Victoria Line – 50 Years of Resilience (So Far)

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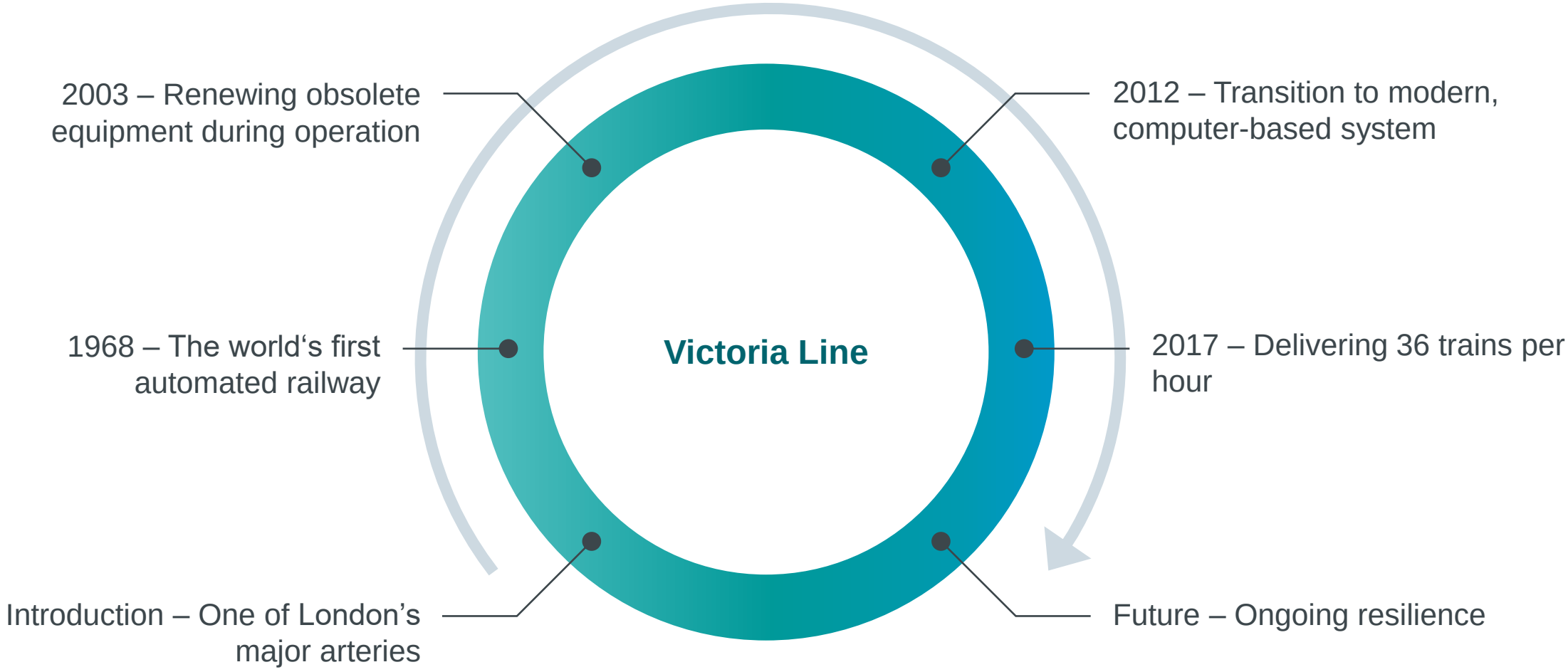
Overview



Introduction – One of London's major arteries

- Built 1968
- 16 stations
- 21 kilometres
- 200 million passengers per year
- 36 trains per hour (every 100s)
- 2009 Bombardier trains (Movia family)
- Most intensively used London Underground line (by journeys per mile)

What is resilience?

Ability to maintain consistent socio-economic benefit

1968 – The world's first automated railway

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Ingenuity for life

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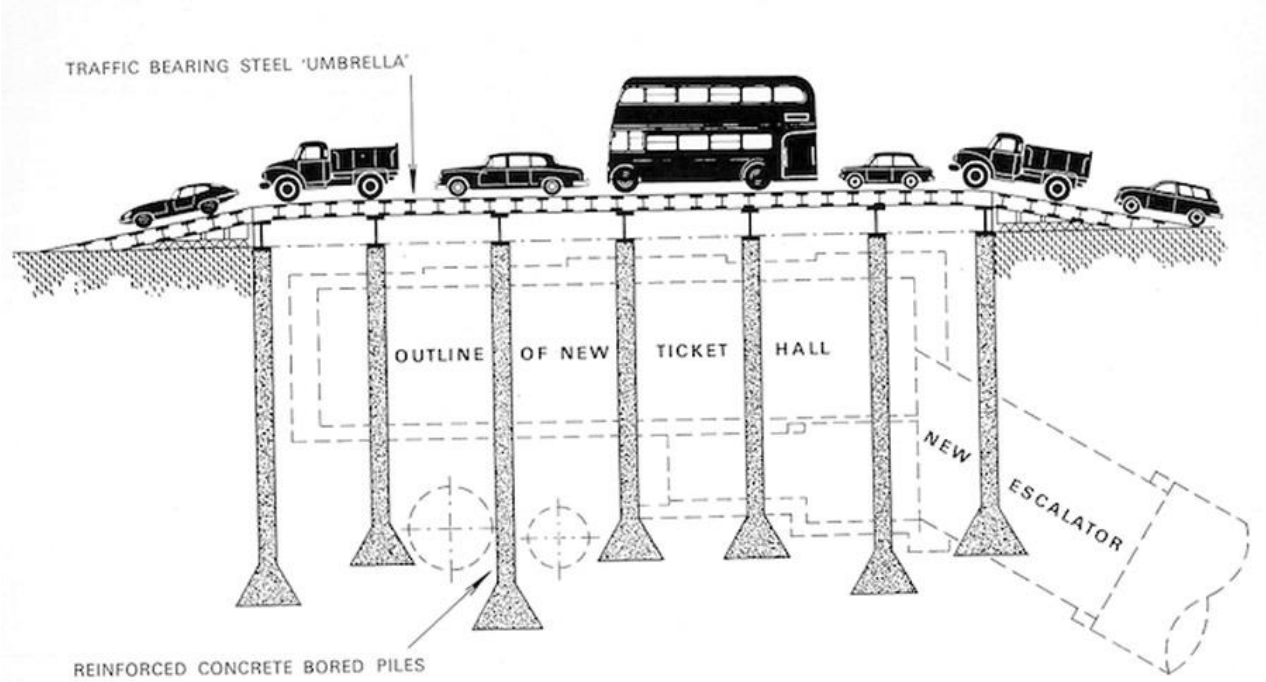
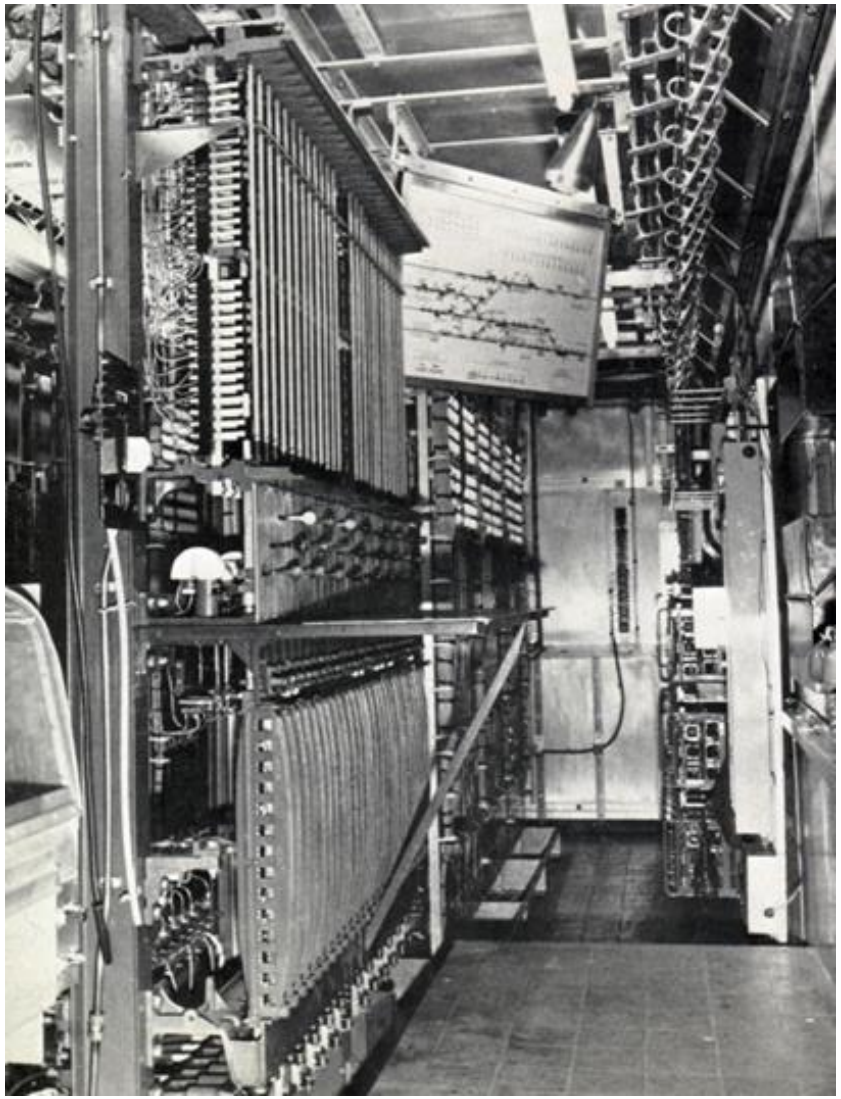


Difficult construction

- 'Steel umbrella' used

1968 – The world's first automated railway



Trackside systems

- Fixed block signalling
- Track circuits with frequency codes
- Electropneumatic 'V' frame interlockings
- Timetable – programme machines
- Remote control centre (Coburg Street)

Engineering resilience

Resilience through engineering design and redundancy

1968 – The world's first automated railway

Onboard

- Safety box
  - Receives track codes to supervise braking
- Autodriver
  - Receives frequency tones to regulate speed
- Identra
  - Communicate train identity

Engineering resilience

Resilience through engineering design and redundancy

2003 – Renewing obsolete equipment during operation

Ageing equipment

- Autodriver boxes replaced twice
- Safety box difficult to upgrade
- Poor availability of bespoke electronics
- Rolling stock amount oldest on network

Resilience

Ongoing resilience due to skilled operations and maintenance teams

2003 – Renewing obsolete equipment during operation

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METRONET

invensys
WESTINGHOUSE
rail systems

BOMBARDIER

Public Private Partnership

- Metronet delivered renewal of BCV (Bakerloo, Central, & Victoria lines) including new rolling stock and signalling
- 47 new Bombardier trains
- Distance to Go – Radio command, control and signalling system

Resilience as a KPI

Requirements in terms of service disruption, reliability, and availability.

2012 – Transition to modern, computer-based system

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Upgrades to Victoria Line

- Trains
- Traction power
- Stations
- Signalling system

Major challenges

- Trains could not stop running
- Changeover to new signalling system
- Lack of space in equipment rooms

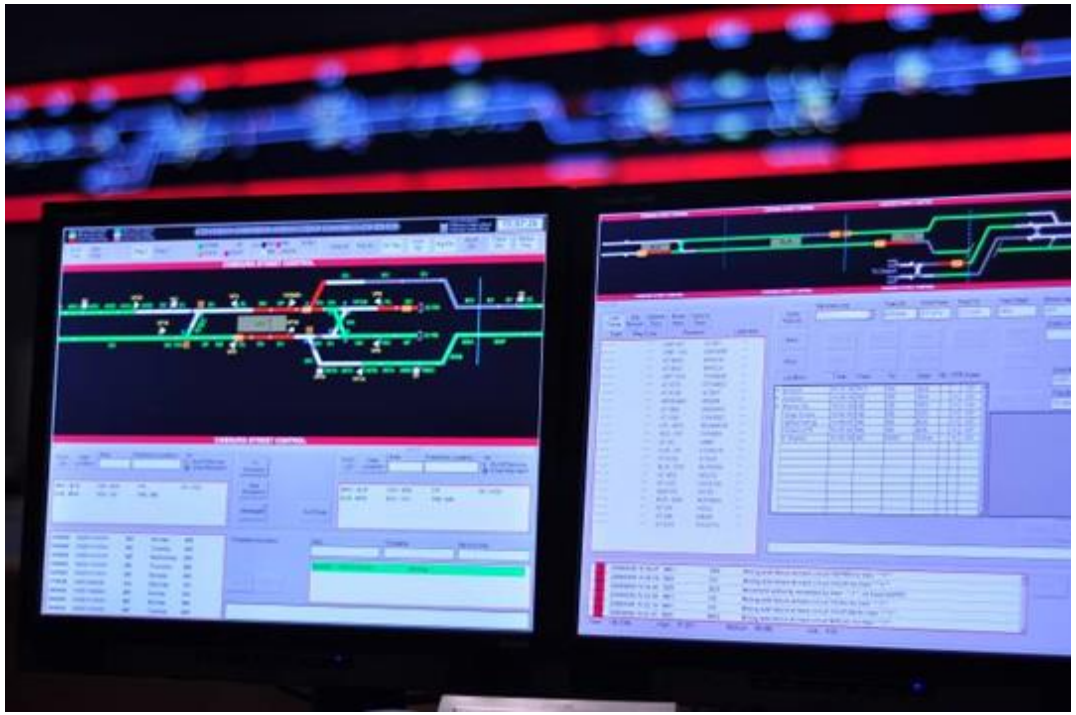
New system

- On-board ATP (2 out of 3)
- Mobile radio unit (duplicated)
- Interlocking (hot standby)
- Trackside ATP (2 out of 3)

Resilience

Resilience through redundancy of key hardware components

2012 – Transition to modern, computer-based system



Phased changeover to new system

- New Westrace interlocking working in overlay with electro-pneumatic interlocking
- New trains gradually introduced
- Combination of off-site and on-site testing

Commissioning

- 9 weekends line closure – Westrace given functional control
- Over and back testing to build confidence

Resilience

Off-site testing and simulation contributed to system resilience

2017 – Delivering 36 trains per hour

Victoria Line Upgrade 2 – system upgrades

- Signalling
- Control systems
- Rolling stock
- Tunnel cooling
- Infrastructure

Automatic Train Regulation

- Assesses performance and makes 1s adjustments to timetable to recover from disruption

Resilience

Resilience through automation of timetable management

Future – Cyber Security and digital systems

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Cyber Security challenges

- Ensuring both safety and security in parallel
- Moving from closed to connected networks

Potential future changes

- Will we see cloud based interlockings?
- Safety assurance built into software?

Digital benefits

- Reduced dependence on bespoke hardware
- Improved system intelligence

Digital challenges

- Increased risk of cyber attack causing service affecting failure

Resilience

How to counter new and unknown threats?

Future – Obsolescence

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People trends

- Shift towards simple line-replaceable units and less bespoke skills

People challenges

- How do we maintain required skills and knowledge to carry out complex tasks?

Hardware trends

- Moving away from bespoke components
- Increased importance of industry standards
- Larger user-base
- Increased availability of spares

Hardware challenges

- Complications with understanding behaviour through hardware / software changes

Resilience

How to maintain resilience with changing people and hardware?

Future – Changing Demand

- 36 trains per hours approaching physical limitations
- System performance dependent on dwell time rather than platform reoccupation time
- Minor passenger disruption (bags caught in doors) have significant knock-on effects
- New requirement to understand passenger psychology and manage expectations

Resilience

How to maintain resilience with increasing demand?

Future – Passenger Expectations

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Passengers expect reliability

- Reliable technology seen as standard
- Complexity of railway systems largely hidden
- Confidence is quickly lost in event of delay

Potential solutions

- Integrated systems (escalators, other trains) to deliver passengers on time
- Station management
- Computing-based approaches

Resilience

How to maintain reliable service levels to uphold passenger expectations?

Conclusion