#### TRANSPORT FOR LONDON

LoHAM P5.1 Development

# TfL's Experience with SATURN 11.6

Leeds 23 March 2023

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## **Presentation Plan**

- Introduction
- Background to LoHAM
- LoHAM P5.1 Development
- LoHAM and SATURN 11.6
  - Area based charging
  - SATPATH
  - Error Identification and Management
- Questions



## LoHAM and SATURN 11.6

**INTRODUCTION AND** BACKGROUND

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## LoHAM Development





# LoHAM Annual Update 2022 (Version 5.1)

## SATURN 11.6.02V

- Maintain consistency with rest of MoTiON
  - Updated PPM/PPK according to latest TAG (November 2022 v1.20)
  - Bus Network consistent with Railplan
  - Cycle network consistent with Cynemon (Cycle PCU 0.2)
- Uses new SATURN 11.6.02V
- Changes
  - Base Year 2019 Started from Silvertown model
  - Planning and Hybrid future year forecasts
  - Zones increased to 5421 from 5411 (Silvertown + Hemel Hempstead)
  - Motorway modelling from SERTM, Network and signal plan updates from ONE & Model Returns
- General tidying up







## LoHAM and SATURN 11.6

### AREA BASED CHARGING

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## AREA Based Charging – Glossary of Terms

- Area Based Charge A charge where all trips within a single zone are charged at a single rate
- Link Based Charge A charge applied to an individual link (often used for toll bridges)
- TAC Traffic Area Charge (System)
- TAZ Traffic Area Zone
- DCF Discretionary Choice Flows
- Discretionary Charge A charge that can be avoided by modifying a route
- Mandatory Charge A charge that cannot be avoided by modifying a route
- Compliance This relate to a vehicle meeting an emissions standard in ULEZ or CAZ
- Boundary or Cordon The outer limit of a charge zone
- **Toll** This is normally a cost attributed to a link





## LoHAM Greater London ULEZ and CCZ Coding 2026

- SATURN 11.6 incorporates upgrades and enhancements to Area Based Charging
- LoHAM P5.1 under development will incorporate the following coding:
  - 2019 CCZ and Central Area ULEZ
  - 2026 CCZ and Greater London ULEZ
  - 2031 CCZ only
  - 2041 CCZ only
- LoHAM P5.1 employs 1 TAC where one zone is represented and 2 TACs where 2 zones are represented
- Where a network incorporates two TACS the TACs are overlaid so the ULEZ TAC covers all of London and the CCZ is a cumulative charge on top of the ULEZ TAC.



Example Charge Area as a single TAC with separate matrix levels for compliance (i.e. 9 user classes)



#### **Zone 1 (Central Area)**

- Defined by TAZ boundary
- Apply TAC charge 1 (Congestion) and a discretionary charge 2 (Clean Air Zone) to all links within TAZ boundary
- In this example the Congestion and Clean Air Zone Charge are the same area
- The grey area represents the rest of the network where no charge is applied



MoTiON



## Area Charging - Coding Methodology 1 TAC Model

Best Practice with Area Based Charging.

# Area based charging is coded into the SATURN Network DAT file in the 44444 Section.

#### The coding below shows a single TAC or charge area



- In the coding on the left the TAC area defines the charge with the TAC identifier and description.
- The model has 9 user classes and UC2, UC4 and UC 8 are non compliant and therefore subject to higher charges as the ULEZ charge applies.
- UC1, UC3, UC 5, UC6, UC7 and UC9 are not charged as they are compliant.
- TAZ is the Cordon Definition







## Example 2 TAC Model with factors for compliance





#### Zone 1

- Defined by TAZ 1 boundary
- Apply *TAC 1* to all links within TAZ 1 boundary

#### Zone 2

- Larger zone defined by TAZ 2 boundary
- Apply *TAC 2* to all links within TAZ 2. This includes the links within TAZ 1
- Discretionary charge applied here and compliance levels

#### **TAZ free route**

- Allows for charge free travel through the zone
- Each route coded separately







## Area Charging - Coding Methodology 2 TAC Model

```
44444
      ZONE 1 £5.00
TAC
500.0 500.0 0.0 0.0 500.0 500.0
                                   CHARGE
TAZ
      ZONE 1
     16207
                          CORDON - This will contain the full
                16022
     16258
                16257
                          set of cordon links.
99999
      ZONE 2 £7.50
TAC
*1 Work 2 non-Work 3 PHV 4 Taxi 5 LGV 6 OGV
750.0 750.0 0.0 0.0 750.0 0.0
                                      CHARGE
COM 0.800 0.700 0.0 0.0 0.500 0.0
TAZ
      ZONE 2
     36132
                36000
                                COMPLIANCE
     87194
                87004
99999
TA7
      FREE ROUTE 1
     56516
                56515
99999
TAZ
      FREE ROUTE 2
                70191
     70203
99999
TAZ
      FREE ROUTE 3
     70503
                70000
99999
```

Area Based Charging 2 TAC Network.

- In this illustration we have 2 Charge areas Zone 1 and Zone 2
- Zone 1 is fully inside zone 2.
- Zone 1 had a charge of £5.00
- Zone 2 a charge of £7.50
- The Zone 2 charge is only applied to UC1, UC2 and UC5
- TAZ Definitions allow for the coding of free routes through a charge area such as a bypass on the strategic road network.



## SATURN ANNUAL UGM – MARCH 2023 Insights from outputs (1)





#### **Discretionary trips**

- Trips with an origin or destination inside the zone will continue to be made.
- However trips with an origin and destination outside the zone could reroute to avoid charges
- New features allow for the change in routing of these 'discretionary trips' to be plotted
- SATURN Plots these trips using the DCF Function



## Insights from outputs (2)





#### **Discretionary trips**

- Similar example to previous slide
- In this case the trip has an origin outside the charge area but has a destination within the Zone 2 Charge area
- The trip can decide to travel through or avoid the central charge area
- Other costs such as time, distance and tolls will influence the route taken





## Area Charging – Modelling Advantages (1)

- Modelling charge areas will add a cost to each individual trip where the trip enters the charge area
- If the trip has an origin and destination outside the charge area this trip has the option to re-route and avoid the charge area
- The trip will only re-route where the overall cost of the trip is less than if the trip entered the charge area. Other factors in the generalised costs play a role such as distance and time
- If avoiding the charged area had a considerable increase in time that made the cost higher than paying the charge then the trip would opt to pay the charge
- Where an origin or destination is inside the charge area then the trip won't have the option to re-route as a result of the charge and will pay the charge. It could still re-route to avoid congestion within the charge area







## Area Charging – Modelling Advantages (2)

- If there are multiple zones (TAC Areas) coded then re-routeing may take place if an origin or destination is not inside a particular TAC area
- Area charging charged on the first link the trip makes within a charge (TAC) area and then no subsequent charges are applied within that area
- Area based charging therefore allows more robust modelling of the boundary areas without distortion
- Area based charging being separate from link tolls allows both charging methods to work together
- You can for example have an area based charge with a toll bridge within the charge area and the toll bridge can be modelled correctly irrespective of the area charge







## Area Charging – interaction with Demand Models

- Highway modelling do not exist in isolation
- When area charging is implemented in a model it is possible to output area charge skims
- SATURN now allows the output of discrete Area Charge (AC) skim matrices
- These Area Change skimmed costs can then interact in an iterative process of a four stage demand model where area charges will impact decisions related to mode shift or changes to origin or destination choices
- When you employ Area Charging in a stand alone assignment model you only get a partial picture of the response.







SATPATH

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## LoHAM and SATURN 11.6

## SATPATH

- A SATPIG replacement with additional data on the Charging Zones that routes pass through, e.g. ULEZ, CCZ
- SATPIG was ad-hoc program to produce a file of origin-destination route flows from a SATURN assignment. Originally used to provide route flows for micro-simulation models. Used the SATURN assignment UFC file.
- SATPATH works with the new SATURN 11.6 .UFF file
  - LoHAM 9UC .UFS (146,345 KB)
  - SATUFF
  - LOHAM 9UC .UFF (7,890,067 KB) 54 times bigger than UFS
- Produce .TFL file using SATPATH with UFF file
  - Output big CSV text file (for 9UC LoHAM has 687,181,482 lines and is 362,620,957 KB) 46 times bigger than UFF







## .TFL files

- A text CSV file with the assigned paths and user class flows on them
- Records of 2 lines for each path
  - Record/Line 1
  - The sequential origin number
  - The origin name
  - The sequential destination number
  - The destination name
  - Path counter (i.e. 1 for first path, 2 for second path)
  - Number of nodes included in record 2
  - TAC Groups of path
  - For each User Class
    - Fraction of total for current path to total for same O/D pair
    - UC Flow (PCU/hr)
  - Record/Line 2
  - The full set of nodes per O-D path (Origin Zone,N1,N2,N3,....Nn-1,Nn,Destination Zone)





## SATPATH .TFL Output File of Path Flows



Origin Destination Path No n Path Nodes TAC 1 TAC 2

For each UC {Fraction of total, UC Flow (PCU/hr)}

H	<b>ئ - رو</b>	- <del>-</del>									L5-	1_2019_9UC_	_5421Z_R020_	AM_F12Line	s.CSV - E	xcel								Æ			×
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7																											-
D20	)	- X	~	f <sub>x</sub>																							~
	А		С	D	E	F	G	Н	1	J	к	L	M	Ν	0	P	Q	R	S	T	U	V	w	x	Y	z	
1	1	10001	2	10002	1	11	1	1	1	0.00288	1	0.000965	1	0.001768		1 0.000592		1 0.028817	1	0.27336		1 0.063987	1	0.030111	1		
2	10001	12845	12846	13237	12580	12813	13238	13239	13240	13237	12846	12845	10002														
3	1	1 01	3	100_3	1	2	1	1	1	0.00945		00316	1	0.033681		1 0.011285		1 0.190936				1 0.077505	1	1 0.036473	1		
4	10 <mark>0</mark> 01	104 03	102 1	10128	10205	10283	10206	10137	:0011	12013	10003									<u>(</u> )							
5	1	100(1		10003	2	9	1	1											1	0.103061							
6	10 <mark>0</mark> 01	1040.	10404	10281	10128	1 1205	102.76	10137	10011	10013	, 1003									<u>í</u> 1							
7	1	10001	4	10004	1	7	1	1	1	0.007-51		0.0025	1	0.029665		0.003238		0.10571				1 0.116581	1	0.054862	1		_
8	10(01	10403	10281	10128	101.24	10257	10256	10394	1000-1											<u> </u>							
9	1	10001	4	0004	2	8	1	1											1	0.049933							_
10	10(01	10403	10404	10281	10128	10124	1 1257	10256	10394	10004																	
11	1	10001	5	10005	1	8	1	1	1	0.005998	1	0.90201		0.002555		1 0.000856	24	1 0.112502				1 0.051833	1	1 0.024392	1		_
12	10(01	10403	10281	10123	10205	1 283	10206	10137	10.11	10005																	
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Origin Zone, Node 1, Node 2, Node 3, Node 4, Node 5, Node 6, Node 7, Node 8, Node 9, Node 10, Node 11, Destination Zone



## **Potential Analysis**

#### • Trip Length Distributions

- Area, e.g. within a Borough, GLA, CCZ etc
- User Class (Car, ULEZ Compliant, Taxi, HGV, ZEV etc)
- Area Charging Regime

#### • Road Use in Area

- Origin / Destination
- User Class
- Area Charging Regime
- Python Scripts





## **Example Python Script**

## • Python Borough Road Use Tool

- Developed to answer question from Boroughs
- What % of traffic in the Borough is through traffic (external to external)
- To answer need to know the paths that each vehicle makes travelling through the network, the origin, the destination and whether and how the path goes through the Borough
- Have written a Python script to analyse .TFL files to answer this question
- Borough Road Use Script
  - Read all model link lengths from .UFN file via SATDB
  - Read path flows from .TFL file
  - Go through paths and calculate km travelled on each path link
  - Categorise using Origin Zone, Destination Zone, link Borough and User Class and sum flows
  - Output totals to spreadsheet





**KEEPING LONDON MOVING** 

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## Borough Road Use Example













Summary outputs produced for each Borough & User Class

- Trips From The number of trips originating in the region
- Trips To The number of trips going to the region
- Km From The km travelled by trips originating in the region
- Km To The km travelled by trips going to the region
- Km In The km travelled on roads in the region
- Km In From The km travelled on roads in the region originating in the region
- Km In To The km travelled on roads in the region with their destination in the region
- Km In Internal The km travelled on roads in the region with the origin and destination in the region
- Km In Through The km travelled on roads in the region with origin and destination outside the region
- % Through The percentage of km travelled by through trips







## Car Not In Work (AM Peak Hour 2016) – Hammersmith & Fulham









## SATPATH



- Developing a set of Python scripts to analyse LoHAM assignment results via SATPATH
- Will give a greater understanding of the routing effects on the highway network of any modelled schemes and changes in demand, e.g. Planning forecast vs Hybrid
  - By Area (e.g. Borough, Region, Charging Zone, etc)
  - By User Class (e.g. Car In Work, Car Not In Work, Goods Vehicle, Zero Emissions Vehicle, ULEZ Compliant Vehicle, Taxi, etc)





## LoHAM and SATURN 11.6

ERROR AND WARNING MANAGEMENT

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## **Error and Warning Management**

- In a model the size of LoHAM it is necessary to keep track changes between assignment versions and also decide if warnings are considered OK or need to be fixed
- SATURN provides sophisticated tools in the form of ERL files to fulfil this function
- The section will show three ways to check and investigate Errors in SATURN
  - **1.** Define Previous ERL in Network DAT File and examine LPN Outputs
  - 2. Use ERL Output files to check and Filter by Error / Warning Types
  - 3. Define Errors / Warnings of note and plot them in P1X







## Error and Warning Management (Example 1)

OPEN THE INPUT .ERL FILE DEFINED BY FILERL IN &OPTION: L5-1\_2019\_9UC\_5421Z\_R020\_AM\_V11.ERL ON CHANNEL 13 IN ORDER TO COMPARE WITH ERRORS GENERATED ON THIS RUN OF SATNET

CLOSE CHANNEL 12 FILE L5-1\_2019\_9UC\_5421Z\_R020\_AM\_F.TMP

DELETED FILE: L5-1\_2019\_9UC\_5421Z\_R020\_AM\_F.TMP

OUTPUT OF THE ERL FILE NOW COMPLETE: L5-1\_2019\_9UC\_5421Z\_R020\_AM\_F.ERL WITH73961\_RECORDS

OF THE 73961 NODE-BASED ERRORS IDENTIFIED 278 ARE NEW COMPARED TO THE &OPTION INPUT .ERL FILE "FILERL".

COMPARISON OF THE ERRORS GENERATED BY THIS RUN OF SATNET WITH THOSE GENERATED BY A PREVIOUS RUN AND STORED IN FILE:

L5-1\_2019\_9UC\_5421Z\_R020\_AM\_V11.ERL

NONE IDENTIFIED

 ERRORS THAT OCCURRED IN THE CURRENT NETWORK BUT NOT IN THE PREVIOUS .ERL FILE; I.E., THEY ARE NEW ERRORS

10203, 10114, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 10182, 10181, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 10396, 10256, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 12086, 13044, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 14069, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 14799, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 14154, 14090, 14279, 14186, 0, 99,1, 0, Miscellaneous warning - See the .LPN file 14279, 14277. 0, 99,1, 0, Miscellaneous warning - See the .LPN file

(2) ERRORS THAT OCCURRED IN THE PREVIOUS NETWORK BUT NOT IN THE CURRENT .ERL FILE (E.G., THEY HAVE BEEN CORRECTED?)



#### MoTiON C C R

# Define Previous ERL in Network DAT File and examine LPN Outputs

```
WSTART = F
FILERL = 'L5-1_2019_9UC_5421Z_R020_AM_V11.ERL'
&END
* Title and File History
```

When an ERL file from a previous run is defined in the Network DAT file it generates a table of outputs where new errors or warning have entered the model

It also reports errors that have been fixed.











## Error and Warning Management (Example 2)



ERL RAW FORMAT – Exported from SATNET RUN

A-NODE,	B-NODE,	-C-NODE,	ERROR	NUMBER	, P2	ARAM1, PARAM2, TEXT
1004	6, 1	.0000,	Ο,	33,0,	Ο,	Suspicious link distance - Input values differ markedly
	0, 1	.0001,	Ο,	16,0,	Ο,	Rather long intergreen time for a stage (> 20 seconds)
	0, 1	.0001,	Ο,	183,0,	Ο,	LCY for a node differs from its neighbours
1013	1, 1	.0001,	Ο,	33,0,	Ο,	Suspicious link distance - Input values differ markedly
1018	8, 1	.0001,	Ο,	33,0,	Ο,	Suspicious link distance - Input values differ markedly
1000	5, 1	.0002,	10294,	68,0,	Ο,	A priority marker G looks suspiciously like a merge! (M)
1018	8, 1	.0002,	Ο,	24,0,	Ο,	Input link time/speed out of range from speed-flow record
1018	8, 1	.0002,	Ο,	33,0,	Ο,	Suspicious link distance - Input values differ markedly
1029	4, 1	.0002,	Ο,	33,0,	Ο,	Suspicious link distance - Input values differ markedly
1000	5, 1	.0006,	Ο,	135,0,	Ο,	2+ give-way turns in a single lane: Major arm priority jcn.

#### Copy and Rename an output ERL file as a CSV and Filter Errors in Excel

A-NODE 🔽	B-NODE 💌	C-NODE 💌	ERROR NUMBER	PARAM1 🔽	PARAM2 🔽	TEXT	-
22672	22505	22504	14	0	0	Roundabout turn sat flow less than circulation sat flow	
70495	70194	70285	14	0	0	Roundabout turn sat flow less than circulation sat flow	
70495	70194	70361	14	0	0	Roundabout turn sat flow less than circulation sat flow	
74658	74016	74625	14	0	0	Roundabout turn sat flow less than circulation sat flow	

In this example I have used the same ERL file and filtered by Error 14 relating to Roundabout SAT Flows being less than Circulation flows





## Error and Warning Management (Example 3)



#### ERL RAW FORMAT – Exported from SATNET RUN

A-NODE 💌	B-NODE 💌	C-NODE 💌	ERROR NUMBER 💌	PARAM1 💌	PARAM2 🕶	TEXT
10000	10180	0	175	0	2	Flare length exceeds link distance and/or 100 metres
14074	14164	14733	187	0	4	Mixture of late cut-offs and opposed stages for sig. X-turns
22672	22505	22504	14	0	5	Roundabout turn sat flow less than circulation sat flow
30188	28794	0	175	0	2	Flare length exceeds link distance and/or 100 metres
31001	30188	0	175	0	2	Flare length exceeds link distance and/or 100 metres
62014	62016	62171	187	0	4	Mixture of late cut-offs and opposed stages for sig. X-turns
65521	64027	0	175	0	2	Flare length exceeds link distance and/or 100 metres
64924	64231	64923	187	0	4	Mixture of late cut-offs and opposed stages for sig. X-turns
68239	68092	68131	187	0	4	Mixture of late cut-offs and opposed stages for sig. X-turns
70495	70194	70285	14	0	5	Roundabout turn sat flow less than circulation sat flow
70495	70194	70361	14	0	5	Roundabout turn sat flow less than circulation sat flow
74658	74016	74625	14	0	5	Roundabout turn sat flow less than circulation sat flow
74162	74827	0	175	0	2	Flare length exceeds link distance and/or 100 metres
85932	85838	85820	187	0	4	Mixture of late cut-offs and opposed stages for sig. X-turns

In this example a filter was set for Error Number 14, 175 and 187 Three different numbers representing the three errors were added to the PARAM2 Column The full file was then saved out as a PRN file and renamed back to the original ERL filename





## Error and Warning Management (Example 3)





The plot shows the three warnings highlighted on the previous slide by adding values to the PARAM2 column

SWARN 175 SWARN 187 WARN 14



TFL STRATEGIC MODELLING FORUM

# **Thank You**

## Questions

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