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Capacity Analysis

Evaluating Capacity Utilisation and its Upper Limits at Railway Nodes

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Overview

- Background
- Initial development: OCCASION project
- Application of methods: CCR
- CCR follow-up
- DITTO Railway Systems project
- ACCVA project
- Ongoing work
- Summary and Conclusions

Background

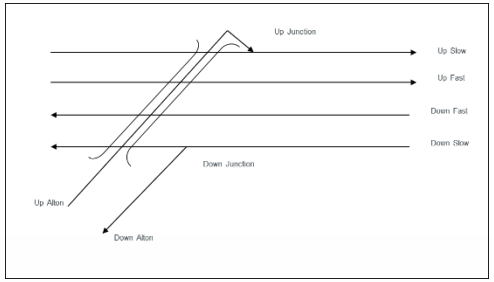
- Increasing passenger and freight demand
- (Largely) static network
  - HS1 and HS2
  - Crossrail, Thameslink, London Overground
  - Re-openings: Stirling – Alloa, Airdrie – Bathgate, etc.
- Need to maximise capacity of existing network
  - Focus on bottlenecks
  - Additional capacity for minimal outlay
  - DfT, RSSB, EPSRC call for proposals

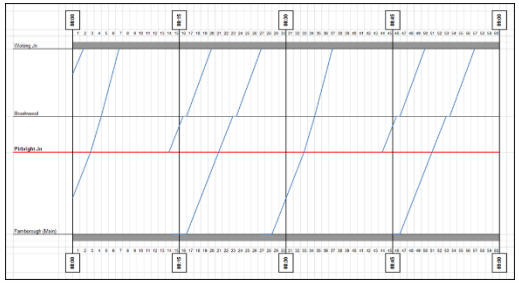
OCCASION project: 2010-2012

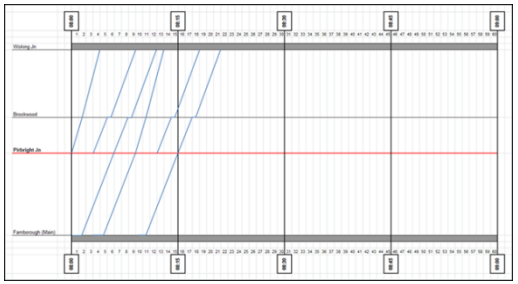
- Objectives
  - Extend capacity utilisation measures from links to nodes
  - Optimise timetables at nodes – times and routes
  - Consider wider network
- UIC: Infrastructure capacity not easily defined
  - Measure capacity utilisation at nodes
  - Identify reliable upper limits
  - Use of Capacity Utilisation Index (CUI)

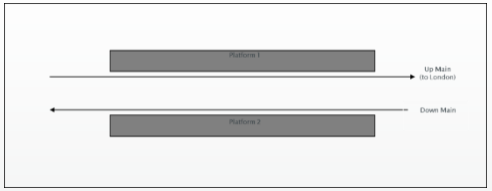
OCCASION project: 2010-2012

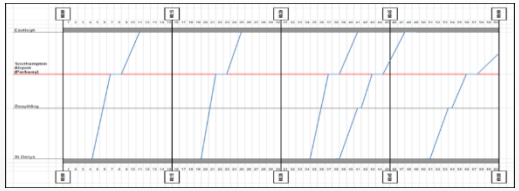
- Approach – first, analyse simple nodes using CUI principles

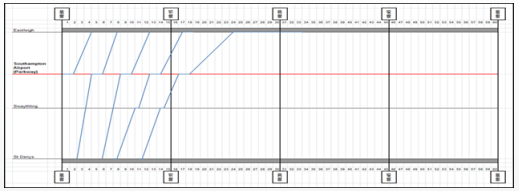


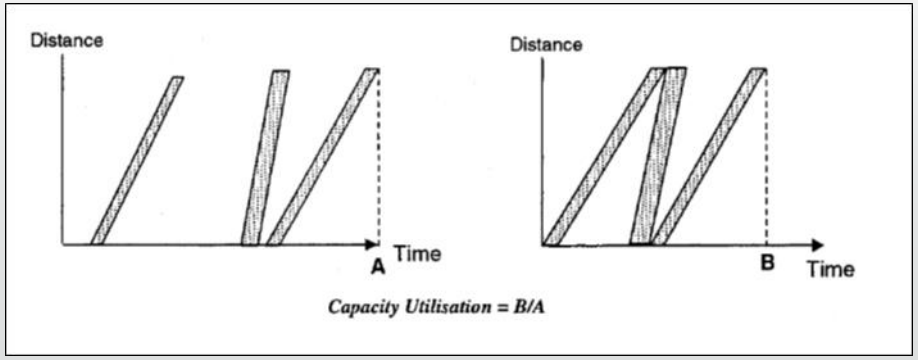












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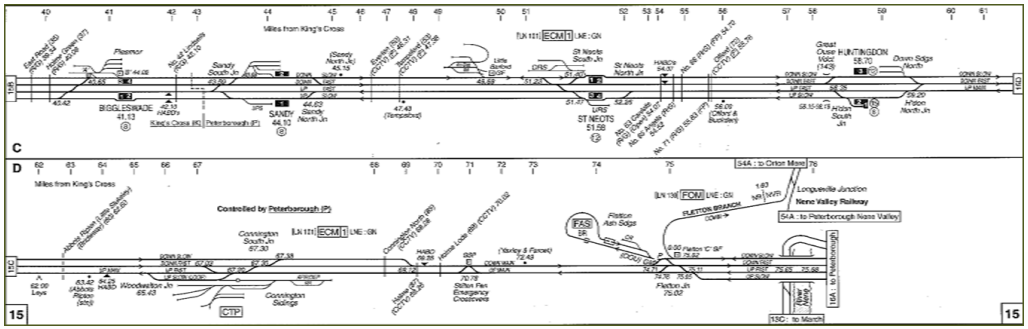
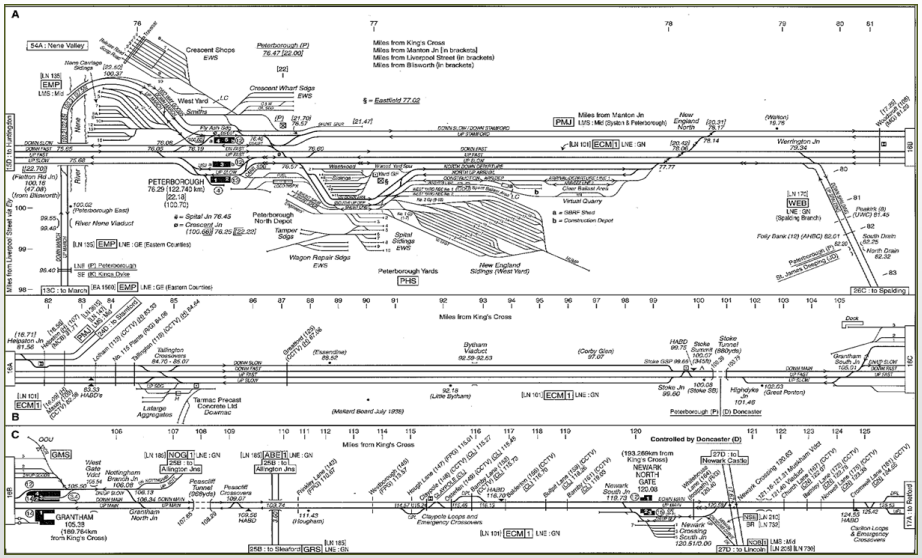
OCCASION project: 2010-2012

- Then, more complex example on East Coast Main Line





Huntingdon – Peterborough – Grantham

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OCCASION project: 2010-2012

- Peterborough area CUI Assessment Process
  - CIF Timetable Data
    - Detailed routeings of trains through individual nodes and links of local network during 2-hour AM Peak
    - Detailed timings interpolated from TIPLOC times in CIF
  - Aggregation and sorting of train times by individual node and link
  - Compression of headways
  - CUI values

Capacity Charge Recalibration (CCR)

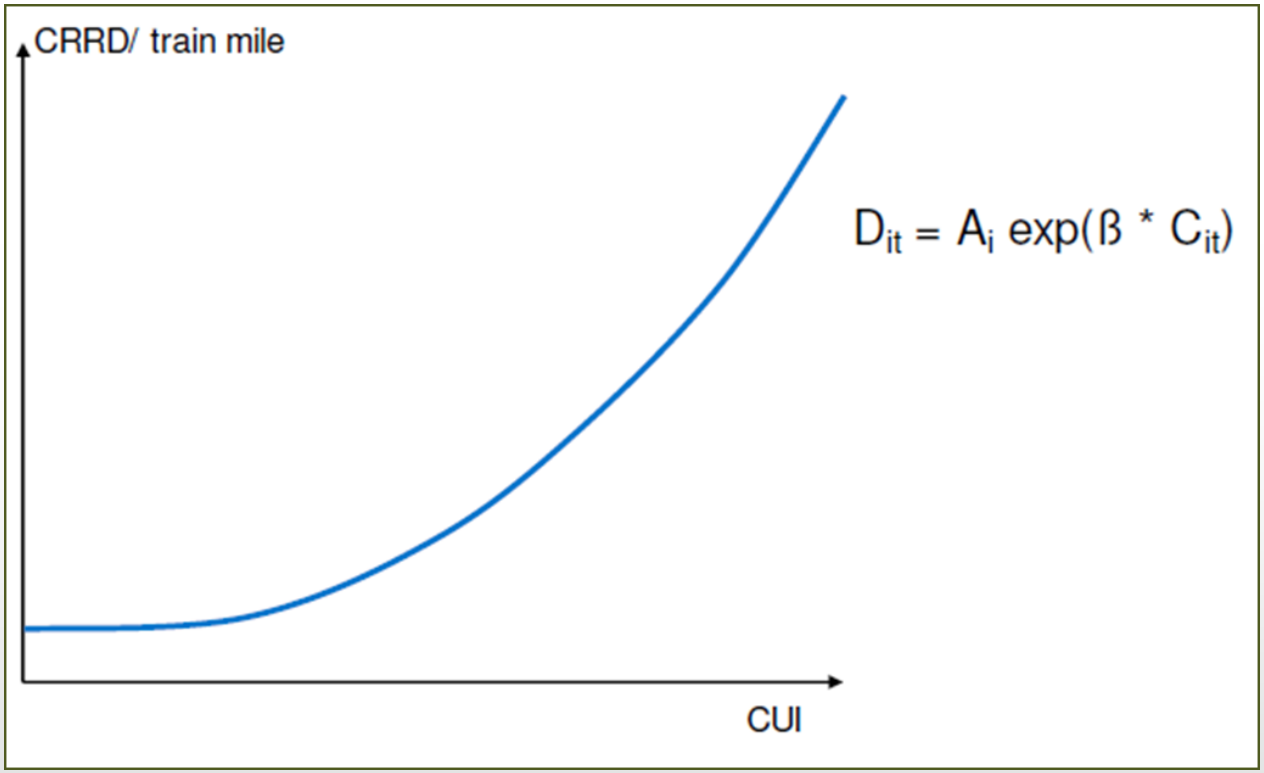
- Capacity Charge: variable element of Track Access Charges
  - Reflects varying levels of busyness across network by day (weekday, Saturday or Sunday), time and location
  - Designed to encourage efficient use of network
- Based on relationship between link-based CUI and Congestion-Related Reactionary Delay (CRRD)
- Application of OCCASION CUI calculation techniques
- Used 2012 timetable and CRRD data

Capacity Charge Recalibration (CCR)

- Network Model: ~6,800 Constant Traffic Sections (CTSs) between network nodes
- CIF-based timetable data: ~60,000 trains
  - ~26,000 weekday, 22,000 Saturday and 13,000 Sunday services
- TRUST-derived CRRD data: ~1.85m records
- Timetable and delay data assigned to network to determine CUI/CRRD relationship

Capacity Charge Recalibration (CCR)

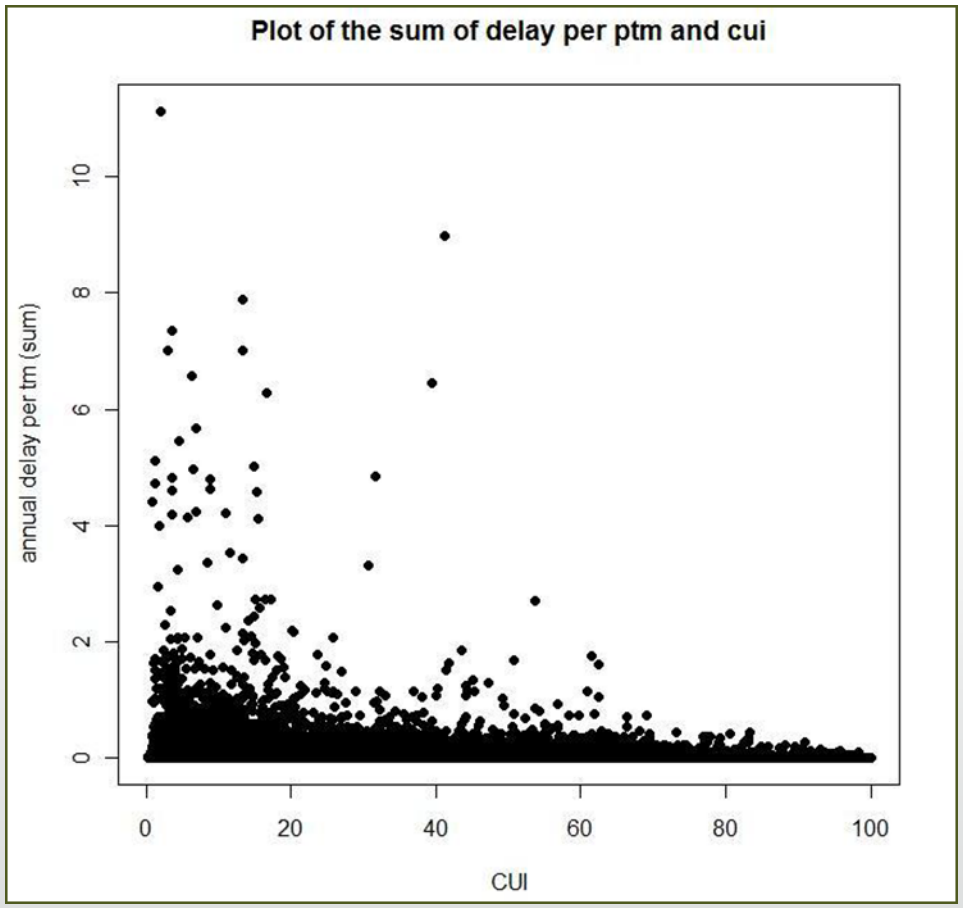
- Theoretical relationship



(Source: Faber Maunsell, 2007: PR2008 CCR)

Capacity Charge Recalibration (CCR)

- Actual relationship



» Many outliers, esp. at low CUI values
» Considerable data cleansing required
» Significant CRRD/CUI relationship identified

CCR Outputs and Follow-Up

- Outputs
  - Capacity Charge tariffs by Service Group
  - Excel-based tool to calculate updated tariffs based on changes in CUI and train counts by Service Group
  - Report (online)
- Follow-up
  - Tariffs and tool updates for additional services in East London
  - Planned and potential new services
  - CP6 Recalibration

DITTO Railway Systems project objectives

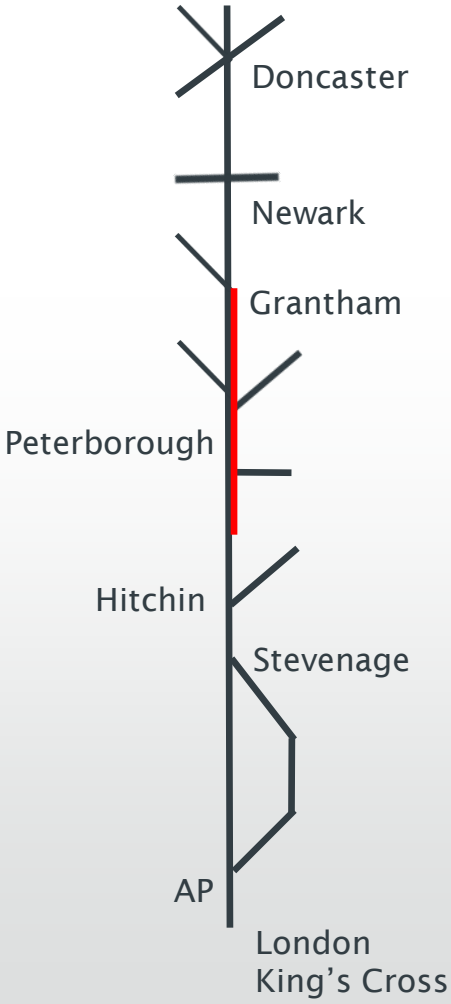
- Developing Integrated Tools To Optimise Railway Systems

1. Develop optimisation approaches to maintain safe operating conditions within theoretical capacity limits.
2. Quantify trade-offs between provision of additional train services and service quality, so as to develop timetables that optimise capacity utilisation without compromising service reliability.
3. Combine dynamic data on the status of individual trains to produce an optimal system-wide outcome.
4. Use Artificial Intelligence to produce tractable solutions to real-time traffic control.

DITTO Railway Systems project elements

- WA1: Safety Validation & Theoretical Capacity
- WA2.1: Examining Capacity/Reliability Trade-Off
- WA2.2: Stochastic Optimisation at Nodes
- WA3.1: Dynamic Simulation at Network Level
- WA3.2: Static Optimisation at Network Level
- WA4:Network Integration and Dynamic Optimisation using Artificial Intelligence

DITTO Railway Systems project



- Geographic scope
  - London to Doncaster, including Peterborough area covered by OCCASION
  - Area of detailed modelling TBC

ACCVA project

- Follow-up to UIC 406 update
  - Improve recommended capacity limit values
  - Address influence of line section length on results
  - Provide further examples of nodal capacity calculations
  - Develop calculation model to identify unique capacities of lines, switch areas and stations
  - Complete leaflet annexes – list of abbreviations and glossary

Ongoing work for DITTO and ACCVA (1)

- Mapping of nodal Capacity Utilisation to nodal CRRD
  - CRRD dataset
    - Nodal delays extracted, classified by node type and size

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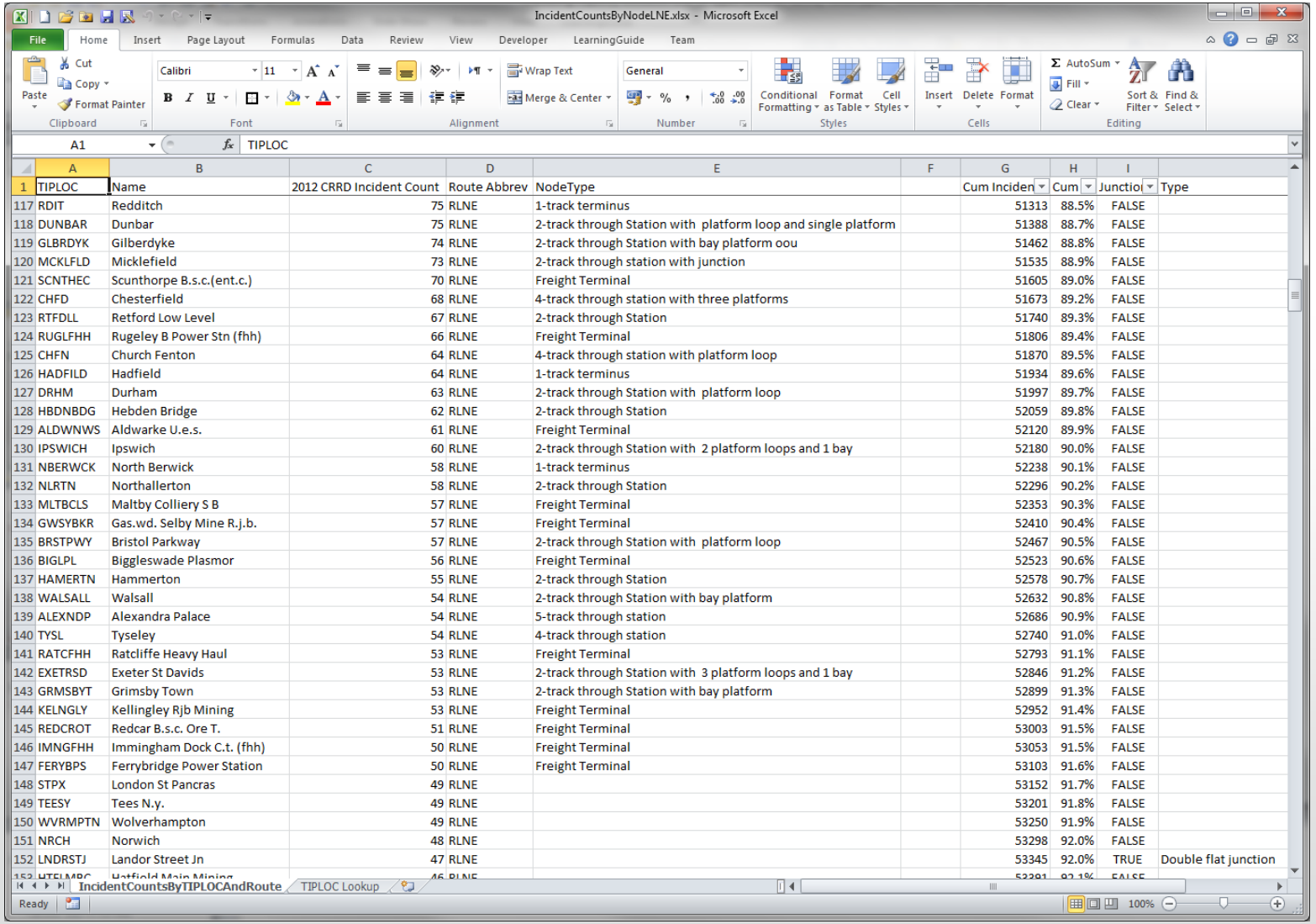
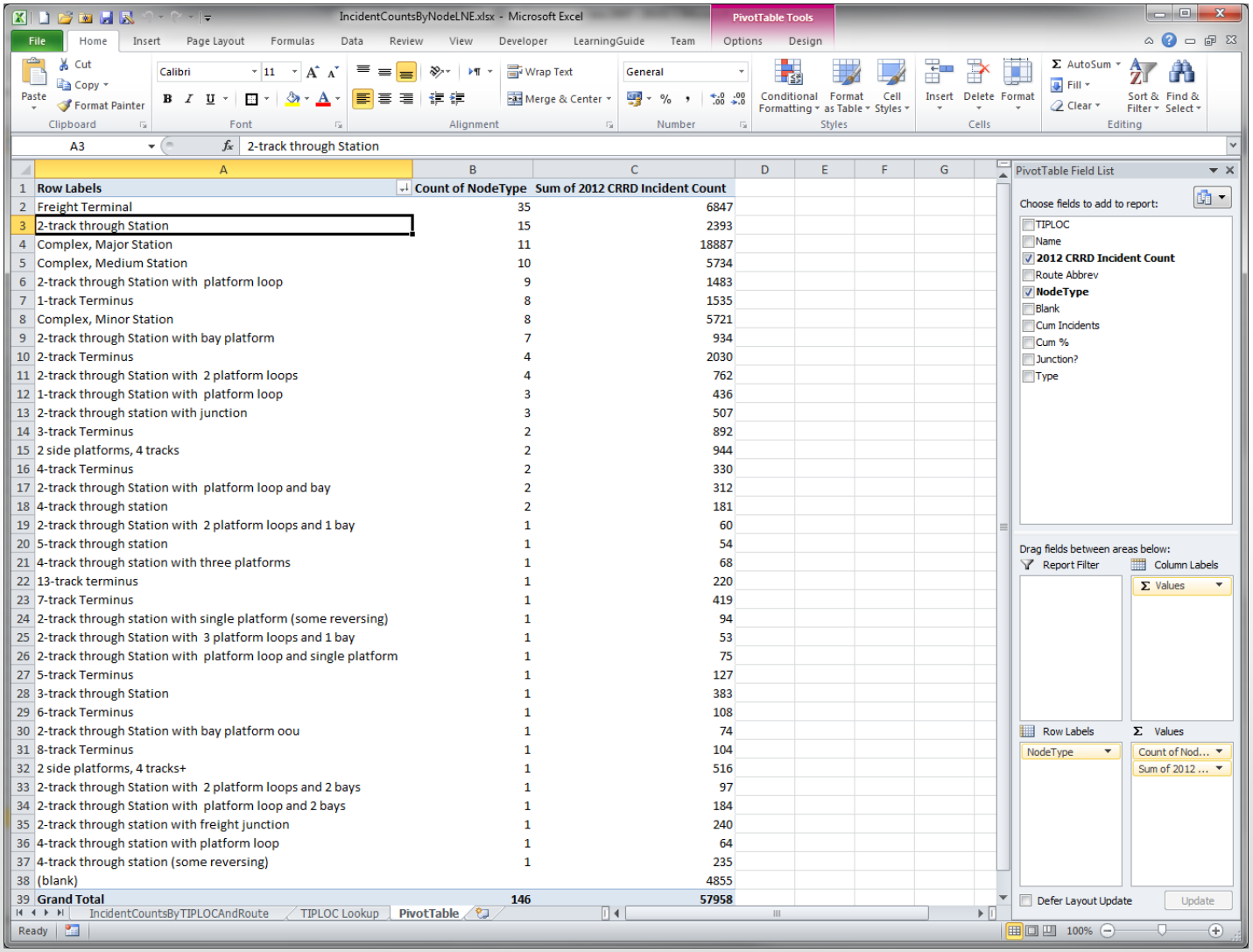
Ongoing work for DITTO and ACCVA (1)



IncidentCountsByNodeLNE.xlsx - Microsoft Excel

TIPLOC	Name	2012 CRRD Incident Count	Route Abbrev	NodeType	Cum Inciden	Cum	Junctio	Type
RDIT	Redditch	75	RLNE	1-track terminus	51313	88.5%	FALSE	
DUNBAR	Dunbar	75	RLNE	2-track through Station with platform loop and single platform	51388	88.7%	FALSE	
GLBRDYK	Gilberdyke	74	RLNE	2-track through Station with bay platform oou	51462	88.8%	FALSE	
MCKLFLD	Micklefield	73	RLNE	2-track through station with junction	51535	88.9%	FALSE	
SCNTHEC	Scunthorpe B.s.c.(ent.c.)	70	RLNE	Freight Terminal	51605	89.0%	FALSE	
CHFD	Chesterfield	68	RLNE	4-track through station with three platforms	51673	89.2%	FALSE	
RTFDLL	Retford Low Level	67	RLNE	2-track through Station	51740	89.3%	FALSE	
RUGLFHH	Rugeley B Power Stn (fhh)	66	RLNE	Freight Terminal	51806	89.4%	FALSE	
CHFN	Church Fenton	64	RLNE	4-track through station with platform loop	51870	89.5%	FALSE	
HADFILD	Hadfield	64	RLNE	1-track terminus	51934	89.6%	FALSE	
DRHM	Durham	63	RLNE	2-track through Station with platform loop	51997	89.7%	FALSE	
HBDNBDG	Hebden Bridge	62	RLNE	2-track through Station	52059	89.8%	FALSE	
ALDWNWS	Aldwarke U.e.s.	61	RLNE	Freight Terminal	52120	89.9%	FALSE	
IPSWICH	Ipswich	60	RLNE	2-track through Station with 2 platform loops and 1 bay	52180	90.0%	FALSE	
NBERWCK	North Berwick	58	RLNE	1-track terminus	52238	90.1%	FALSE	
NLRTN	Northallerton	58	RLNE	2-track through Station	52296	90.2%	FALSE	
MLTBCLS	Maltby Colliery S B	57	RLNE	Freight Terminal	52353	90.3%	FALSE	
GWSYBKR	Gas.wd. Selby Mine R.j.b.	57	RLNE	Freight Terminal	52410	90.4%	FALSE	
BRSTPWY	Bristol Parkway	57	RLNE	2-track through Station with platform loop	52467	90.5%	FALSE	
BIGLPL	Biggleswade Plasmor	56	RLNE	Freight Terminal	52523	90.6%	FALSE	
HAMERTN	Hammerton	55	RLNE	2-track through Station	52578	90.7%	FALSE	
WALSALL	Walsall	54	RLNE	2-track through Station with bay platform	52632	90.8%	FALSE	
ALEXNDP	Alexandra Palace	54	RLNE	5-track through station	52686	90.9%	FALSE	
TYSL	Tyseley	54	RLNE	4-track through station	52740	91.0%	FALSE	
RATCFHH	Ratcliffe Heavy Haul	53	RLNE	Freight Terminal	52793	91.1%	FALSE	
EXETRSD	Exeter St Davids	53	RLNE	2-track through Station with 3 platform loops and 1 bay	52846	91.2%	FALSE	
GRMSBYT	Grimsby Town	53	RLNE	2-track through Station with bay platform	52899	91.3%	FALSE	
KELNGLY	Kellingley Rjb Mining	53	RLNE	Freight Terminal	52952	91.4%	FALSE	
REDCROT	Redcar B.s.c. Ore T.	51	RLNE	Freight Terminal	53003	91.5%	FALSE	
IMNGFHH	Immingham Dock C.t. (fhh)	50	RLNE	Freight Terminal	53053	91.5%	FALSE	
FERYBPS	Ferrybridge Power Station	50	RLNE	Freight Terminal	53103	91.6%	FALSE	
STPX	London St Pancras	49	RLNE		53152	91.7%	FALSE	
TEESY	Tees N.y.	49	RLNE		53201	91.8%	FALSE	
WVRMPTN	Wolverhampton	49	RLNE		53250	91.9%	FALSE	
NRCH	Norwich	48	RLNE		53298	92.0%	FALSE	
LNDRSTJ	Landor Street Jn	47	RLNE		53345	92.0%	TRUE	Double flat junction

Ongoing work for DITTO and ACCVA (1)



Row Labels	Count of NodeType	Sum of 2012 CRRD Incident Count
Freight Terminal	35	6847
2-track through Station	15	2393
Complex, Major Station	11	18887
Complex, Medium Station	10	5734
2-track through Station with platform loop	9	1483
1-track Terminus	8	1535
Complex, Minor Station	8	5721
2-track through Station with bay platform	7	934
2-track Terminus	4	2030
2-track through Station with 2 platform loops	4	762
1-track through Station with platform loop	3	436
2-track through station with junction	3	507
3-track Terminus	2	892
2 side platforms, 4 tracks	2	944
4-track Terminus	2	330
2-track through Station with platform loop and bay	2	312
4-track through station	2	181
2-track through Station with 2 platform loops and 1 bay	1	60
5-track through station	1	54
4-track through station with three platforms	1	68
13-track terminus	1	220
7-track Terminus	1	419
2-track through station with single platform (some reversing)	1	94
2-track through Station with 3 platform loops and 1 bay	1	53
2-track through Station with platform loop and single platform	1	75
5-track Terminus	1	127
3-track through Station	1	383
6-track Terminus	1	108
2-track through Station with bay platform oou	1	74
8-track Terminus	1	104
2 side platforms, 4 tracks+	1	516
2-track through Station with 2 platform loops and 2 bays	1	97
2-track through Station with platform loop and 2 bays	1	184
2-track through station with freight junction	1	240
4-track through station with platform loop	1	64
4-track through station (some reversing)	1	235
(blank)		4855
Grand Total	146	57958

Ongoing work for DITTO and ACCVA (1)

- Mapping of nodal Capacity Utilisation to nodal CRRD
  - CRRD dataset
    - Nodal delays extracted, classified by node type and size
    - Assessment of Capacity Utilisation - ongoing
      - Updated OCCASION, UIC 406 and other approaches
    - Compare and assess results
- Determine CU/CRRD relationships

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Ongoing work for DITTO and ACCVA (2)

- Nodal Modelling and Simulation
  - Unperturbed nodal models
  - Introduce primary delay
  - Add trains: assess CUI and CRRD
- Again, range of node types and sizes
  - Compare with/validate CU/CRRD relationships
  - Assess upper limits → DITTO, ACCVA

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Summary and Conclusions

- Increasing traffic demand and infrastructure costs emphasise need to maximise reliable capacity of existing infrastructure
- Need improved understanding of capacity/reliability trade-offs and limits, esp. at nodes
- OCCASION/UIC 406 update → CCR → DITTO/ACCVA
- Improved understanding → industry can maximise capacity provision while maintaining service quality

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Questions?

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