



26th annual **INCOSE**
international symposium

Edinburgh, UK
July 18 - 21, 2016

Infrastructure/Train Borne Measurements in support of Railway System Performance Modelling

Wilson Fung, Amir Toossi, Lloyd Barson
Network Rail

UK Rail Background



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Challenges



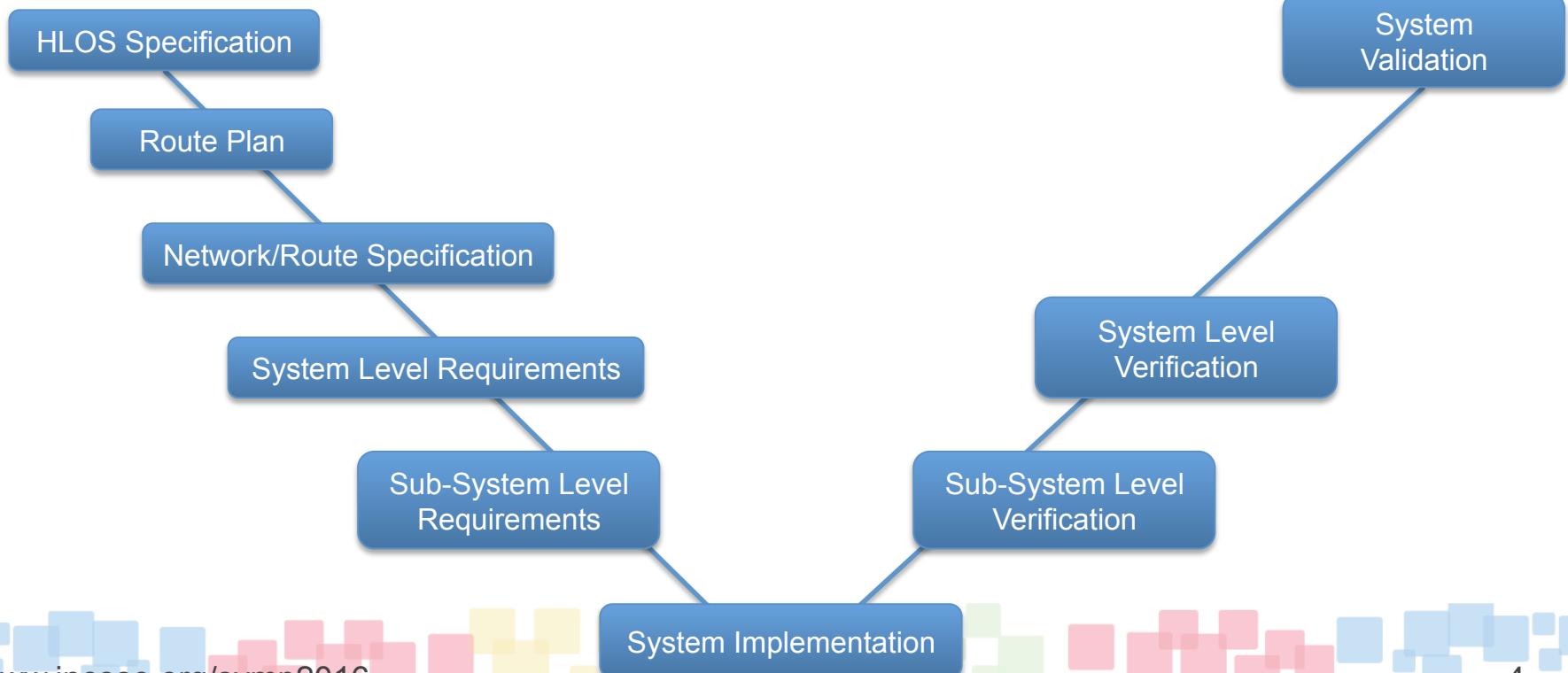
1.7 Billion
Passengers
Journeys a
Year

200%
Overcrowding
During Peak
Time

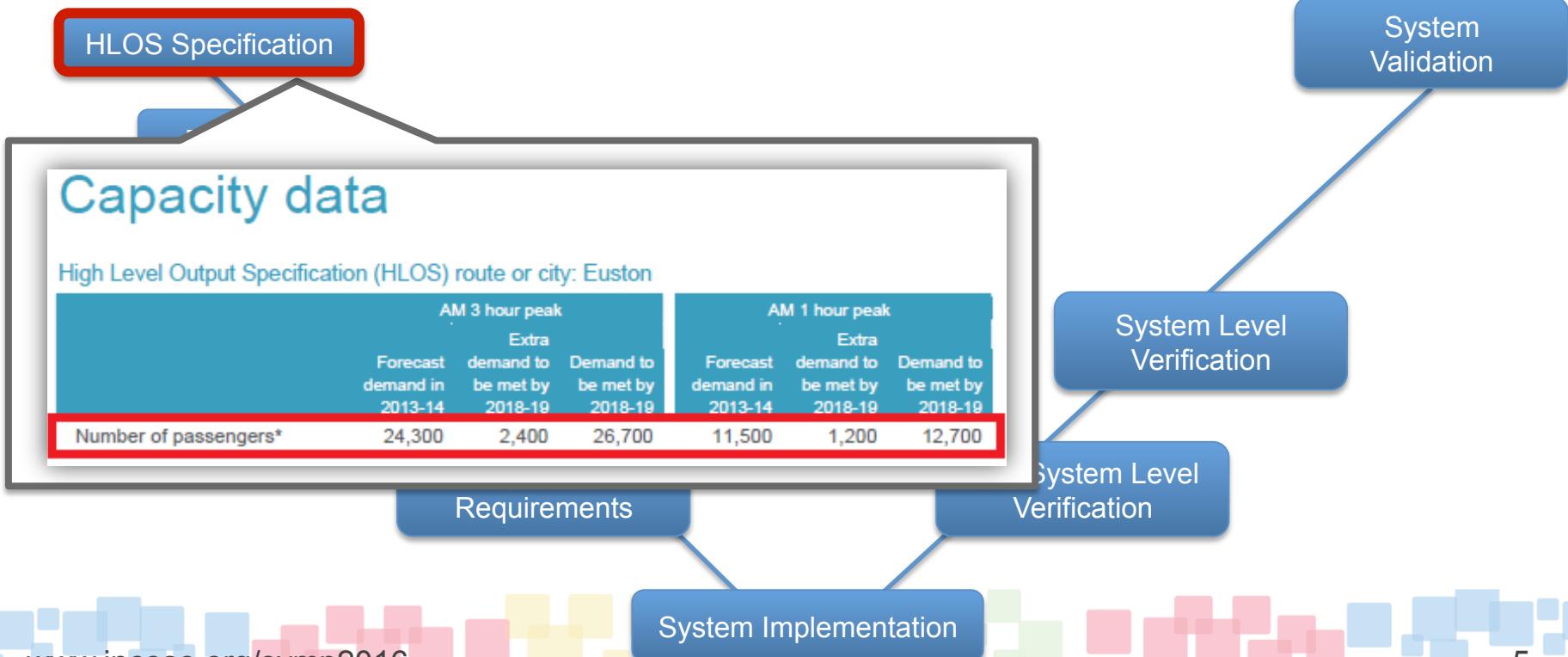
22%
Passengers
Require to
Stand

70% Increase
in Freight

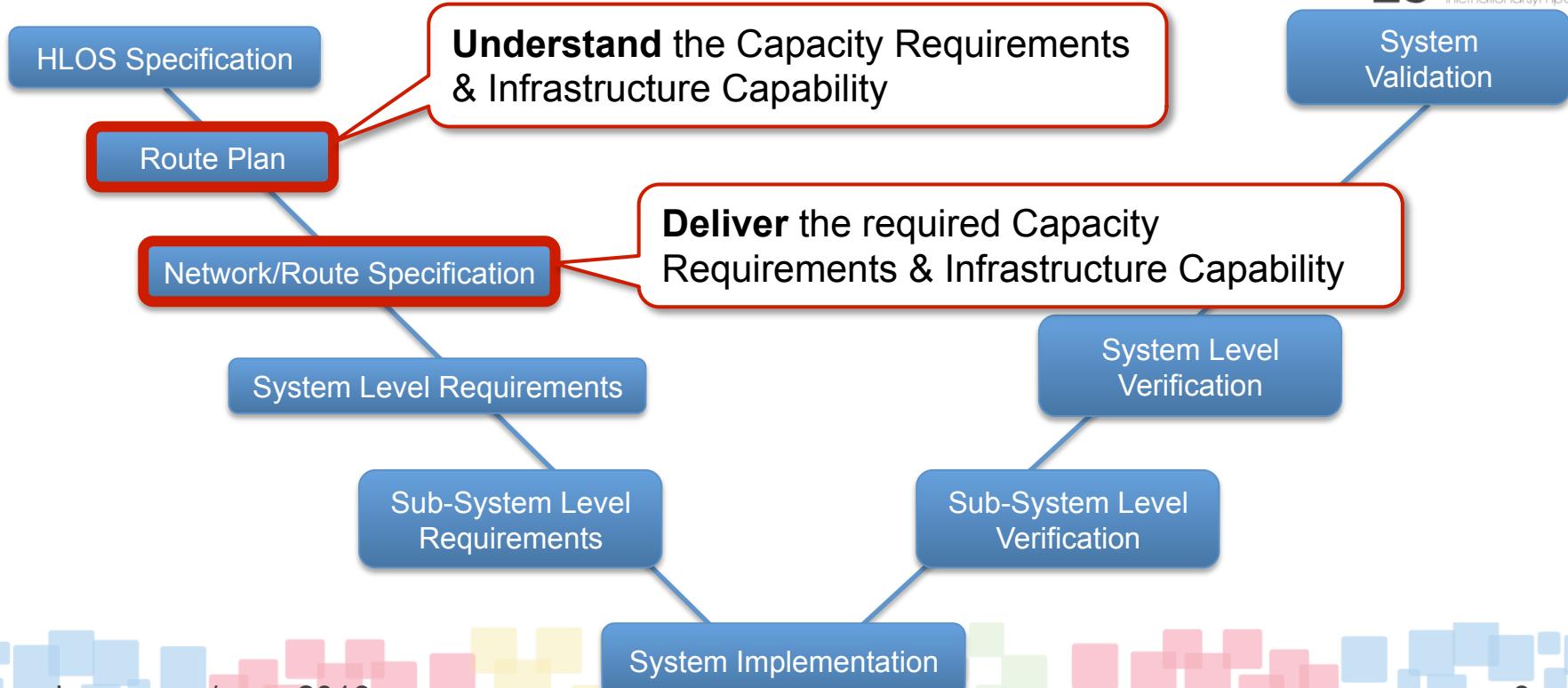
Modelling within the Systems Development Lifecycle



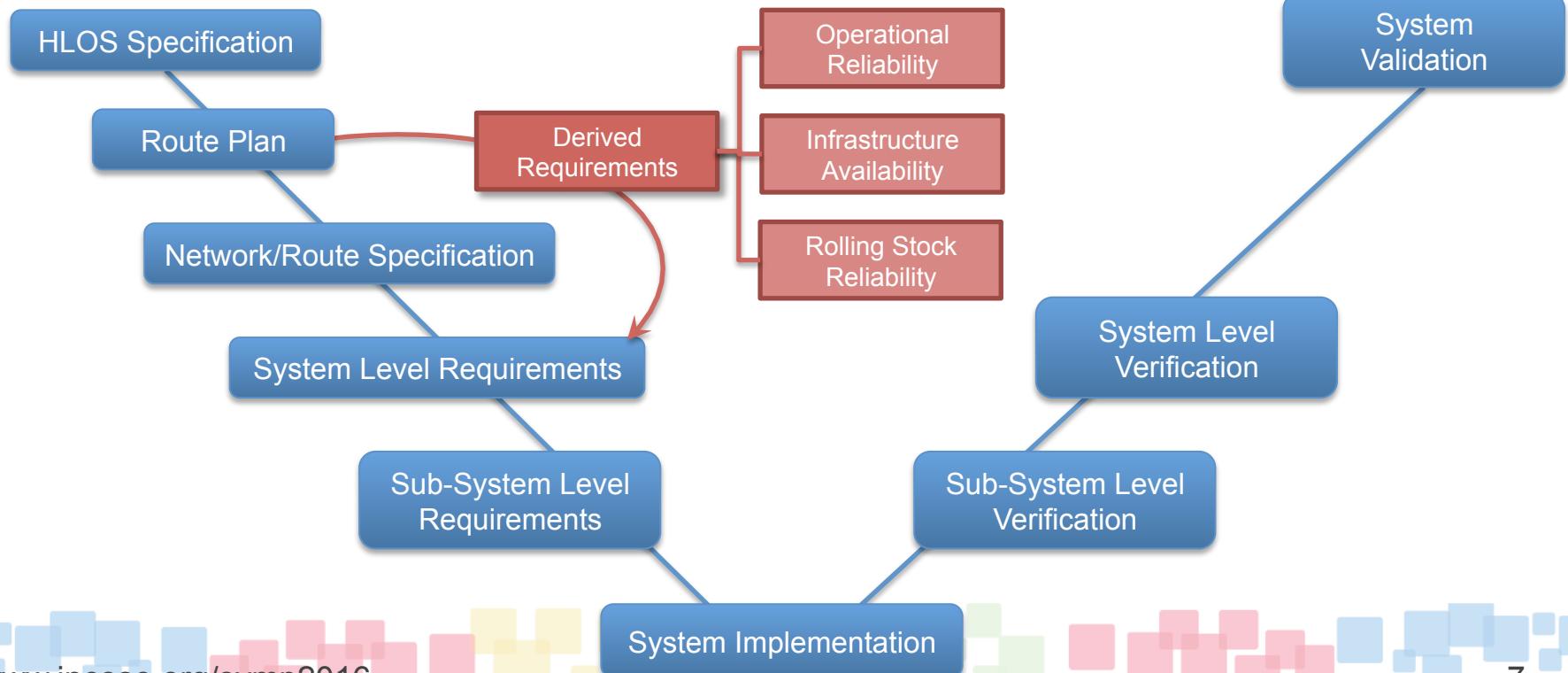
Modelling within the Systems Development Lifecycle



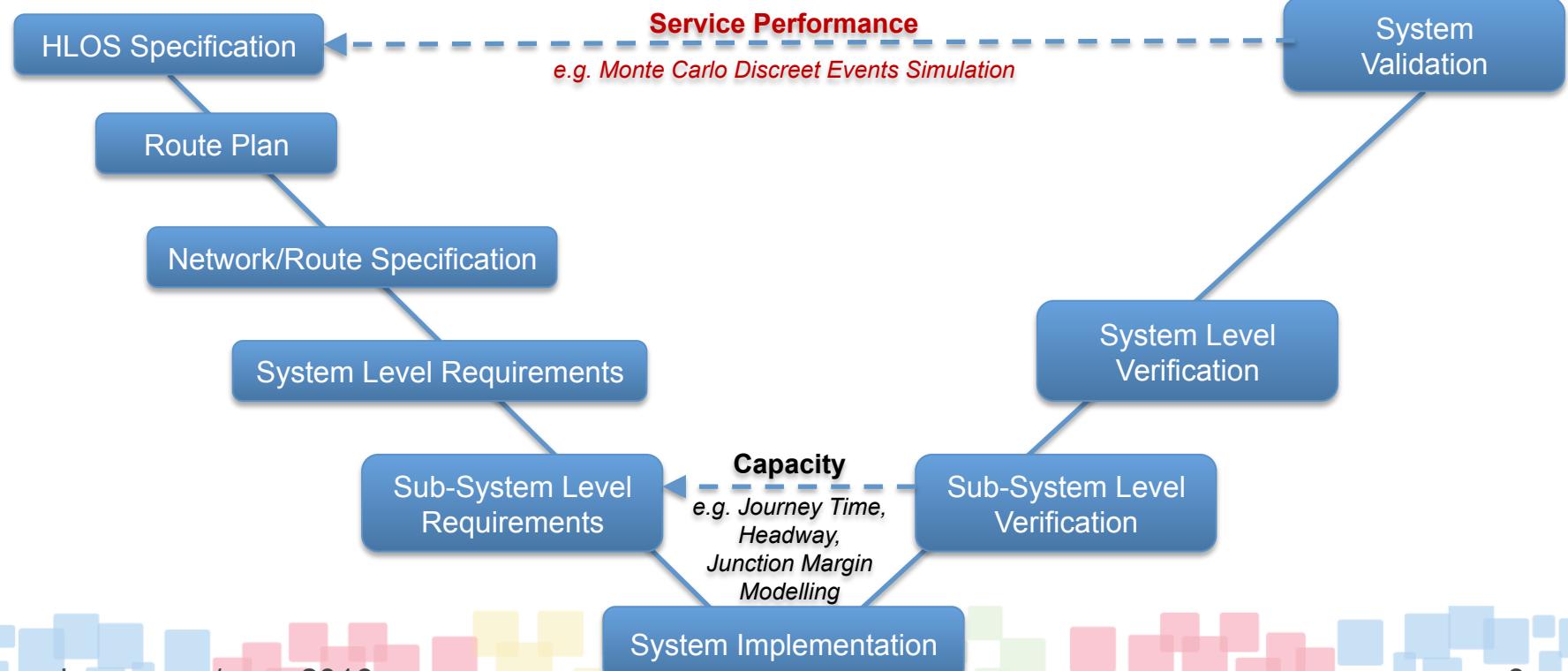
Modelling within the Systems Development Lifecycle



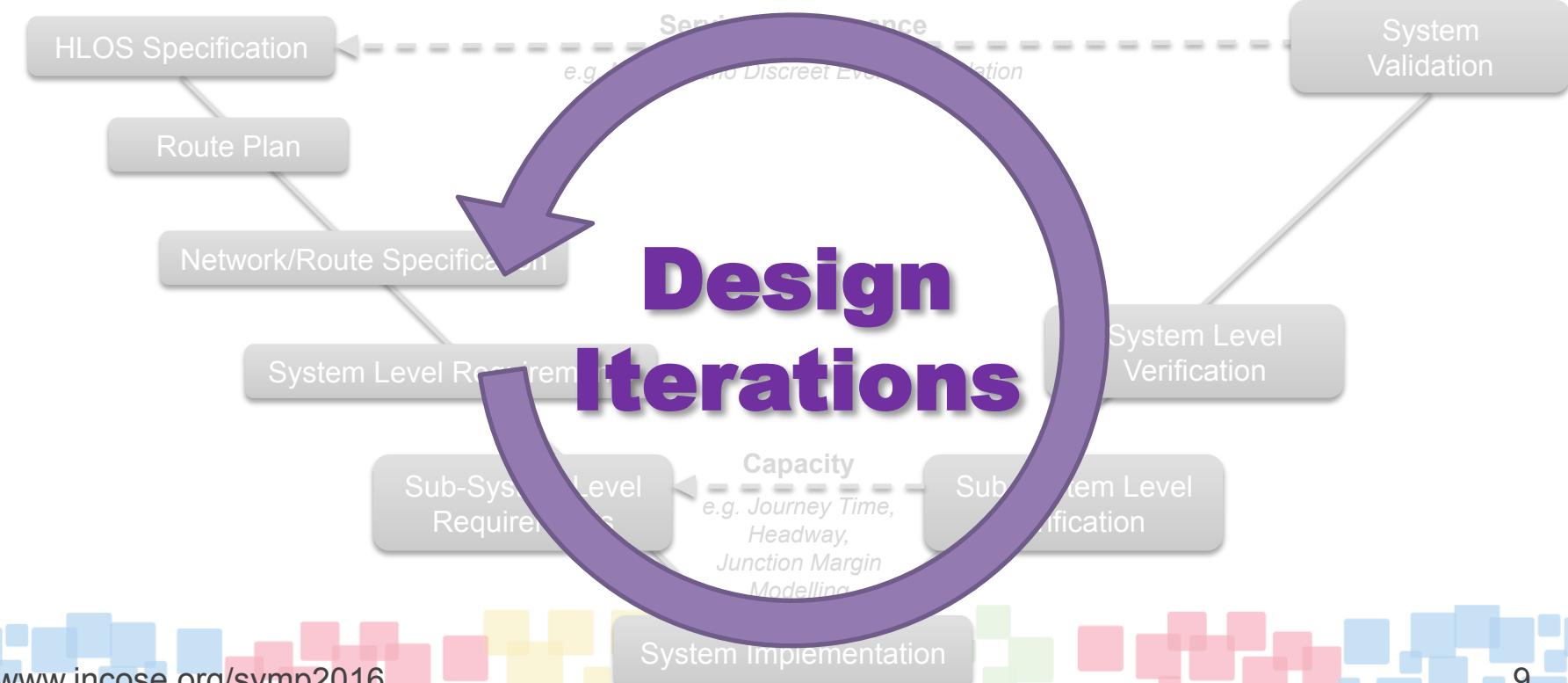
Modelling within the Systems Development Lifecycle



Modelling within the Systems Development Lifecycle



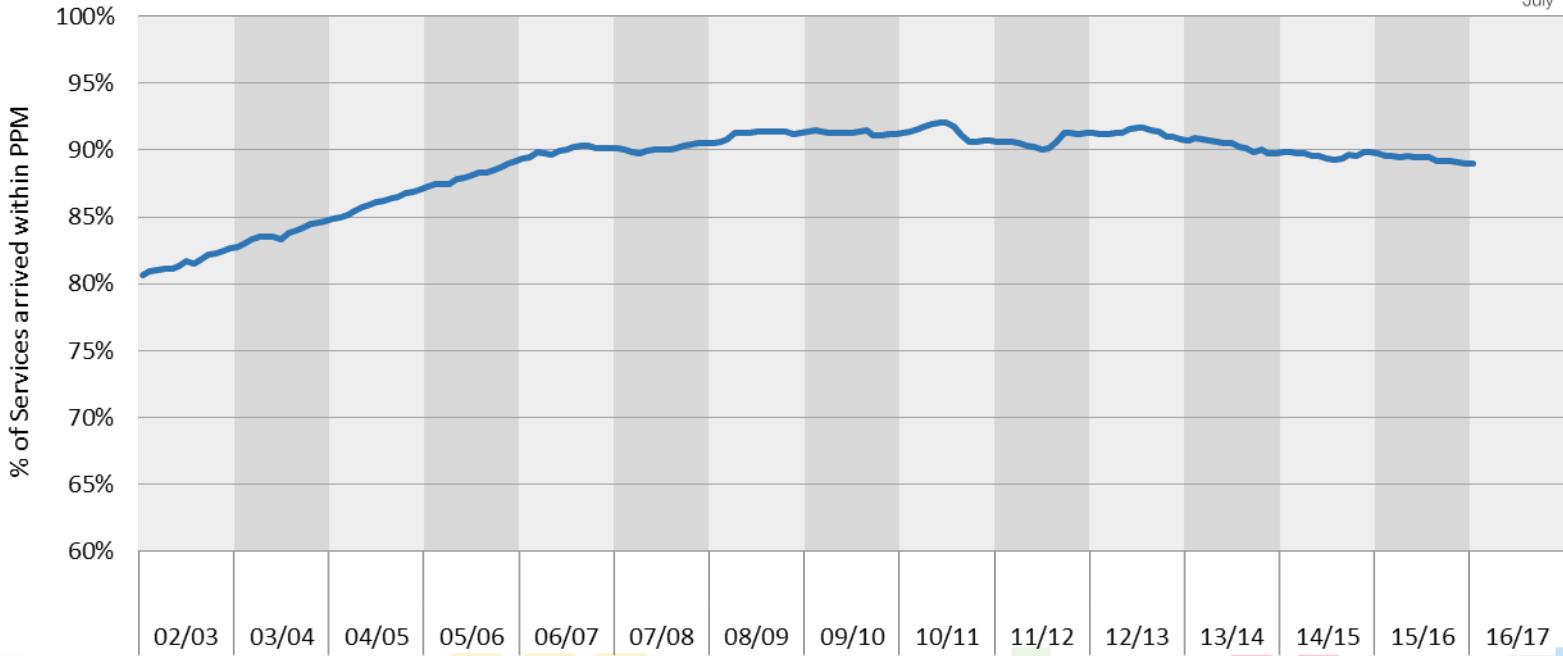
Modelling within the Systems Development Lifecycle



Service Punctuality - PPM



Arrivals at terminating station within 5 minutes for commuter services and within 10 minutes for long distance services.

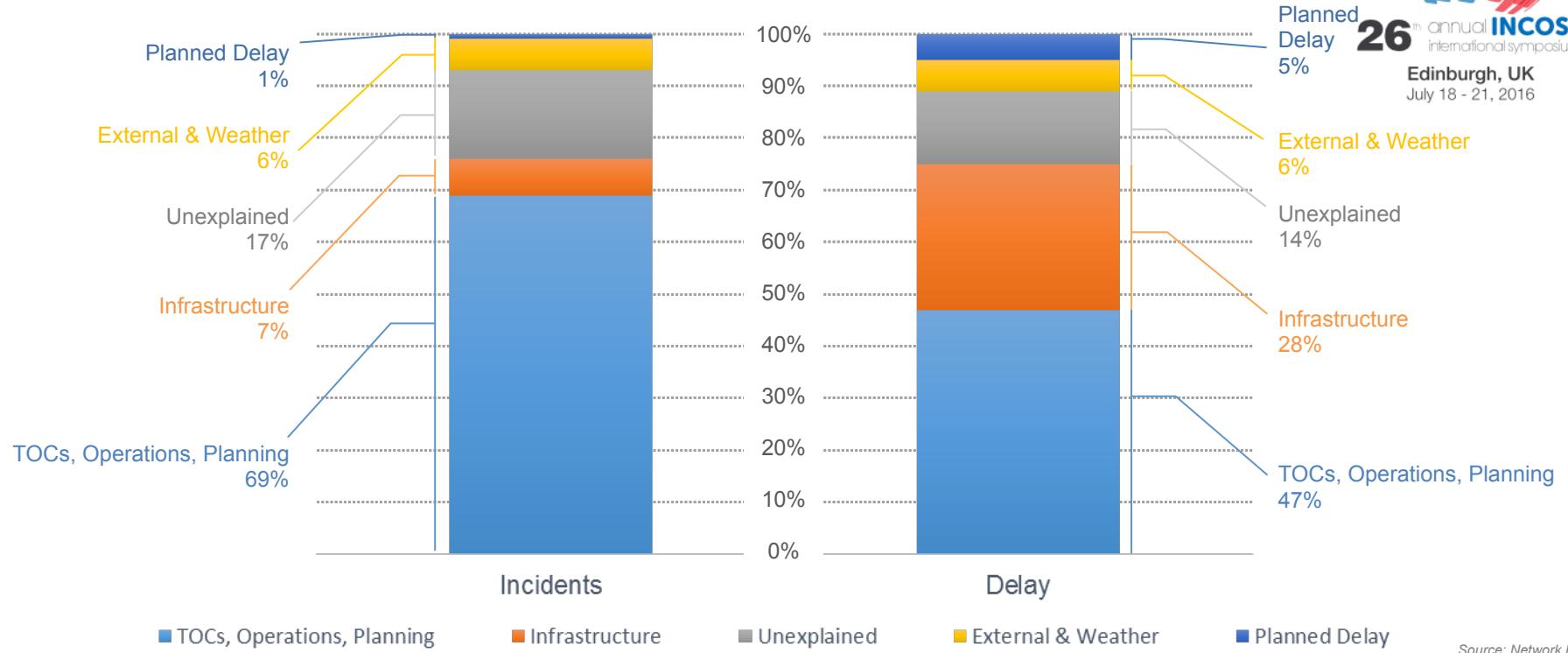


Root Causes of Service Delays



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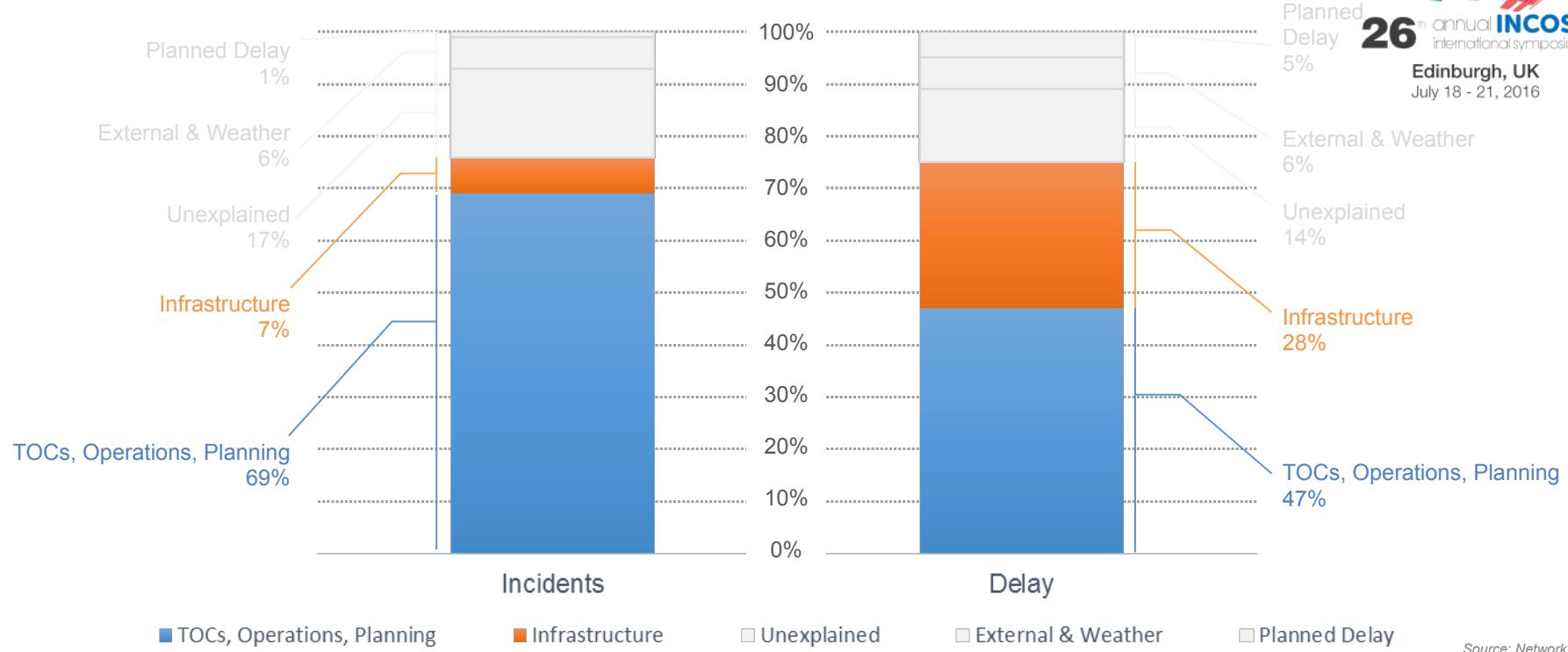


Source: Network Rail

Root Causes of Service Delays



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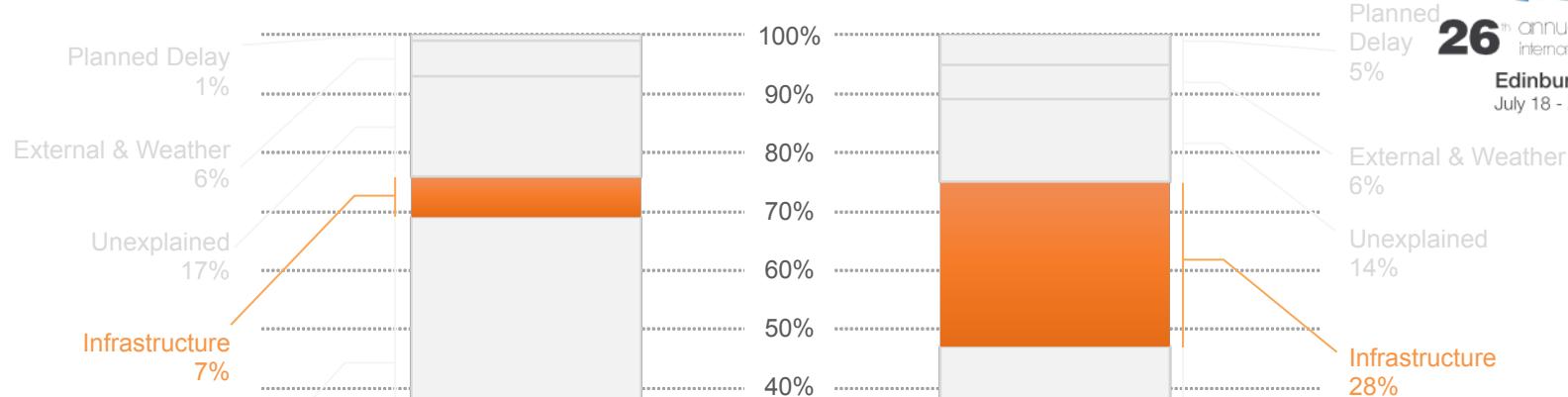


Source: Network Rail

Root Causes of Service Delays



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Special Cause (well understood)

Low-frequency, high-impact events which are inherently unpredictable and are typically assignable within the system to a root cause

Root Causes of Service Delays

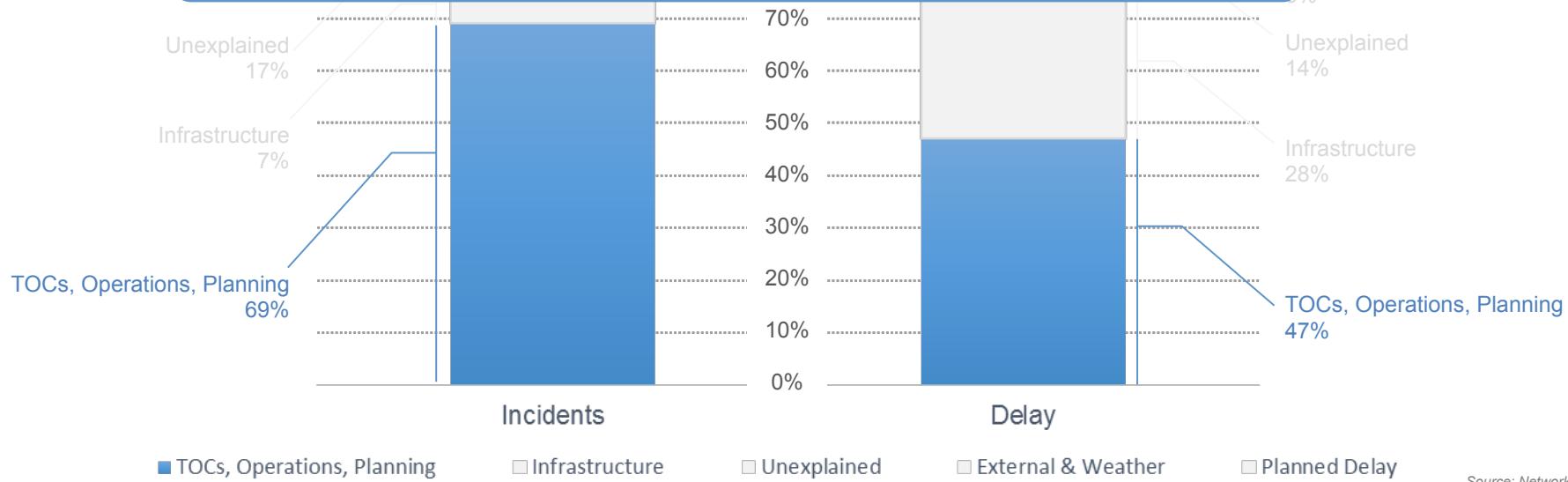


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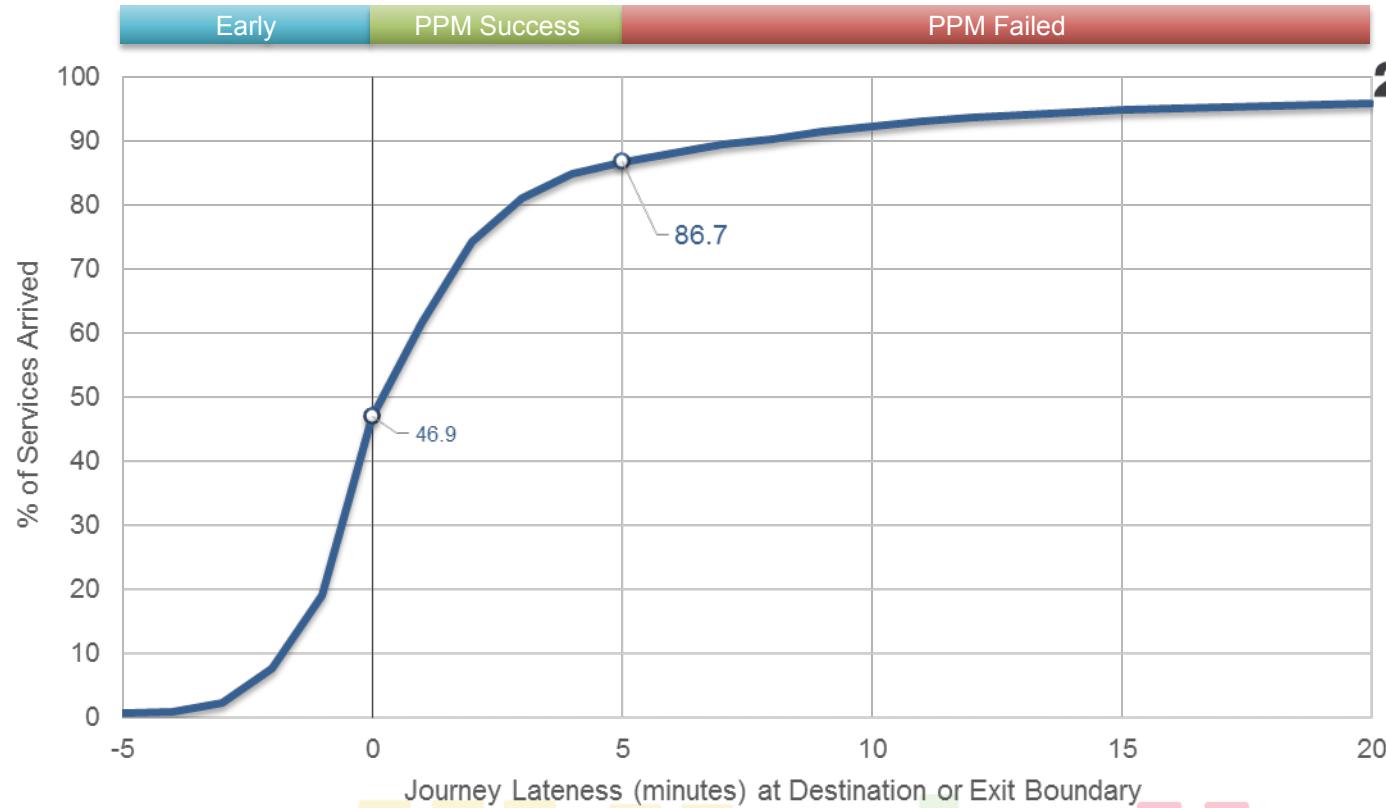
Common Cause

High-frequency, low-impact events that are typically unassigned within the system to a root cause.



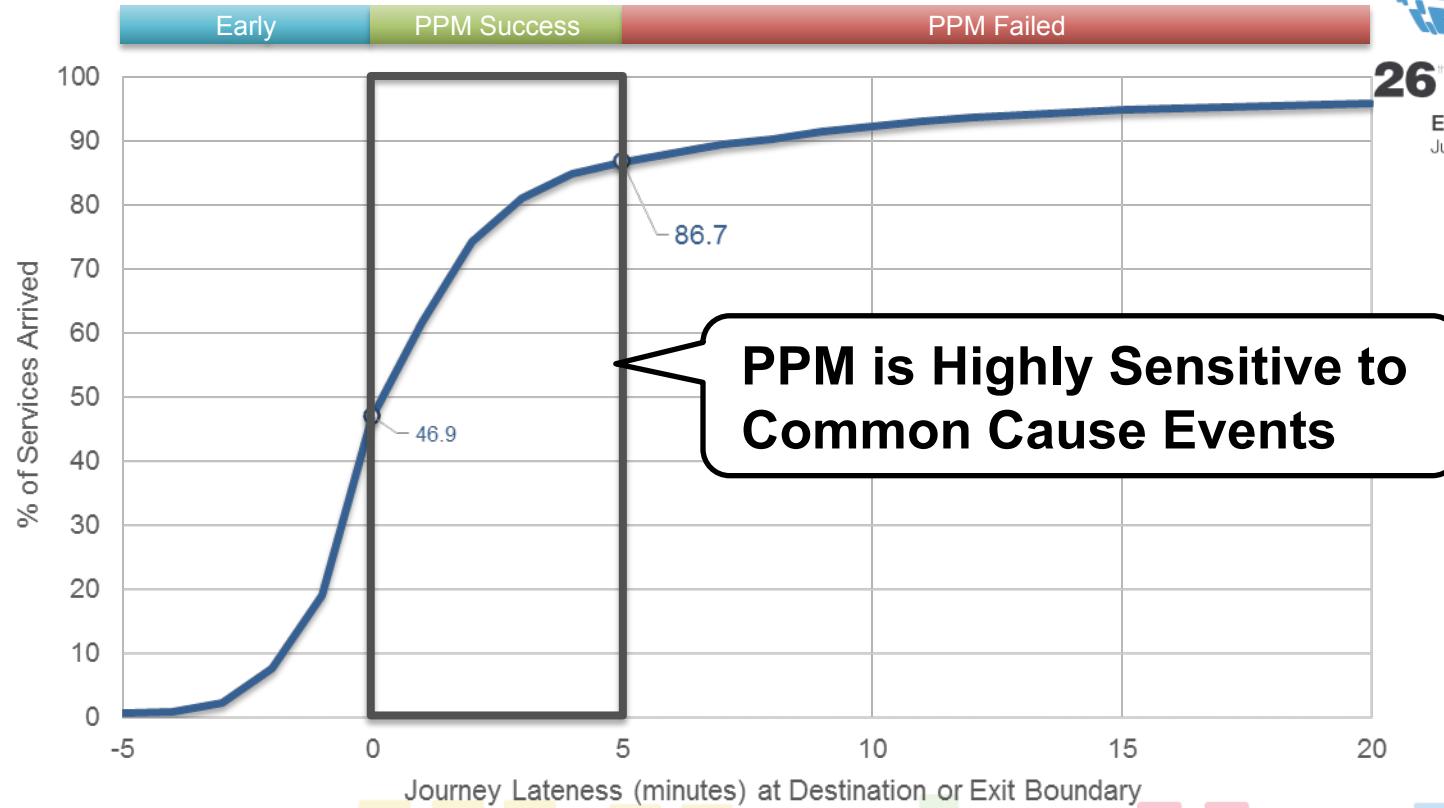
Source: Network Rail

Service Performance



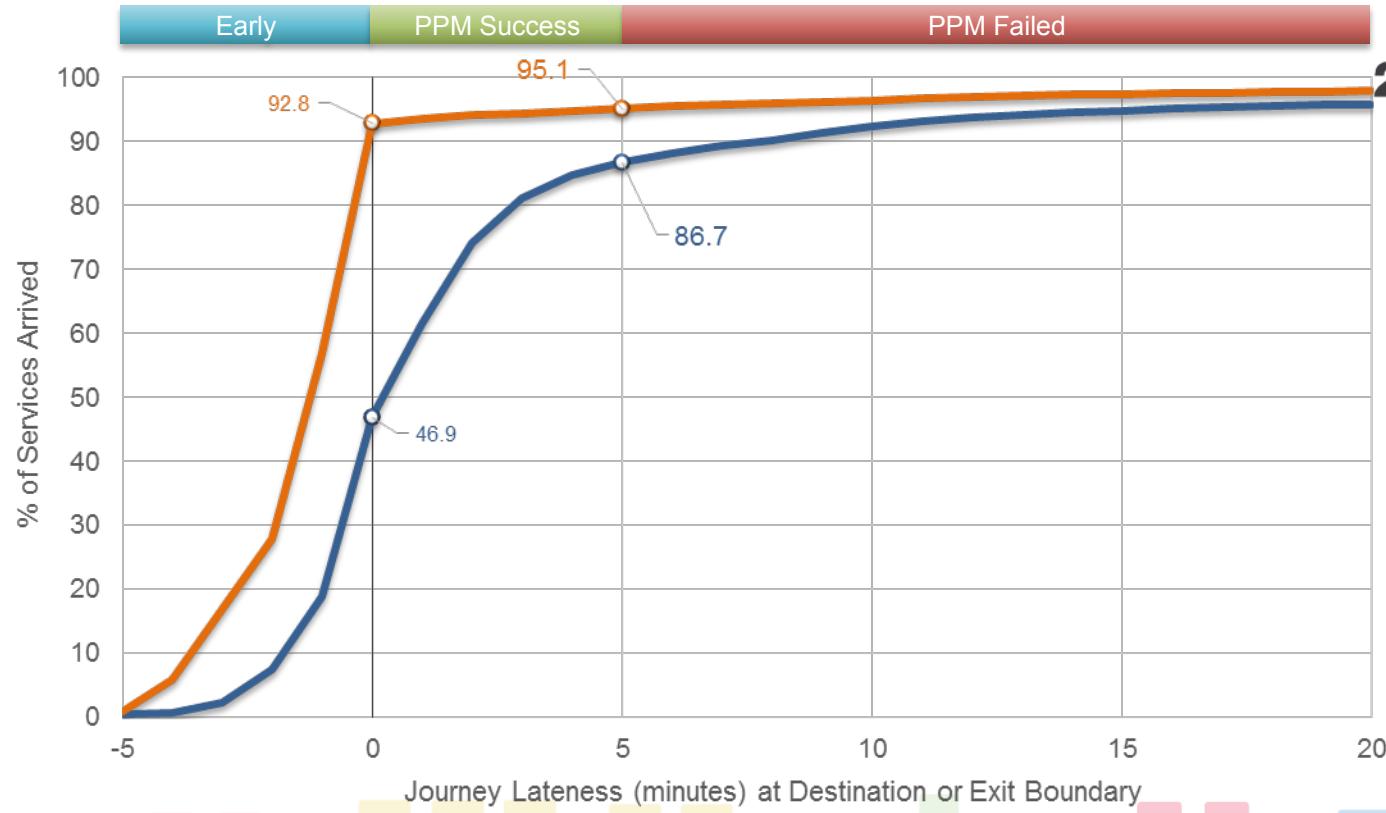
Source: Network Rail

Service Performance



Source: Network Rail

Service Performance



Journey Lateness (minutes) at Destination or Exit Boundary

Source: Network Rail

Aims & Objectives



To obtain higher fidelity measurements of the actual railway system capacity using:

- Infrastructure based measurement systems
- Train Borne measurement systems

These measurements will improve our understanding of common cause incidents and quantify their impact on performance.

Measurement Systems



Infrastructure Based

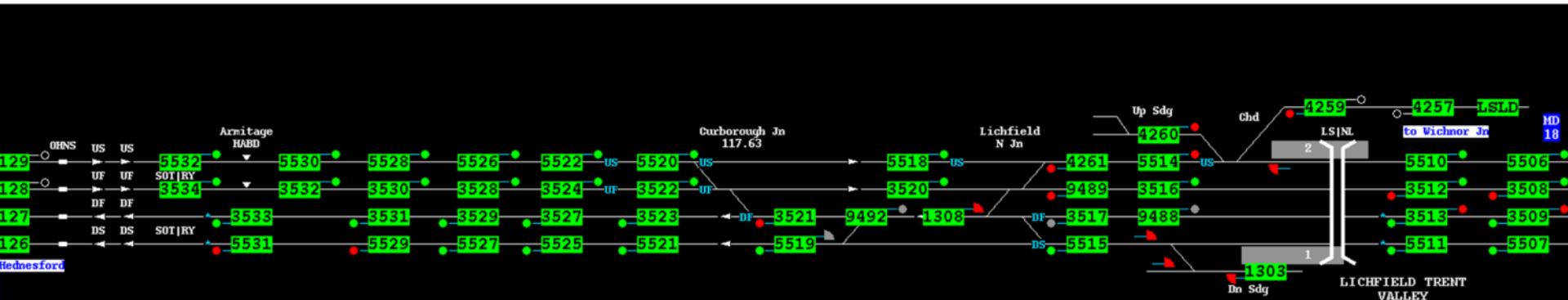
- **TRUST** (Train Running System on TOPS (Total Operations Processing System))

Date	Financial Year & Period	Service Group Code	TSC	Head code	Unit Class	Train Id	Geography Code	Geography Name	Timing Event Name	Platform Name	WTT Datetime	Actual Datetime : HH24:mi DD-Mon-YYYY	WTT Lateness	Actual Dwell	Planned Dwell	Operator	Operator Full Name	Actual Origin Location	Actual Dest Location Full Name	Timing Event Sequence
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	27263	Chestrid	D	1	14:20:30	14:19:00	-2	1	1 EM	East Midlands	Norwich	Liverpool Lime Street	45079043	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	27265	Chesterfield SouthP			14:16:30				1 EM	East Midlands	Norwich	Liverpool Lime Street	45078040	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	55120	Radfordjn	P		13:51:00	13:51:00	0		1 EM	East Midlands	Norwich	Liverpool Lime Street	45072033	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	56127	Alfreton	A		14:07:30	14:07:00	-1	1	1 EM	East Midlands	Norwich	Liverpool Lime Street	45076037	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	56127	Alfreton	D	M	14:08:30	14:08:00	-1	1	1 EM	East Midlands	Norwich	Liverpool Lime Street	45076039	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	56524	Langleyml	P	1	14:02:00	14:01:00	-1		1 EM	East Midlands	Norwich	Liverpool Lime Street	45074035	
12/05/2014	2014/15_P02	EM03	2226900	1R82		481R82MH12	56550	Trowell South JuncP	R		13:57:00	13:57:00	0		1 EM	East Midlands	Norwich	Liverpool Lime Street	45073034	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	27263	Chestrid	A	1	15:20:00	15:18:00	-2	2	1 EM	East Midlands	Norwich	Liverpool Lime Street	45071041	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	27263	Chestrid	D	1	15:21:00	15:20:00	-1	2	1 EM	East Midlands	Norwich	Liverpool Lime Street	45151043	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	55120	Chesterfield SouthP			15:18:00				1 EM	East Midlands	Norwich	Liverpool Lime Street	45150040	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	56127	Radfordjn	P		14:51:00	14:51:00	0		1 EM	East Midlands	Norwich	Liverpool Lime Street	45144033	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	56127	Alfreton	A		15:07:00	15:08:00	1	0	1 EM	East Midlands	Norwich	Liverpool Lime Street	45148037	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	56127	Alfreton	D	M	15:08:00	15:08:00	0	0	1 EM	East Midlands	Norwich	Liverpool Lime Street	45148039	
12/05/2014	2014/15_P02	EM03	2226900	1R86		481R86MJ12	56524	Langleyml	P	1	15:01:30	15:01:00	-1		1 EM	East Midlands	Norwich	Liverpool Lime Street	45146035	
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12/05/2014	2014/15_P02	EM03	2226900	1R90		481R90ML12	27263	Chestrid	D	1	16:21:00	16:21:00	0	3	1 EM	East Midlands	Norwich	Liverpool Lime Street	45224043	
12/05/2014	2014/15_P02	EM03	2226900	1R90		481R90ML12	27265	Chesterfield SouthP			16:18:30				1 EM	East Midlands	Norwich	Liverpool Lime Street	45223040	
12/05/2014	2014/15_P02	EM03	2226900	1R90		481R90ML12	55120	Radfordjn	P		15:51:00	15:51:00	0		1 EM	East Midlands	Norwich	Liverpool Lime Street	45217033	
12/05/2014	2014/15_P02	EM03	2226900	1R90		481R90ML12	56127	Alfreton	A		16:07:00	16:08:00	1	0	1 EM	East Midlands	Norwich	Liverpool Lime Street	45221037	
12/05/2014	2014/15_P02	EM03	2226900	1R90		481R90ML12	56127	Alfreton	D	M	16:08:00	16:08:00	0	0	1 EM	East Midlands	Norwich	Liverpool Lime Street	45221039	
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12/05/2014	2014/15_P02	EM03	2226900	1R94		481R94MN12	27263	Chestrid	A	3	17:17:30	17:27:00	10	1	1 EM	East Midlands	Norwich	Liverpool Lime Street	45298041	
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12/05/2014	2014/15_P02	EM03	2226900	1R94		481R94MN12	27265	Chesterfield SouthP			17:16:00				1 EM	East Midlands	Norwich	Liverpool Lime Street	45297040	
12/05/2014	2014/15_P02	EM03	2226900	1R94		481R94MN12	55120	Radfordjn	P		16:51:00	16:51:00	0		1 EM	East Midlands	Norwich	Liverpool Lime Street	45291033	
12/05/2014	2014/15_P02	EM03	2226900	1R94		481R94MN12	56127	Alfreton	A		17:07:00	17:16:00	9	1	1 EM	East Midlands	Norwich	Liverpool Lime Street	45295037	
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12/05/2014	2014/15_P02	EM03	2226900	1R98		481R98MP12	27265	Chesterfield SouthP			18:17:30				1 EM	East Midlands	Norwich	Liverpool Lime Street	45370041	
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Measurement Systems

Infrastructure Based

- **CCF** (Control Centre of the Future)



Measurement Systems



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Train Based

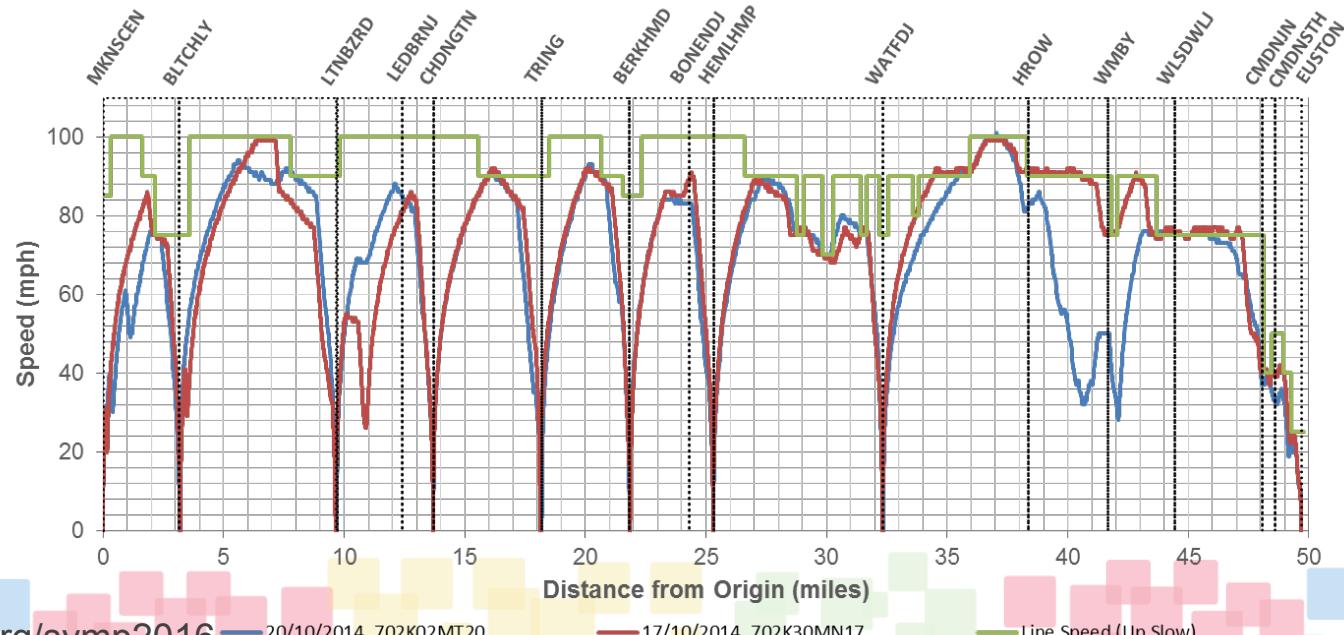
- **OTMR** (On Train Measurement Recorder)

Date	Time	Time from start (sec)	Speed (mph)	Odometer	Distance from start (miles)	Power	Brake	TPWS Warning	
17/10/2014	12:46:50	12	17	347.5770252	0.027340332	0.66	0	0	
17/10/2014	12:46:50	12	16	347.5782679	0.028583075	0.66	0	0	ng
17/10/2014	12:46:50	12	18	347.5795107	0.029825817	0.66	0	0	ng
17/10/2014	12:46:50	12	18	347.5807534	0.03106856	0.66	0	0	0 ng
17/10/2014	12:46:51	13	19	347.5819961	0.032311302	0.66	0	0	0 0 0 ng
17/10/2014	12:46:51	13	19	347.585103	0.035418158	0.66	0	0	0 0 0 0 ng
17/10/2014	12:46:52	14	20	347.5875885	0.037903643	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:52	14	20	347.5888312	0.039146385	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:52	14	20	347.5894526	0.039767756	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:52	14	20	347.5906953	0.041010499	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:52	14	21	347.5913167	0.04163187	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:52	14	21	347.5925595	0.042874612	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:53	15	22	347.5938022	0.044117355	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:53	15	22	347.5950449	0.045360097	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:53	15	22	347.5962877	0.046602839	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:53	15	22	347.5975304	0.047845582	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:53	15	22	347.5987732	0.049088324	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:54	16	23	347.6000159	0.050331067	0.66	0	0	0 0 0 0 0 0
17/10/2014	12:46:54	16	23	347.6012586	0.051573809	0.66	0	0	0 0 0 0 0 0

Measurement Systems

Train Based

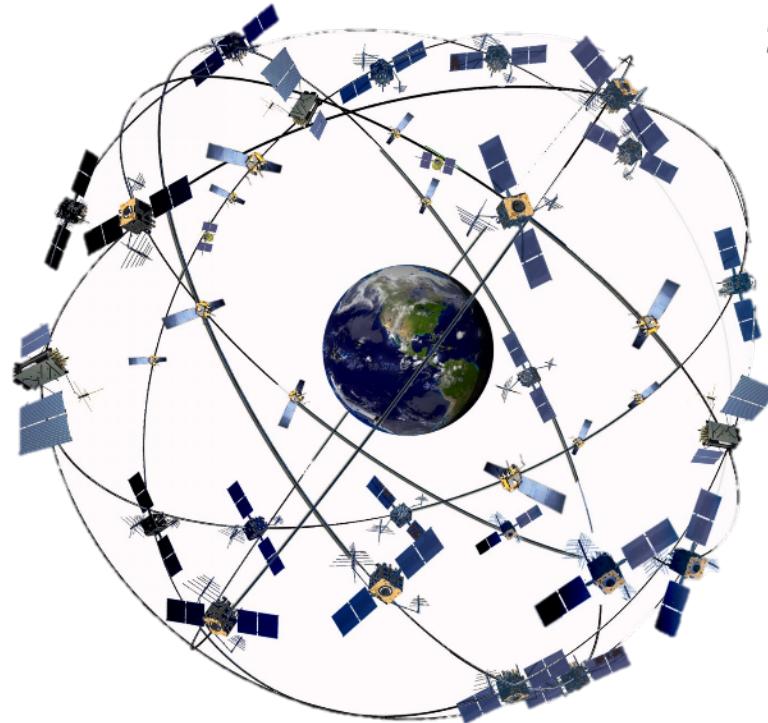
- **OTMR** (On Train Measurement Recorder)



Measurement Systems

Train Based

- **GPS** (Global Position System)



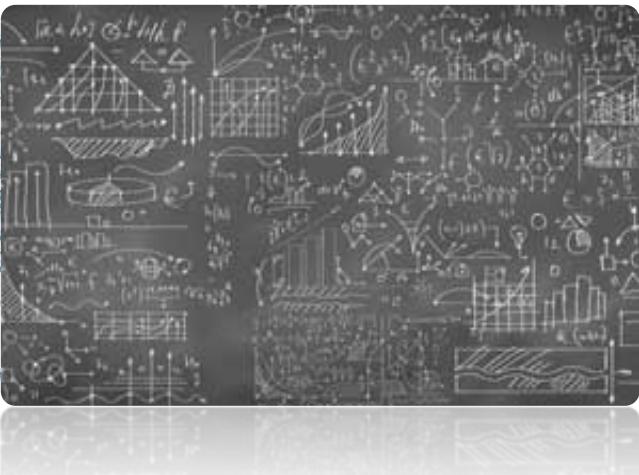
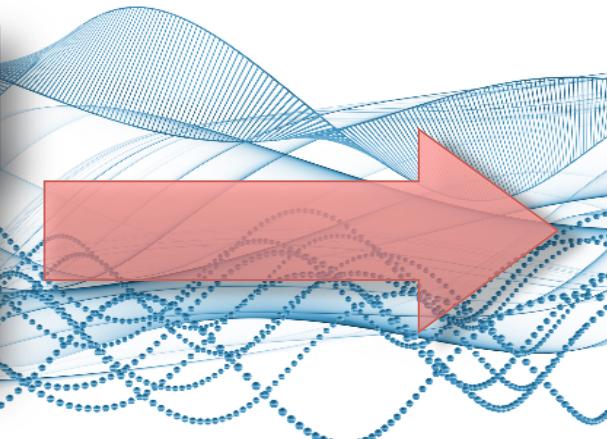
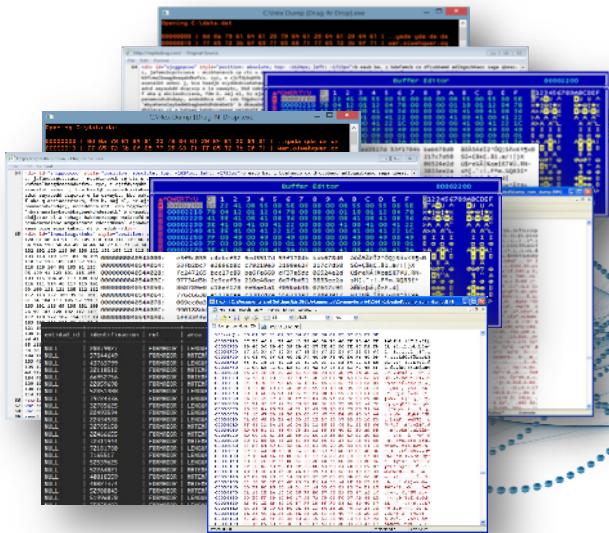
Case Study



Northern Rail Tracking System Through the analysis of OTMR and GPS data



OTMR Data Processing

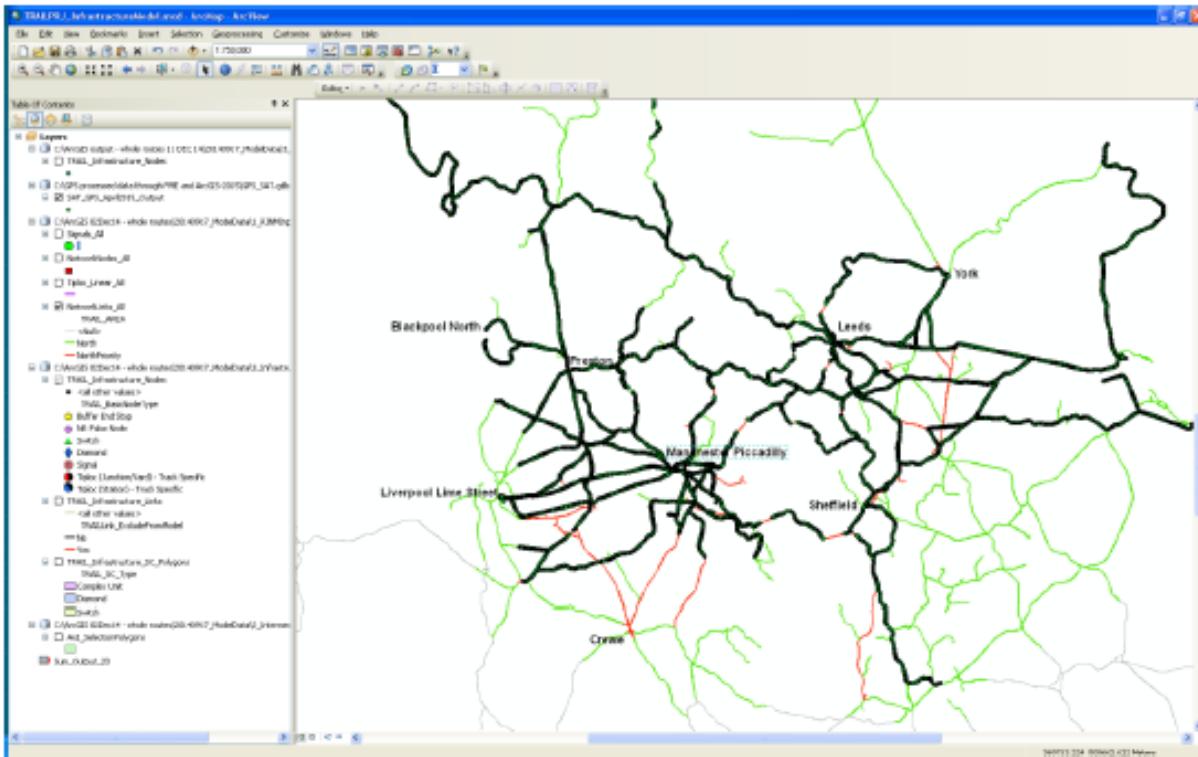


GPS Data Processing



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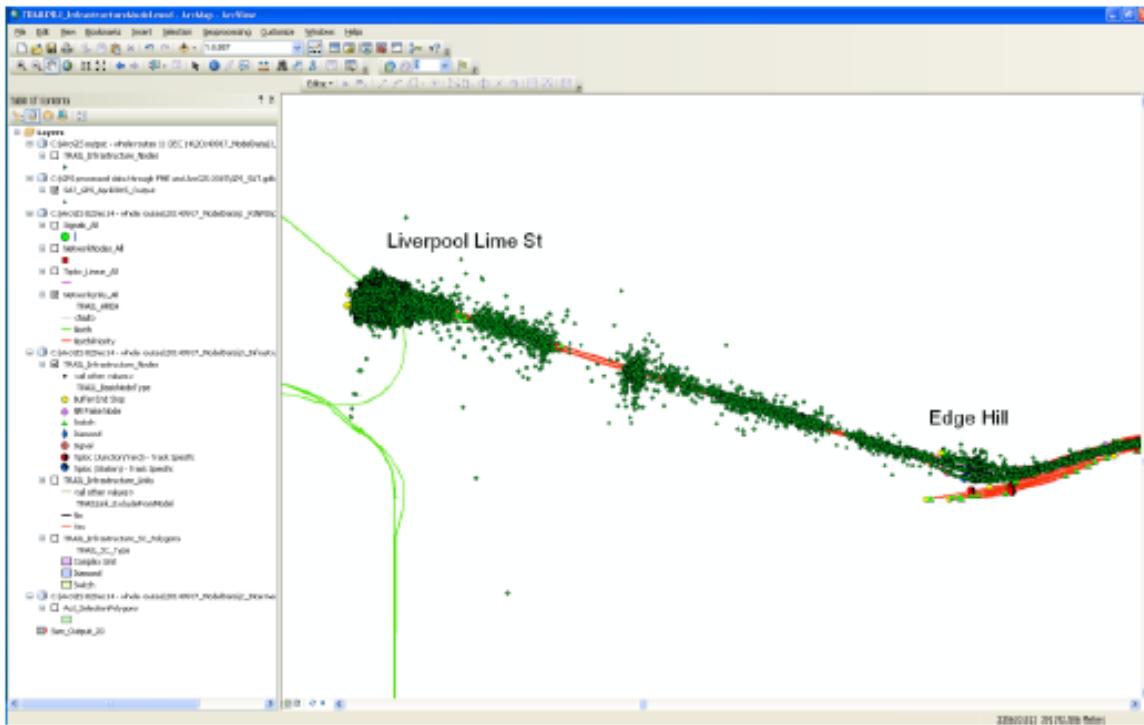


GPS Data Processing



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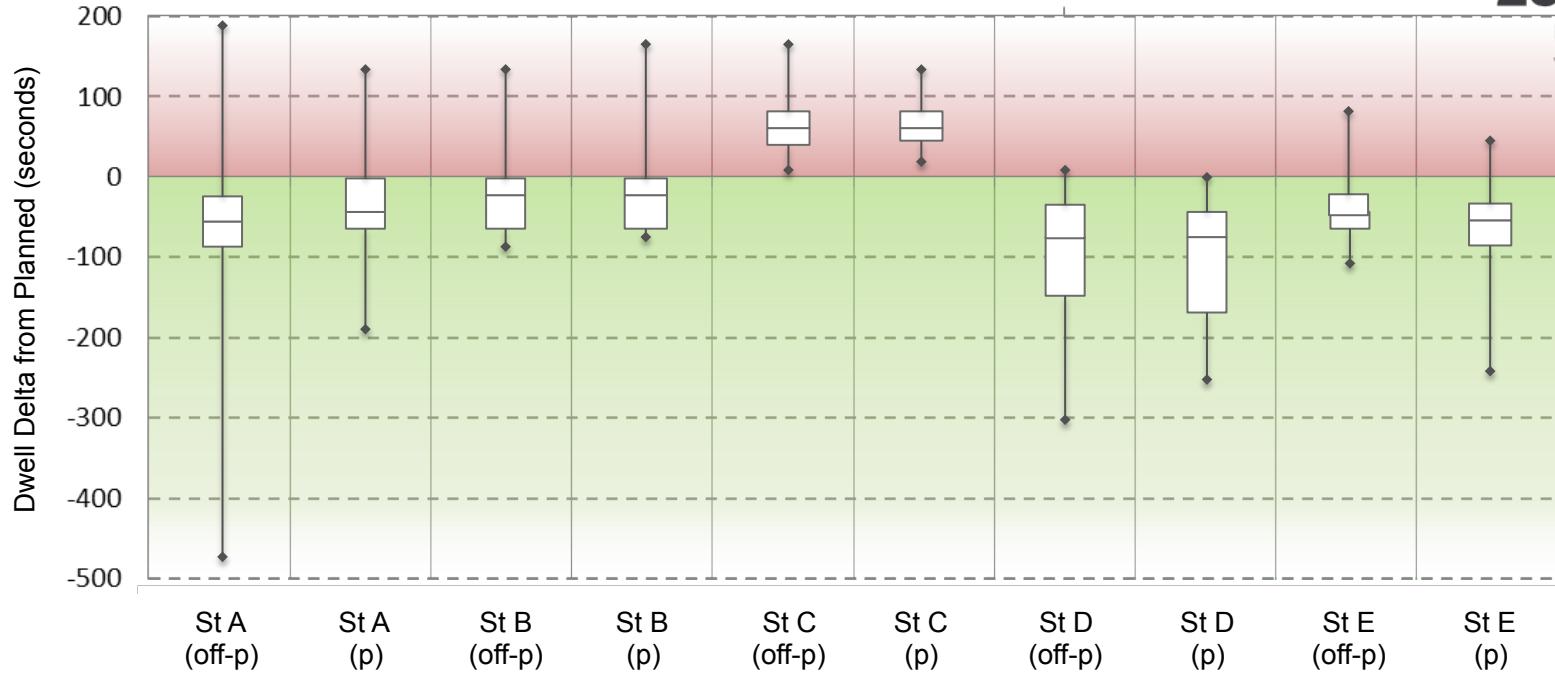
Edinburgh, UK



Observed Station Dwell Time



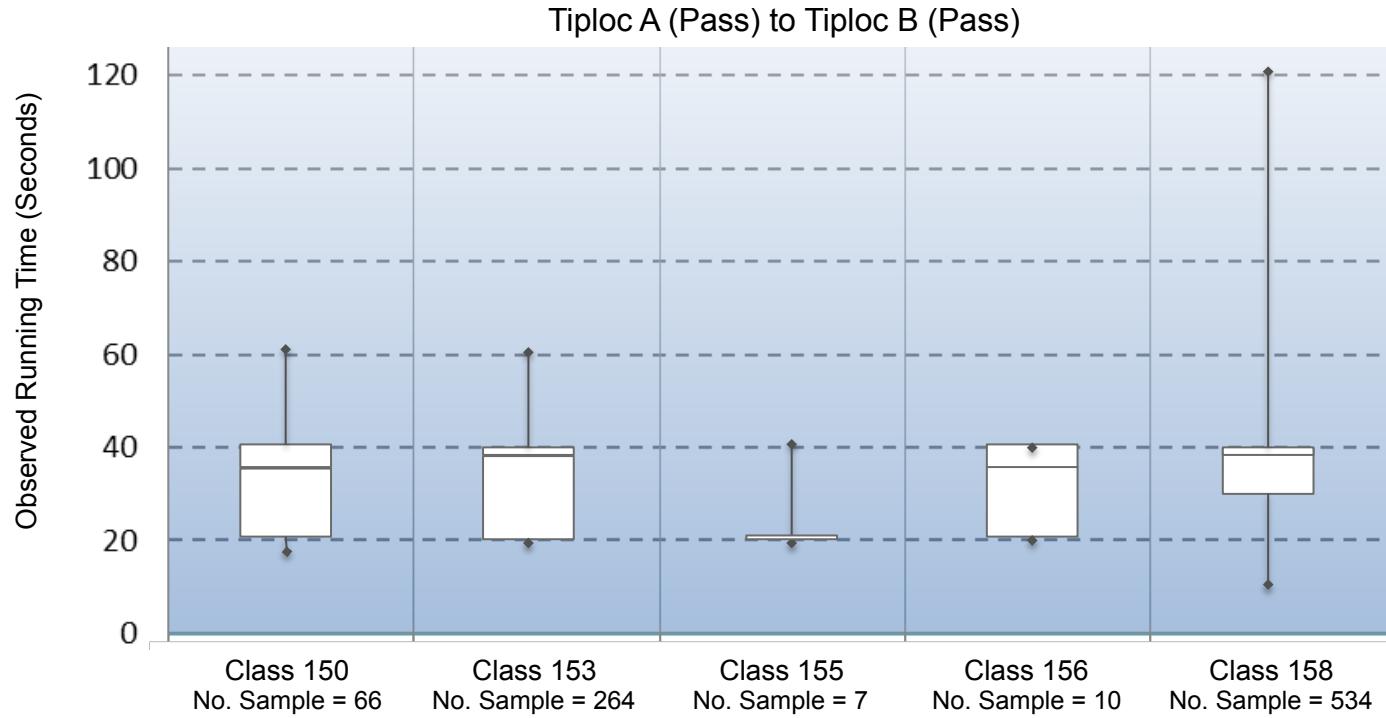
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Observed Running Times



Edinburgh, UK
July 18 - 21, 2016



Conclusion



Challenges in aligning Infrastructure and Train Borne Measurement Data

To deliver a rapid whole system analysis, we need to improve

- Data acquisition processes
- Precision of GPS
- Data format consistency
- Availabilities of OTMR data
- Labour intensive

Future Work

Opportunities exist to integrate all the available data layers,

- Signalling System State
- Weather Conditions
- Train Loading
- Level of Platform Crowding

Questions



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