade project that includes a new passenger entrance with lift and escalator connections, a new train and platform tunnel, and new tunnels and other internal connections. The team used LEGION Model Builder to develop the station model scenarios and LEGION Simulator for validation and passenger simulation analysis capabilities, including benchmarking existing station performance, in the planning and design processes. Station modeling can be a long and complex process. By using LEGION, the London Underground Limited team was able to simulate congestion relief

## PROJECT SUMMARY

### ORGANIZATION

London Underground Limited

### SOLUTION

Passenger Simulation

### LOCATION

London, England, United Kingdom

### PROJECT OBJECTIVES

- ◆ To deliver station improvements and designs that are fit for purpose, cost-effective, and sustainable.
- ◆ To improve passenger access, circulation, and interchange at the Bank-Monument station.

### PROJECT PLAYBOOK

LEGION Model Builder, LEGION Simulator

### FAST FACTS

- ◆ The Bank-Monument station is used by more than 52 million passengers each year, and is one of the most complex subterranean railway stations in the world.
- ◆ The Bank-Monument Station Capacity Upgrade project will provide an additional 45% capacity during peak hours.
- ◆ LEGION Model Builder and LEGION Simulator provided design and validation capabilities throughout the design process.

### ROI

- ◆ By redesigning the station, London Underground Limited increased station capacity by an additional 45% during peak hours.
- ◆ The average time saved is predicted to be 3 minutes, 17 seconds in the morning peak and 37 seconds in the evening peak.
- ◆ The upgraded station will provide handicap access to the Docklands Light Rail and Northern Line platforms.
- ◆ The upgrade will future-proof the station until 2081.

“LEGION is one application used by Transport for London to assess and quantify station congestion impacts across the network. It is instrumental, providing not only visual outputs identifying congestion hotspots, but also outputs that can easily be monetized, directly contributing to a benefit-cost ratio.”

– Madeleine Cox, Principal Planner, London Underground Limited



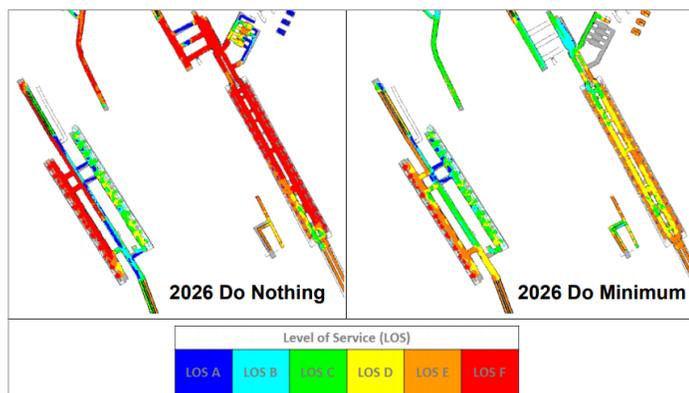
schemes, helping with design improvements and social benefit calculations, as well as keeping the models simple enough to avoid confusion.

With LEGION, team members were able to test crowd management, construction impact, and evacuation plans in the model, which allowed the team to make data-driven decisions before construction began. LEGION Simulator helped optimize station layouts for operational tests, commercial use, and business cases.

Using LEGION Model Builder and LEGION Simulator, London Underground Limited determined the best way to make the station more accessible was to install two new lifts and upgrade the existing lift. These changes improve step-free access to the Northern Line and Docklands Light Railway trains from street level. These improvements will give passengers with reduced mobility – including wheelchair users and those with heavy luggage who cannot use stairs or escalators – greater independent access to the station. In addition, they will provide additional operational resilience for emergency station evacuation. The new station entrance and associated subsurface reconfiguration accommodate the increase in passenger throughput without major congestion and with quicker journey times through the station compared with the existing baseline.

### IMPROVED ECONOMIC FEASIBILITY AND IMPACT

The redesign reduces congestion and improves journey times through the Bank-Monument station, delivered through improved capacity. The average time saving is predicted to be three minutes and 17 seconds for the morning peak and 37 seconds for the evening peak. London Underground determined in its economic evaluation that the project has a benefit to cost ratio of 4:1, predominantly from congestion relief and journey time savings calculated using LEGION. This ratio is based on a conservative methodology as a result



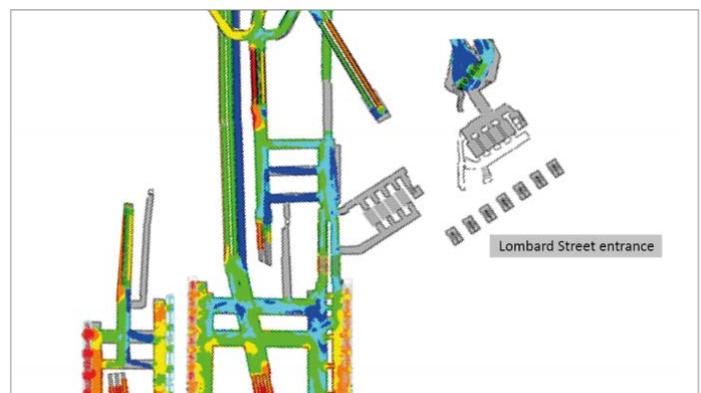
Level of service projections with alternative scenarios.

of difficulties in modeling major congestion relief projects and does not include several unquantified benefits. For a major project with the level of capital investment proposed, it is considered significant and shows how the upgrade will allow the organization to save costs for many years to come.

The economic impact of the project is wider than the important direct benefits to passengers at the Bank-Monument station. The project is part of a wider network that will allow for the continued success of London as a whole. This success will, in turn, have a major beneficial impact on the London and the United Kingdom economy.

The upgrade proposals will allow the station to support London Underground Limited's projected passenger numbers for 2026, plus an additional 31%. The increased capacity will allow the station to provide safe and efficient travel 60 years after its original opening, giving the organization time to begin its longer-term scheme assessment. The proposed design will future-proof the station through 2081 by creating more space and improved legibility to help passengers move through the station, improving accessibility and providing quicker and safer fire evacuation routes.

The upgraded station will allow for a reduction in station closures and increased control measures at nearby stations, benefitting passengers outside the peak periods as well as improving regular service and reducing wait times for trains. Congestion relief will allow the Northern Line Upgrade program to deliver the required train frequency and realize its full passenger benefits, while the Docklands Light Railway will also be positively impacted. Lastly, the upgrade will provide more energy-efficient measures, which will cut the amount of operational carbon dioxide emissions generated by the station by an estimated 23%. The project will generate significant long-term benefits for passengers who will use the station, as well as the city and the greater London area.



Major junctions level of service heat maps.