

Optimising the Power Upgrade Solution of the Sub Surface Railway

Case Study in London Underground

*RTS 2010
Railway Traction Systems
13-15 April 2010
Birmingham UK*



Cogitare



**Transport
for London**

M Morfis, M Chymera, L Fawkner, D Hetherington, P Carmichael



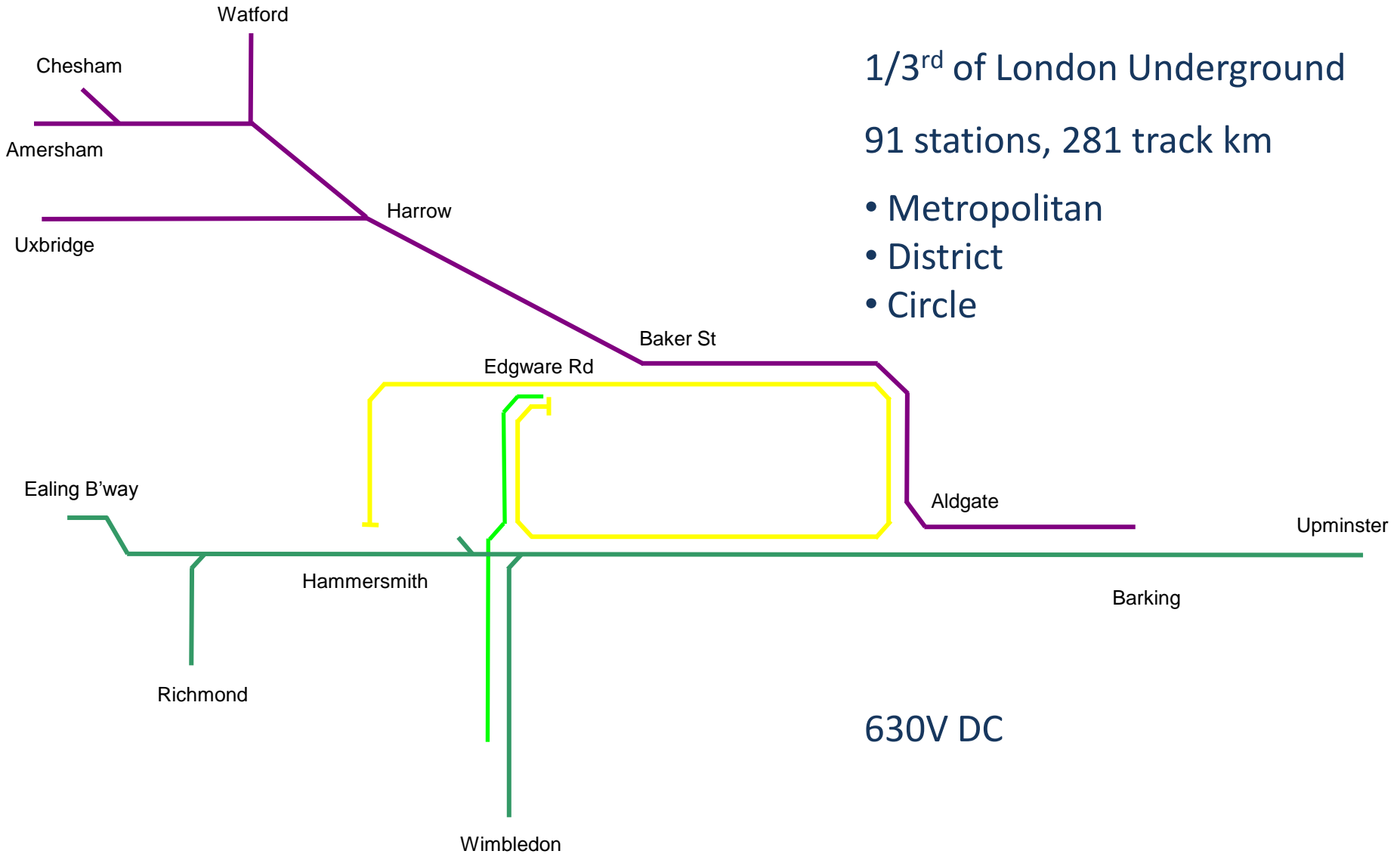
Background of SSR Upgrade

Targets & Constraints

System Optimisation

Conclusions

Sub Surface Railway (SSR)



SSR Upgrade

SSR Upgrade in 2018:

- New rolling stock, with regen, through gangways, air con
- New ATO signalling control system
- Increase in service frequencies (28 to 33+ core / 22 to 30 outer)
- Faster run times by 13%

To achieve:

- 18% improvement in Customer Journey Time
- Improved Customer Ambience

Requires:

- Significant power supply infrastructure upgrades
- Track and station upgrades

Targets & Constraints

- Target Upgrade Plan:
 - Routes
 - Service levels
 - Run times
 - Projected passenger demand from 2018 to 2055
- PPP/PFI Contracts:
 - Metronet (until 2008)
 - EDF Energy Powerlink (Power Infrastructure PFI)
- LU Standards

System Optimisation

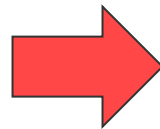
Problem

Meet Objectives:

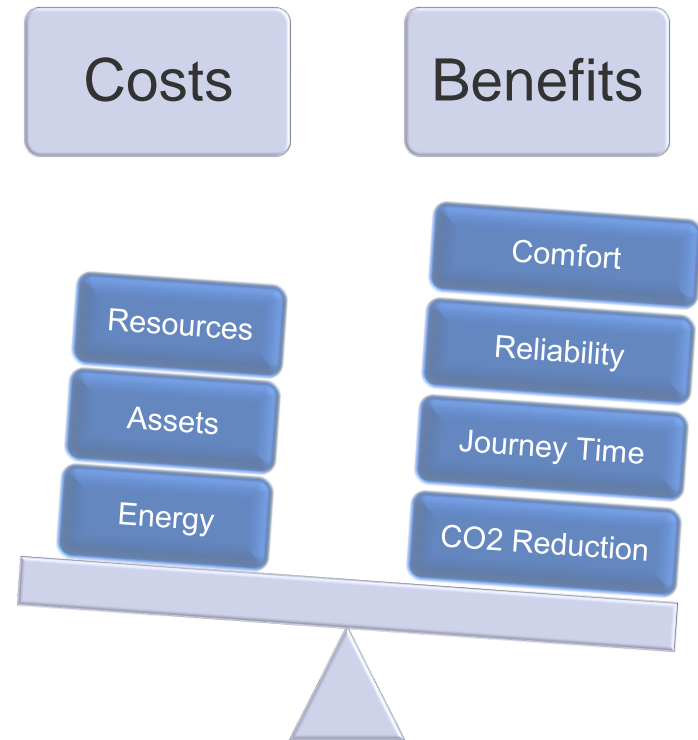
- Deliverable
- Affordable
- Value for Money
- Energy Efficiency / CO2 reduction
- Capacity
- Reliability
- Mode shift: Transfer people from road to rail



Generate Ideas & Options



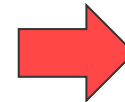
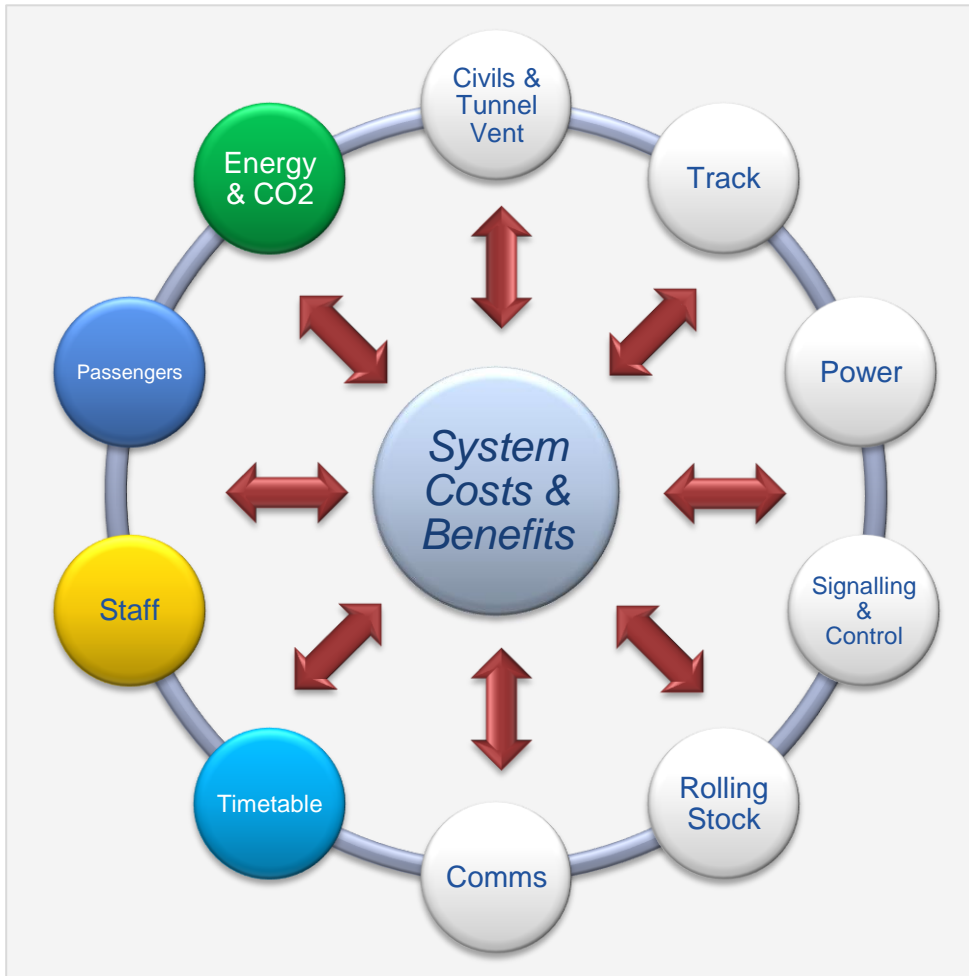
**Predict System Performance &
Find **Optimised & Affordable** System Solution**



Optimise whole-life costs and benefits

SSR Power Upgrade Optimisation

Evaluate and optimise **SYSTEM** wide interdependencies:



GOAL:

- Minimise Capex & WLC
- Maximise Energy Efficiency
- For no loss in Journey Time

SSR Power Upgrade Optimisation

- Optimised the System Upgrade Solution:

- Substations
- Conductor rail
- Electrical trackside equipment
- Rolling stock performance
- ATO run profiles

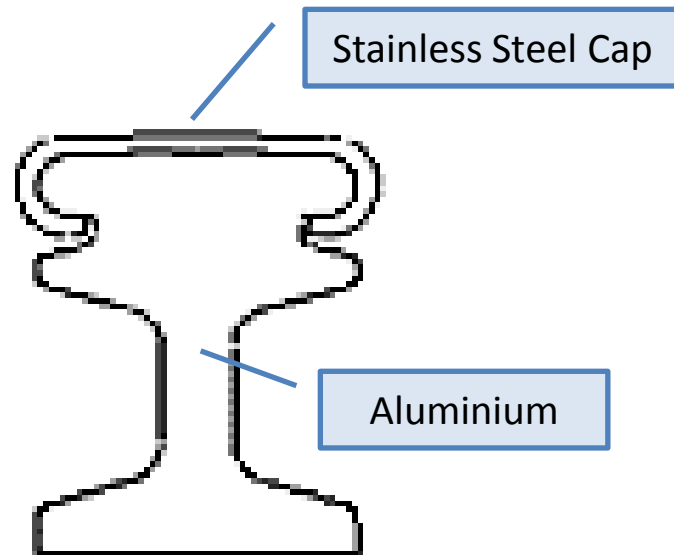
- Justified:

- Updates to LU standards and working practices
- Approvals and Railway Safety Cases
- Engineering train upgrades

Phase 1

Opportunities Studied

- Composite Conductor Rail
(up to 70% lower electrical resistance vs. steel)
 - **Avoided building new substations for voltage support**
 - **£500m CAPEX Saving**

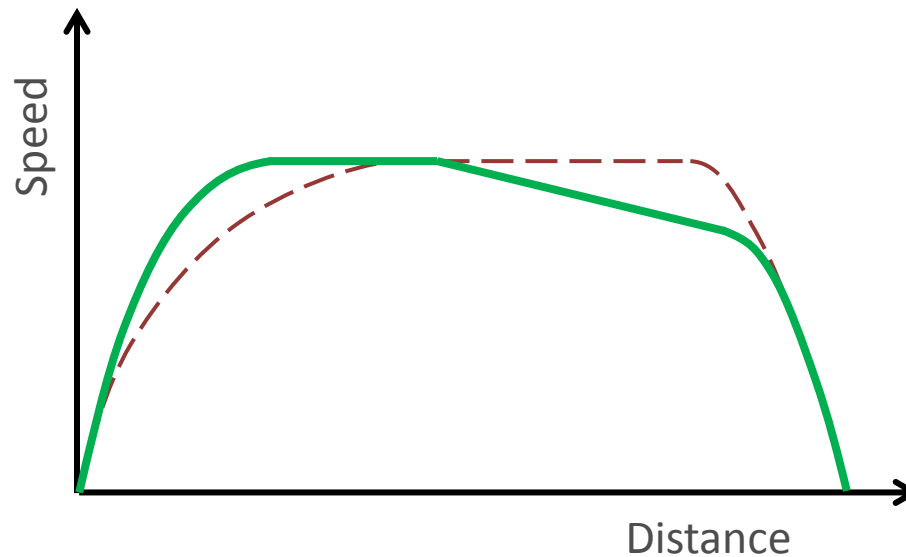


Phase 2

Opportunities Studied

- Higher motor power
- Run profiles with coasting, same run times

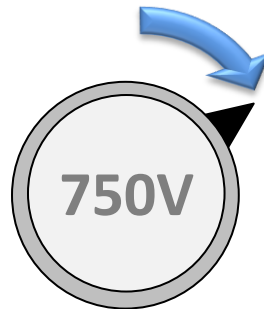
➤ 15% Energy Savings



Phase 2

Opportunities Studied

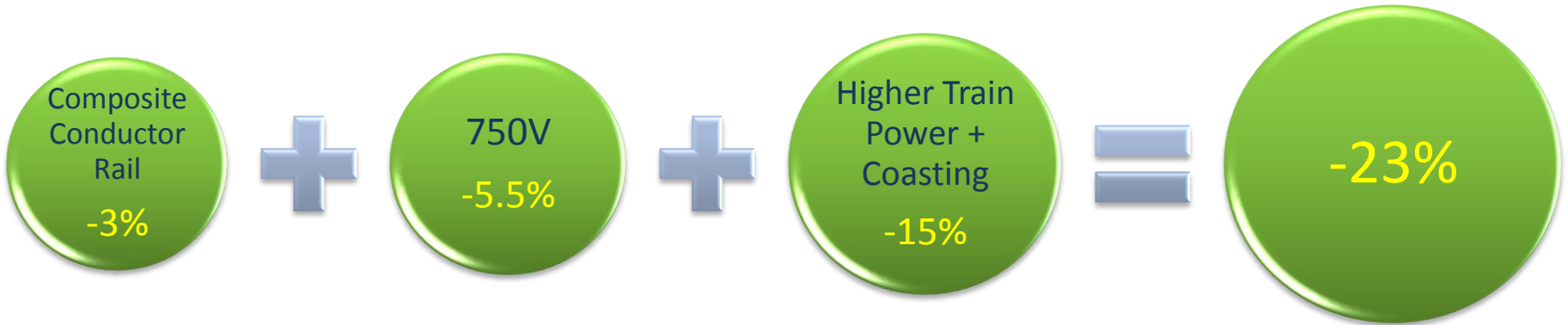
- Higher power supply voltage, from 630V to 750V
 - Higher regenerative braking voltage from 790V to 890V
- 6.5% Energy Savings
- 57% less Capex for Composite Conductor Rail



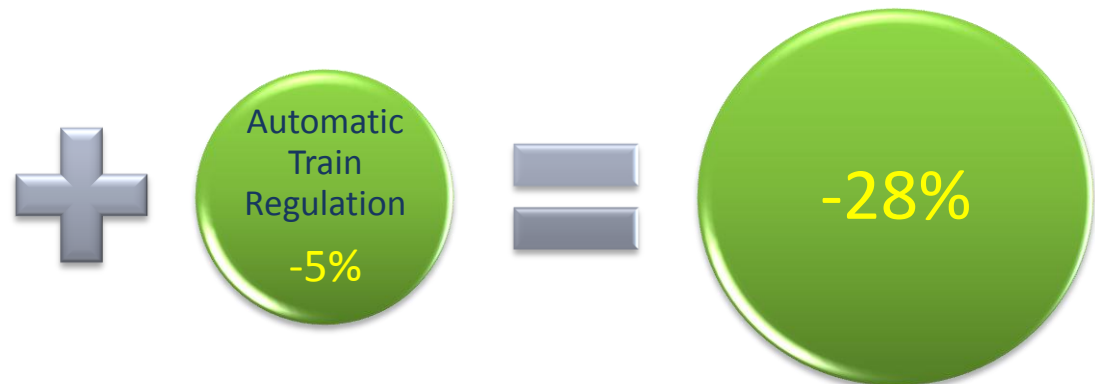
Phase 1 + 2

Total Energy Efficiency Benefits

- Achieved:



- Still further opportunities to be exploited...

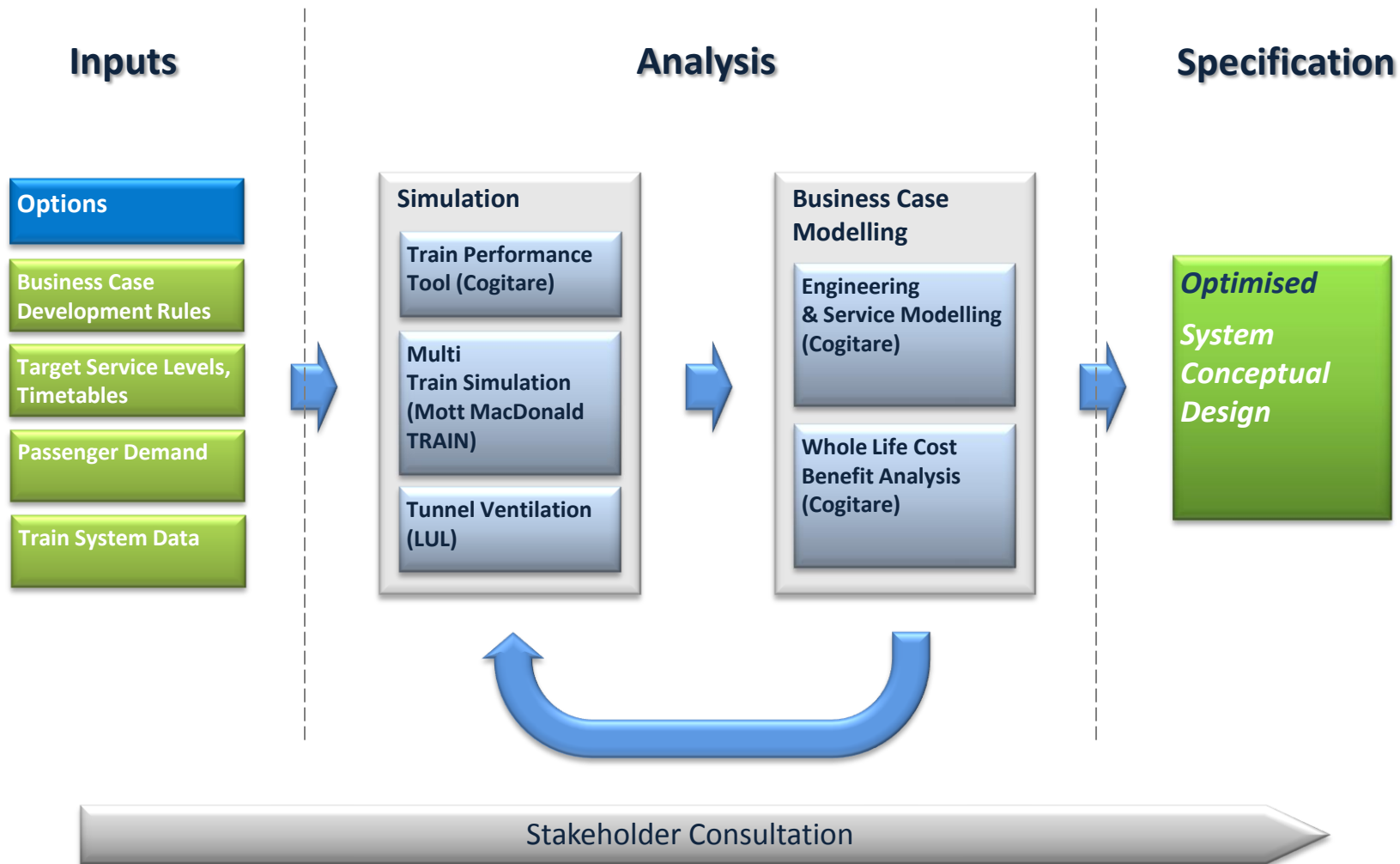


SSR Business Case Options

(same run time performance)

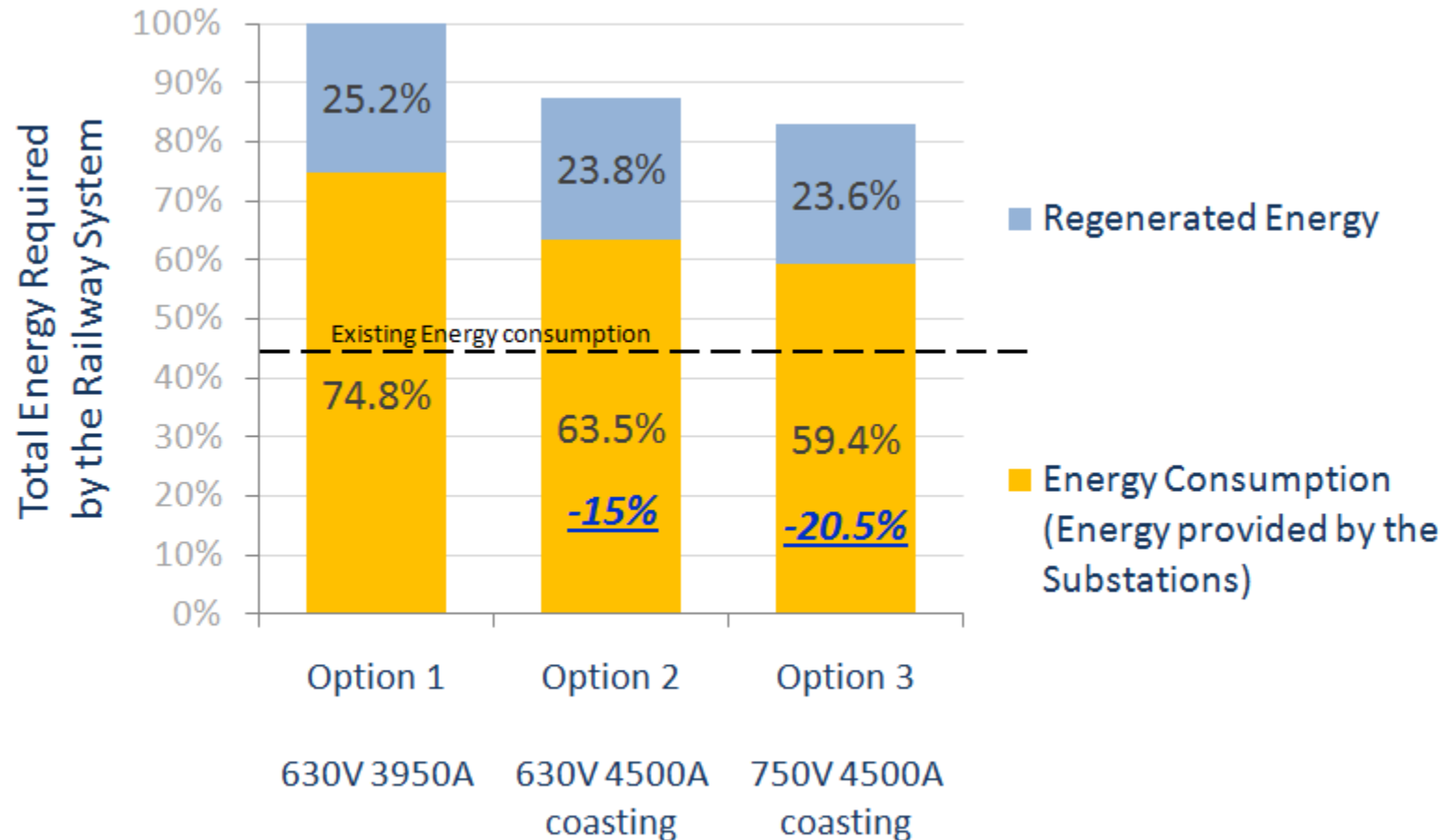
Option	Power Supply Voltage	Rolling stock Line Current	Run Profiles	Conductor Rail installed
2006 (Existing)	630 V	Existing		
PPP Upgrade (Base Case)	630 V	3950 A	Flat-out	Existing steel
1	630 V	3950 A	Flat-out	LL CCR
2	630 V	4500 A	Coasting	ELL CCR
3	750 V	4500 A	Coasting	ELL CCR

System Optimisation Process



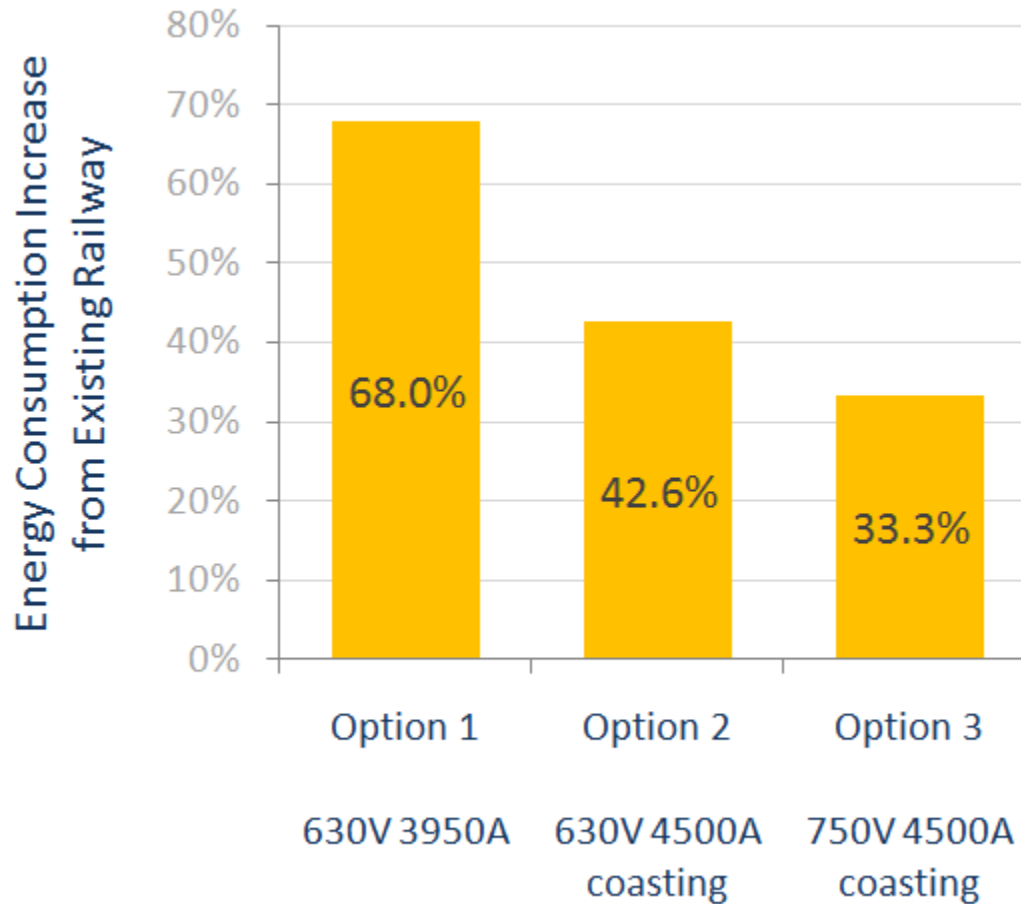
SSR Business Case Options

Energy Efficiency



SSR Business Case Options

Energy Efficiency



SSR Business Case Options

Power Upgrade Solution

	Phase 1	Phase 2		
	PPP Upgrade	Option 1	Option 2	Option 3
Power Supply Voltage	630 V	630 V	630 V	750 V
Train Line Current Limit	3950 A	3950 A	4500 A	4500 A
Run Profiles	flat-out	flat-out	coasting	coasting
Conductor Rail	Steel	LL CCR	ELL CCR	ELL CCR
Journey Time Performance	----- same -----			
Substations	44 new 30 upgrades	6 new 39 upgrades	6 new 39 upgrades	4 new 39 upgrades
Conductor Rail Replacement	-	147 track km LL CCR	147 track km ELL CCR	63 track km ELL CCR
Electrical Trackside Equipment	£37m	£37m	£40m	£40m
HV/AC Reinforcement	£235m	£235m	£258m	£240m
Other				£8.7m +£25m risk

SSR Business Case Options

Business Case

	Phase 1		Phase 2		
	PPP				
	Upgrade	Option 1	Option 1	Option 2	Option 3
Power Supply Voltage	630 V		630 V	630 V	750 V
Train Line Current Limit	3950 A		3950 A	4500 A	4500 A
Run Profiles	flat-out		flat-out	coasting	coasting
Conductor Rail	Steel	LL CCR	LL CCR	ELL CCR	ELL CCR
Journey Time Performance	----- same -----		----- same -----		
Capital Expenditure (Capex)				-£79	£25
Future Capex Avoided				£1	-£37
Operating Expenditure (Opex)				£37	£83
Total Whole Life Costs		£518		-£41	£71

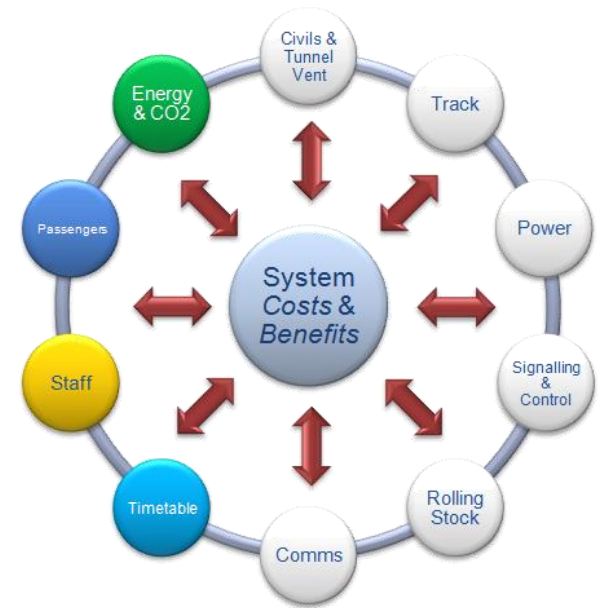
Additional Business Case Benefits

- Tunnel Ventilation:
 - Lower temperatures by 1.5 to 2°C, or
approx. £50m Capex saving
- Benefits to Network Rail (shared sections):
 - Allows Network Rail activation of regen
 - Improved Network Rail performance
- Standardisation with European norms

Conclusions

Conclusions

- System Optimisation:
 - Exploits system wide trade-offs:
 - Big Energy Efficiency gains
 - Big Capex and Whole Life Cost savings
 - Affordable Customer Journey Time Improvements
 - Justifies change in asset areas for big system benefits
- The earliest in the design the biggest the benefits



Conclusions

System Optimisation currently helps LUL to:

- Optimise System Conceptual Design for Line Upgrades:
 - Maximise Customer Journey Time Benefit with limited funding available by TfL
- Optimise Asset Management Strategies
- Inform stakeholders and assist decision making
- Justify funding for major projects/service capacity enhancements

The End

Could your organisation benefit from applying systems optimisation...?

