AtkinsRéalis

Phase 2: 2024 Present Year Validation Technical Report

Buckinghamshire Council

03 June 2026

BSTM2-PYV-RP01

BSTM2 2024 PRESENT YEAR VALIDATION

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Client signoff

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1. Introduction

1.1 Background

In March 2024, AtkinsRéalis, the framework consultants to Buckinghamshire Council (BC), was commissioned to update the Buckinghamshire Strategic Transport Model (BSTM The commission included incorporating a public transport proxy representation, developing a variable demand model (VDM), and enhancing network detail in selected areas. At the time of the commission, it was agreed that the baseline year would remain as 2019 The updated model - referred to as BSTM2 - was completed in March 2025.

BSTM2 comprises a Highway Assignment Model (HAM)1, a Variable Demand Model (VDM)2 and a proxy representation of Public Transport (PT Proxy). It retains a 2019 base year and covers the entire the Buckinghamshire area, with particular emphasis on enhancing the network representation within designated Model Improvement Areas (MIAs) in key urban areas, including Buckingham, Aylesbury, High Wycombe, Marlow and Bourne End.

AtkinsRéalis has subsequently been commissioned to undertake a Present Year Validation (PYV) of the emerging BSTM2. The PYV is being delivered in three phases:

- Phase 1 - Traffic data collection and processing (completed);
- Phase 2 - 2024 Present Year Validation; and
- Phase 3 - 2045 Forecast Modelling.

Phase 2 involves validating BSTM2 for the year 2024 to provide a more current and realistic representation of travel patterns, reflecting changes between 2019 and 2024 such as the impacts of the COVID-19 pandemic and broader economic trends. For the BSTM2 PYV 2024, updates were applied to trip ends, VDM, HAM, and PT Proxy to reflect these changes. Additionally, the updates incorporate the latest version of the Department for Transport (DfT) Transport Analysis Guidance (TAG) data book released in May 2025.

BSTM2 will be used primarily for testing highway network interventions, changes in global factors affecting public transport services and, the impacts of development proposals in future years, as well as growth and transport strategies and for the development of the Local Plan.

1.2 Purpose of this report

This document outlines the development of BSTM2 PYV 2024 and the adjustments made to account for COVID-19 impacts. It also presents the key model outputs alongside the validation results.

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[1] BSTM2 BY 2019 - BSTM2 HAM Development and Validation Report - Draft v2.0 submitted 28/02/2025
[2] BSTM2 BY 2019 - BSTM2 VDM Development and Validation Report - Draft v1.0 submitted 28/02/2025

1.3 Report structure

Following this introduction, the report is structured as follows:

- Chapter 2 outlines the base model overview and PYV approach;
- Chapter 3 describes the highway network updates made to reflect the present year conditions;
- Chapter 4 describes the process followed to develop the PT skim and fares matrices;
- Chapter 5 outlines the update of model costs and parameters;
- Chapter 6 outlines the travel demand calculation, including updated land use and trip ends assumptions;
- Chapter 7 outlines the VDM validation outputs, including trip matrices, mode share distribution and trip lengths;
- Chapter 8 outlines the HAM validation outputs, including traffic flows at links, traffic flows at screenline flows and journey routes travel times; and
- Chapter 9 summarises the key findings.

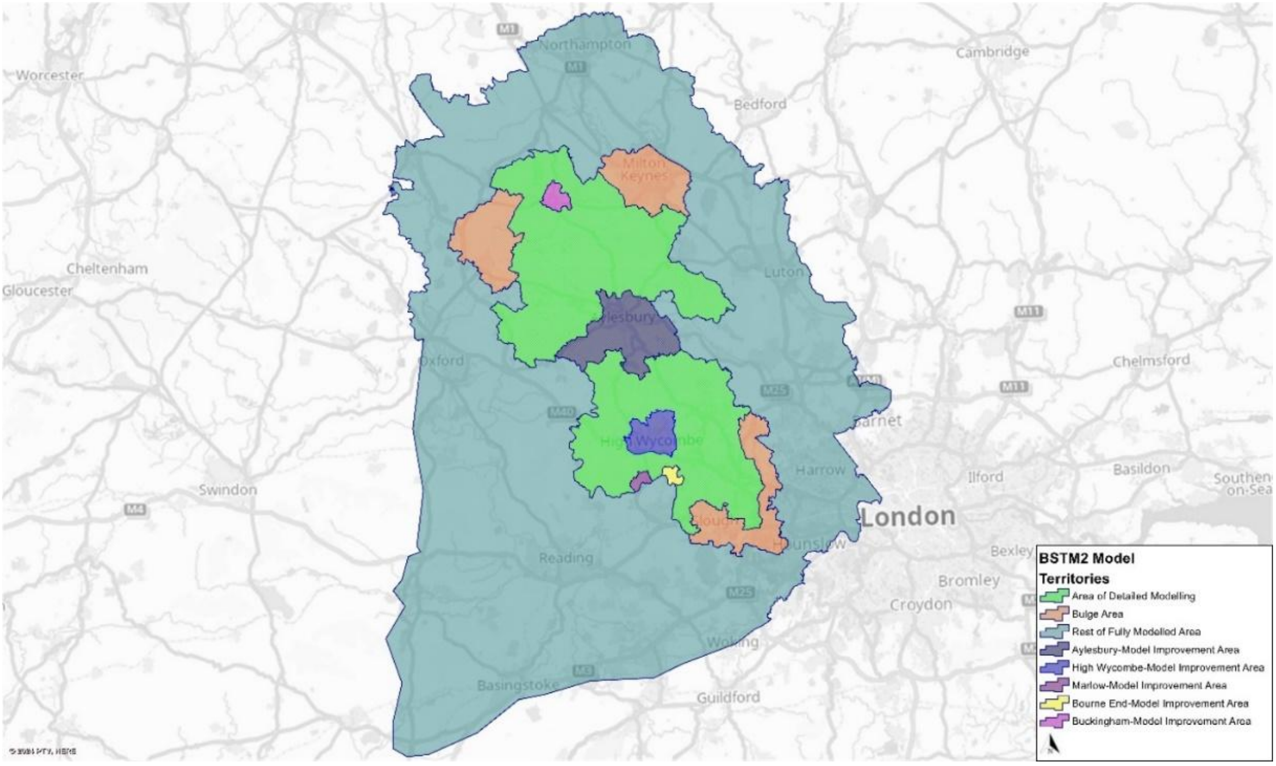
2. Present year validation

2.1 BSTM2 overview

2.1.1 Base model

The BSTM2 was built for the 2019 base year (pre-COVID 19), using inputs from that year. This included the calibration and validation of the HAM, development of PT Proxy and the calibration and validation of the VDM. Figure 2-1 shows the extent of the BSTM2 Area of Detailed Modelling (AoDM) and Fully Modelled Area (FMA).

Figure 2-1 - BSTM2 modelled area



The BSTM2 represents an average weekday (Tuesday to Thursday) during a neutral month. The HAM simulates the following time periods:

- **AM Peak hour (08:00 to 09:00):** represents the busiest hour of the morning peak across the modelled area;
- **Inter-Peak (10:00 to 16:00):** represents an average hour across this six-hour period; and
- **PM Peak hour (17:00 to 18:00):** represents the busiest hour of the evening peak across the modelled area.

The user classes used in the HAM for representing highway demand are defined across five distinct categories:

- UC1 – Car Commute;
- UC2 – Car Employer’s Business (EB work);
- UC3 – Car Other;
- UC4 – Light goods vehicles; and
- UC5 – Heavy goods vehicles.

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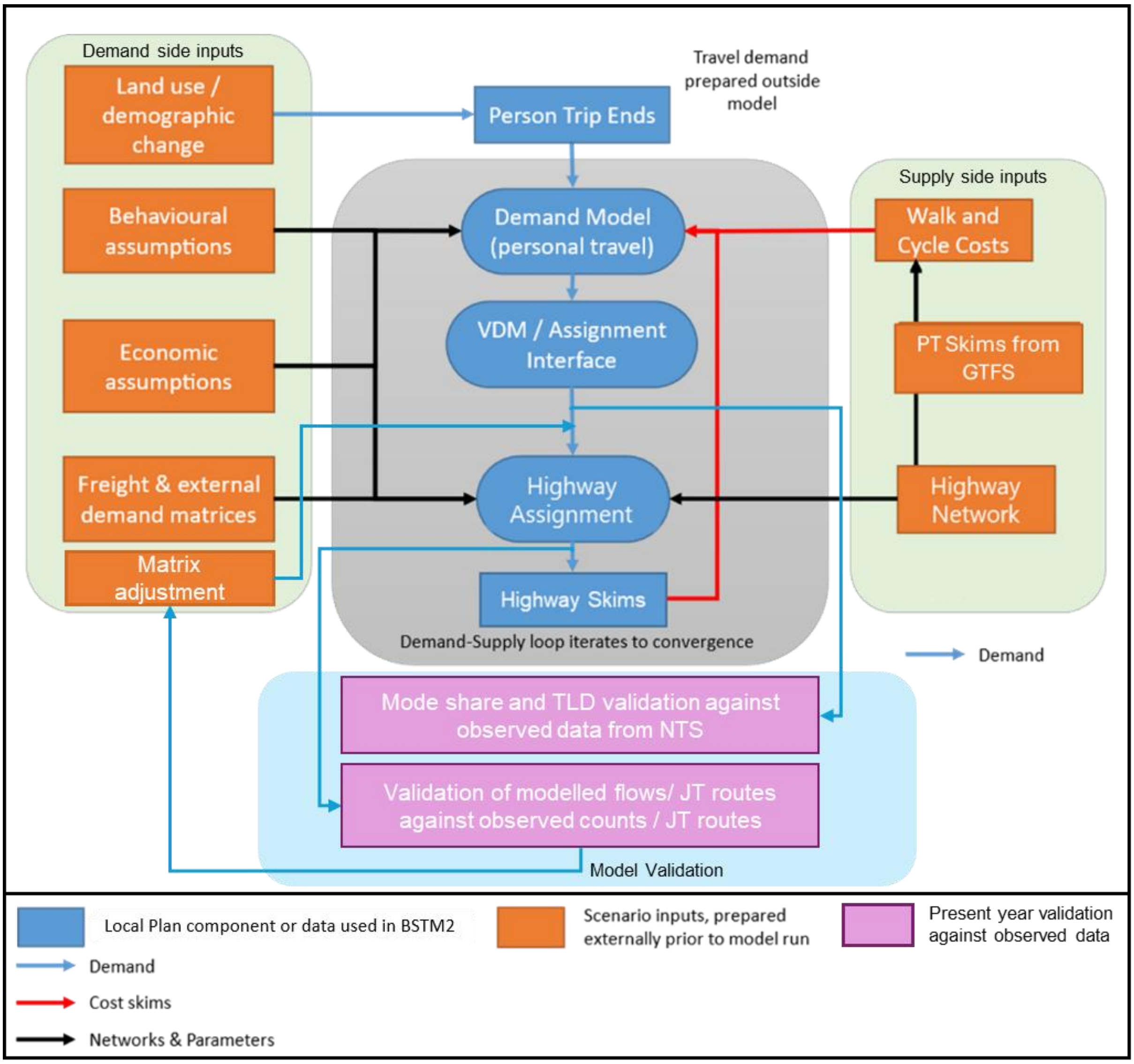
2.1.2 Forecast model

The BSTM2 forecast model will be developed in the next phase of this commission for 2045 future year to support future growth scenario testing. This includes assessing the adopted Local Plan (LP) alongside committed transport schemes, as well as the emerging LP development areas and the transport networks required to accommodate the planned growth. In addition, BSTM2 will assist developers in testing development proposals and identifying appropriate mitigation measures.

2.2 Present year validation approach

The BSTM2 2019 was the starting point for forecasting BSTM2 PYV 2024 by incorporating new land use developments and changes to highway network that occurred in Buckinghamshire between 2019 and 2024, as well as changes to PT Proxy. This process also involved applying growth factors for external-to-external car trips and freight trips as well as updating trip rates to reflect post-COVID-19 travel behaviour as detailed in later subsections of this report. Figure 2-2 illustrates the key aspects of the BSTM2 PYV 2024 development.

Figure 2-2 - Overview of BSTM2 PYV 2024 development



The following steps were undertaken to build the BSTM2 PYV 2024:

- **Travel demand:** Deriving 'Person Trip Ends' based on the completed developments between 2019 and 2024. This includes population, employment, and school attraction factors such as jobs, schools' students' places, leisure, and retail jobs;
- **Economic and behavioural assumptions:** Updating model parameters (e.g. value of time and vehicle operating costs) in line with the latest DfT TAG data book released in May 2025 that feed into the VDM and the HAM;
- **Car external-to-external, Light Good Vehicle (LGV) and Heavy Good Vehicles (HGV) trips**: Deriving Growth factors from DfT's National Road Traffic Projections (NRTP22) and applying it to BSTM2 2019 matrices;
- **Explicitly modelled developments LGV and HGV trips:** Calculating these trips using Trip Rate Information Computer System (TRICS) trip rates and distributing it based on donor zones;
- **Highway network changes:** Implemented main changes to the highway network between 2019 and 2024 in Buckinghamshire to the HAM and re-running it to produce revised skims for travel distances, times, and costs;
- **PT skims:** Developing a new PT Proxy using General Transit Feed Specification (GTFS) data to update PT skims based on 2024 conditions;
- **PT fares:** Projecting 2019 PT fares in nominal terms using TAG Unit A5.3 data book for rail and historical trends of bus fare from DfT's local bus fare index based on the latest versions of the TAG data book and Local Bus Fare Indices (see sections 4.4, 4.5 and 5.1.2);
- **Model Rerun:** Iterating the model to feed the changes in HAM travel times to the VDM;
- **VDM/Assignment Interface:** Pivoting using a process known as Absolute Model Applied Incrementally (AMAI) that is applied to BSTM2 2019 assignment matrices to BSTM2 PYV 2024 matrices; and
- **Model validation:** Validating BSTM2 PYV 2024 by comparing mode shares and trip length distributions against National Travel Survey (NTS) data, and by checking modelled traffic flows and journey times against observed counts and journey time datasets.

3. Highway Network Update

3.1 Road network topology

For the BSTM2 PYV 2024, the road network topology within Buckinghamshire was updated to incorporate any relevant highway schemes that were completed and opened between 2019 and 2024. This process involved reviewing the highway uncertainty log in collaboration with BC to confirm which projects should be included in the present-year model. Additional details were requested from BC regarding any long-term road closures that began after 2019 and remained in effect in 2024, ensuring these were accurately represented in the BSTM2 PYV 2024 HAM. The schemes were modelled for 2024 using the BSTM2 2019 network as the starting point. Table 3-1 summarises the updates applied to reflect actual ground conditions in 2024.

Table 3-1 - Highway network updates incorporated in BSTM2 PYV 2024

Reference	Scheme	Scheme Update	Location
1	Beaconsfield Relief Road	Scheme coded as per ground condition during 2024	South Buckinghamshire
2	Eastern Link Road (N)	Scheme coded as per ground condition during 2024	Aylesbury
3	Stocklake Link Road	Scheme coded as per ground condition during 2024	Aylesbury
4	Seven Hills Improvement	Scheme coded as per ground condition during 2024	South Buckinghamshire
5	Primary public transport corridor on A41 approaching Aylesbury	Scheme coded as per ground condition during 2024	Aylesbury
6	A41 / King Edwards Avenue Junction improvement	Scheme coded as per ground condition during 2024	Aylesbury
7	Bowood Lane	Road closure due to HS2 construction during 2024	South Heath to Wendover (Aylesbury)
8	Small Dean Lane	Road closure due to HS2 construction during 2024	Aylesbury
9	Nash Lee	Realignment due to HS2 construction during 2024	Aylesbury
10	Marsh Lane	Road closure due to HS2 construction during 2024	Stoke Mandeville
11	A418 Oxford Road	Realignment due to HS2 construction during 2024	Southwest Aylesbury
12	Blackgrove Road and A41 East and West roads	Realignment and scheme coded as per ground during 2024	Putlowes to Waddesdon
13	Station Road	Road closure due to HS2 construction during 2024	Waddesdon to Quainton

Reference	Scheme	Scheme Update	Location
14	School Hill Road	Road closure due to HS2 construction during 2024	Calvert South
15	Addison Road and Perry Hill Road	Realignment due to HS2 construction during 2024	Calvert North
16	A422 Brackley Road	Realignment due to HS2 construction during 2024	Westbury to Turweston

All the schemes listed above were coded based on ground conditions observed in 2024. Additional inputs, such as road closures were sourced from the HS2 Plans of BSTM2 FY 2045 in discussion with BC. Figure 3-1 shows the locations of the highway schemes included in the BSTM2 PYV 2024.

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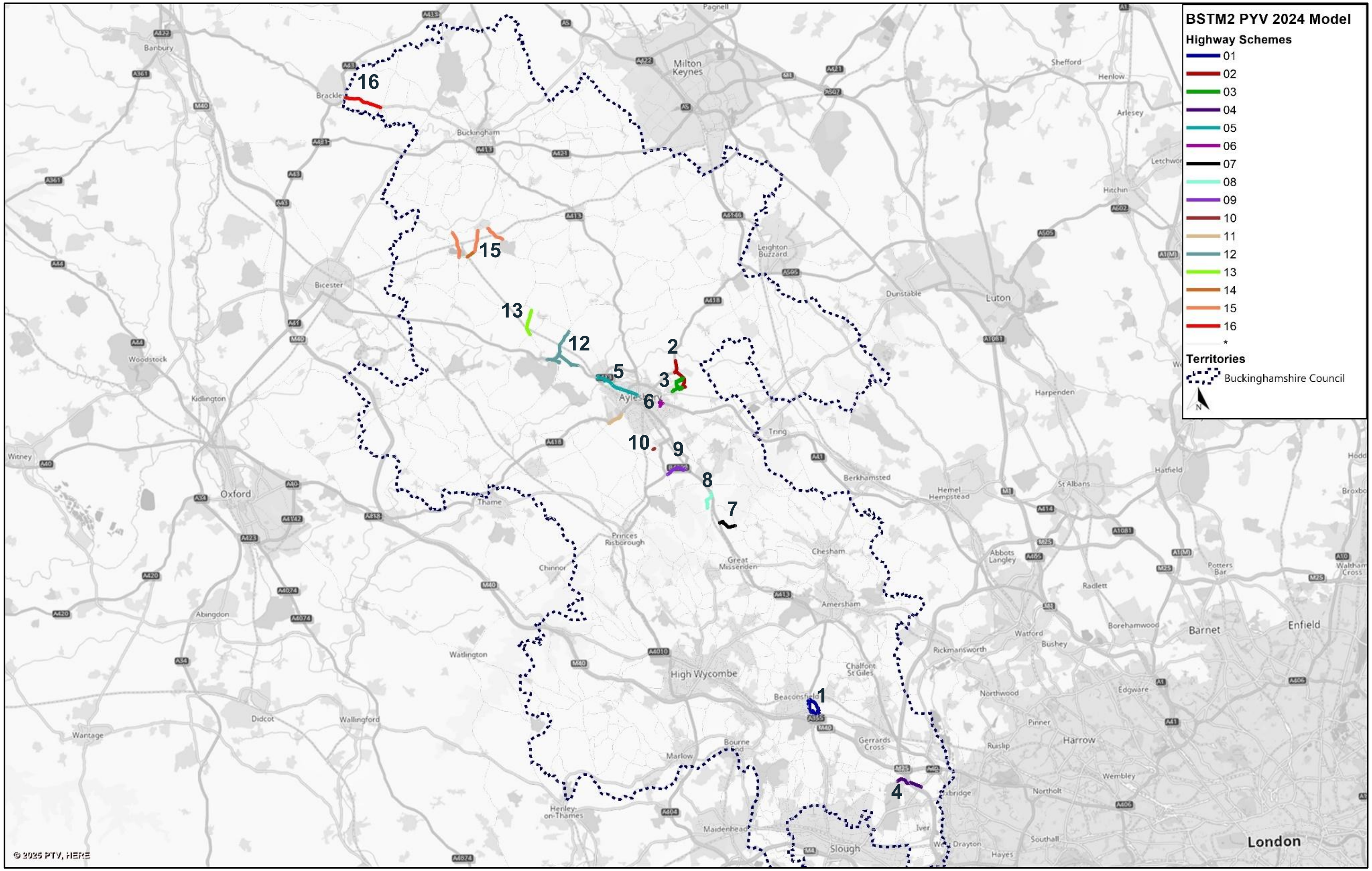
Figure 3-1 - Road Schemes coded as per 2024



3.2 Traffic signal timing

As part of the road network updates for BSTM2 PYV 2024, signal timing data for all signalised junctions within Buckinghamshire (inside MIAs) was requested from BC, resulting in the provision of recorded signal data for 15 signalised junctions extracted from the existing adaptive traffic control systems like SCOOT. A single day 12-hour signal timings data (07:00 to 19:00) was received for each of the 15 junctions that was processed to obtain averages for signal phases' green times and inter-greens for the following time periods:

- AM peak – 07:00 to 10:00;
- Inter-Peak (IP) – 10:00 to 16:00; and
- PM peak – 16:00 to 19:00.

Further LinSig model files have been shared to assist in identifying signal stages.

In addition to updating signal timings for 15 junctions, 20 new signalised junctions were added to the BSTM2 PYV 2024 network. These include 1 vehicle signal, 8 Toucan crossings, 7 Puffin crossings, 3 bridge shuttles, and 1 Pegasus crossing. Table 3-2 provides a detailed list of signals that were updated or added in the BSTM2 PYV 2024.

Table 3-2 - Signals updated or added in BSTM2 PYV 2024

No	Location	Signal Type	Location
1	A413 Buckingham Road / A4157 Weedon Road / Elmhurst Road	Updated Existing Signal	Aylesbury
2	Gyratory Nodes 1 & 2 - A413 Walton Street / Walton Road	Updated Existing Signal	Aylesbury
3	Gyratory Node 3 - A413 Wendover Road	Updated Existing Signal	Aylesbury
4	Gyratory Node 4 - B4443 Stoke Road / Walton Street	Updated Existing Signal	Aylesbury
5	A41 Bicester Road (Berry fields) / Paradise Orchard / Sir Henry Lee Crescent	Updated Existing Signal	Aylesbury
6	A413 Buckingham Road / Watermead / Prince Rupert Road (Watermead Junction)	Updated Existing Signal	Aylesbury
7	A40 Frances Dove Way / Easton Street (formerly Abbey Way)	Updated Existing Signal	High Wycombe
8	A40 London Road / Abbey Barn Road	Updated Existing Signal	High Wycombe
9	A40 London Road / Micklefield Road / Ryemead Boulevard (Wycombe Marsh Retail Park)	Updated Existing Signal	High Wycombe
10	A40 London Road / Hammersley Lane	Updated Existing Signal	High Wycombe
11	A40 London Road / Gomm Road	Updated Existing Signal	High Wycombe
12	A40 London Road / Cock Lane	Updated Existing Signal	High Wycombe
13	A418 Aylesbury Road, Bierton	New Signal coded as per ground during 2024	Aylesbury
14	A41 Bicester Road / Jackson Road / Dickens Way	Updated Existing Signal	Aylesbury
15	B4443 Stoke Road / Mandeville Road / Old Stoke Road (Black Bridge)	Updated Existing Signal	Aylesbury

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No	Location	Signal Type	Location
16	A40 London Road/ Rayners Avenue	Updated Existing Signal	High Wycombe
17	Daws Hill Lane nr Knights Templar Way	Toucan Crossing	High Wycombe
18	A413 London Road, Buckingham	Toucan Crossing	Buckingham
19	A418 Bierton Road nr. Manor Road	Toucan Crossing	Aylesbury
20	B4443 Lower Road, Aylesbury	Toucan Crossing	Aylesbury
21	A355 Wilton Park Diversion	Toucan Crossing	Outside MIA
22	Stocklake Link Road (Rural) Village 2	Toucan Crossing	Aylesbury
23	A413 Padbury	Toucan Crossing	Outside MIA
24	Wilton Park, Beaconsfield	Toucan Crossing	Outside MIA
25	A40 London Road / Gordon Road, High Wycombe	Puffin Crossing	High Wycombe
26	A4157 Weedon Road and Holman Street	Puffin Crossing	Aylesbury
27	Mill End Road, High Wycombe	Puffin Crossing	High Wycombe
28	Chartridge Lane, Chesham	Puffin Crossing	Outside MIA
29	Hatters Lane, High Wycombe	Puffin Crossing	High Wycombe
30	A418 Aylesbury Road, Wing near Church Street	Puffin Crossing	Outside MIA
31	Cambourne Avenue nr Turnfurlong Lane, Aylesbury	Puffin Crossing	Aylesbury
32	Broughton Lane bridge, Bierton	Bridge shuttle	Aylesbury
33	Furze Lane, Winslow	Bridge shuttle	Outside MIA
34	Herds Hill, Steeple Claydon	Bridge shuttle	Outside MIA
35	A41 near Stonebridge, Aylesbury	Pegasus Crossing	Aylesbury

Table 3-3 summarises the signals that were updated or added in the BSTM2 PYV 2024 categorised by area and type of signalised junction.

Table 3-3 - Summary of signals updated or added in BSTM2 PYV 2024

MIA/Junction Type	Signals	Toucan Crossing	Puffin Crossing	Bridge Shuttle	Pegasus Crossing	Total
Aylesbury	9	3	2	1	1	16
High Wycombe	7	1	3	0	0	11
Buckingham	0	1	0	0	0	1
Marlow	0	0	0	0	0	0
Bourne End	0	0	0	0	0	0
Outside MIA	0	3	2	2	0	7
Total	16	8	7	3	1	35

4. Public transport skims update

This section describes the methodology used to develop the PT Proxy, bus and rail journey distance and journey time matrices (skims), for the BSTM2 PYV 2024. The process outlined below was applied across all three modelled time periods. Details on public transport fares are provided in Chapter 5.

4.1 Difference in approach with BSTM2 BY 2019

BSTM2 PYV 2024 uses General Transit Feed Specification (GTFS) data instead of TRACC data to calculate public transport (PT) skim matrices, marking a key change from the earlier BSTM2 BY 2019 model. TRACC data comes from the Basemap accessibility tool and provides measures of accessibility from place to place with assumptions for accessing and egressing the PT services. However, GTFS data contains detailed, stop-to-stop travel information derived from actual routes, lines, stops, and timetables that is imported into the model together with the BSTM2 PYV 2024 traffic zones. VISUM tools are then used to establish connectivity between zones and public transport stops, enabling the generation of PT skim matrices directly from timetable-based network data.

This shift was driven by the advantages and convenience offered by GTFS. GTFS is open-source, easily integrates with other software platforms, and uses CSV-format files that are simple to read, edit, and process. Furthermore, GTFS data can be imported into VISUM, where public transport routes and journeys are built and explored. These features made GTFS a more suitable choice given the project's timescales and objectives.

4.2 Bus data source and coverage

To develop the bus skim matrices for the BSTM2 PYV, the required inputs were obtained from the UK Government's Bus Open Data Service (BODS) online portal[3]. BODS provides access to relevant bus service data across the UK and allows planners to extract GTFS datasets. These datasets served as the primary input for the bus skim matrices and include key attributes such as transport operators, stops, stop times, trips, routes, frequencies, and transfers.

As Buckinghamshire is in the southeast of England, the data extracted from BODS primarily covers this region in greater detail, with a limited number of bus lines connecting it to other parts of the UK and Europe (see Figure 4-1). To focus the analysis on services relevant to Buckinghamshire, external-to-external bus services were excluded from the dataset.

The resulting dataset comprises:

- 2,222 bus lines, which represent the public-facing transit services including timetables, operators, and vehicle types;
- 9,245 bus line routes, which define the specific physical paths taken by above lines through the network, including stop sequences and directional variants; and
- 54,467 stop points within the area of interest.

It is worth noting that the GTFS data downloaded from BODS included London Underground lines under the "subway/metro" category. To avoid mixing transport modes, these Tube lines were excluded from the bus network and instead incorporated into the rail network.

[3] Bus Open Data (BODS): Available at https://data.bus-data.dft.gov.uk/

Figure 4-1 - Bus GTFS area coverage

4.3 Rail data source and coverage

For the rail network, GTFS data was sourced from the Rail Delivery Group website4, which hosts the Rail Data Marketplace funded by the UK Government. Similar to the bus data, the extracted rail dataset includes key attributes such as transport operators, stops, stop times, trips, routes, frequencies, and transfers.

Unlike the bus network, which focused on the southeast region, the entire UK rail network was retained in the model. This includes external-to-external services, allowing for a comprehensive representation of first and last mile rail journeys (see Figure 4-2).

The resulting dataset comprises 6,098 rail lines, which represent the service identities of train operations (including timetable, operator, and train type), 15,071 rail line routes, which define the exact physical paths trains take through the network (including station sequences and track segments), and 2,891 stop points across the UK.

[4] Rail Delivery Group (RDG) – Rail Data Marketplace, available at: https://raildata.org.uk/

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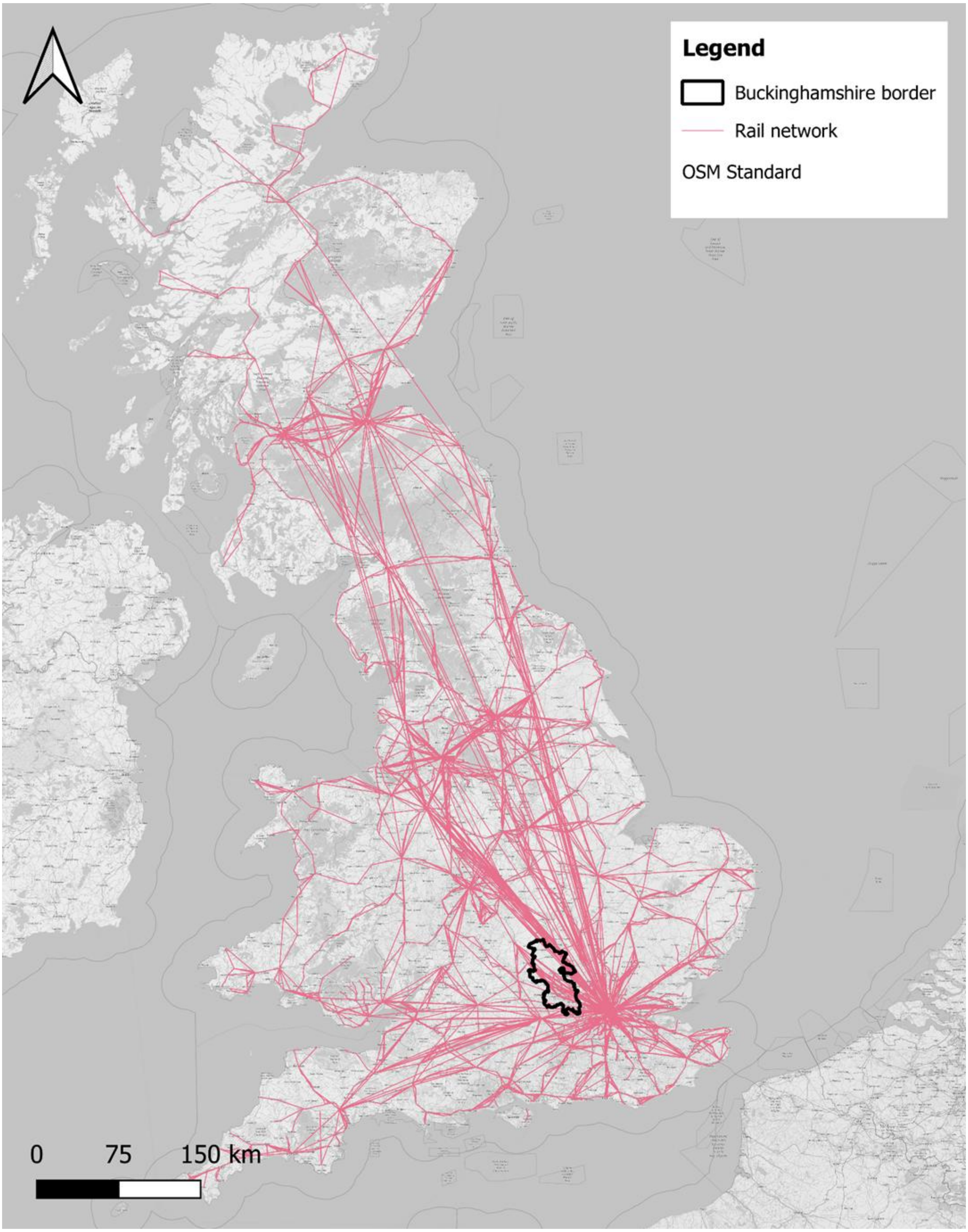
Figure 4-2 - Rail GTFS area coverage



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4.4 Methodology for bus skim matrices

The GTFS dataset extracted from BODS was used to generate a PTV VISUM version file, which stores and maps all available bus network information. Once the version file was created, additional model components such as zones and zone centroids were uploaded to enrich the network with all Origin-Destination (O-D) pairs and finalise the PT Proxy for bus network. To complete the bus network required for calculating bus skim matrices, zone connectors were established based on proximity. Specifically, connectors were created for stops located within 5 km of a zone centroid, assuming pedestrian access at a walking speed of 4 km/h. Each centroid was assigned up to four connectors to ensure adequate network coverage.

With the connectors in place, the following steps were conducted using PTV VISUM:

1. Create and O-D demand matrix with a constant value of 0.10 for all its O-D pairs. This value was chosen to ensure that all possible paths are activated and evaluated during the skims extraction process, which would not occur if the O-D pairs were left at zero;
2. Select the skim matrices to be calculated. These included: journey time, ride time, in-vehicle time, origin wait time, transfer wait time, walk time, access time, egress time, perceived journey time, number of transfers, journey distance, and in-vehicle distance;
3. Apply weighting coefficients to specific attributes to better reflect realistic public transport user behaviour. In accordance with TAG Unit M3.2 (Table 1: Recommended Generalised Cost Weights and Penalties), a coefficient of 2.00 has been applied to access time, egress time, walking time, transfer waiting time, and origin waiting time; and
4. Define the time period accordingly: 07:00 – 10:00 in the AM, 10:00 – 16:00 in the IP, and 16:00 – 19:00 in the PM.

After completing the skims calculation process, a sample of Origin-Destination (O-D) pairs within urban areas of the model like Buckingham, Aylesbury, High Wycombe, Marlow, and Bourne End was randomly selected to validate the skims result against real-world conditions. Using Google Maps and VISUM's Shortest Path Search feature, the team compared routes, journey times, and transfers for each time period to ensure the skims produced are reliable data and that the appropriate connectors were used at the start, during, and end of each trip. An example of this is shown in Table 4-1 illustrating a bus journey in AM peak between zone 586 and zone 693 within the High Wycombe modelled area. The comparison reveals a good match between the modelled skim for the example OD pair and the Google Maps results.

Table 4-1 – PT Proxy vs Google Maps journey comparison (Bus) – AM peak

Origin Zone	586 (Marlow Road, High Wycombe)
Destination Zone	693 (Magnolia Dene, High Wycombe)
VISUM Travel Time (hh:mm:ss)	00:33:36
Google Maps Travel Time (hh:mm:ss)	00:36:00
Travel Time Error (%)	-7%
VISUM Distance (m)	6,415
Google Maps Distance (m)	6,200
Distance Error (%)	3%

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4.5 Methodology for rail skim matrices

The methodology to calculate the rail skim matrices is very similar to the one followed to get the bus skim matrices, with a few key differences.

As with the bus network, connectors were created for stops located within 5 km of a zone centroid, assuming pedestrian access at a walking speed of 4 km/h. This was followed by the introduction of a second type of connector for rail stations located between 5 and 25 kilometres from zone centroids that did not have a station within a 5 km radius. These connectors assumed access by car, travelling at a speed of 54 km/h, to ensure that all zones were realistically connected to their nearest railway station and finalise the PT Proxy for rail network.

With the connectors in place, the skims calculation process was carried out using the same steps previously described for the bus network.

As with the bus skims, a sample of O-D pairs across the modelled area was randomly selected to validate the results against real-world conditions. Using Google Maps and VISUM's Shortest Path Search feature, the team compared routes, journey times, and transfers for all time periods to ensure the assignment produced reliable data and that the correct connectors were used throughout each trip.

An example of these checks is shown in Table 4-2 illustrating a rail trip between zone 177 (Aylesbury) and zone 777 (London). The comparison reveals a good match between the modelled skim for the example OD pair and the Google Maps results.

Table 4-2 – PT Proxy vs Google Maps journey comparison (rail) – AM peak

Origin Zone	177 (Aylesbury, Buckinghamshire)
Destination Zone	777 (London)
VISUM Travel Time (hh:mm:ss)	01:22:42
Google Maps Travel Time (hh:mm:ss)	01:30:00
Travel Time Error (%)	-8%
VISUM Distance (m)	58,809
Google Maps Distance (m)	61,340
Distance Error (%)	-4%

4.6 Summary and outputs

In summary, the shift from TRACC to GTFS data in developing the PT Proxy reflects the limitations of TRACC specifically its licensing constraints, incomplete network coverage, and restricted data accessibility. Being an open-source database, GTFS not only provides an easier way to extract data, but also it is easier to integrate given the timeframe of the project. Furthermore, it provides a better coverage of the public transport network in the area of interest creating more opportunities for public transport travel in the model, which in turn made PT mode more attractive in BSTM2 PYV 2024 when compared to BSTM2 2019. Therefore, to improve model validation with respect to updated PT skims, Alternate Specific Constants (ASC) were added and adjusted in the process to make sure that the modelling results reflected reality as accurately as possible. ASCs are modelling parameters that tune the utility of each mode which accounts for unobserved factors that systematically influence mode choice probabilities.

By applying the aforementioned methodology, the below skim matrices obtained are used for building generalised time:

- In-vehicle Time (IVT)
- Origin Wait Time (OWTA)
- Transfer Wait Time (TWTA)
- Walk Time (WKT)
- Access Time (ACT)
- Egress Time (EGT)
- Number of Transfers (NTR)
- Journey Distance (JRD)
- In-vehicle Distance (IVD)

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5. Updating costs and parameters

5.1 Model parameters update

While developing BSTM2 PYV 2024, it was necessary to update the model parameters in line with the latest version of the DfT TAG data book (v2.01), released in May 2025. This update introduced changes to several parameters compared to those used in the BSTM2 BY 2019, which was based on TAG data book v1.22 (November 2023). All values remained in 2019 prices, which is the model's price base.

In accordance with TAG guidance:

- The value of people's time is assumed to increase in line with GDP growth;
- The cost of operating a private vehicle is projected to decrease due to improved fuel efficiency and electrification of the vehicle fleet;
- Public transport fares are assumed to rise in line with RPI adjusted for GDP inflation, resulting in a relatively greater increase in public transport costs compared to car travel in the region (see section 5.1.2); and
- Car parking fees are kept constant (in real terms) as BSTM2 base 2019.

5.1.1 Values of time and vehicle operating costs

Table 5-1 summarises the impedance coefficients used in the HAM model for the AM, IP, and PM peak periods in the present year 2024. These coefficients are calculated as the ratio of Value of Time (VoT) in pence per minute to Vehicle Operating Costs (VOC) in pence per kilometre. To maintain consistency with the calibrated approach adopted in BSTM2 BY 2019, HGV VoTs have been doubled to reflect the greater importance of time in HGV routing, in line with TAG guidance (Unit M3.1). HGV VOCs were derived assuming an average network speed of 54 km/h and a 50:50 split between OGV1 and OGV2 vehicle types, consistent with the 2019 base year assumptions. In accordance with TAG Unit M4, car occupancy levels for 2024 have been retained at the same values as in the 2019 base year.

Table 5-1 - HAM Impedance coefficients for 2024

User Class	VoT/VOC *TAG data book (May 2025 v2.01), A1.3.1*		
	AM	**IP**	**PM**
Car - Commuting	0.01801	0.01772	0.01795
Car - Business	0.02330	0.02273	0.02296
Car – Other	0.02610	0.02451	0.02493
LGV	0.03465	0.03465	0.03465
HGV	0.04855	0.04855	0.04855

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Table 5-2 presents the VoT values adopted in the VDM for the present year 2024 values in 2019 prices.

Table 5-2 – VDM Values of Time (pence per minute, 2024 values in 2019 prices)

Purpose	Value of Time *TAG data book (May 2025 v2.01), A1.3.1*		
	Car	Rail	Bus, Walk & Cycle
HB Work (HBW)	21.68	21.68	21.68
HB Employer's Business (HBEB)	32.38	53.41	18.35
HB Education (HBEd)	9.90	9.90	9.90
HB Leisure (HBL)	9.90	9.90	9.90
HB Personal Business and Shopping (HBPS)	9.90	9.90	9.90
NHB Employer's Business (NHBEB)	32.38	53.41	18.35
NHB Others (NHBO)	9.90	9.90	9.90

5.1.2 Public transport fares

5.1.2.1 Rail fares

TAG Unit A5.3 paragraph 2.3.6 states: *"Demand and revenue forecasts should be based on current fares policy (usually a nominal increase of RPI+X%). Nominal fare increases should be converted to real terms using the GDP deflator. TAG Data Book Table A5.3.1 provides the relevant GDP deflator and RPI series".*

Rail fares typically increase at 1% over the RPI in nominal terms and is converted to real terms using the GDP deflator. The summary of fare index in real terms is shown in Table 5-3. The analysis shows that the rail fare increases by 18% in 5 years from 2019 to 2024 which is an annual average increase of approximately 3.4%.

Table 5-3 – Rail fare index (constant prices, GB)

Financial Year	Rail Fare Index (Constant Prices)
2019/20	100
2024/25	118

5.1.2.2 Bus Fares

The changes in the bus fares over time in nominal terms were derived using historical fare data taken from DfT's local bus fare index table BUS0405a5. The analysis showed that the bus fares in nominal terms increased by about 47% from 2011 to 2021. This trend in nominal terms is extrapolated for the forecast years and is adjusted using GDP deflator to convert to real terms. Bus fare index in real terms is summarised in Table 5-4 which reflects an average annual real decrease by 3.5% from 2019 to 2024.

[5] Bus statistics (Bus statistics - GOV.UK (www.gov.uk))

Table 5-4 – Bus fare index (constant prices, GB)

Financial Year	Bus Fare Index (Constant Prices)
2019/20	100
2024/25	83

Additionally, to reflect Buckinghamshire's 2024 fare policy, a £2.00 cap was applied to internal bus journeys (i.e., trips where both origin and destination are within the Buckinghamshire) with a journey distance under 32 km. Although this cap was increased to £3.00 in 2025[6], the £2.00 limit was retained in the model to remain consistent with the present year 2024. The result of this process is a fare matrix that shows the cost of travelling between different O-D pairs, based on journey distance and zone type.

[6] National Bus Fare Cap, UK Parliament (2024): [Written statements - Written questions, answers and statements - UK Parliament]

6. Travel demand

6.1 Land use and trip end assumptions

The change in demand is a direct result of changes in the numbers of people living, working, and engaging in shopping, recreational, educational, and other activities across the study area. To estimate the present year 2024 travel demand, it was therefore important to estimate the levels and patterns of land use activities which in turn generate person trips. These levels were then translated into trip ends for the present year 2024 using the assumptions and methodology described below.

6.1.1 Dwelling completions and jobs (2019 – 2024)

For any forecast year modelling scenario, the numbers of new dwellings and new jobs within the study area are required to forecast resident population and determine job locations. Being a present year model, for the BSTM2 PYV 2024, the following methodology was followed:

- **Within Buckinghamshire:** data on dwellings and employment for development sites completed between 2019 to 2024 (as confirmed by BC) is included in the full 2024 Uncertainty Log, broken down by the former districts: Aylesbury Vale, Wycombe, Chiltern, and South Bucks, as shown in Table 6-1. Developments with more than 75 dwellings or over 1,000 sqm of employment space were explicitly modelled. To calculate background growth, the total number of dwellings and jobs from the full 2024 Uncertainty Log was compared with those in the explicitly modelled developments. The residual growth, representing smaller sites, was treated as background growth for each former district. For explicitly modelled developments, the numbers of dwellings and jobs were added directly to the BSTM2 BY 2019 base zone values where the development is planned, without creating separate zones for these developments.
- **For external areas outside AoDM:** trip ends for present year 2024 were derived using growth from NTEM version 8.1 Core scenario.

Table 6-1 - BSTM2 PYV 2024: Full growth of jobs and dwellings within Buckinghamshire

Former Districts	No. of dwellings	No. of jobs
Aylesbury Vale	5,904	7,953
Children	177	1,026
South Bucks	689	32
Wycombe	1,713	3,426
Total	8,483	12,437

6.1.2 Trip ends estimation: productions

The dwellings information and assumptions detailed in section 6.1.1 directly influence trip growth at the trip production level. To calculate trip productions for the 2024 forecast scenario, the following process was applied:

- At zonal level for AoDM, population growth was calculated based on the number of new dwellings;
- The population profile change from NTEM was applied at person group level to capture the changes in car ownership, population per dwelling trends and the aging of population;
- For external zones outside AoDM, the NTEM 2024 growth is applied on base year population using the same internal-external proportions applied during the BSTM2 BY 2019 development;
- Changes in trip rates between NTS 2011–2019 and NTS 2023 as presented in the Phase 1 report ‘Present Year (2024) Data Analysis and Trends’ were applied to the BSTM2 trip rates. These adjustments were made

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by trip purpose, person type, and area type. The revised trip rates were then applied to present year 2024 population to calculate trip productions for each purpose and demand strata.

- The non-home-based trip productions were generated within the VDM by applying the NHB trip rates (gamma factors) to the modelled zonal home-based trip attractions by purpose. As with home-based trip rates, the 2024 gamma factors were derived from changes between the combined NTS 2011–2019 and NTS 2023 datasets.

Table 6-2 compares trip production levels by purpose between 2019 and 2024. The analysis indicates a decline in productions for HBW, HBEB, HBPS, and NHBEB trips, while HBEd, HBL, and NHBO trips show an increase over the same period. These changes reflect post-COVID-19 travel behaviour, as discussed in the Phase 1 technical note "Present Year (2024) Data Analysis and Trends." Overall, total trip productions increased slightly by 0.4% from 2019 to 2024.

Table 6-3 presents the production growth by internal LADs (former Local Authority Districts). Both Aylesbury and Wycombe have growth in trip productions from 2019 to 2024 which is attributable to higher residential developments in Aylesbury Vale and Wycombe compared to the other LADs.

Table 6-2 – BSTM2 BY 2019 vs PYV 2024: 24-hour home-based productions by purpose

Purpose	Total Productions		Abs. Difference	% Difference
	BSTM2 BY 2019	BSTM2 PYV 2024		
HBW	188,695	158,387	-30,309	-16.1%
HBEB	25,464	19,729	-5,735	-22.5%
HBEd	145,120	151,951	8,042	4.7%
HBPS	235,479	230,331	-6,360	-2.2%
HBL	169,060	177,802	8,742	5.2%
NHBEB	15,282	13,985	-1,297	-8.5%
NHBO	92,234	122,610	30,378	32.9%
Total	**871,335**	**874,796**	**3,461**	**0.4%**

Table 6-3 – BSTM2 BY 2019 vs PYV 2024: 24-hour home-based productions by LAD

Former Districts	Total Productions		Abs. Difference	% Difference
	BSTM2 BY 2019	BSTM2 PYV 2024		
Aylesbury Vale	269,938	281,255	11,317	4.2%
Chiltern	130,372	126,981	-3,391	-2.6%
South Bucks	98,661	97,915	-746	-0.8%
Wycombe	236,699	240,989	4,290	0.5%
Internal Total	738,670	747,040	8,370	1.1%
External	132,665	127,756	-4,909	-3.7%
Total	**871,335**	**874,796**	**3,461**	**0.4%**

6.1.3 Trip ends estimation: attractions

Attractions for all purposes act as weights, except for Home-Base Education (HBEd) and Home-Base Work (HBW) purposes, where the attractions in the model serve as targets. Table 6-5 presents the growth in attraction between 2019 and 2024.

The following methodology was used to forecast attractions for each journey purpose:

- HBW, HBEB, NHBEB
  - At zonal level within the AoDM, the growth in number of jobs was derived using the Uncertainty Log;
  - The calculated growth in jobs is then added to the base year job figures; and
  - For external zones, attractions were proportioned using the same JTW proportions internal-external proportions applied during the BSTM BY 2019 development.
- HBEd – Due to limited data on school provision, school place estimates were used to calculate the present year 2024 values as shown in Table 6-4. These estimates were based on the assumption that new schools would be constructed in developments exceeding certain size thresholds. The additional school places were then added to the base year school places. It is worth noting that the total education places are implicitly scaled within PTV VISUM to match the required number of education trips produced by the projected pupil population.

Table 6-4 – Estimates of school places per dwelling

Education Stage	School places (per dwelling)	Minimum size of the development (dwellings)
Primary School	0.2	100
Secondary School	0.13	200
Sixth form	0.04	200

- HBPS - Base year zonal attractions were scaled based on the growth between base year and forecast year for non-B class jobs.
- HBL – Base year zonal attractions were scaled using the population growth between base year and the forecast year.
- NHBO – Base year zonal attractions were scaled using the total growth of population and jobs between base year and the forecast year.

External trip attractions were calculated by applying the growth in jobs from 2019 to 2024 from NTEM. External zone attractions for all purposes, except HBW (which was proportioned by Census JTW proportions), were capped at 30%, the same as BSTM2 base year 2019. This is because, according to JTW data, the proportion of trips originating from Buckinghamshire to all external zones are within 29%.

Table 6-5 illustrates the growth in attraction weights by purpose between the 2019 and 2024. The largest increases are in areas where the Uncertainty Log developments are concentrated, the most significant being the Aylesbury Vale district showing an increase of 6.5% as presented in Table 6-6.

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Table 6-5 – BSTM2 BY 2019 vs BSTM2 PYV 2024: Attraction by purpose

Purpose	BSTM2 BY 2019	BSTM2 PYV 2024	Abs. Difference	% Difference
HBW	188,695	158,387	-30,309	-16.1%
HBEB	25,464	19,729	-5,735	-22.5%
HBEd	145,120	151,951	6,831	4.7%
HBPS	235,479	230,331	-5,148	-2.2%
HBL	169,060	177,802	8,741	5.2%
NHBEB	15,282	13,985	-1,297	-8.5%
NHBO	92,234	122,612	30,378	32.9%
Total	**871,335**	**874,796**	**3,461**	**0.40%**

Table 6-6 – BSTM2 BY 2019 vs BSTM2 PYV 2024: Attraction by LAD

LAD	BSTM2 BY 2019	BSTM2 PYV 2024	Abs. Difference	% Difference
Aylesbury Vale	276,942	288,521	11,579	4.2%
Chiltern	125,056	125,029	-27	0.0%
South Bucks	112,523	113,725	1,202	1.1%
Wycombe	264,659	264,878	219	0.1%
Internal Total	779,179	792,152	12,973	1.7%
External	92,155	82,644	-9,511	-10.3%
Total	**871,335**	**874,796**	**3,461**	**0.40%**

6.1.4 Car exogenous and freight growth factors

Goods vehicle movements (LGVs and HGVs) and external-to-external car trips, both origin and destination lie outside the AoDM, are excluded from the VDM process. Instead, fixed adjustments are applied to the HAM base matrices (BSTM2 BY 2019) using DfT's National Road Traffic Projections (NRTP 22) to reflect changes to 2024. Details of these adjustments are provided in the following sub-sections.

6.1.4.1 Car external-to-external trips

External-to-external HAM car trips include movements that either cross but do not stop within Buckinghamshire or bypass Buckinghamshire entirely. The NRTP22 dataset provides traffic growth factors by region, vehicle type, and road type. For external-to-external car movements within BSTM2, growth rates for cars in the South East region across all road types are applied as the most appropriate basis for estimating changes between the BSTM2 2019 and BSTM2 PYV 2024 matrices. Table 6-7 presents the growth rates and the resulting changes in external-to-external car trips by time period.

Table 6-7 – DfT NRTP22 derived growth for car external-to-external movements

	BSTM2 2019	BSTM2 PYV 2024
NRTP22 South East, All road types, growth rate	-	2.8%
AM peak car trips	310,099	318,782
Inter-peak car trips	165,562	170,198
PM peak car trips	318,310	327,222

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6.1.4.2 Goods vehicles trips

For goods vehicle trips, the HAM matrix fixed adjustment was applied to all LGV and HGV movements both within and outside of the AoDM. For external-to-external movements, the process was the same as for car external-external trips by applying growth factors for goods vehicles to their base year matrices using growth rates derived from the NRTP22 forecasts for all types of roads combined (A road, minor, motorway, and trunk road) in the South East region.

Table 6-8 presents the overall growth rates derived from the NRTP22 forecasts. The forecasts indicate a significant increase in LGV trips, reflecting growth in local deliveries and online shopping, while the growth in HGV trips is comparatively lower.

Table 6-8 – DfT NRTP22 derived growth rates for LGV and HGV EE trips

Vehicle Type	2019-2024
LGV	12.36%
HGV	2.66%

For internal zones, the overall growth was aligned with NRTP22 forecast levels, after first accounting for trips generated by new development sites using TRICS trip rates. The development-related LGV and HGV trips were calculated using TRICS rates presented in Table 6-9 and Table 6-10 respectively.

The resulting LGV and HGV trips for each internal zone were distributed based on the proportional distribution of LGV and HGV trips in BSTM2 2019 matrices. For zones with zero freight trips in the BSTM2 2019 matrices, alternative zones with non-zero freight trips within a 4 km buffer were considered in the trip distribution process.

The quantum of development goods vehicles trips generated by explicitly modelled developments in each time period in 2024 is shown in Table 6-11.

Table 6-9 – TRICS trip rates for LGVs

Land use	Units	AM Peak (08:00-09:00)		Interpeak (average hour 10:00-16:00)		PM Peak (17:00-18:00)	
		Arrivals	Departures	Arrivals	Departures	Arrivals	Departures
Residential	Per Dwel.	0.030	0.044	0.023	0.022	0.054	0.022
B1a - Office	Per 100sqm GFA	0.027	0.015	0.019	0.019	0.003	0.011
B2 - Industrial Unit		0.047	0.022	0.029	0.031	0.010	0.033
B2 - Industrial Estate		0.067	0.057	0.057	0.058	0.021	0.035
B2 Average		0.057	0.040	0.043	0.044	0.016	0.034
B8 - Warehousing (Commercial)		0.021	0.014	0.018	0.020	0.009	0.010
Retail - Retail Park incl Food		0.065	0.061	0.081	0.084	0.061	0.054
Retail - Retail Park excl Food		0.105	0.070	0.111	0.109	0.072	0.092
Retail - Food Superstore		0.095	0.076	0.137	0.132	0.118	0.123
Others		0.048	0.041	0.053	0.055	0.035	0.035

Table 6-10 – TRICS trip rates for HGVs

Land use	Units	AM Peak (08:00-09:00)		Interpeak (average hour 10:00-16:00)		PM Peak (17:00-18:00)	
		Arrivals	Departures	Arrivals	Departures	Arrivals	Departures
Residential	Per Dwel.	0.002	0.002	0.001	0.001	0.000	0.000
B1a - Office	Per 100sqm GFA	0.003	0.002	0.002	0.002	0.000	0.001
B2 - Industrial Unit		0.013	0.013	0.016	0.014	0.007	0.006
B2 - Industrial Estate		0.018	0.018	0.019	0.019	0.009	0.009
B2 Average		0.016	0.016	0.017	0.017	0.008	0.008
B8 - Warehousing (Commercial)		0.029	0.036	0.031	0.029	0.034	0.023
Retail - Retail Park incl Food		0.011	0.019	0.009	0.010	0.000	0.005
Retail - Retail Park excl Food		0.009	0.010	0.009	0.009	0.005	0.003
Retail - Food Superstore		0.018	0.016	0.017	0.017	0.007	0.011
Others		0.013	0.018	0.011	0.012	0.006	0.007

Table 6-11 – BSTM2 PYV 2024: Explicitly modelled developments' goods vehicle trips (in vehicles)

	AM Peak (08:00-09:00)		Inter Peak (average hour 10:00-16:00)		PM Peak (17:00-18:00)	
LGV	**Arrival**	**Departure**	**Arrival**	**Departure**	**Arrival**	**Departure**
Residential	174	217	153	144	327	132
Employment / Retail	46	30	36	38	12	23
HGV	**Arrival**	**Departure**	**Arrival**	**Departure**	**Arrival**	**Departure**
Residential	11	11	4	4	0	0
Employment / Retail	15	16	14	14	11	9

7. BSTM2 PYV 2024: Demand Model Validation

This section summarises the validation of overall demand patterns in the VDM benchmarked against the National NTS: 2011–2019; 2023 and the BSTM2 BY 2019. Mode shares are compared with NTS and BSTM2 BY 2019; trip length distributions with NTS and BSTM2 BY 2019; and trip patterns with BSTM2 BY 2019. Across these comparators, the model performs as expected.

7.1 Mode shares

7.1.1 Mode shares by purpose

Table 7-1 compares trip production-level mode shares by purpose between BSTM2 PYV 2024 and NTS 2023 for Buckinghamshire (i.e. internal-to-internal and internal-to-external trips). Overall, mode share differences are minimal, with combined variations across all purposes not exceeding ±2%. At the trip-purpose level, discrepancies variations remain within ±5%.

Table 7-1 - Main mode shares (BSTM2 PYV 2024 vs NTS 2023) by purpose

Purpose	Car		PT		Walk		Cycle	
	BSTM2 PYV	NTS	BSTM2 PYV	NTS	BSTM2 PYV	NTS	BSTM2 PYV	NTS
HBW	71%	68%	15%	18%	9%	10%	5%	4%
HBEB	78%	75%	14%	15%	6%	8%	2%	1%
HBEd	40%	38%	18%	17%	38%	43%	3%	2%
HBPS	58%	62%	11%	7%	31%	31%	1%	1%
HBL	74%	73%	5%	9%	17%	16%	4%	3%
NHBEB	73%	74%	8%	7%	18%	18%	0%	1%
NHBO	71%	70%	8%	7%	21%	22%	0%	1%
Total	62%	64%	12%	11%	24%	23%	3%	2%

7.1.2 Mode shares by former districts

Table 7-2 and Table 7-3 present the mode shares for production and attraction by former districts across all trip purposes. Overall, the mode share patterns in BSTM2 PYV 2024 closely resemble those observed in BSTM2 BY 2019, which is consistent with expectations. In particular, the former Buckinghamshire districts continue to exhibit a dominant reliance on car travel, followed by walking. However, a 1-2% decline in car mode share is observed across all internal districts when compared to BSTM2 BY 2019, consistent with findings from the Phase 1 report indicating a reduction in traffic between 2019 and 2024.

The decrease in cycling and the increase in public transport use in BSTM2 PYV 2024 compared with BSTM2 BY 2019 are attributable to the improved representation of public transport. Consequently, the cycling mode share now corresponds more closely with the National Travel Survey than in the BSTM2 BY 2019.

Table 7-2 – 24-hour productions mode share by LAD in BSTM2 PYV 2024 compared to BSTM2 BY 2019

Former Districts	BSTM2 PYV 2024 : 24hr P/A Trips				Mode Share				Diff to Base Year			
	Car	PT	Walk	Cycle	Car	PT	Walk	Cycle	Car	PT	Walk	Cycle
Aylesbury Vale	173,691	34,439	65,777	7,247	62%	12%	23%	3%	-2%	4%	1%	-2%
Wycombe	147,671	25,921	60,807	6,591	61%	11%	25%	3%	0%	2%	1%	-2%
Chiltern	80,624	14,654	28,957	2,746	63%	12%	23%	2%	-1%	2%	1%	-2%
South Bucks	64,235	11,385	20,049	2,246	66%	12%	20%	2%	-1%	1%	2%	-2%
External	102,305	21,481	2,363	1,607	80%	17%	2%	1%	2%	0%	0%	-1%
Total	568,526	107,880	177,954	20,436	**65%**	**12%**	**20%**	**2%**	-1%	2%	1%	-2%

Table 7-3 – 24-hour attractions mode share by LAD in BSTM2 PYV 2024 compared to BSTM2 BY 2019

Former Districts	BSTM2 PYV 2024 : 24hr P/A Trips				Mode Share				Diff to Base Year			
	Car	PT	Walk	Cycle	Car	PT	Walk	Cycle	Car	PT	Walk	Cycle
Aylesbury Vale	182,340	32,795	66,030	7,356	63%	11%	23%	3%	-2%	4%	0%	-2%
Wycombe	169,030	28,343	60,786	6,720	64%	11%	23%	3%	0%	1%	1%	-2%
Chiltern	80,635	13,016	28,730	2,648	64%	10%	23%	2%	0%	2%	1%	-2%
South Bucks	76,318	13,507	21,588	2,312	67%	12%	19%	2%	0%	1%	1%	-2%
External	60,204	20,219	821	1,400	73%	24%	1%	2%	0%	1%	0%	-1%
Total	568,526	107,880	177,954	20,436	**65%**	**12%**	**20%**	**2%**	-1%	2%	1%	-2%

7.2 Trip patterns

Table 7-4 illustrates the changes in trip patterns between BSTM2 BY 2019 and BSTM2 PYV 2024 across the former LADs and external zones (combined). Among the internal former districts, Aylesbury Vale shows the most significant increase in trip productions. Specifically, trips from Aylesbury Vale to Wycombe have risen by 19.57%, to Chiltern by 11.03%, and to South Bucks by 19.38%. The 4% increase in trips both produced by and attracted to Aylesbury reflects the relatively higher expansion in residential dwellings and job opportunities in Aylesbury Vale as compared to the other internal former districts, as outlined in section 6.1.

In contrast, the movement pattern between External and internal former districts shows an overall decline between the two model years. Despite these shifts, the total number of trips across all purposes and modes is forecasted to increase marginally by 0.40%, reflecting minimal growth in overall travel demand.

Table 7-4 – Change in trip pattern (BSTM2 PYV 2024 vs BSTM2 BY 2019) across all purposes and modes

Former Districts	Aylesbury Vale	Wycombe	Chiltern	South Bucks	External	Total
Aylesbury Vale	4.22%	19.57%	11.03%	19.38%	-4.71%	4.16%
Wycombe	8.90%	0.79%	5.19%	5.76%	-14.38%	0.54%
Chiltern	-1.02%	-0.58%	-1.43%	3.69%	-16.57%	-2.60%
South Bucks	-0.26%	-1.15%	2.81%	3.40%	-10.66%	-0.76%
External	3.97%	-8.94%	-6.71%	-5.20%	-	-3.70%
Total	4.18%	0.08%	-0.02%	1.07%	-10.32%	0.40%

7.3 Trip lengths

Figure 7-1 to Figure 7-5 compare the estimated HBW trip length profiles by distance band from the BSTM2 PYV 2024 (designated as ‘VDM016’), BSTM2 BY 2019, national NTS 2011-2019 and NTS 2023 for all the main modes. These plots are of the 24-hour production/attraction trips. It is important to note that the accuracy of designating a modelled trip to a distance band under 3 miles (<1 mile, 1-2 miles, 2-3 miles) is considered low due to the limitations of the strategic representation of the modelled zone and network structure. In BSTM2 PYV 2024:

- HBW car and cycle trips have the same trip length distribution pattern as in BSTM2 BY 2019;
- HBW walk and bus trips lengths follow trends similar to NTS 2011-2019 with minor variations compared to NTS 2023; and
- HBW rail and rail P&R trips show shorter trip lengths than in BSTM2 BY 2019 and better align with NTS 2011–2019.

Figure 7-1 - Trip length distribution comparison for HBW car mode

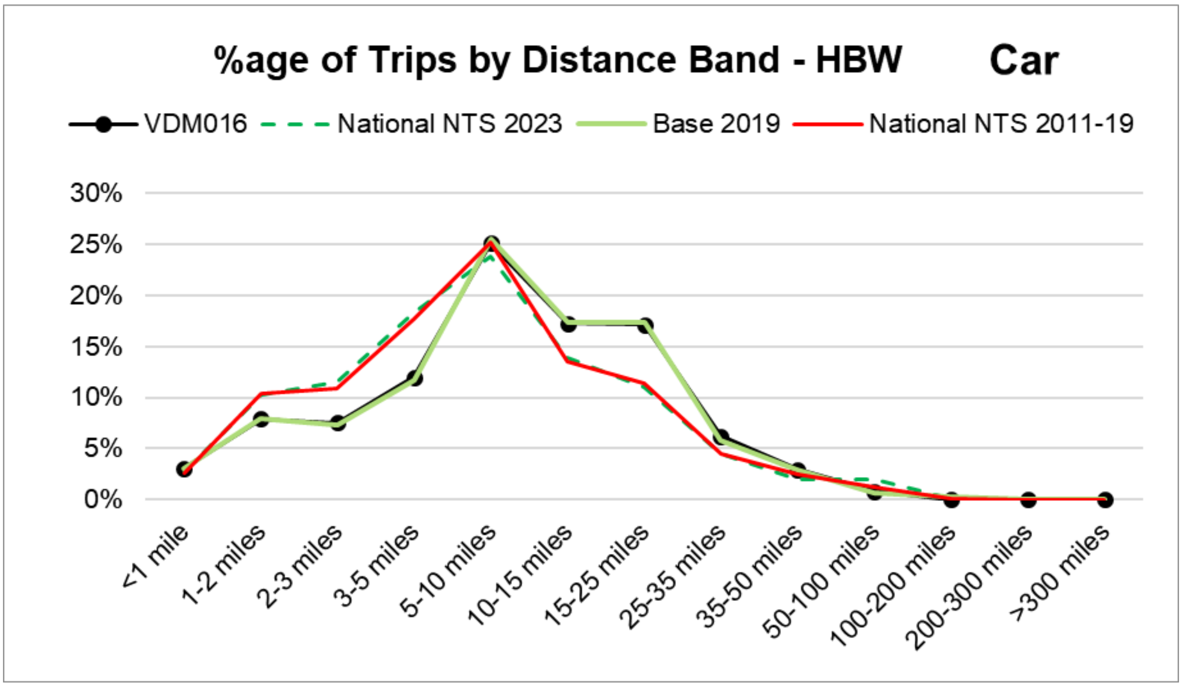


Figure 7-2 - Trip length distribution comparison for HBW walk mode

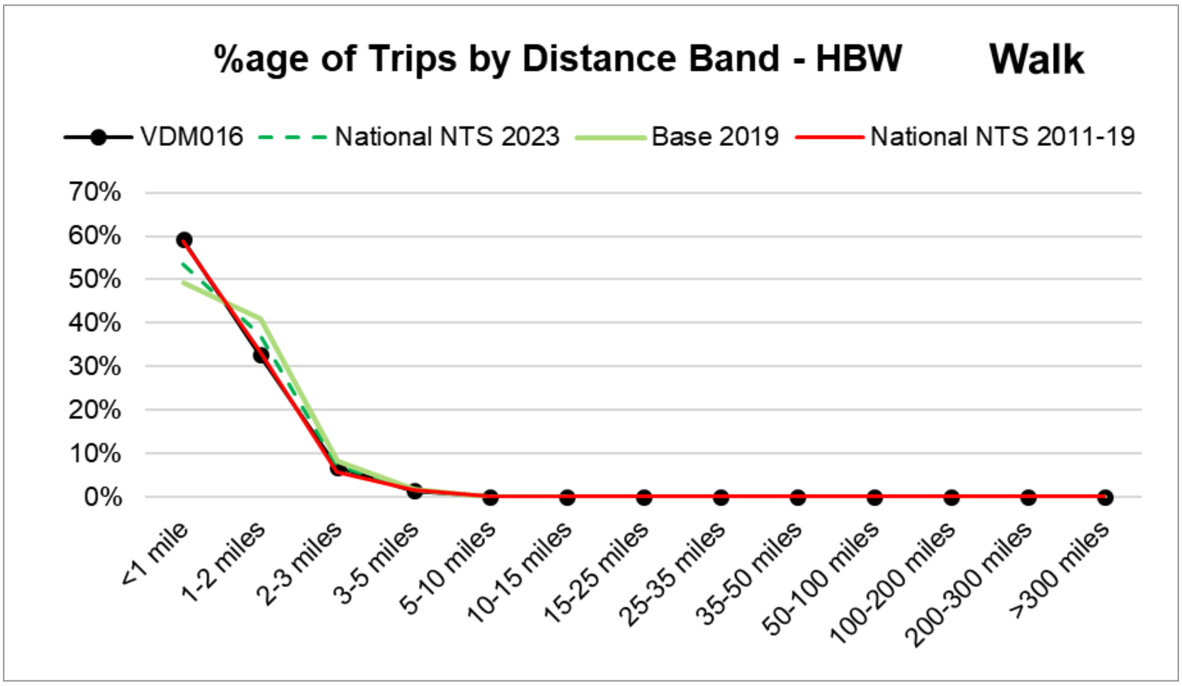


Figure 7-3 - Trip length distribution comparison for HBW cycle mode

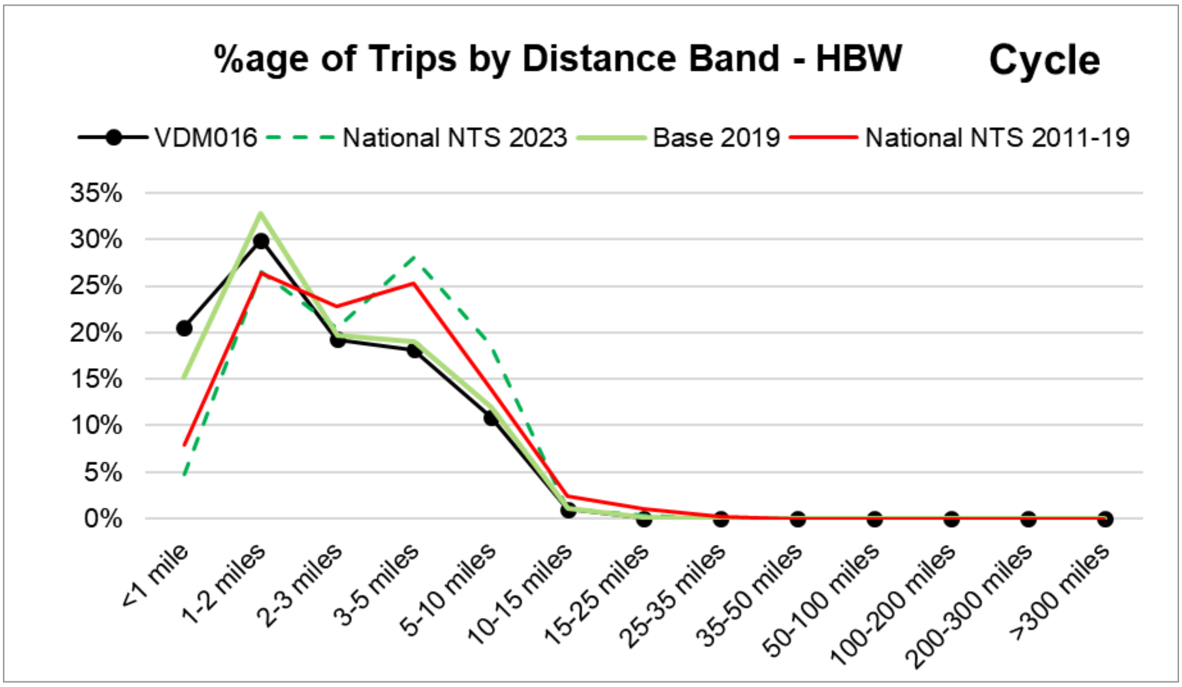


Figure 7-4 - Trip length distribution comparison for HBW bus mode

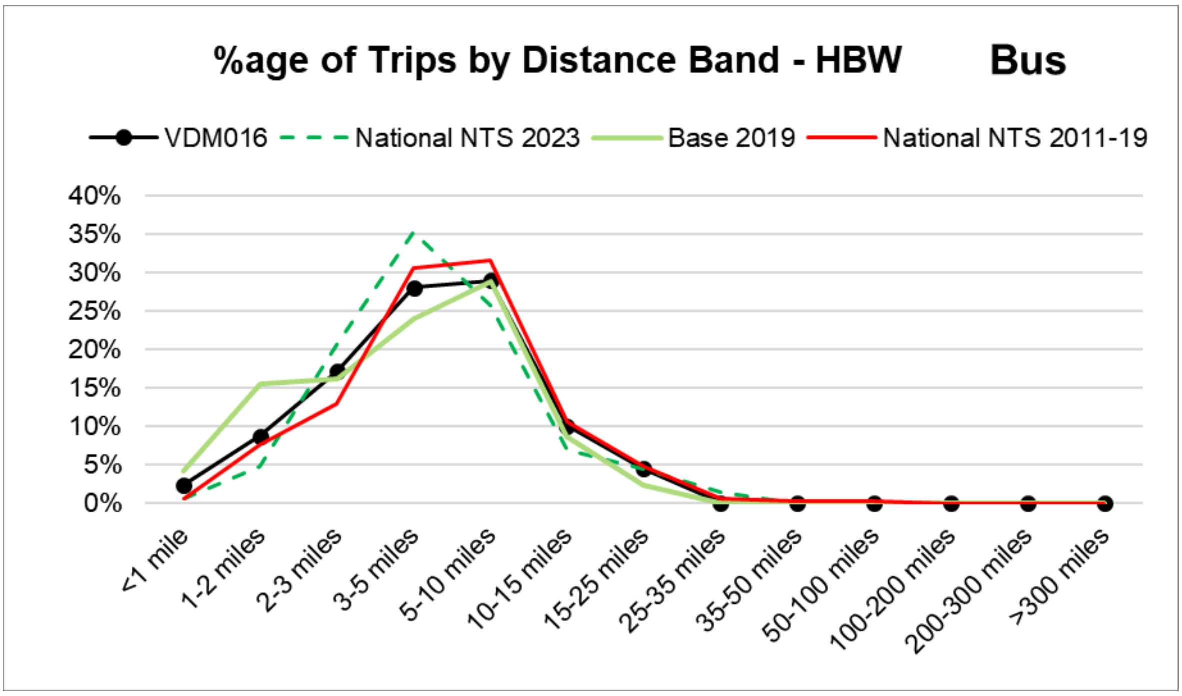


Figure 7-5 - Trip length distribution comparison for HBW rail & rail PR mode

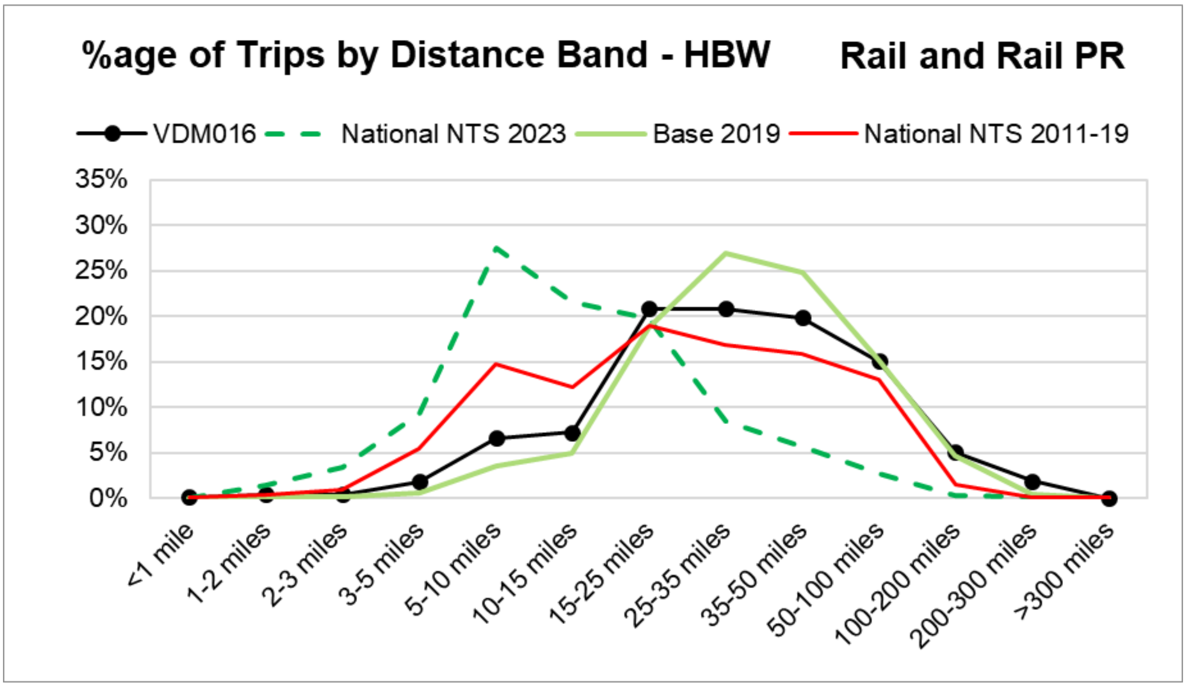


Figure 7-6 to Figure 7-10 compare the estimated HBO, which includes HBEd, HBL and HBPS, trip length profiles by distance band from the BSTM2 PYV 2024 (designated as 'VDM016'), BSTM2 BY 2019, national NTS 2011-2019 and NTS 2023 for all the main mode. In BSTM2 PYV 2024:

- HBO car trips have the same trip length distribution pattern as in BSTM2 BY 2019;
- HBO walk and cycle trips lengths follow trends similar to BSTM2 BY 2019, NTS 2011-2019 and NTS 2023; and
- HBO bus, rail and rail P&R trips have the same trip length distribution pattern as in BSTM2 BY 2019.

Figure 7-6 - Trip length distribution comparison for HBO car mode

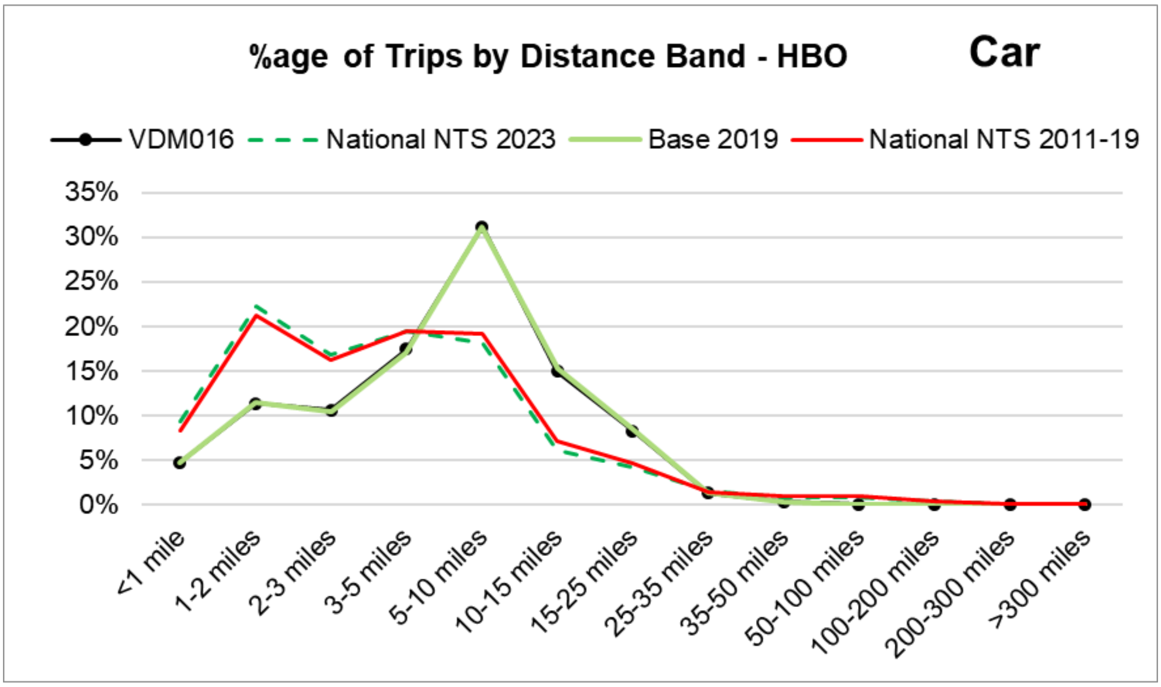


Figure 7-7 - Trip length distribution comparison for HBO walk mode

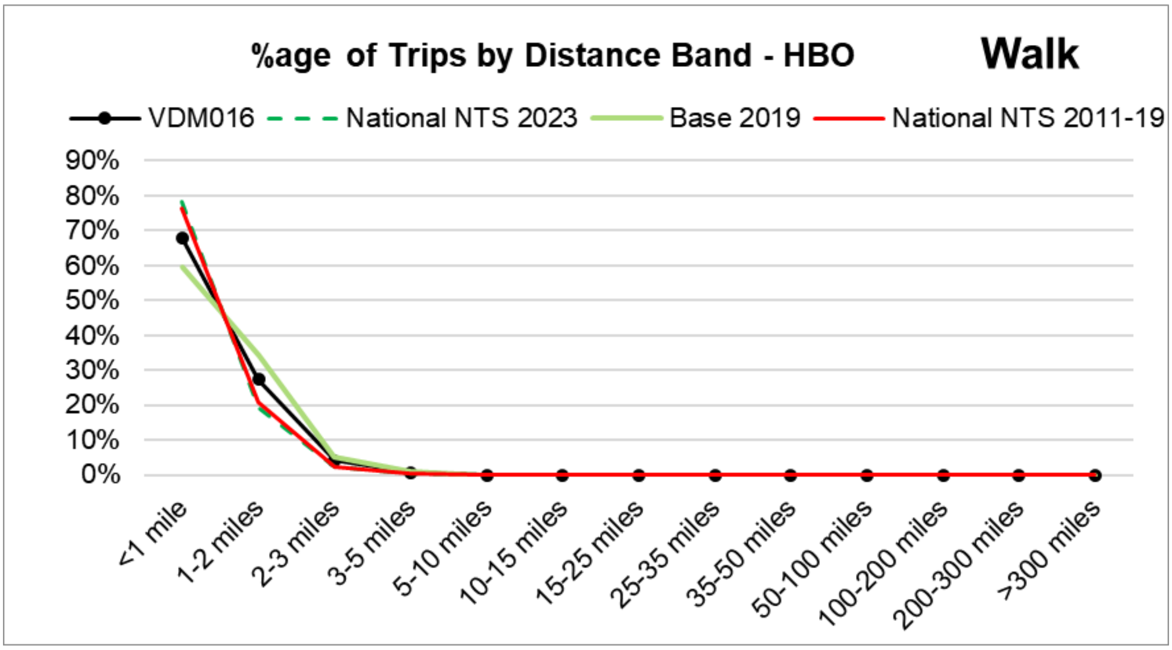


Figure 7-8 - Trip length distribution comparison for HBO cycle mode

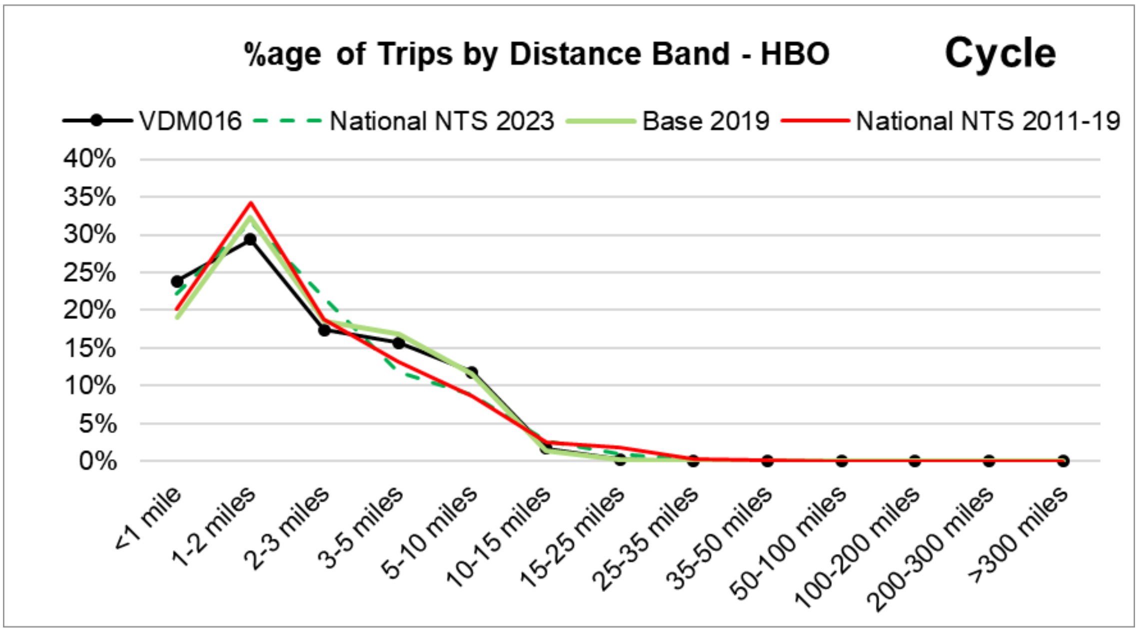


Figure 7-9 - Trip length distribution comparison for HBO bus mode

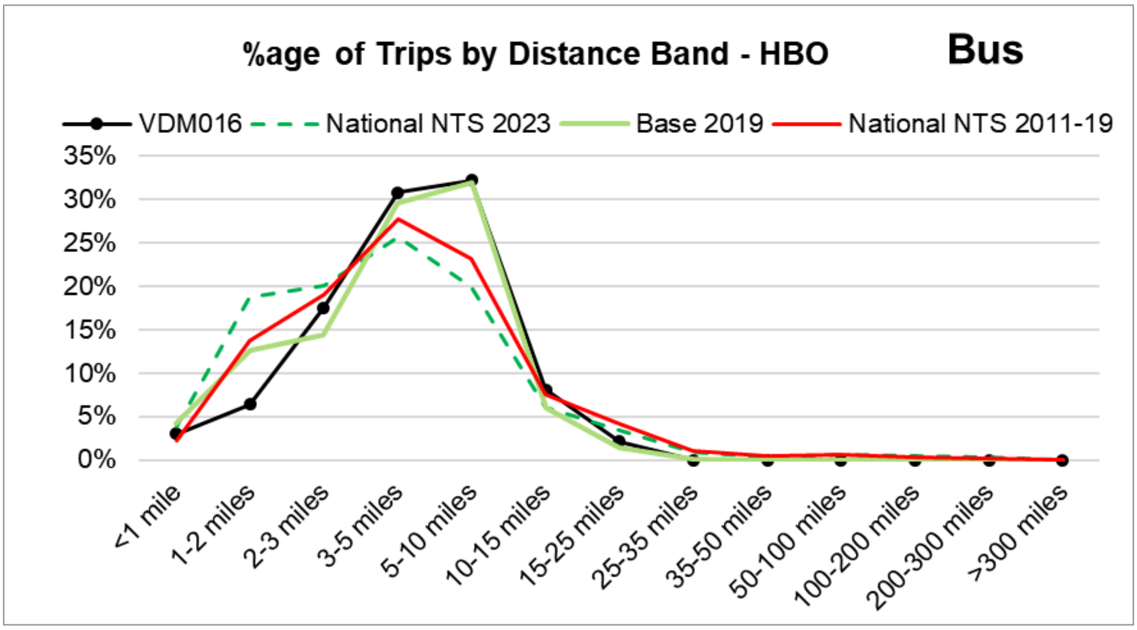
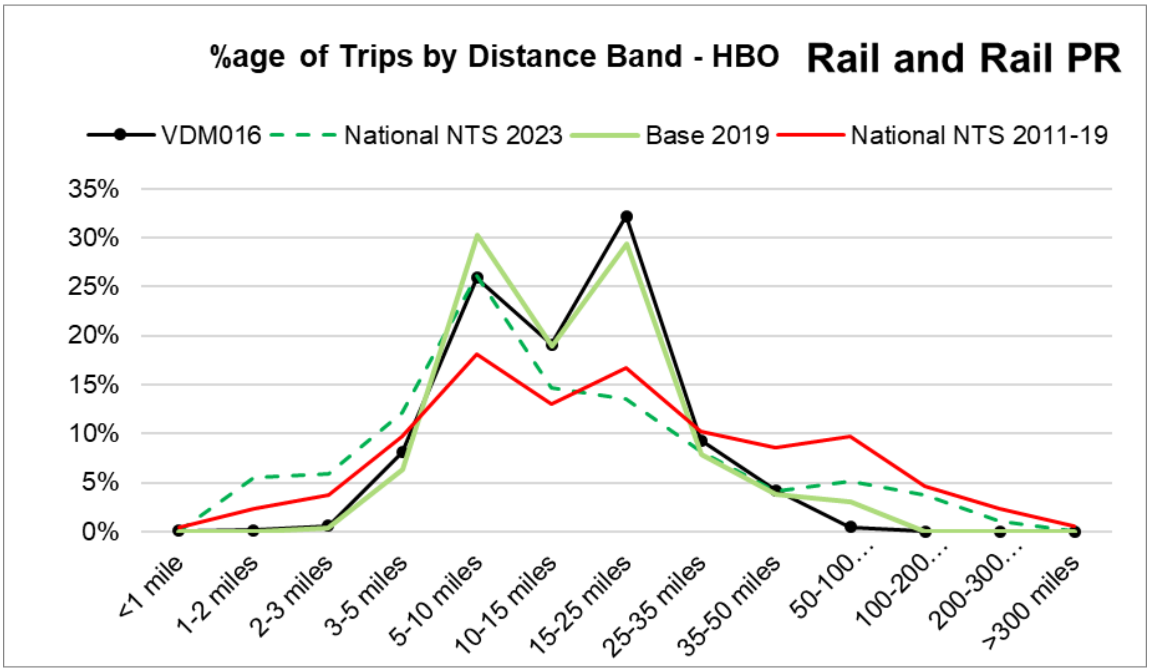


Figure 7-10 - Trip length distribution comparison for HBO rail and rail PR mode



7.4 VDM convergence

The BSTM2 PYV 2024 model converged with a maximum demand-supply gap value of 0.292% for HBW mode and destination choice and a weighted max gap across all choices of 0.113% after 4 iterations. VISUM provides %Gap values separately for individual choice models and hence the convergence is tested by ensuring that the gap values across the choice models for trip purposes is less than 0.2% as per TAG criteria. The gap statistics are shown in Table 7-5 by trip purpose.

Table 7-5 – BSTM2 PYV 2024: %Gap values by trip purpose

Purpose	Mode & Destination choice
HBW	0.29239
HBEB	0.17867
HBEd	0.07444
HBPS	0.05288
HBL	0.04247
NHBEB	0.07033
NHBO	0.04782

The variation between the penultimate and final iterations of the VDM is minimal. Table 7-6 provides a detailed comparison of the BSTM2 PYV 2024 outputs by trip purpose and mode, thereby demonstrating the marginal differences observed between the final two iterations.

Table 7-6 – BSTM2 PYV 2024: Change in trips penultimate and final Iteration of VDM, by purpose and mode

Purpose	BSTM2 PYV 2024				
	Car	PT	Cycle	Walk	Total
HBW	-0.003%	0.026%	-0.017%	-0.012%	0.000%
HBEB	0.002%	-0.001%	-0.002%	0.000%	0.000%
HBEd	0.002%	0.003%	-0.002%	-0.002%	0.000%
HBPS	0.000%	0.001%	-0.001%	-0.001%	0.000%
HBL	0.001%	-0.005%	-0.005%	-0.003%	0.000%
NHBEB	-0.001%	-0.003%	0.008%	0.002%	0.000%
NHBO	0.001%	-0.001%	-0.002%	-0.002%	0.000%
Total	0.000%	0.007%	-0.003%	-0.004%	0.000%

8. PY (2024) Validation – Highway Assignment Model

HAM validation involves comparing the model output data against an independent set of observed data to evaluate the accuracy of the calibrated model and confirm its suitability for forecasting purposes. Where the results highlighted inconsistencies between the model forecasts and observed data, matrix adjustments were applied to the assignment matrices using flow bundles tool in VISUM to address gaps in some O-D pairs. The difference between BSTM2 PYV 2024 HAM post-adjustment and prior-adjustment matrices will be added to the forecast year matrices to account for the HAM matrices adjustment made during present-year validation.

This section presents comparisons for pre-adjusted and post-adjusted matrices and the results for screenline validation, link flow validation, journey time validation and HAM convergence.

8.1 Matrix Adjustment Process

The matrix adjustment process was incorporated into the present-year validation to enhance HAM performance. It was carried out in VISUM for each AUC, producing updated matrices with percentage differences ranging from -0.26% to +0.75% compared to the initial HAM matrices generated after BSTM2 PYV 2024 VDM convergence. These adjustments improved compliance between modelled and observed traffic flows across links and screenlines. Table 8-1 presents the differences between the pre- and post-adjustment matrices. Overall, the net demand adjustments across all AUCs are minimal, ranging from -0.12% to +0.10% for the modelled time periods.

Table 8-1 – Matrix trip totals – pre- and post-adjustment (vehicles)

Time Period (Peak)	User Class	User Class Description	Prior Trips	Post Trips	Difference	Percentage Difference
AM	1	Car Commute	168,637	169,312	674	0.40%
	2	Car Business	25,660	25,837	177	0.69%
	3	Car Other	216,473	218,087	1,613	0.75%
	4	LGV	647,502	646,148	-1,354	-0.21%
	5	HGV	278,920	279,171	251	0.09%
IP	1	Car Commute	48,813	49,042	229	0.47%
	2	Car Business	17,974	18,052	78	0.43%
	3	Car Other	164,526	165,641	1,115	0.68%
	4	LGV	625,310	624,196	-1,114	-0.18%
	5	HGV	267,581	268,363	781	0.29%
PM	1	Car Commute	158,154	158,110	-44	-0.03%
	2	Car Business	25,760	25,819	60	0.23%
	3	Car Other	239,363	239,247	-116	-0.05%
	4	LGV	516,394	515,050	-1,344	-0.26%
	5	HGV	175,643	175,758	115	0.07%
AM	Total	Total	1,337,193	1,338,554	1,361	0.10%
IP	Total	Total	1,124,205	1,125,294	1,089	0.10%
PM	Total	Total	1,115,314	1,113,984	-1,329	-0.12%

Table 8-2 presents the regression statistics (i.e. R-square and slope values), demonstrating a strong correlation between the pre-adjustment and post-adjustment matrices at both the OD pair and trip-end levels.

Table 8-2 – Zonal values – regression statistics (all vehicles)

Measure	Test	Significance Criteria	AM	IP	PM
Matrix Zonal Cell Values	Intercept	Intercept near zero	0.0004	0.0003	-0.0004
	R-square	R-square in excess of 0.95	1.0000	1.0000	1.0000
	Slope	Slope within 0.98 and 1.02	1.0000	1.0000	1.0000
Matrix Zonal Trip Ends (Columns)	Intercept	Intercept near zero	0.3125	0.2210	-0.2866
	R-square	R-square in excess of 0.98	1.0000	1.0000	1.0000
	Slope	Slope within 0.99 and 1.01	1.0000	1.0001	0.9999
Matrix Zonal Trip Ends (Rows)	Intercept	Intercept near zero	0.3294	0.2325	-0.2810
	R-square	R-square in excess of 0.98	1.0000	1.0000	1.0000
	Slope	Slope within 0.99 and 1.01	0.9999	1.0001	0.9999

8.2 Comparison of BSTM2 2019 and BSTM2 2024 PYV matrices

Table 8-3 to Table 8-5 present the Full Modelled Area (FMA) HAM matrix totals by assignment user class (AUC) for BSTM2 BY 2019 and BSTM2 PYV 2024 (post adjustment) in the AM peak, Inter-peak, and PM peak hours respectively. Overall, car trips for commuting and business purposes decrease by approximately 2% to 5% between 2019 and 2024, consistent with trip rate adjustments indicated in Phase 1 report. LGV growth is reaching 12% while HGV growth is lower at around 3%.

Table 8-3 - Matrix totals: AM peak hour (08:00 to 09:00)

User Class	BSTM2 BY 2019	BSTM2 PYV 2024	% Change
Car - Commuting	172,349	169,312	-1.76%
Car - Business	27,195	25,837	-4.99%
Car - Other	209,350	218,087	4.17%
LGV	575,868	646,148	12.20%
HGV	271,645	279,171	2.77%
Total	**1,256,407**	**1,338,554**	**6.54%**

Table 8-4 - Matrix totals: IP average hour (10:00 to 16:00)

User Class	BSTM2 BY 2019	BSTM2 PYV 2024	% Change
Car - Commuting	50,147	49,042	-2.20%
Car - Business	18,870	18,052	-4.34%
Car - Other	159,315	165,641	3.97%
LGV	556,205	624,196	12.22%
HGV	260,616	268,363	2.97%
Total	**1,045,153**	**1,125,294**	**7.67%**

Table 8-5 - Matrix totals: PM peak hour (17:00 to 18:00)

User Class	BSTM2 BY 2019	BSTM2 PYV 2024	% Change
Car - Commuting	161,858	158,110	-2.32%
Car - Business	27,322	25,819	-5.50%
Car - Other	230,993	239,247	3.57%
LGV	459,155	515,050	12.17%
HGV	171,073	175,758	2.74%
Total	**1,050,401**	**1,113,985**	**6.05%**

8.3 Screenline Validation Results

Ten new cordons and screenlines were selected for the validation of the BSTM2 PYV 2024 as shown in Figure 8-1. As indicated in Chapter 7 of the BSTM2 HAM Model Development and Validation Report v2.0 (submitted on 28/02/2025), TAG guidance requires that more than 95% of modelled screenline traffic flows fall within 5% of the corresponding observed traffic flows.

In addition, GEH Statistic has also been considered in assessing the difference between the observed and modelled traffic flows on screenlines, although it is noted that this metric is no longer part of the TAG criteria. GEH values of 5 or below is considered as 'Near Pass' criteria indicating screenlines at are close to meeting the TAG requirement.

Figure 8-1 - BSTM2 PYV 2024 screenlines for validation

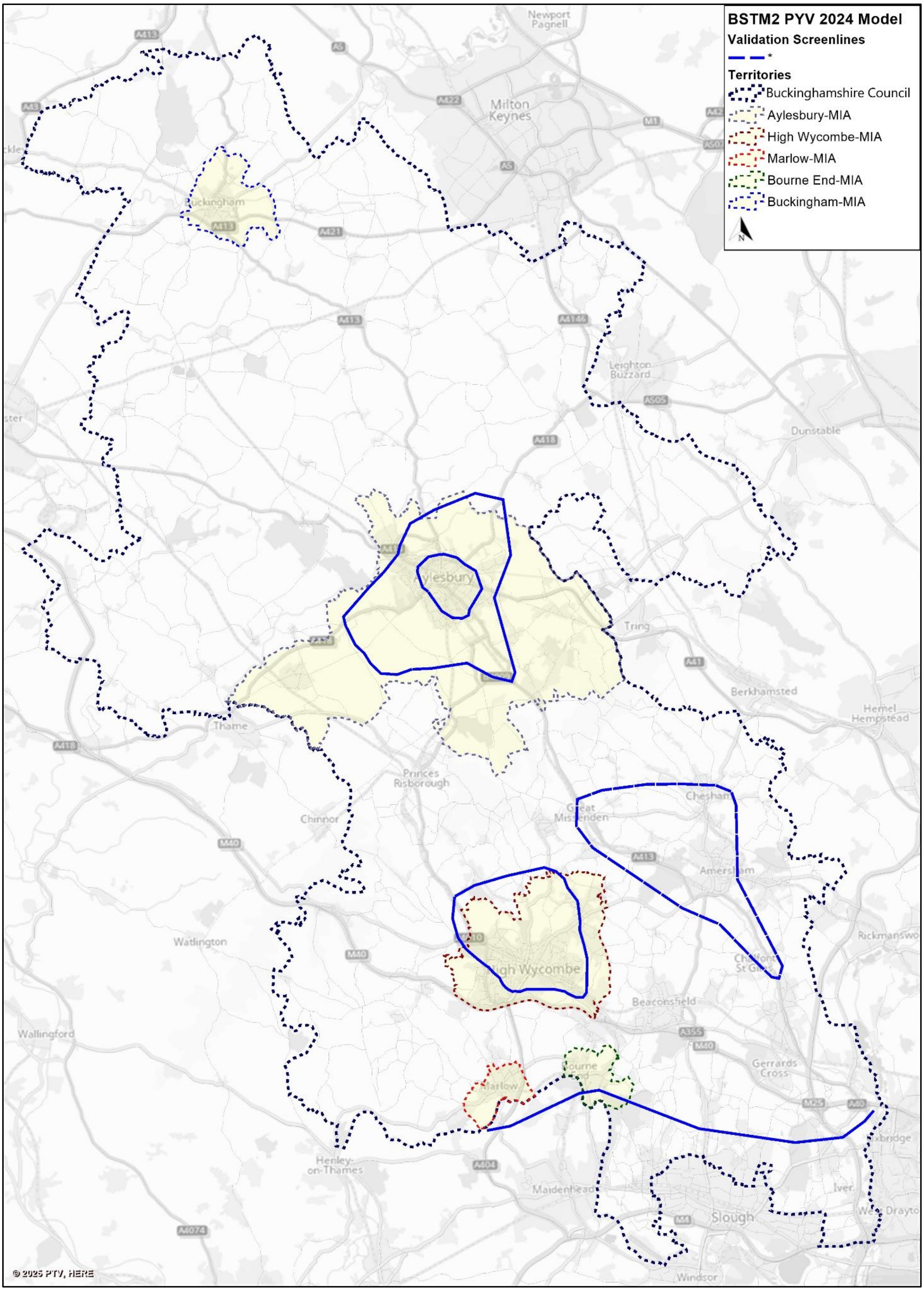


Table 8-6 to Table 8-8 show the screenline validation results for total vehicles for the AM, Inter-Peak and PM peak hours.

Table 8-6 - Screenline validation AM peak hour, total vehicles

Cordon / Screenline	Dir	No of Links	Observed	Modelled	Pass/Fail Criteria			
					Modelled - Observed	Flow Diff (%)	GEH	Pass, Near Pass or Fail
Aylesbury Inner	In	8	6141	6140	-1	-0.01%	0	Pass
Aylesbury Inner	Out	8	6387	6091	-296	-4.63%	4	Pass
High Wycombe Inner	In	9	6102	5757	-345	-5.65%	4	Near Pass
High Wycombe Inner	Out	9	6422	6327	-95	-1.49%	1	Pass
Aylesbury Outer	In	6	4252	4208	-44	-1.03%	1	Pass
Aylesbury Outer	Out	6	4377	4512	135	3.09%	2	Pass
Amersham	In	6	4680	4496	-184	-3.94%	3	Pass
Amersham	Out	6	4640	4618	-21	-0.46%	0	Pass
Marlow Uxbridge	NB	5	10675	10608	-68	-0.63%	1	Pass
Marlow Uxbridge	SB	5	10678	10616	-62	-0.58%	1	Pass

Table 8-7 - Screenline validation IP average hour, total vehicles

Cordon / Screenline	Dir	No of Links	Observed	Modelled	Pass/Fail Criteria			
					Modelled-Observed	Flow Diff (%)	GEH	Pass, Near Pass or Fail
Aylesbury Inner	In	8	5534	5389	-144	-2.61%	2	Pass
Aylesbury Inner	Out	8	5568	5270	-298	-5.36%	4	Near Pass
High Wycombe Inner	In	9	4549	4591	42	0.93%	1	Pass
High Wycombe Inner	Out	9	4667	4636	-31	-0.66%	0	Pass
Aylesbury Outer	In	6	3354	3269	-85	-2.52%	1	Pass
Aylesbury Outer	Out	6	3267	3212	-55	-1.69%	1	Pass
Amersham	In	6	3167	3202	35	1.09%	1	Pass
Amersham	Out	6	3260	3287	27	0.83%	0	Pass
Marlow Uxbridge	NB	5	9450	9289	-160	-1.70%	2	Pass
Marlow Uxbridge	SB	5	9200	9046	-154	-1.68%	2	Pass

Table 8-8 - Screenline validation PM peak hour, total vehicles

Cordon / Screenline	Dir	No of Links	Observed	Modelled	Pass/Fail Criteria			
					Modelled - Observed	Flow Diff (%)	GEH	Pass, Near Pass or Fail
Aylesbury Inner	In	8	7062	6631	-432	-6.11%	5	Near Pass
Aylesbury Inner	Out	8	5986	5812	-173	-2.89%	2	Pass
High Wycombe Inner	In	9	5869	5907	38	0.65%	0	Pass
High Wycombe Inner	Out	9	6068	5943	-125	-2.06%	2	Pass
Aylesbury Outer	In	6	5023	5001	-22	-0.44%	0	Pass
Aylesbury Outer	Out	6	4278	4191	-86	-2.02%	1	Pass
Amersham	In	6	4396	4415	19	0.44%	0	Pass
Amersham	Out	6	4572	4575	2	0.05%	0	Pass
Marlow Uxbridge	NB	5	11071	11158	87	0.79%	1	Pass
Marlow Uxbridge	SB	5	10412	10405	-7	-0.07%	0	Pass

Table 8-6 to Table 8-8 reveal that nine out of ten (90%) of screenlines have a modelled-observed flow difference of less than 5% for all AM, IP and PM peak hours indicating strong alignment with TAG criteria for the majority of screenlines. Although one screenline in each peak period - High Wycombe Inner (In) during the AM peak hour, Aylesbury Inner (Out) during the IP average hour, and Aylesbury Inner (In) during the PM peak hour - exceeds the 5% threshold, all three still satisfy the ‘Near Pass’ criterion based on GEH values. It is also noteworthy that four of the ten screenlines lie outside the Modelled Impact Areas (MIA), demonstrating that the model is performing well not only within the MIAs but also in the rest of Buckinghamshire.

Table 8-9 to Table 8-14 present the screenline validation for total vehicles and cars respectively in all MIAs.

Table 8-9 - Screenline validation AM peak hour by area, total vehicles

Area	Screenlines	AM Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	100%	100%	100%	100%
High Wycombe	2	50%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	90%	100%	100%	100%

Table 8-10 - Screenline validation IP average hour by area, total vehicles

Area	Screenlines	IP Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	75%	100%	100%	100%
High Wycombe	2	100%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	90%	100%	100%	100%

Table 8-11 - Screenline validation PM peak hour by area, total vehicles

Area	Screenlines	PM Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	75%	100%	100%	100%
High Wycombe	2	100%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	90%	100%	100%	100%

Table 8-12 - Screenline validation AM peak hour by area, cars

Area	Screenlines	AM Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	75%	100%	100%	100%
High Wycombe	2	50%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	80%	100%	100%	100%

Table 8-13 - Screenline validation IP average hour by area, cars

Area	Screenlines	IP Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	75%	100%	100%	100%
High Wycombe	2	100%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	90%	100%	100%	100%

Table 8-14 - Screenline validation PM peak hour by area, cars

Area	Screenlines	PM Peak - % Pass			
		Flow Diff <5.00%	Flow Diff <7.00%	Flow Diff <10%	GEH<5
Aylesbury	4	75%	100%	100%	100%
High Wycombe	2	100%	100%	100%	100%
Marlow	2	100%	100%	100%	100%
Outside MIA	2	100%	100%	100%	100%
BSTM2 PYV Area	10	90%	100%	100%	100%

Based on the tables above, all screenlines in Aylesbury, High Wycombe, Marlow, and those located outside the MIAs achieve a flow difference of less than 7% across all peak periods for both cars and total vehicles, indicating a strong level of model validation.

8.4 Link Flow Validation Results

The locations of the counts used for the link flow validation are shown in Figure 8-2. These locations were identified during Phase 1 based on the availability of suitable data. The link validation results for total vehicles and cars are summarised in Table 8-15 which presents the number of links meeting the TAG criteria. These criteria are as follows:

- Individual flows within 100 veh/h of counts for flows less than 700 veh/h;
- Individual flows within 15% of counts for flows from 700 to 2,700 veh/h;
- Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h; or
- GEH<5 for individual flows for at least 85% of count links.

Table 8-15 - Link validation (total vehicles and cars)

Vehicle type	AM peak hour	IP average hour	PM peak hour
Total vehicles (validation links)	94%	98%	95%
	(96 of 102)	(100 of 102)	(97 of 102)
Cars (validation links)	94%	98%	96%
	(96 of 102)	(100 of 102)	(98 of 102)

Figure 8-2 - Validation count locations

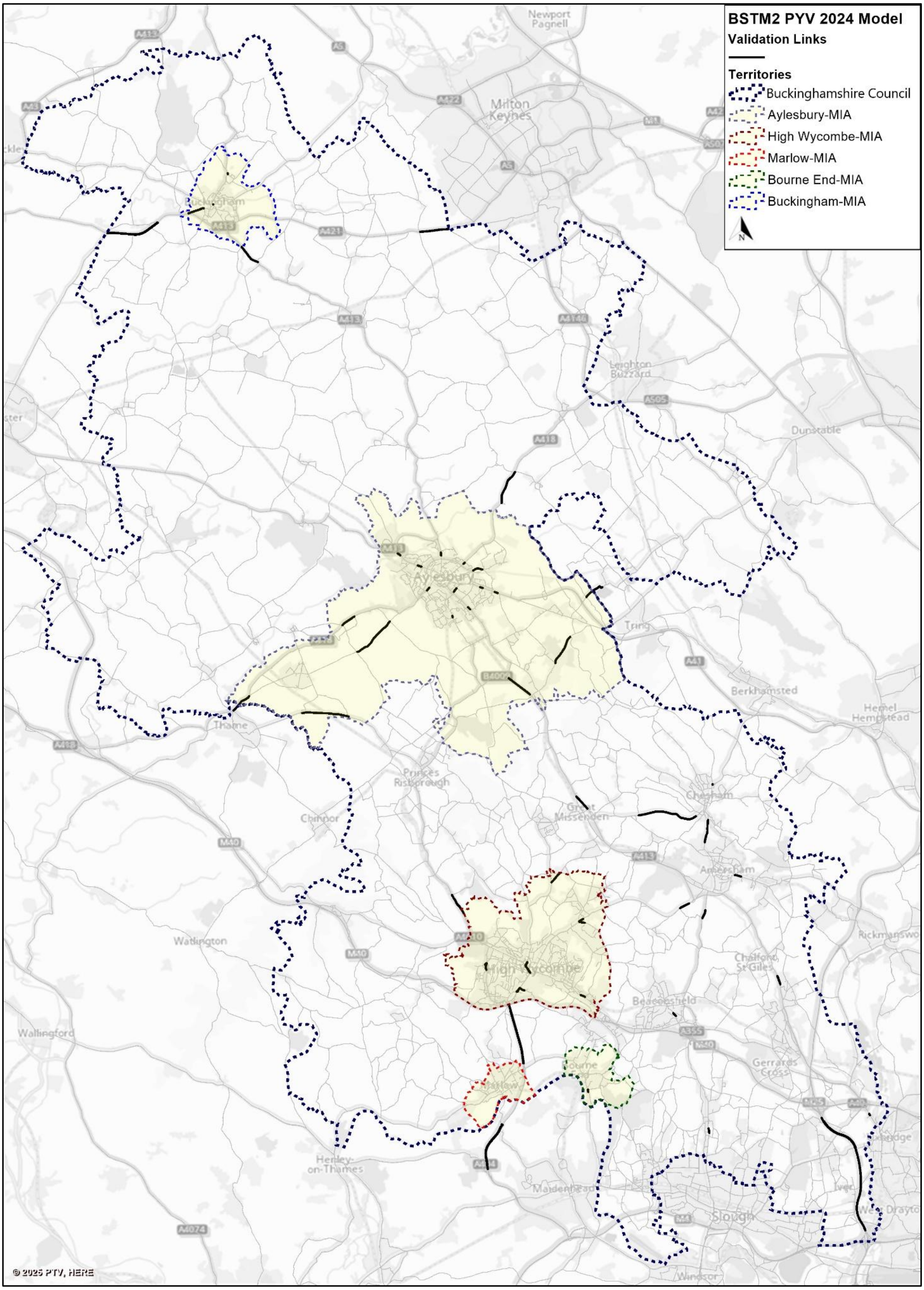


Table 8-16 and Table 8-17 show that 94%, 98% and 95% of links in the AoDM meet the TAG criteria for total vehicles and cars for the AM, Inter-Peak and PM peak hours, respectively. This is illustrated for total vehicles for AM, IP and PM in different MIAs in Figure 8-3 to Figure 8-14.

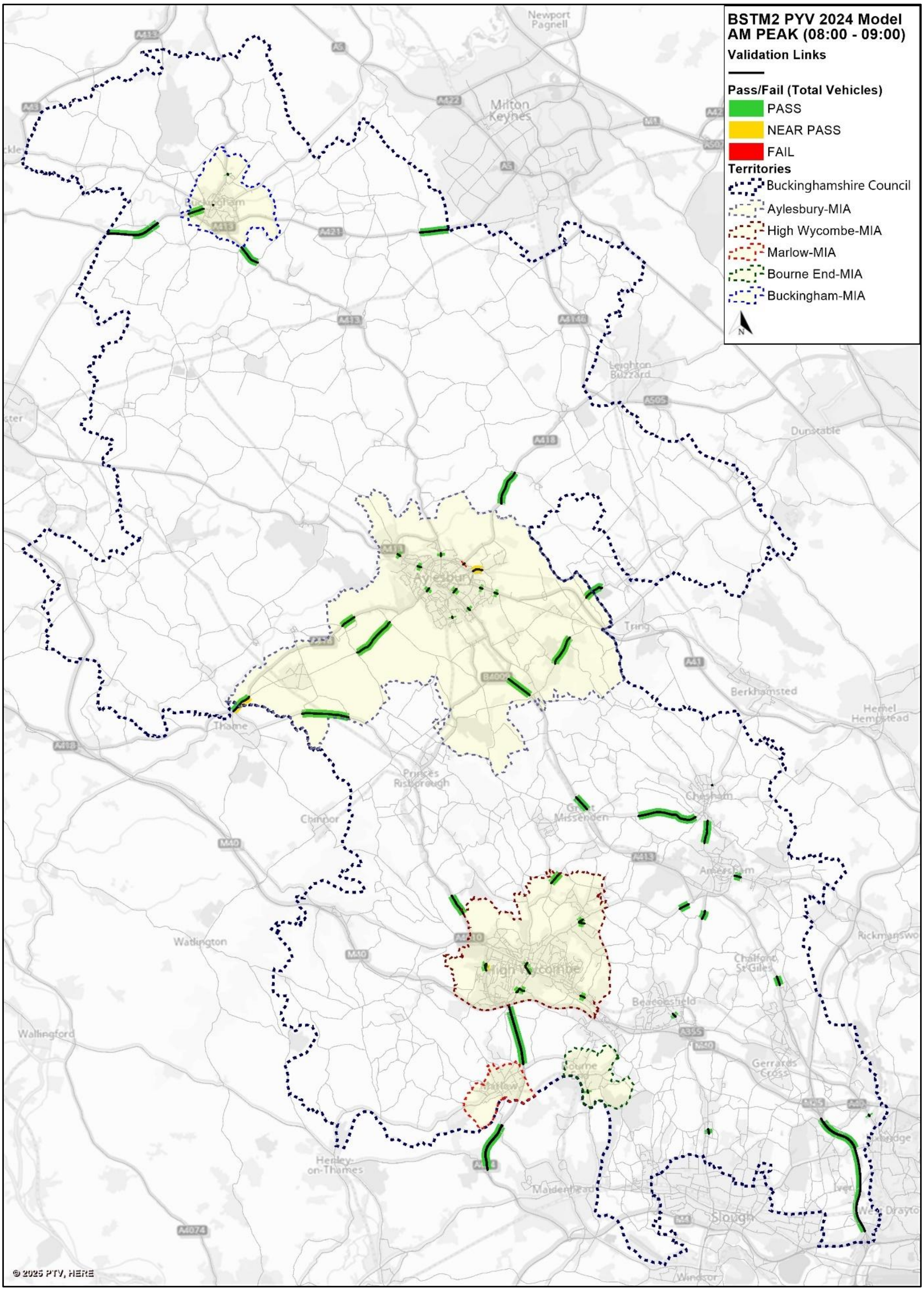
Table 8-16 - Link validation by area - total vehicles

Area	Counts	AM peak hour	IP average hour	PM peak hour
		GEH (<5) or Flow Diff		
Aylesbury	38	87%	97%	92%
High Wycombe	22	95%	95%	100%
Marlow	2	100%	100%	100%
Bourne End	2	100%	100%	100%
Buckingham	10	100%	100%	100%
Outside MIA	28	100%	100%	93%
BSTM2 PYV Area	102	94%	98%	95%

Table 8-17 - Link validation by area - cars

Area	Counts	AM peak hour	IP average hour	PM peak hour
		GEH (<5) or Flow Diff		
Aylesbury	38	87%	97%	92%
High Wycombe	22	95%	95%	100%
Marlow	2	100%	100%	100%
Bourne End	2	100%	100%	100%
Buckingham	10	100%	100%	100%
Outside MIA	28	100%	100%	96%
BSTM2 PYV Area	102	94%	98%	96%

Figure 8-3 - Link flow validation AM peak hour – total vehicles - model extent



Note: a GEH value > 5 and <= 7.5 is classified as a 'Near Pass' for Link Flow validation, indicating links that are close to meeting the TAG requirement.

Figure 8-4 - Link flow validation AM peak hour – total vehicles - Aylesbury

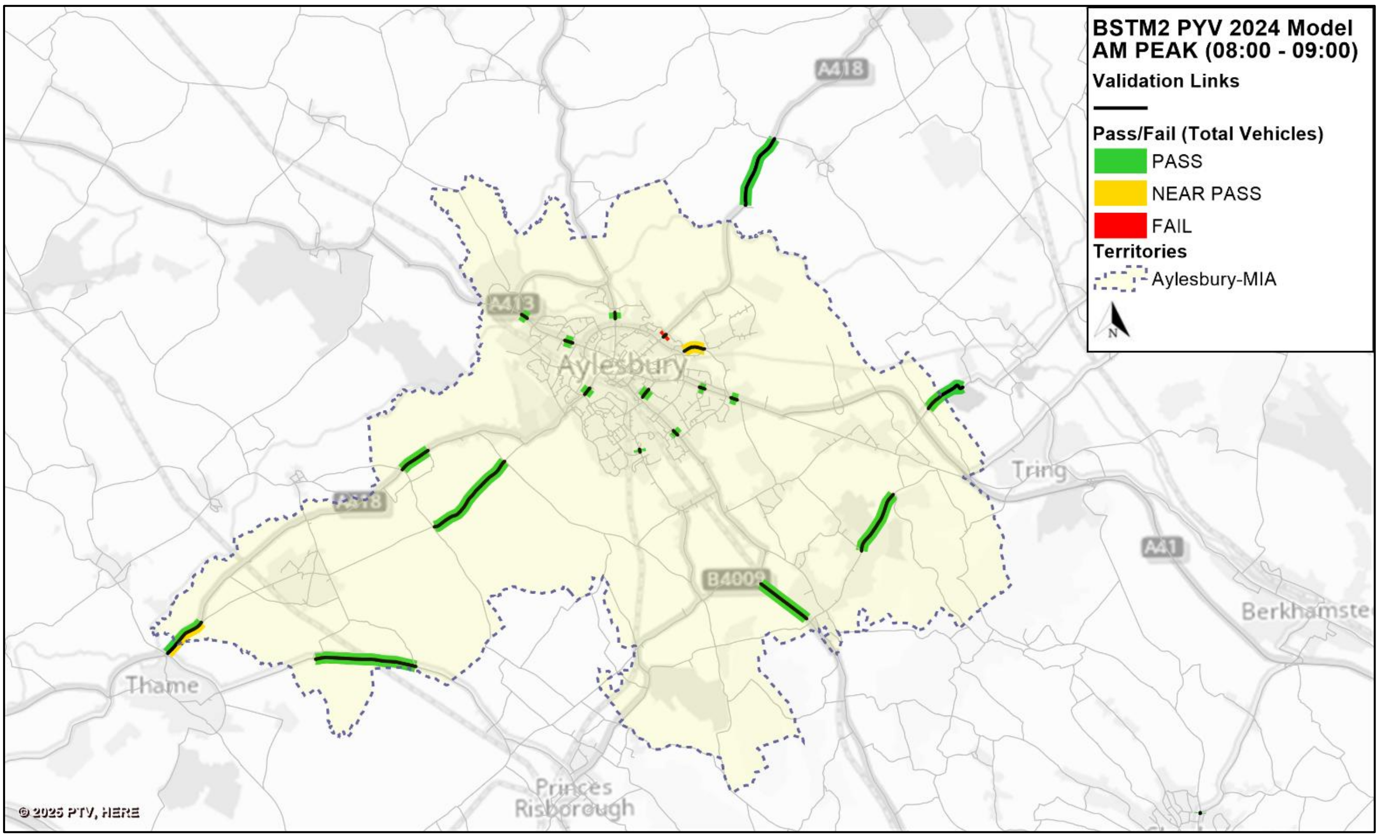


Figure 8-5 - Link flow validation AM peak hour – total vehicles - High Wycombe, Marlow and Bourne End

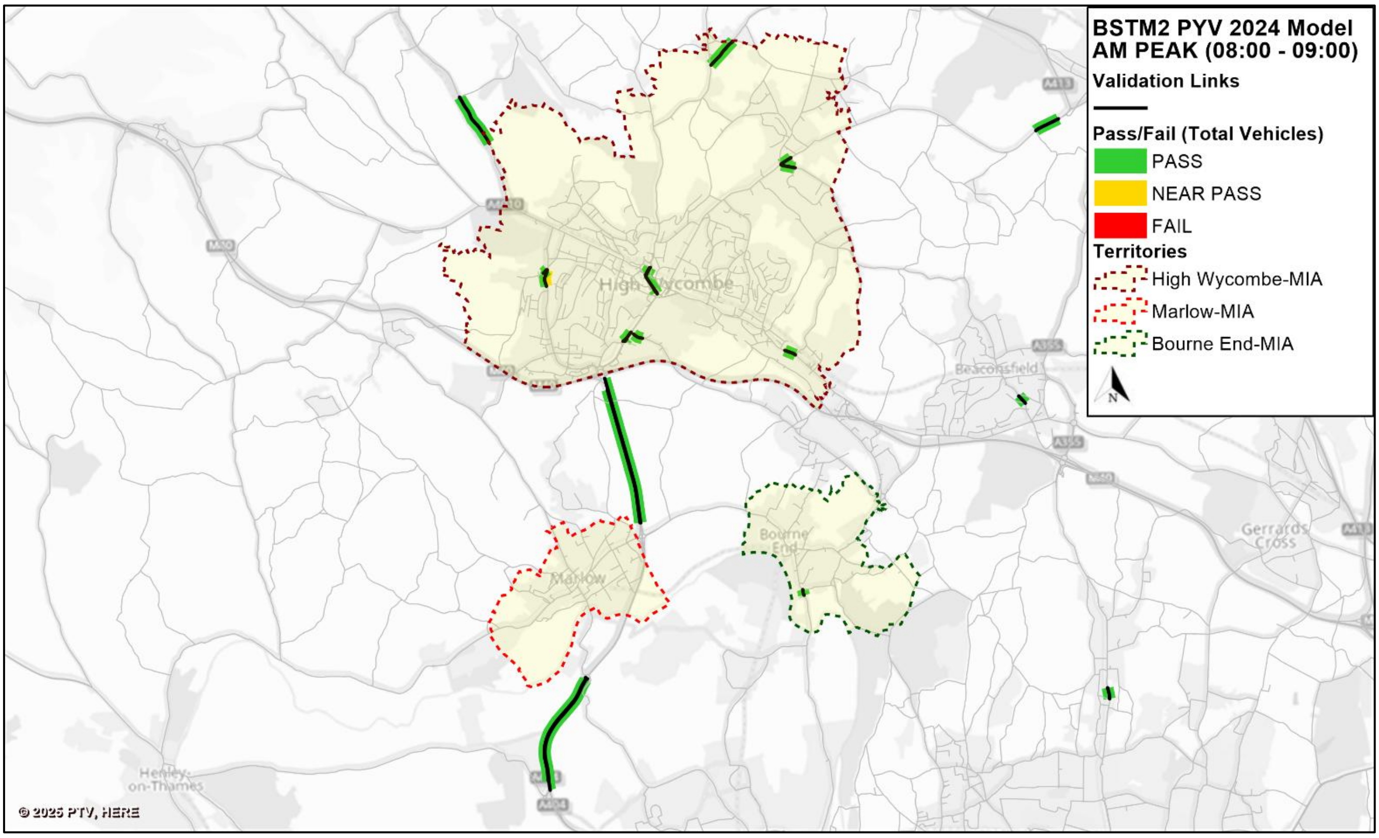


Figure 8-6 - Link flow validation AM peak hour – total vehicles - Buckingham

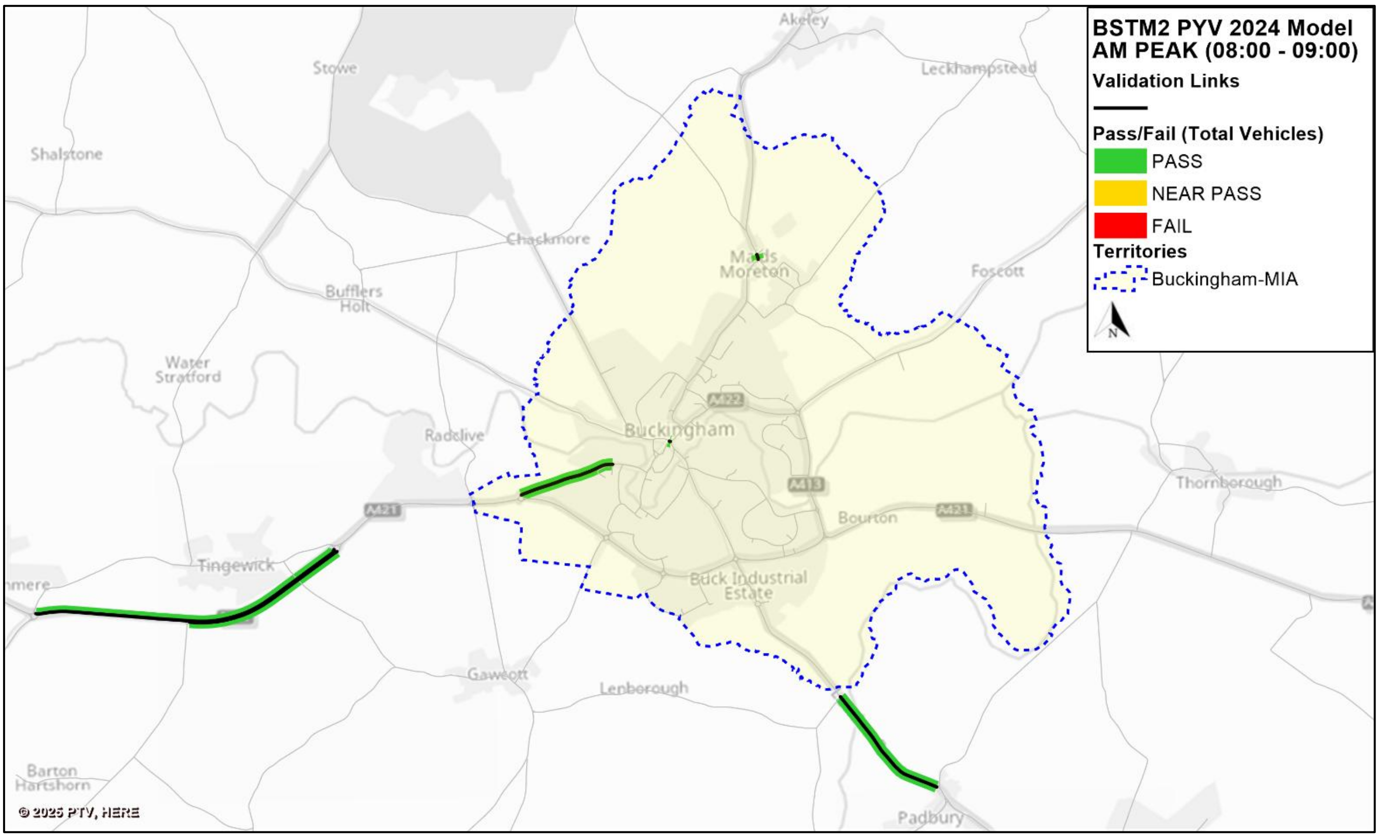


Figure 8-7 - Link flow validation IP average hour – total vehicles - model extent

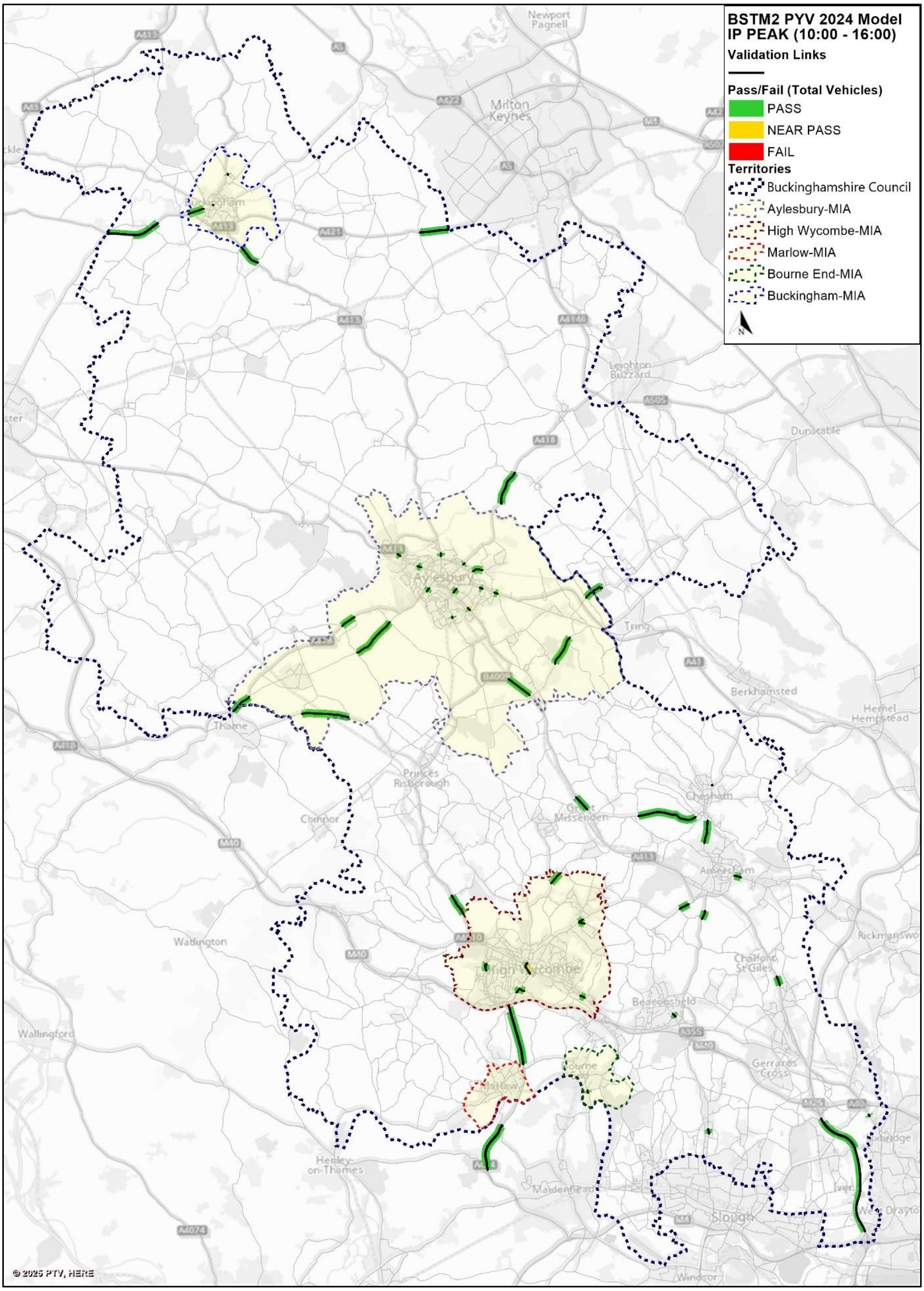


Figure 8-8 - Link flow validation IP average hour – total vehicles - Aylesbury

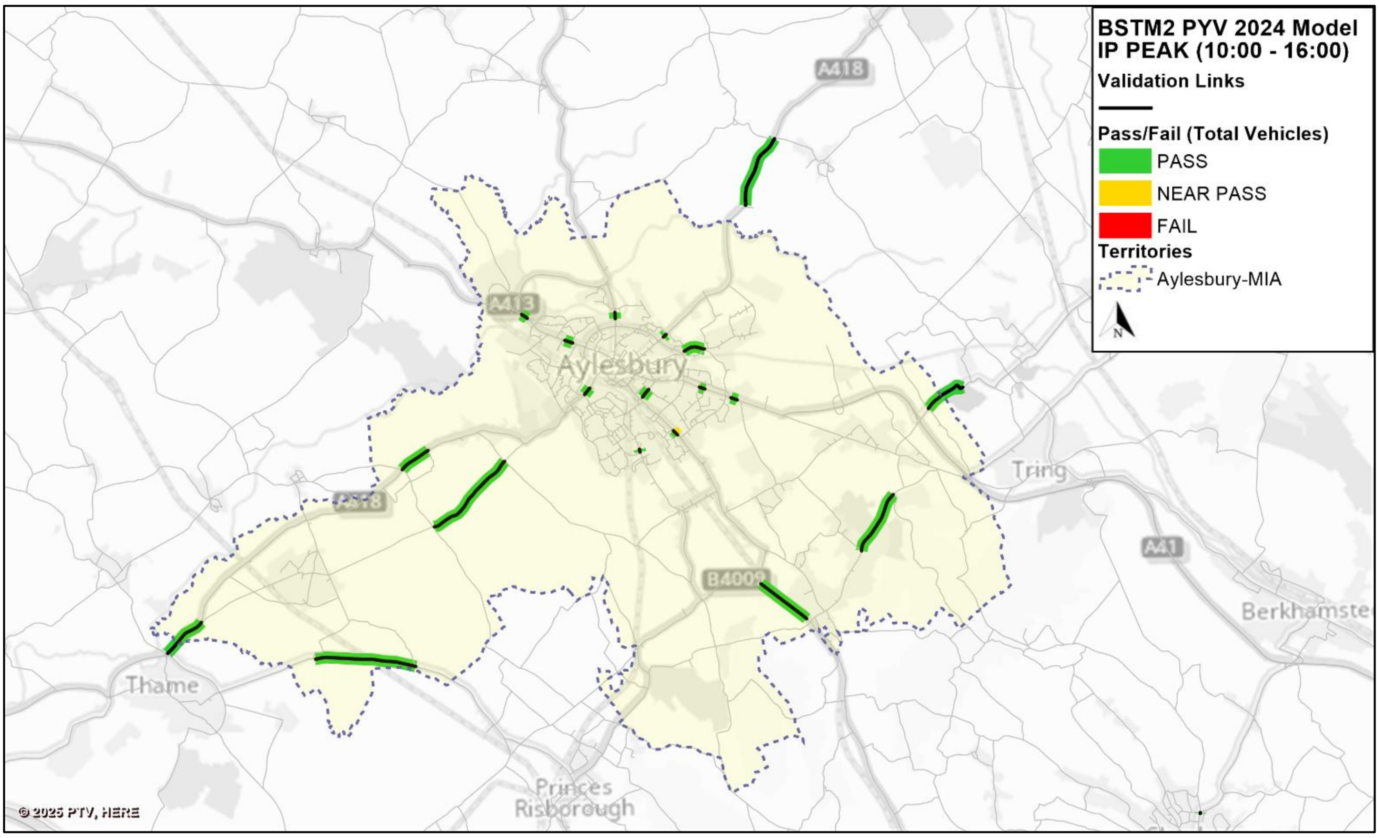


Figure 8-9 - Link flow validation IP average hour – total vehicles - High Wycombe, Marlow and Bourne End

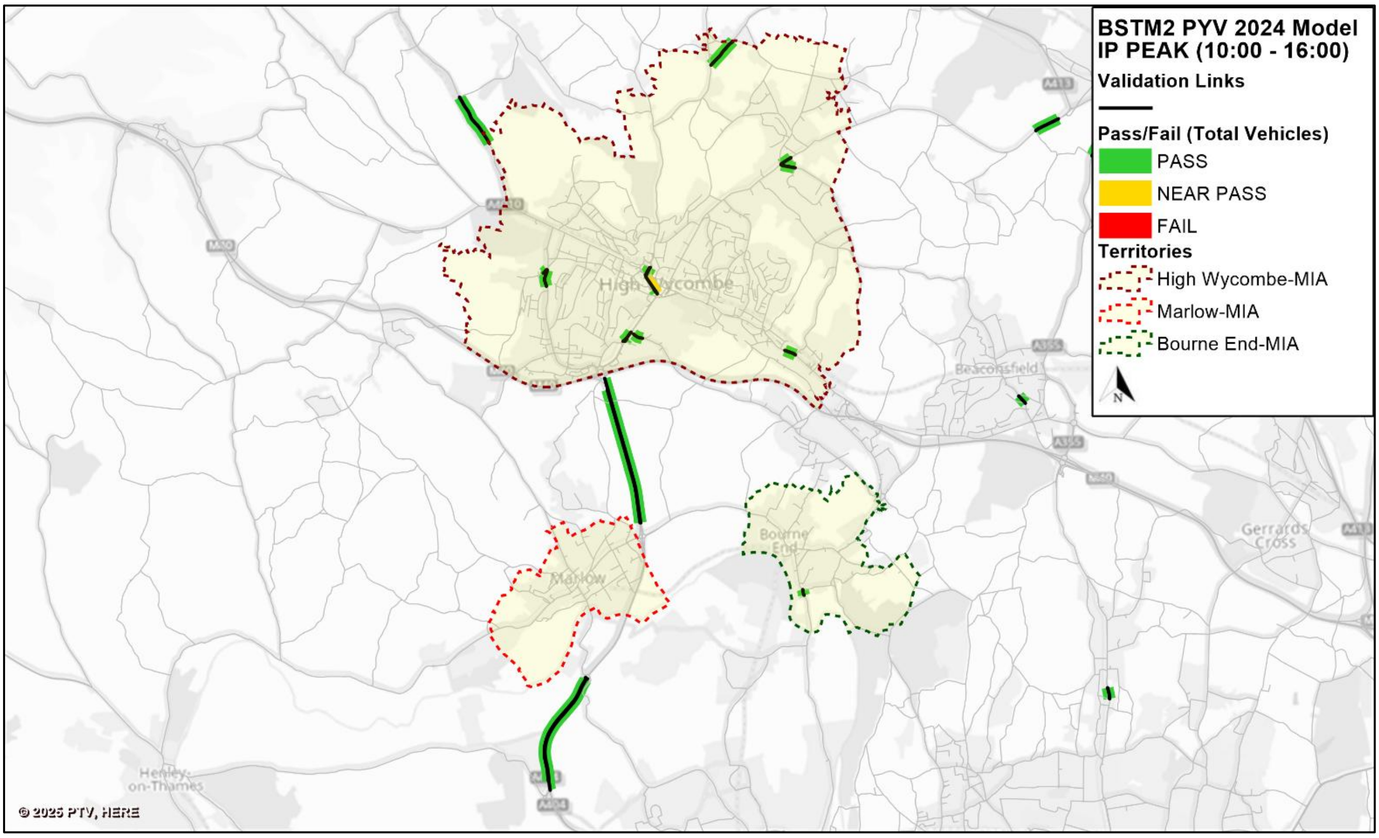


Figure 8-10 - Link flow validation IP average hour – total vehicles - Buckingham

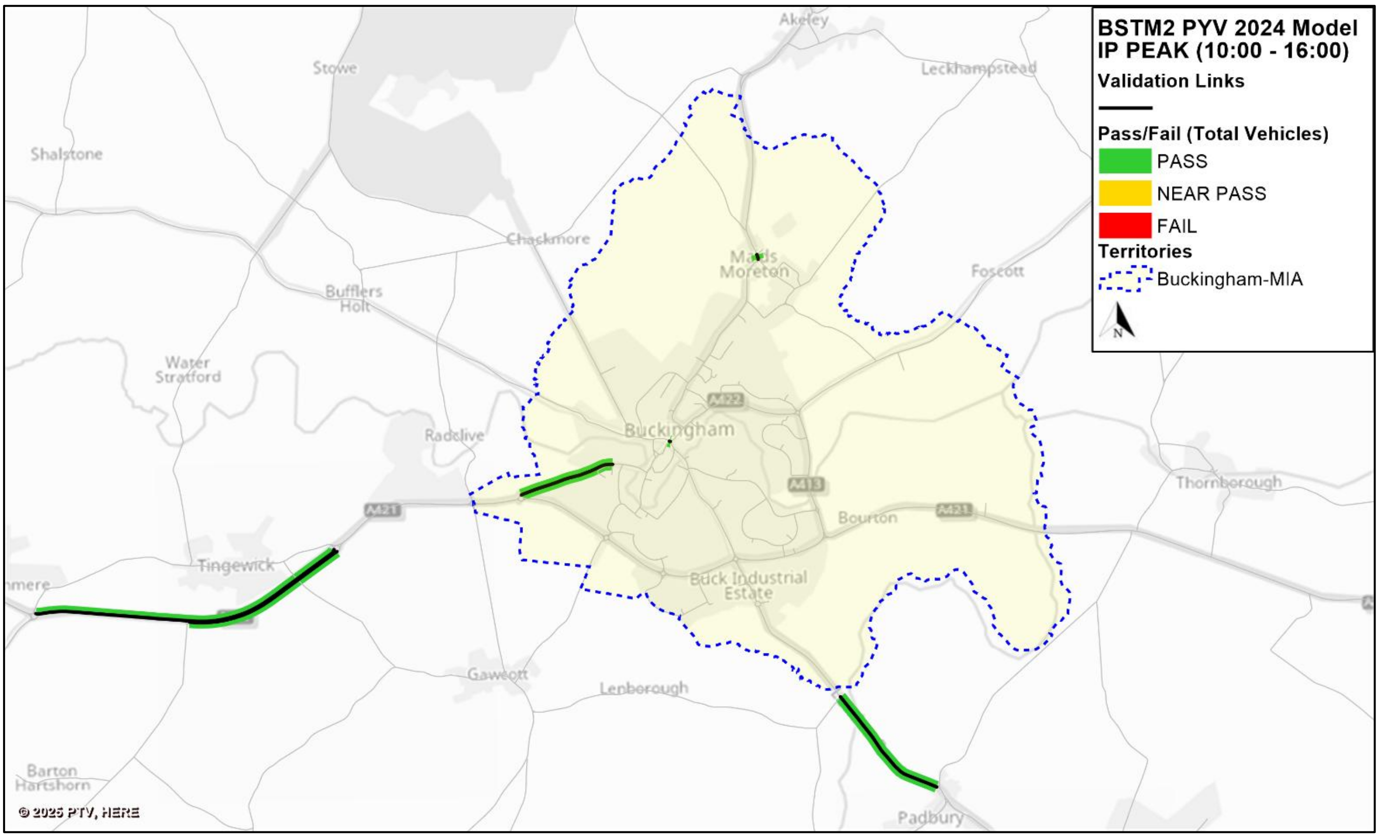


Figure 8-11 - Link flow validation PM peak hour – total vehicles - model extent

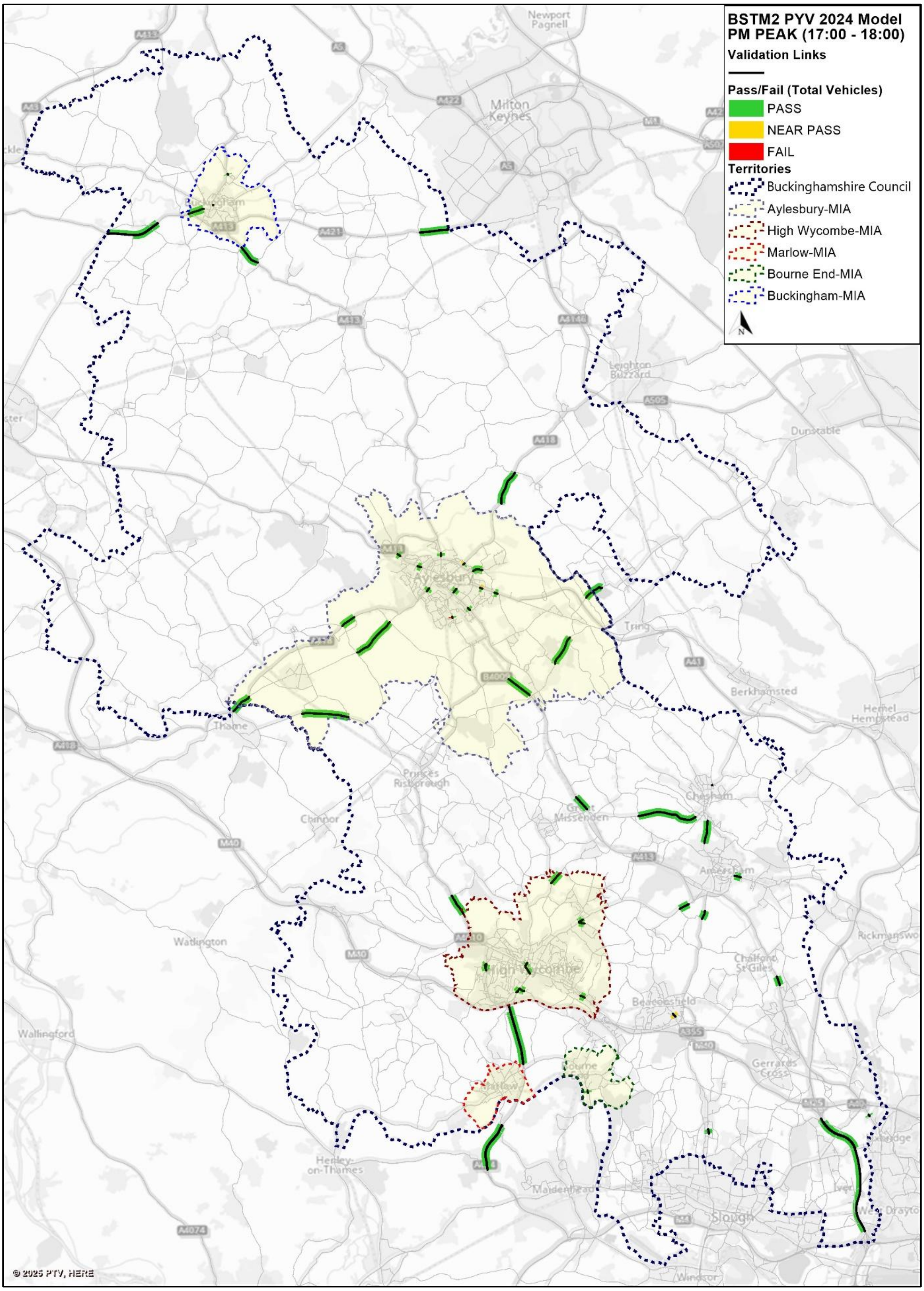


Figure 8-12 - Link flow validation PM peak hour – total vehicles - Aylesbury

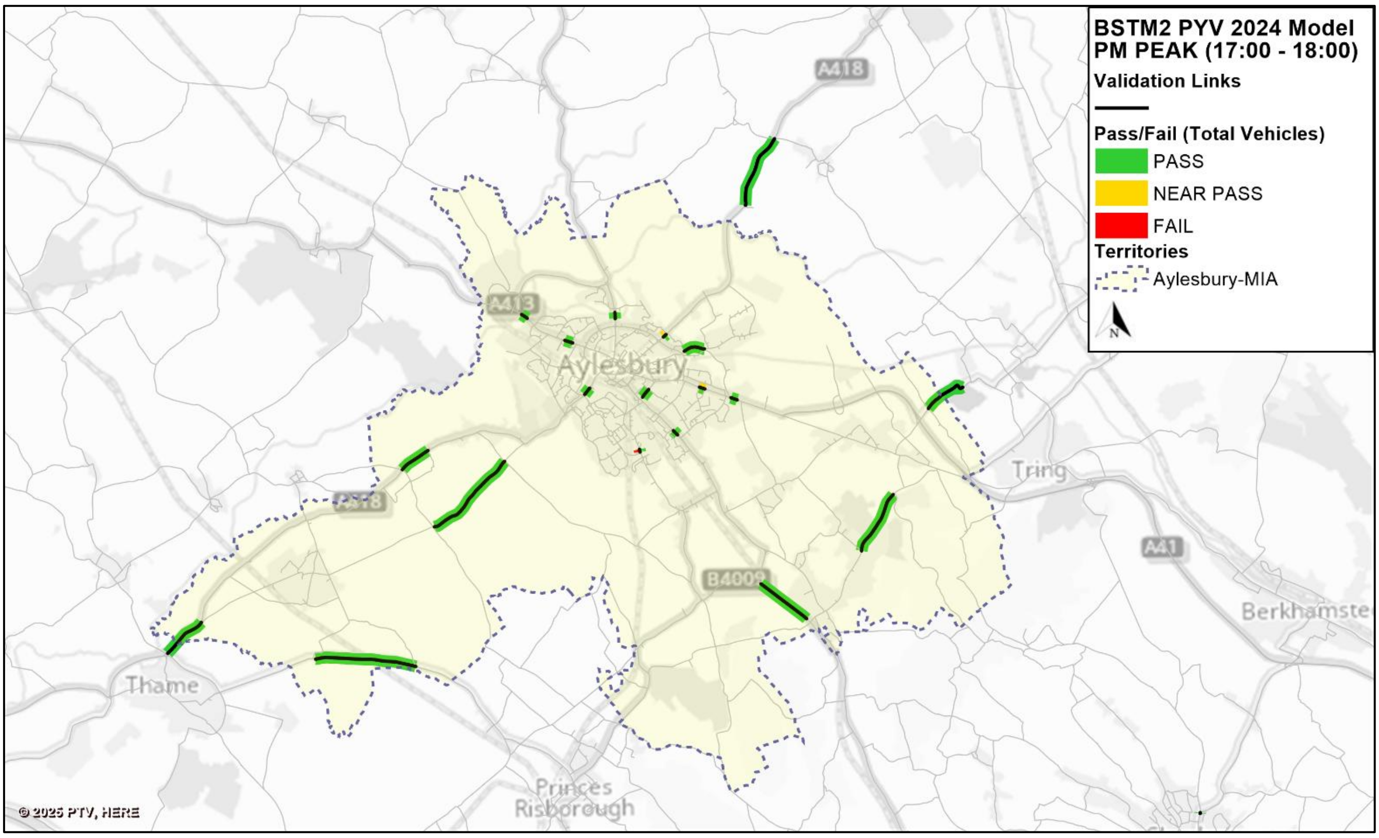


Figure 8-13 - Link flow validation PM peak hour – total vehicles - High Wycombe, Marlow and Bourne End

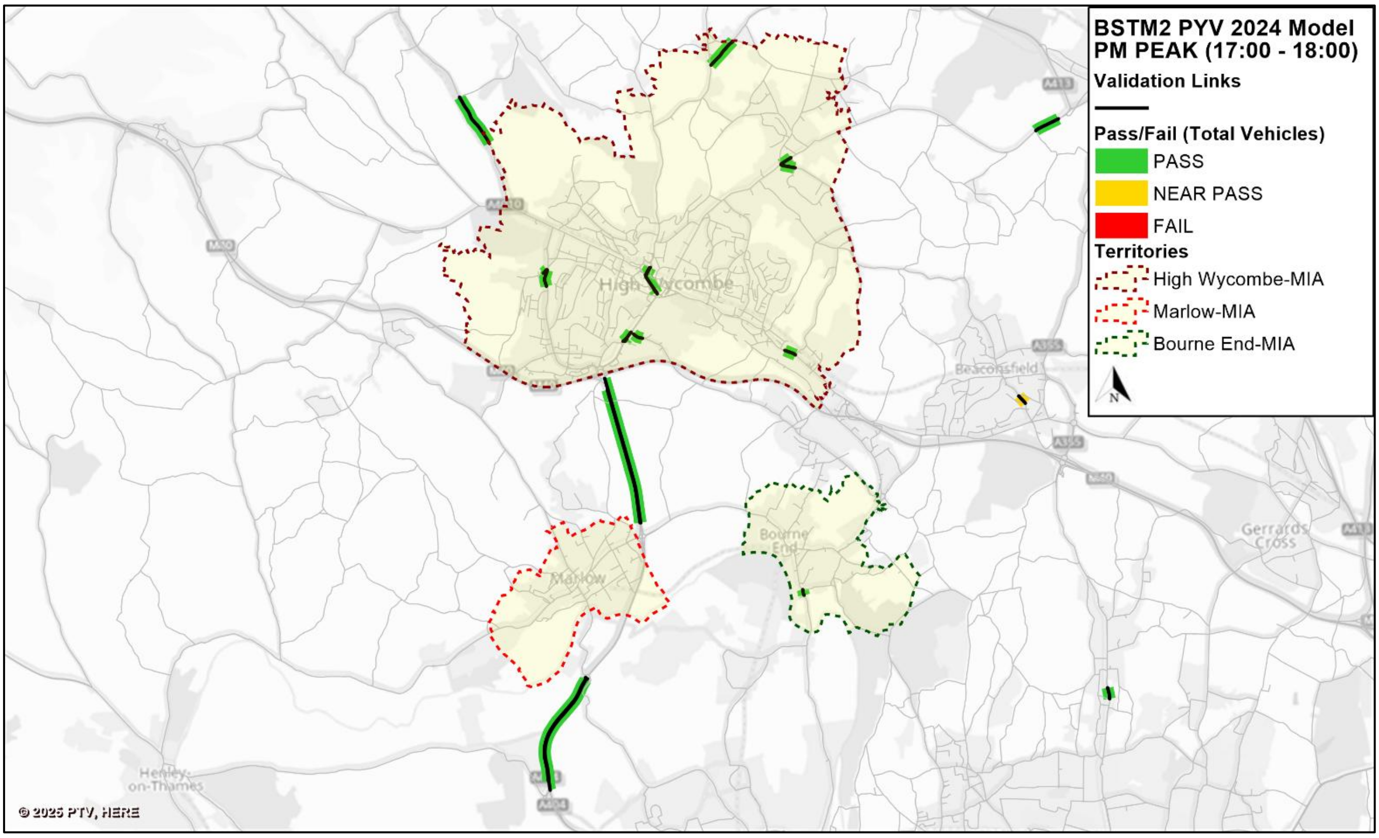
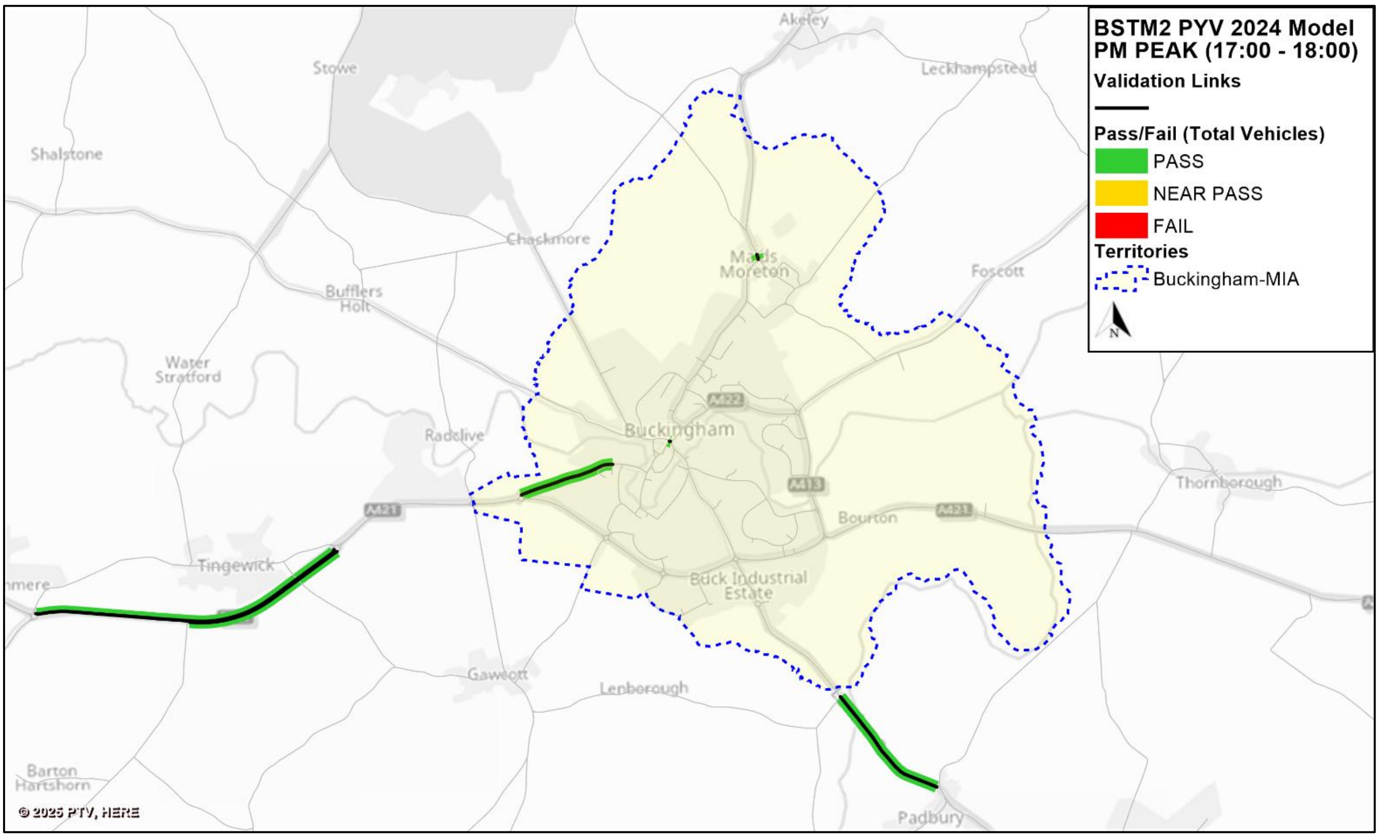


Figure 8-14 - Link flow validation PM peak hour – total vehicles - Buckingham



8.5 Journey time Validation Results

Journey time validation was conducted to ensure that travel times and delays along links and junctions within the MIAs are accurately reflected in the model. This validation involved comparing modelled journey times with observed data collected along 40 survey routes (in both directions). Figure 8-15 shows various journey routes considered for validation in BSTM2 PYV 2024.

As indicated in Chapter 7 of the BSTM2 HAM Model Development and Validation Report v2.0 (submitted on 28/02/2025), TAG guidance requires >85% of model journey time routes to be within 15% or 1 minute from surveyed journey times. However, a deviation of less than 20% is treated as a 'Near Pass' to indicate journey routes that are close to meeting the TAG criterion. A summary of the journey time validation including both the primary TAG compliance and the extended 'Near Pass' results for each time period is presented in Table 8-18.

Table 8-18 - Journey time validation

	AM peak hour	IP average hour	PM peak hour
Total **(TAG criterion)**	88% (35 out of 40)	93% (37 out of 40)	88% (35 out of 40)
Total (including Near Pass)	93% (37 out of 40)	100% (40 out of 40)	93% (37 out of 40)

Figure 8-15 - Journey time routes in BSTM2 PYV 2024

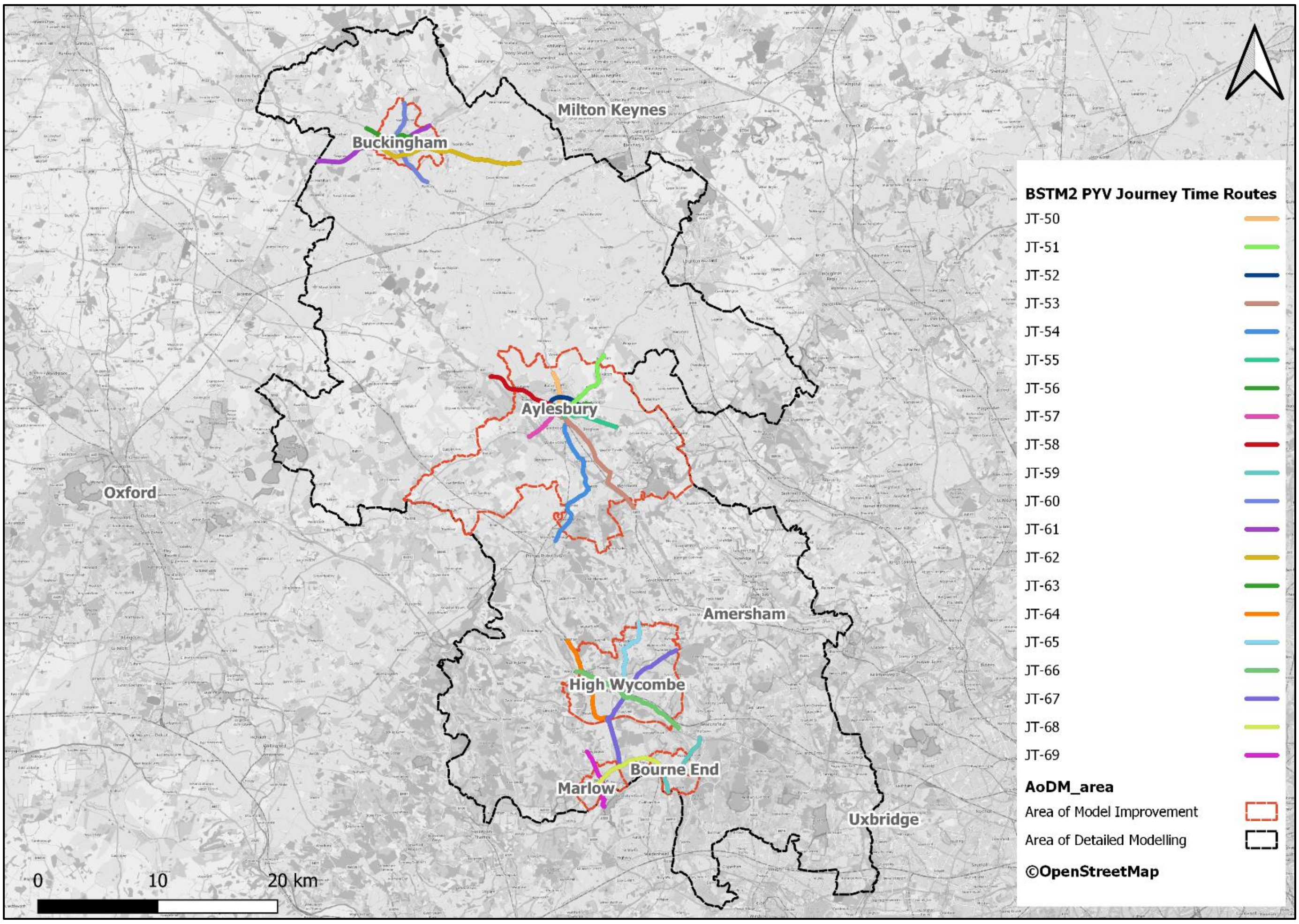


Table 8-19 shows that 88%, 93% and 88% of the journey time routes for the AM, Inter-Peak and PM peak hours respectively have modelled times within 15% or 60-seconds of surveyed times. This meets the TAG criterion that requiring at least 85% of routes to fall within this threshold demonstrating a high level of journey time validation. In addition, the 'Near Pass' assessment shows overall passing rates of 90%, 100%, and 93% for the AM, Inter-Peak, and PM peak hours respectively. A summary of the journey time validation for each time period in each MIA is shown in Table 8-19.

Table 8-19 - Journey time validation by area

Area of model Improvement	No. of Routes	AM peak hour		IP average hour		PM peak hour	
		%Pass	%Near Pass	%Pass	%Near Pass	%Pass	%Near Pass
Aylesbury	18	78%	83%	100%	100%	83%	89%
High Wycombe	8	88%	100%	88%	100%	88%	88%
Marlow	4	100%	100%	50%	100%	100%	100%
Bourne End	2	100%	100%	100%	100%	100%	100%
Buckingham	8	100%	100%	100%	100%	88%	100%
BSTM2 PYV Area	40	88%	93%	93%	100%	88%	93%

AtkinsRéalis - Baseline / Référence

The following observation can be made from Table 8-19 with full details of all 40 routes found in Appendix A:

- High Wycombe, Bourne End and Buckingham all achieve a very high level of journey time validation.
- Aylesbury shows a good level of journey time validation where one route that is close to passing in the AM peak hour would increase the validation level from 78% to 83%, bringing it nearer to the TAG criterion of 85%. Similarly, in the PM peak hour, one near-pass route would raise the validation level from 83% to 89%.
- In Marlow, two routes that are close to passing in the IP average hour would increase the validation level to 100%.

Overall, these results indicate that a high standard of journey time validation has been achieved within the MIAs.

Figure 8-16 to Figure 8-18 illustrate the validation results for individual routes and demonstrate how the model compares with observed journey times across the different time periods.

AtkinsRéalis - Baseline / Référence

Figure 8-16 - Journey Time Validation - AM Peak

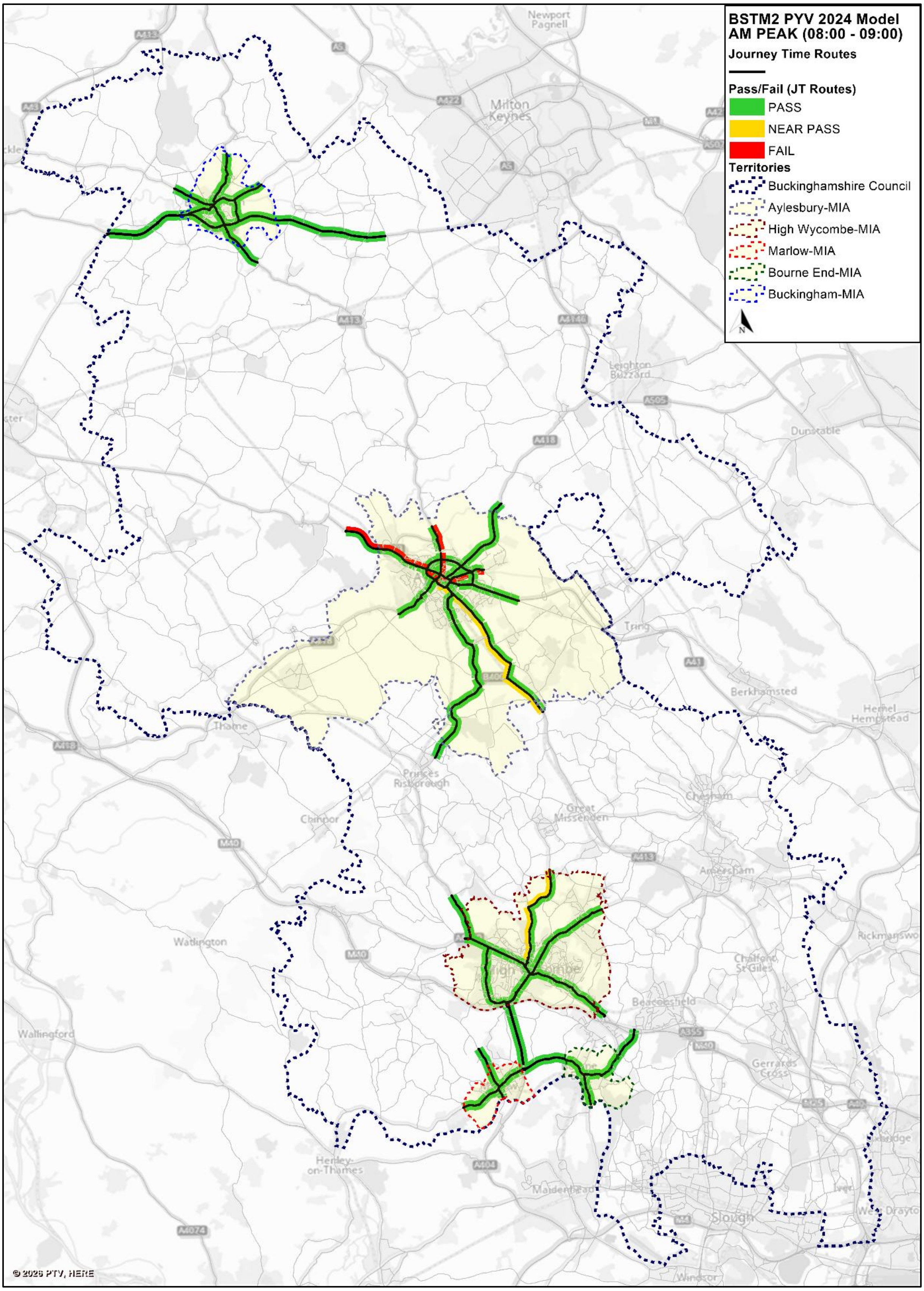


Figure 8-17 - Journey Time Validation - IP Peak

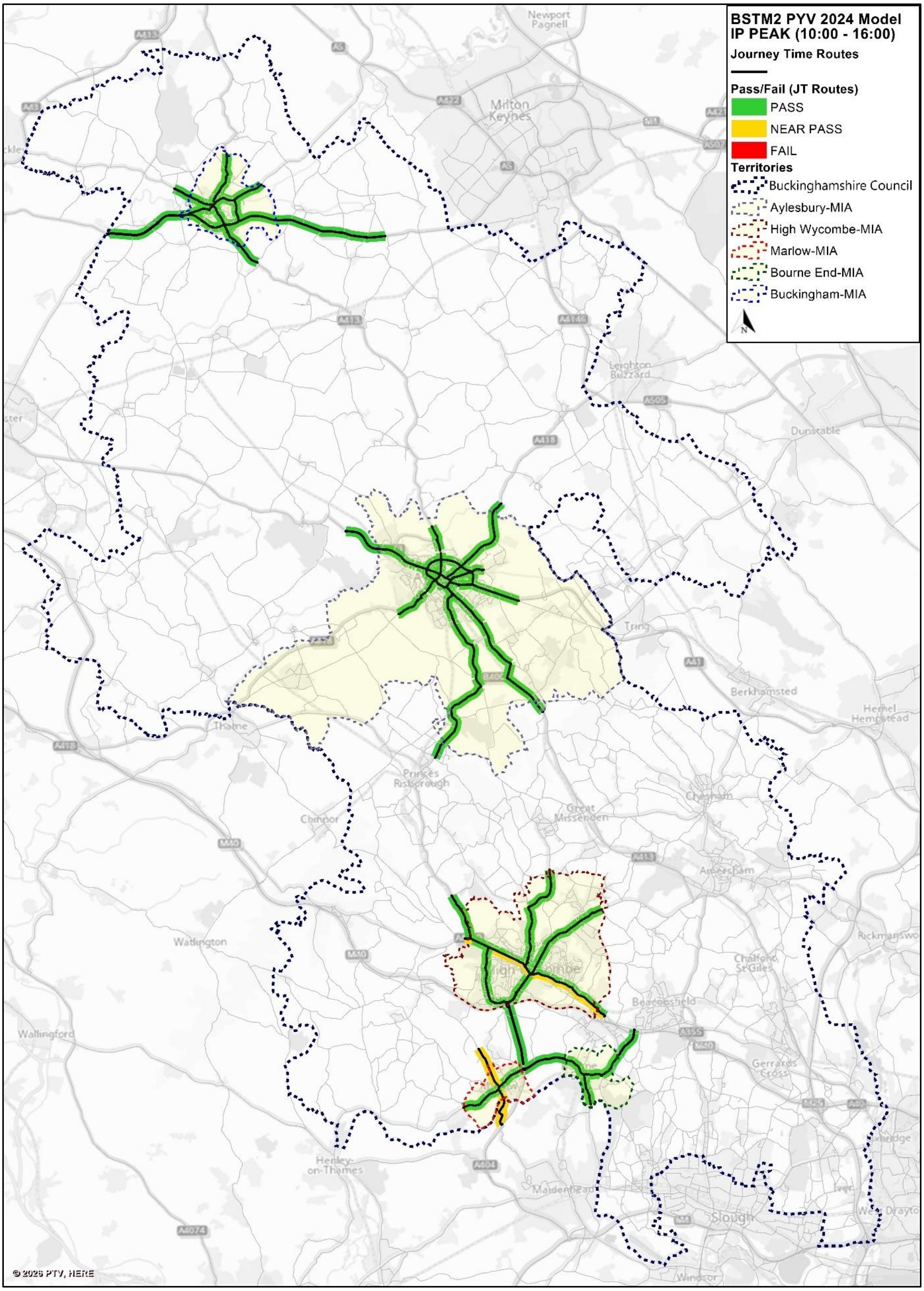
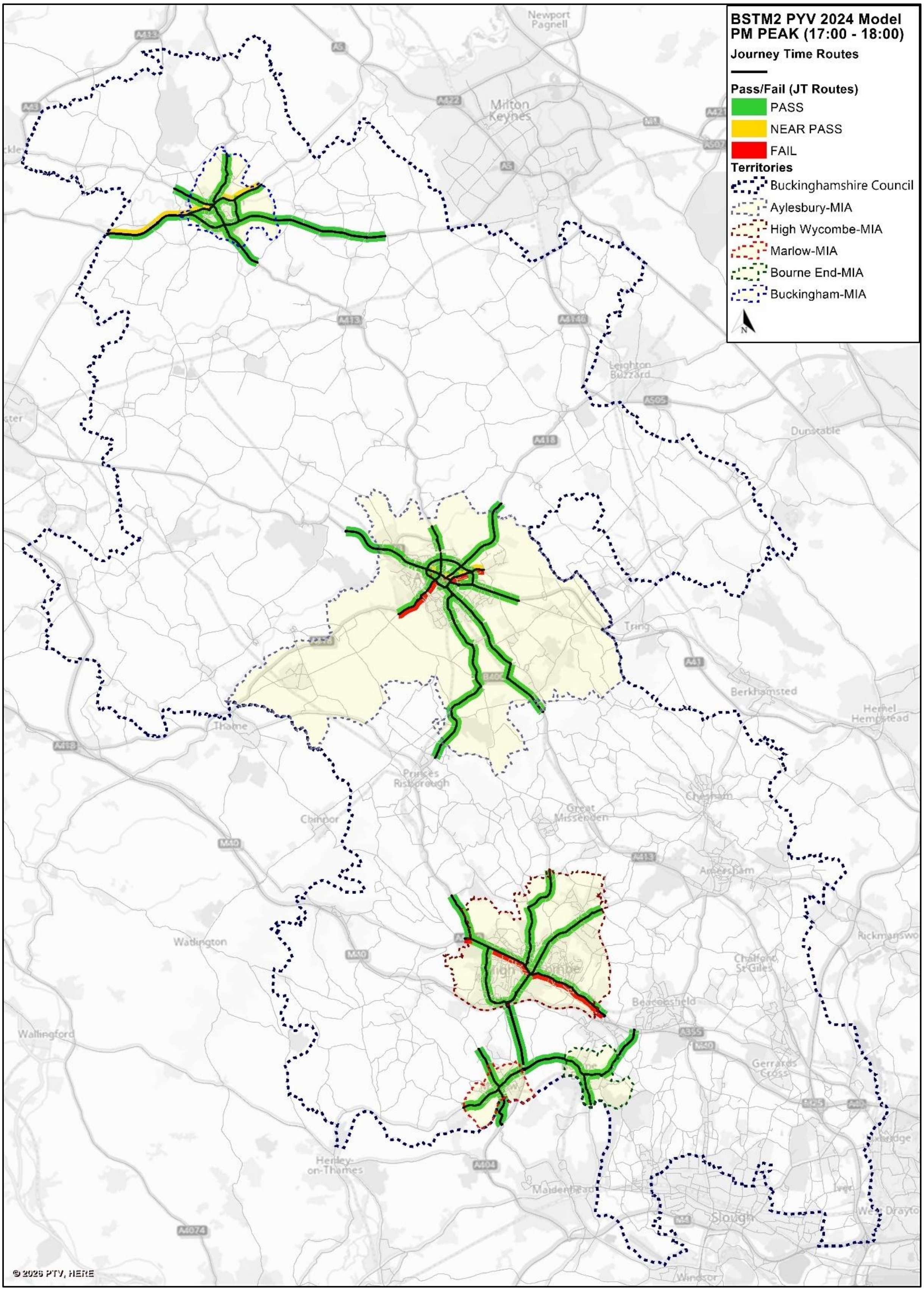


Figure 8-18 - Journey Time Validation - PM Peak



8.6 Convergence

Guidance on highway model convergence is provided in TAG Unit M3.1 as shown in Table 8-20.

Table 8-20 - Summary of HAM convergence measures and acceptable values

Measure of Convergence	Acceptable Values
Delta and %GAP	Less than 0.1%, or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P1) < 1%	Four consecutive iterations greater than 98%
Percentage of links with cost change (P2) < 1%	Four consecutive iterations greater than 98%
Percentage change in total user costs (V)	Four consecutive iterations less than 0.1% (SUE only)

An iteration is considered to have converged when the gap condition and either the flow or cost conditions are met.

The HAM convergence for each modelled time period for the BSTM2 PYV 2024 is shown in Table 8-21.

Table 8-21 - Summary of BSTM2 PYV 2024 model convergence

Time Period	Assignment Iterations	% Flow (P1)	% Cost (P2)	% Gap
AM peak hour	13	95.5	99.0	0.01
	14	96.4	98.9	0.01
	15	95.7	98.9	0.01
	16	97.0	99.1	0.01
IP average hour	6	93.3	99.1	0.01
	7	96.4	99.4	0.01
	8	97.0	99.5	0.00
	9	97.8	99.6	0.00
PM peak hour	10	93.9	98.8	0.01
	11	96.2	99.0	0.01
	12	96.8	99.2	0.01
	13	97.4	99.2	0.01

In all time periods, Table 8-21 demonstrates that the BSTM2 PYV 2024 HAM achieves acceptable convergence levels, with four consecutive iterations where the percentage of links with cost change) < 1% is exceeding 98% for and GAP values that are significantly lower than the recommended threshold of 0.1% meeting TAG guidance criteria. Additionally, the percentage of links with flow change < 1% are slightly lower than 98% in the last four iterations.

The flow and cost criteria confirm that the model is behaving in a stable manner, while the low GAP value indicates adequate convergence, meaning the difference between the costs along the chosen routes and those along the minimum-cost routes is minimal.

9. Summary

9.1 BSTM2 PYV 2024 inputs

The structure of the BSTM2 model used for the 2024 present year validation is consistent with that applied in the base year 2019. The following updated input assumptions have been incorporated:

- **Travel demand:** Derived as Person Trip Ends, reflecting completed developments between 2019 and 2024. Inputs include population, employment, and school-based attraction factors such as jobs, student places, leisure, and retail jobs.
- **Economic and behavioural assumptions:** Updated parameters such as values of time and vehicle operating costs are aligned with the latest DfT TAG data book released in May 2025 at the time of developing BSTM2 PYV 2024. These feed into both the VDM and HAM.
- **Car external-to-external, LGV and HGV Trips:** Growth factors from the DfT's NRTP22 traffic projections are applied to the base year matrices
- **Explicitly modelled developments LGV and HGV trips**: Estimated using TRICS trip rates.
- **Highway Network Changes:** Necessary updates to the highway assignment network are incorporated with the HAM re-run to produce revised travel distances, times, and costs.
- **PT Skims and Fares:** Updated in nominal terms using TAG Unit A5.3 for rail, and bus fare growth based on historical trends from the DfT Local Bus Fare Index. Inputs reflect the latest available TAG data book and Local Bus Fare Index (see section 4.4, 4.5 and 5.1.2).
- **Model Rerun:** Iterative runs are undertaken to ensure that changes in VDM vehicle trips are affecting the HAM costs and fed back as input to VDM.
- **VDM/ Assignment Interface:** A pivoting process known as Absolute Model Applied Incrementally (AMAI) is applied to the base year model assignment matrices.

9.2 BSTM2 PYV 2024 outputs

The BSTM2 PYV 2024 model reflects changes in travel trends influenced by COVID-19 and incorporates land-use growth that occurred between the 2019 base year and the 2024 present year. The changes in travel trends post COVID-19 will be carried over to traffic forecasting undertaken using BSTM2.

Validation results from the VDM model indicate a reasonable alignment between modelled outputs and observed data from the NTS, particularly for mode share and trip length distribution. Nearly all screenlines show differences of less than 5% between modelled and observed flows across AM, Inter-Peak, and PM peak periods, meeting TAG criteria. Link flow validation demonstrates good compliance with the GEH < 5 or flow difference < 5% thresholds across all three model periods. Journey time validation closely meets TAG criteria for AM, Inter-Peak, and PM peak hours.

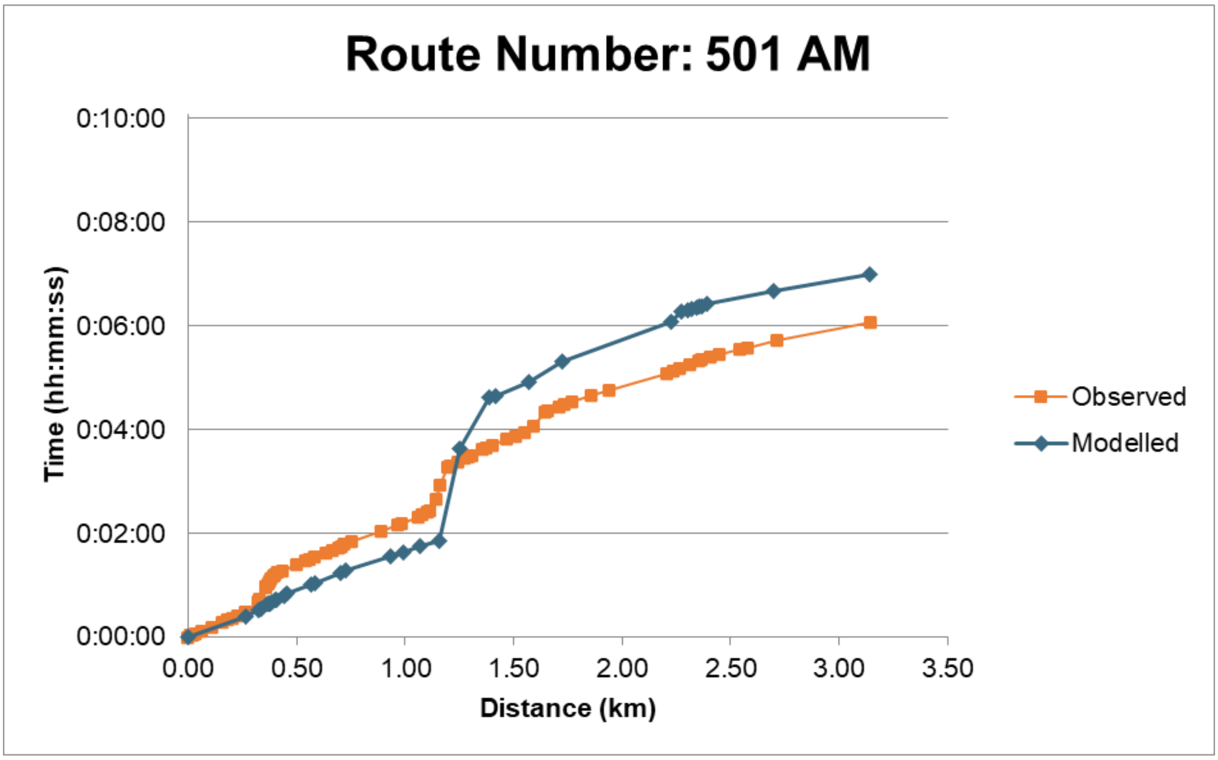
AtkinsRéalis - Baseline / Référence

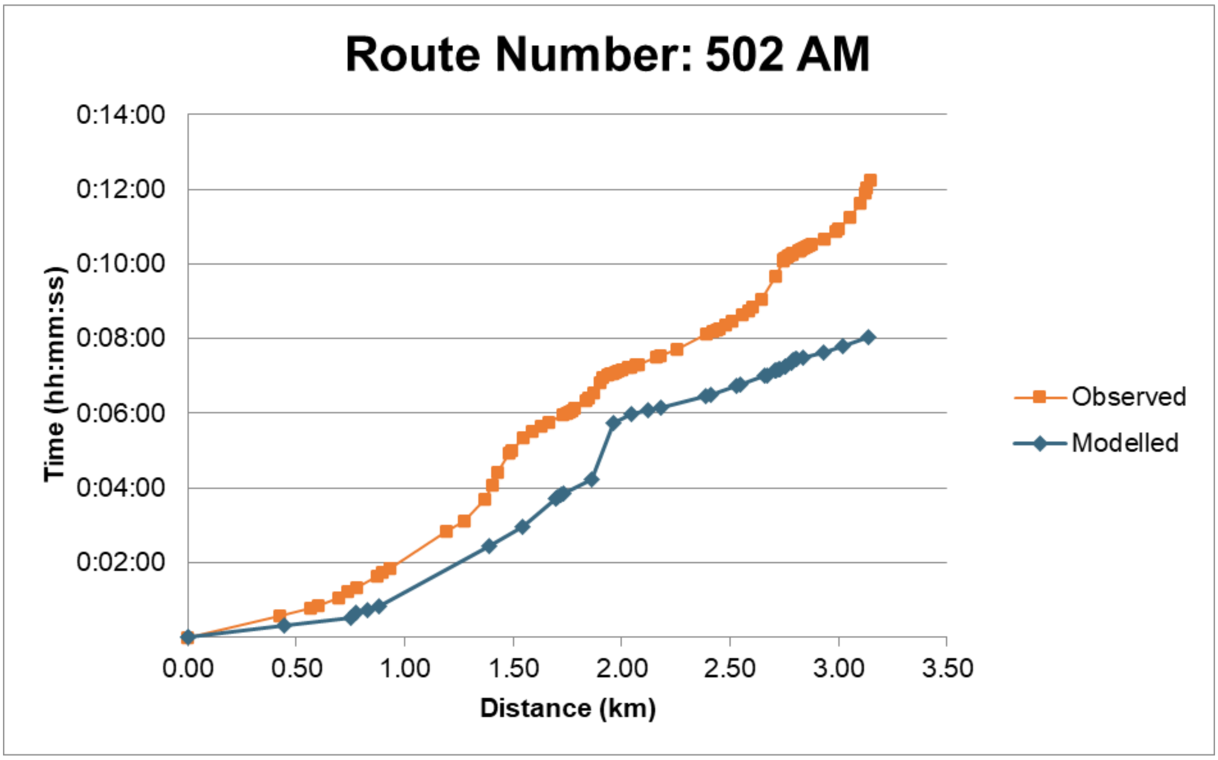
APPENDICES

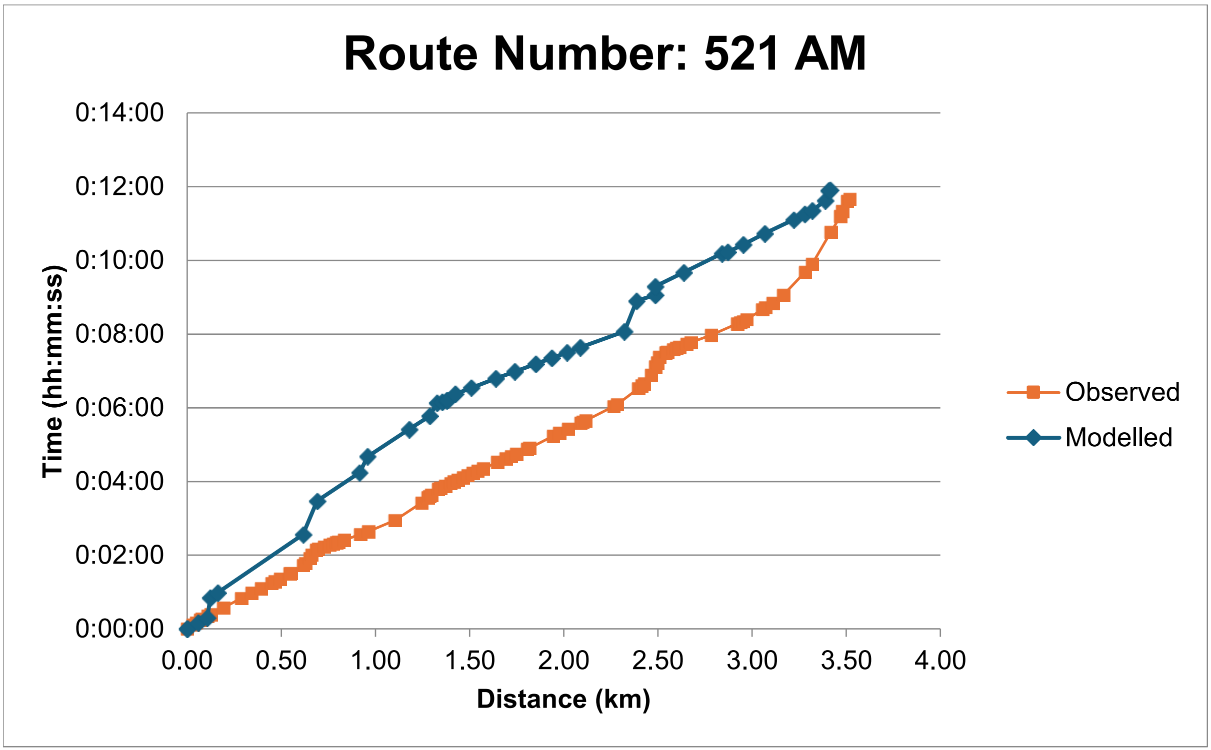
Appendix A. Journey Time Validation Plots

Plots are shown by Route Number XXY where XX denotes the route and Y the direction.

A.1 AM JT plots



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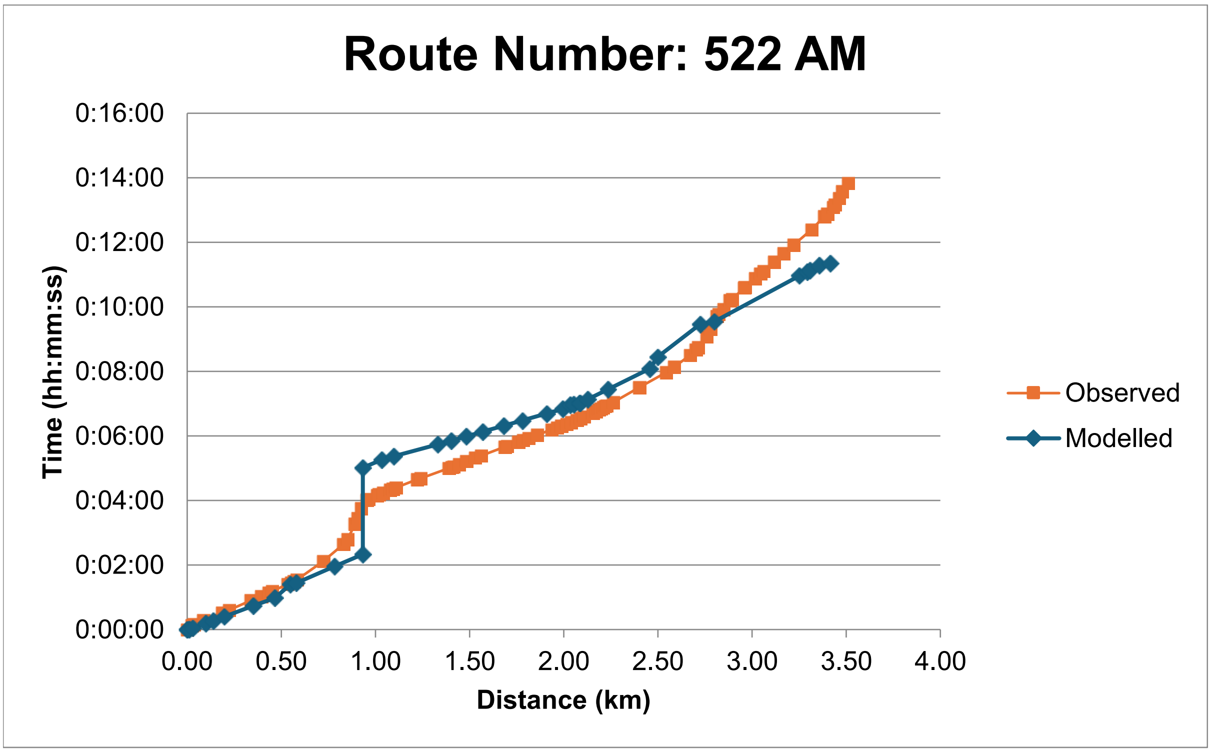
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled


Route Number: 522 AM
Time (hh:mm:ss)
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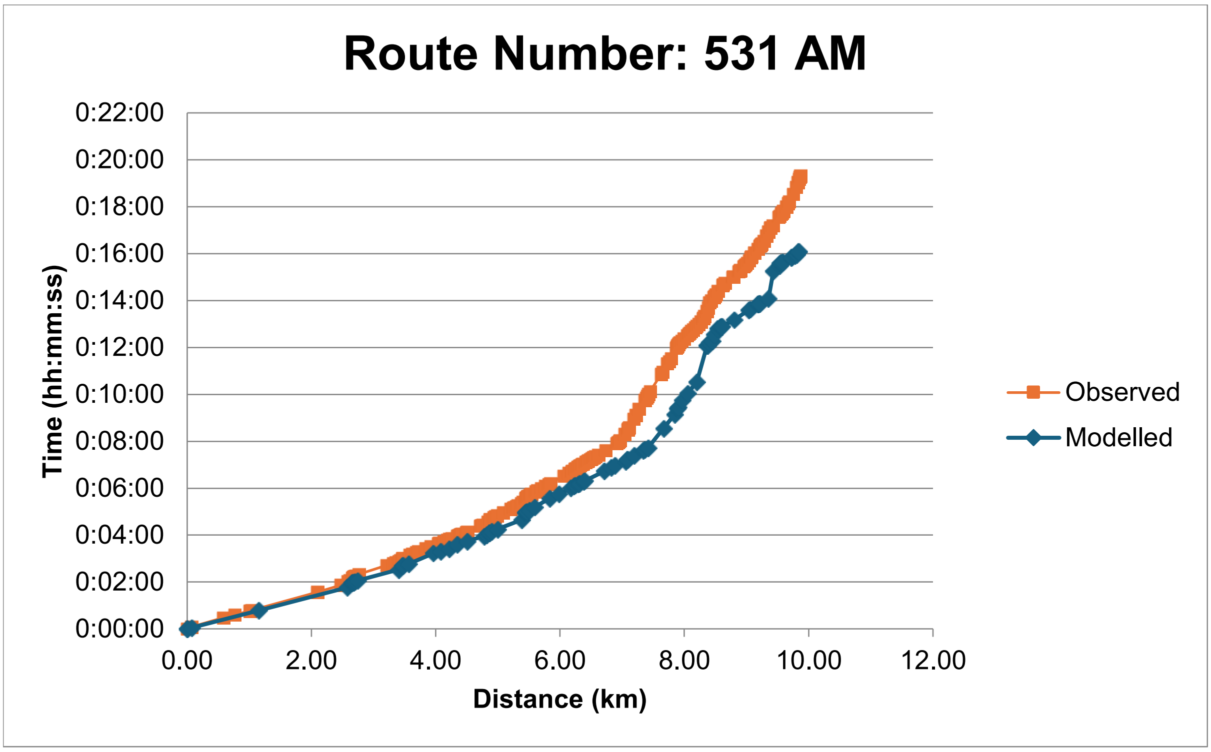
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled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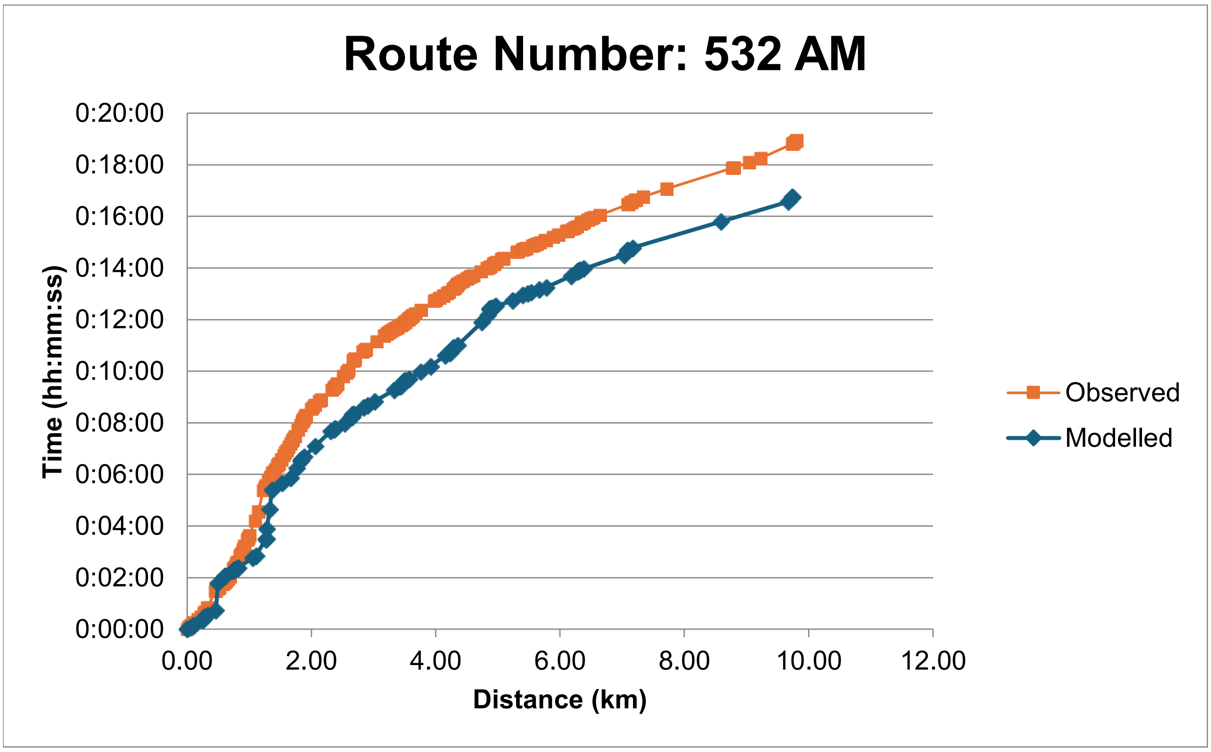
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled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0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
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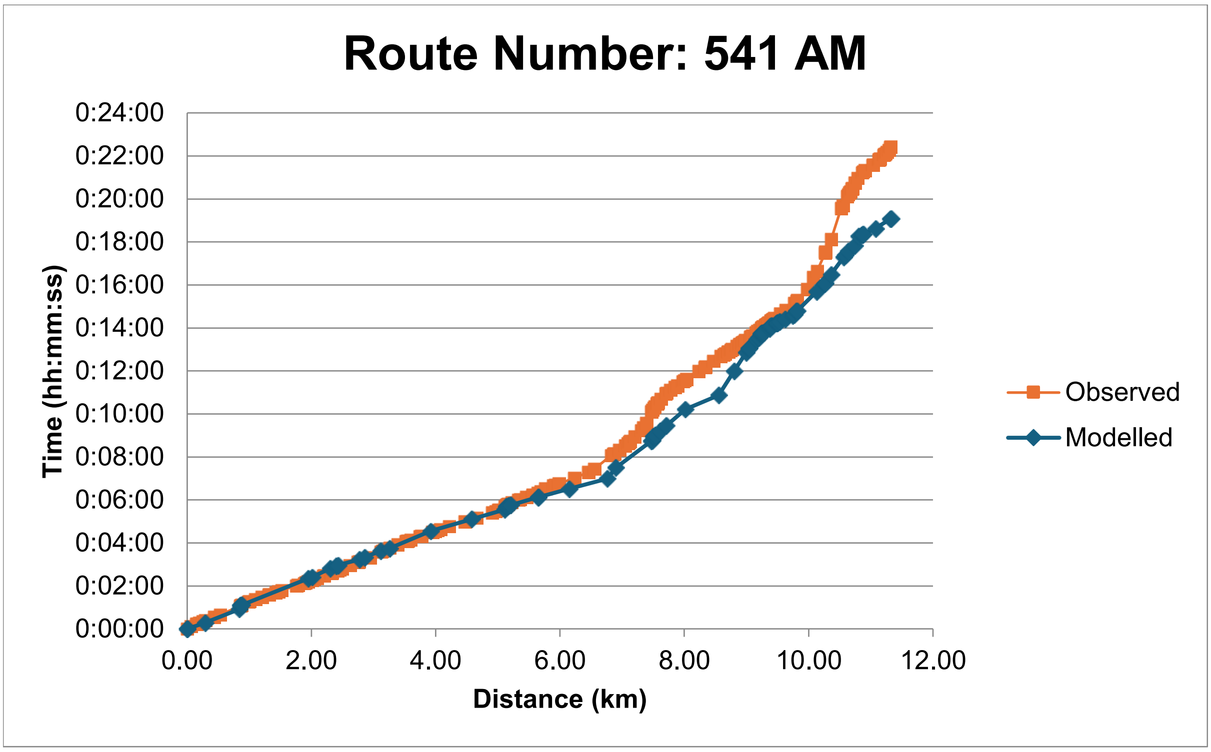
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



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0:12:00
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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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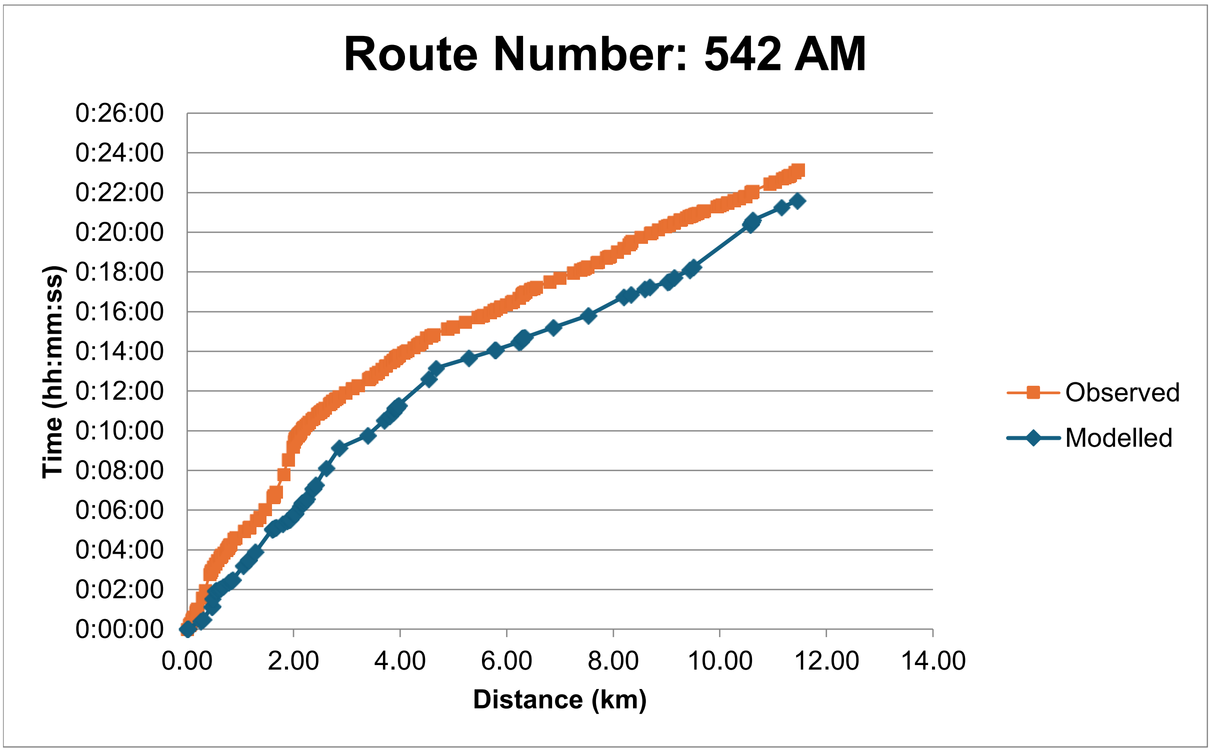
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



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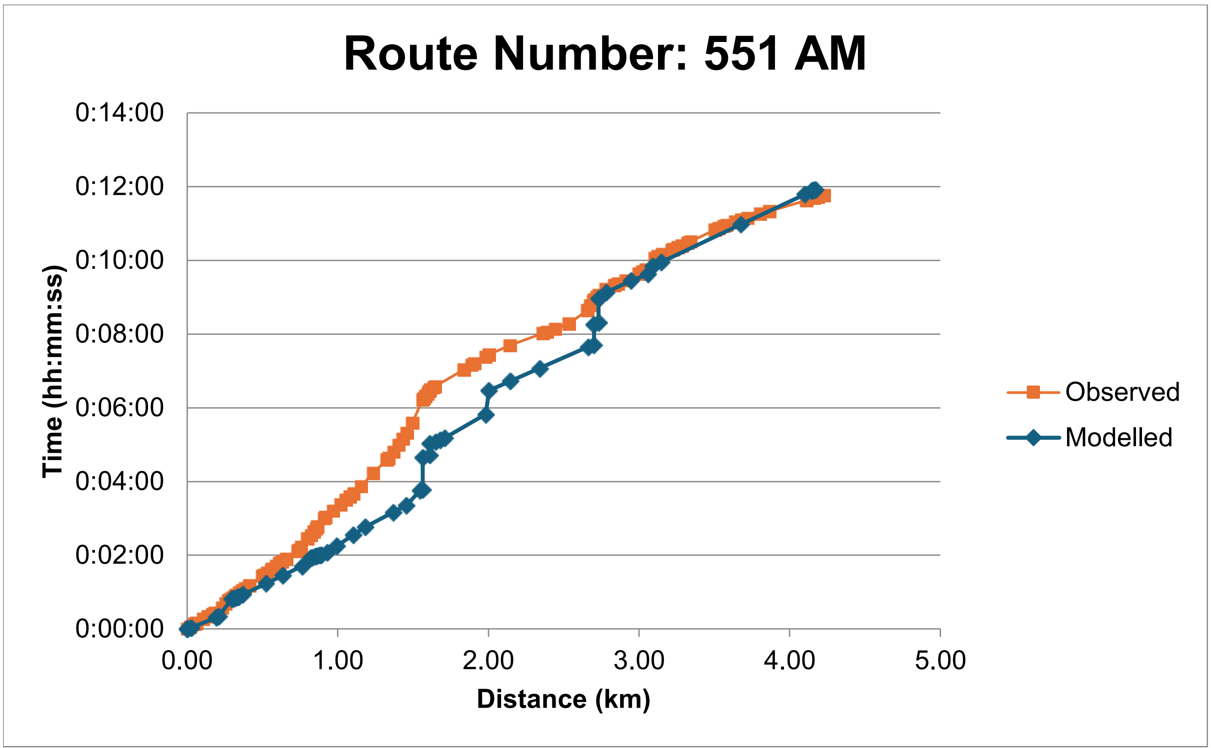
0:18:00
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance (km)
Observed
Modelled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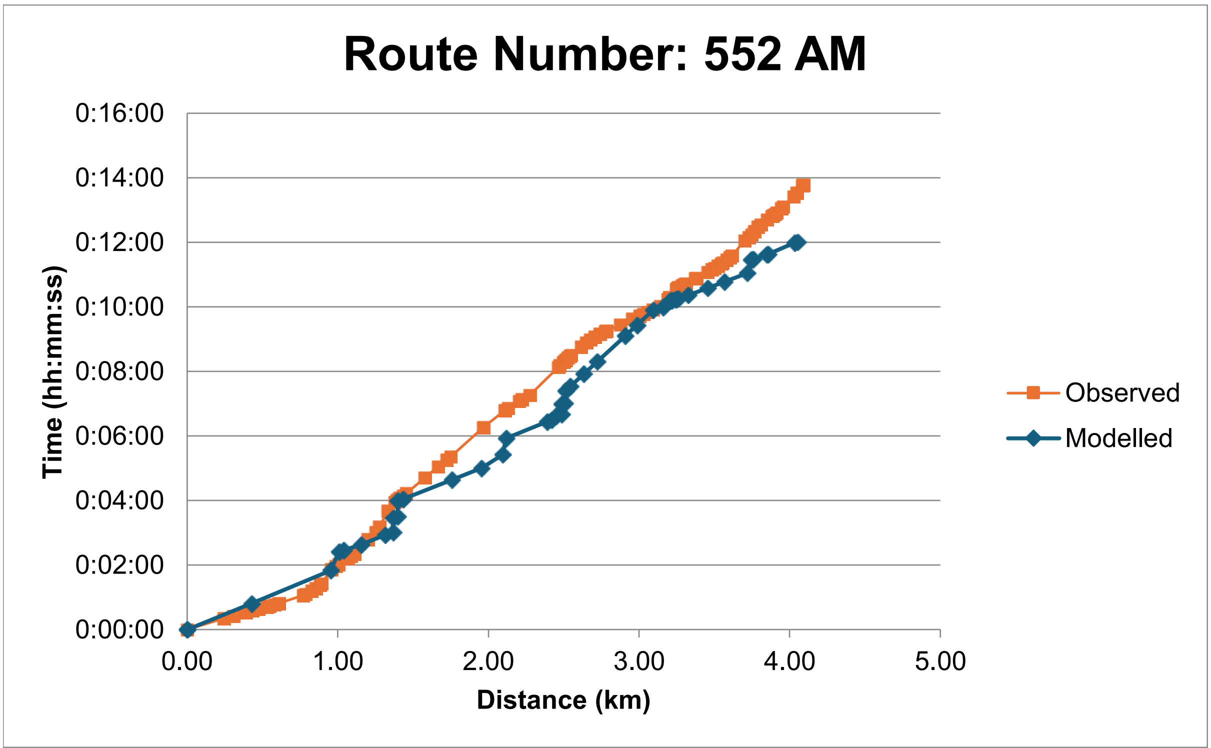
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled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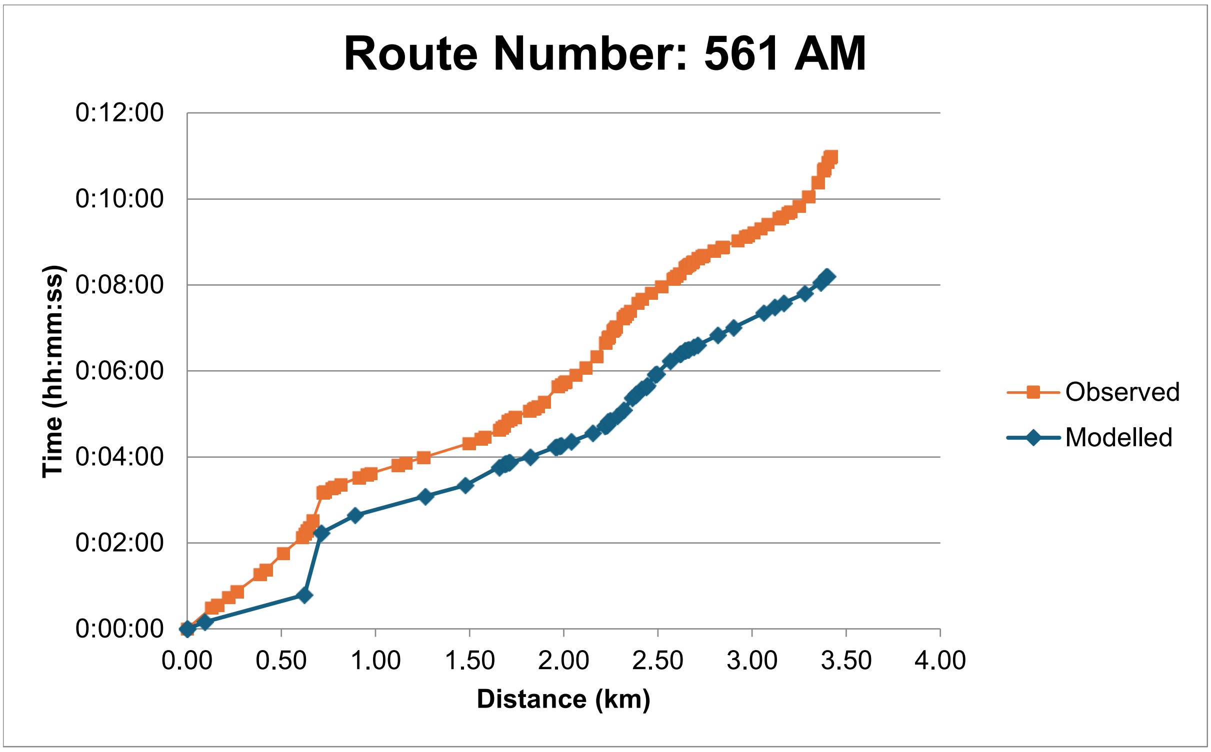
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled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0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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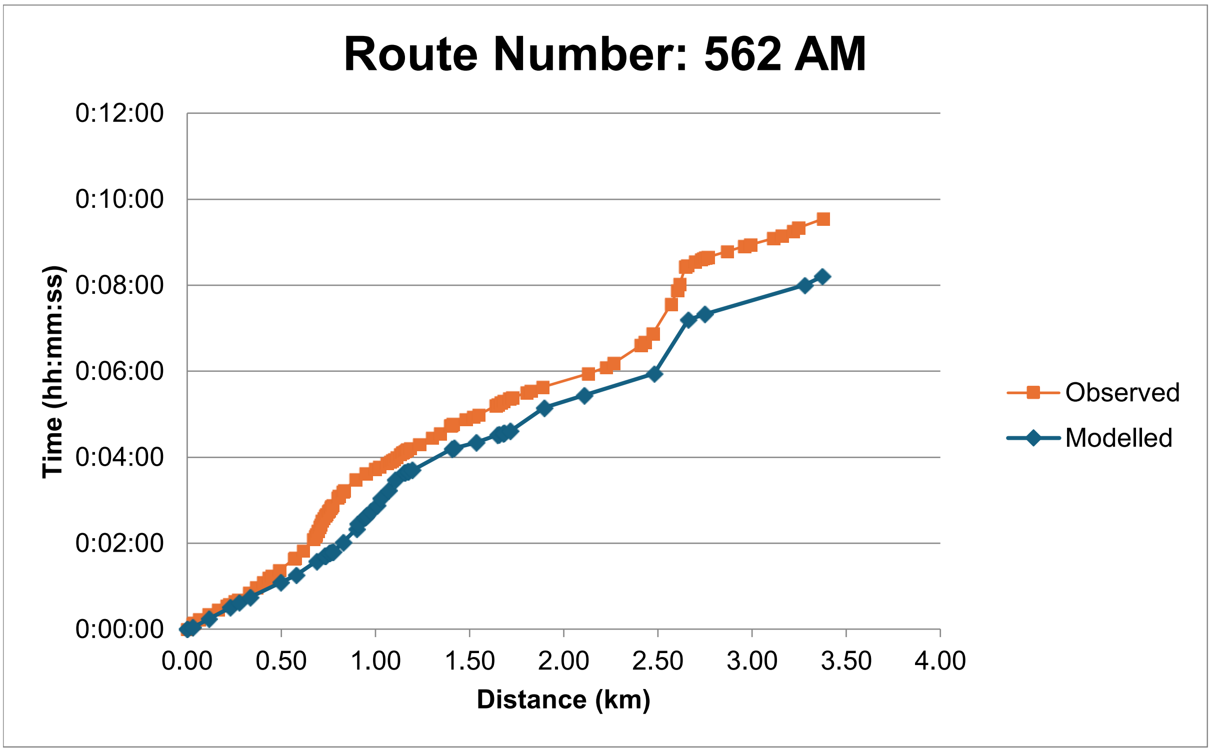
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled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0:00:00
Time (hh:mm:ss)
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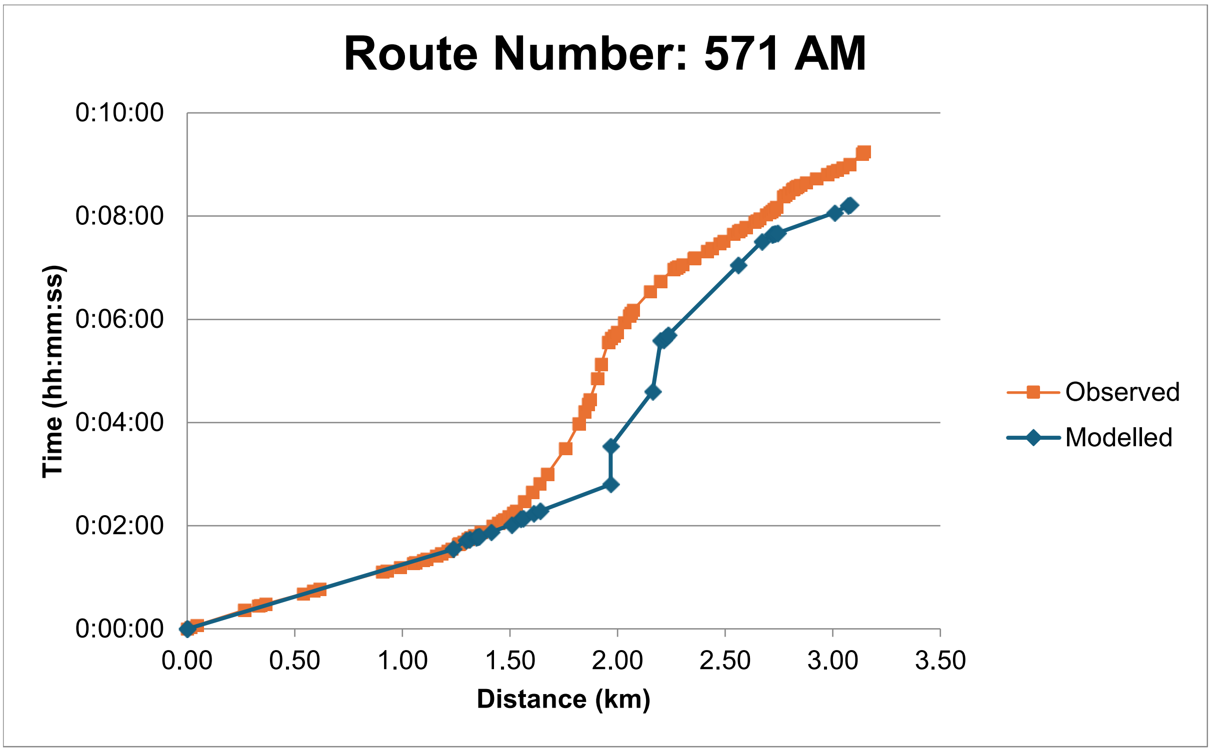
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled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0:02:00
0:00:00
Time (hh:mm:ss)
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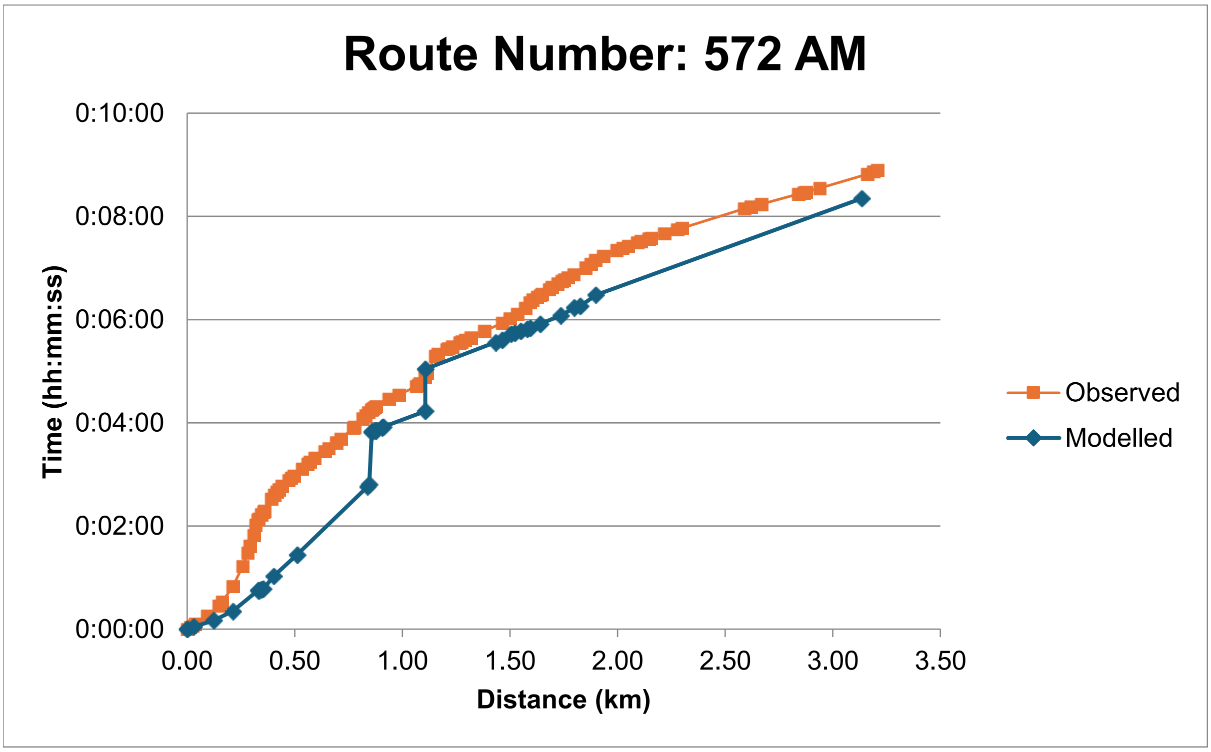
1.00
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled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Time (hh:mm:ss)
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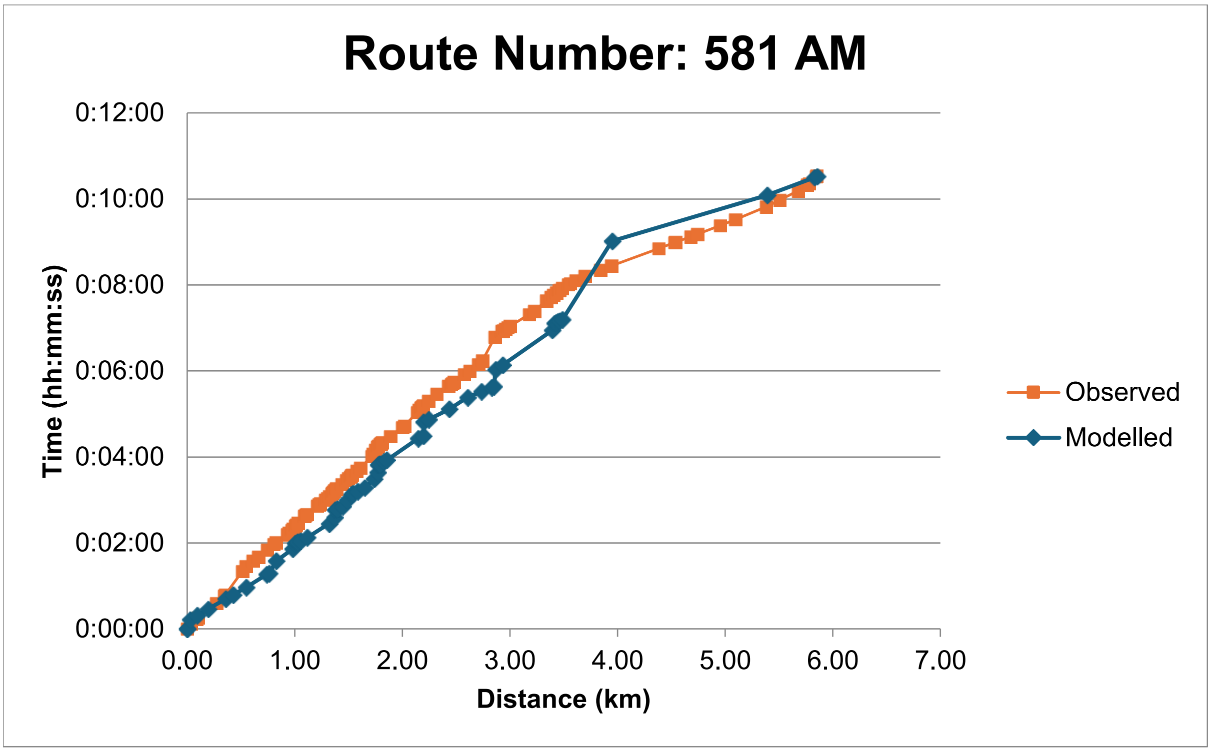
1.00
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled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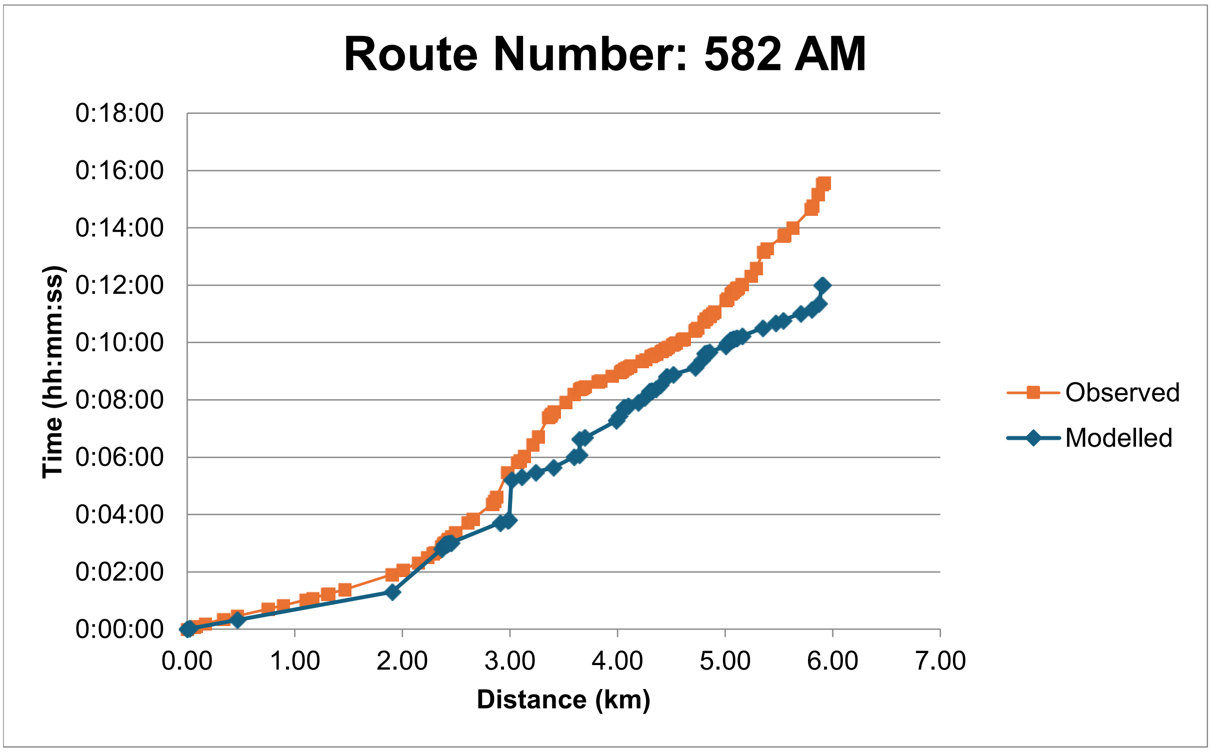
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled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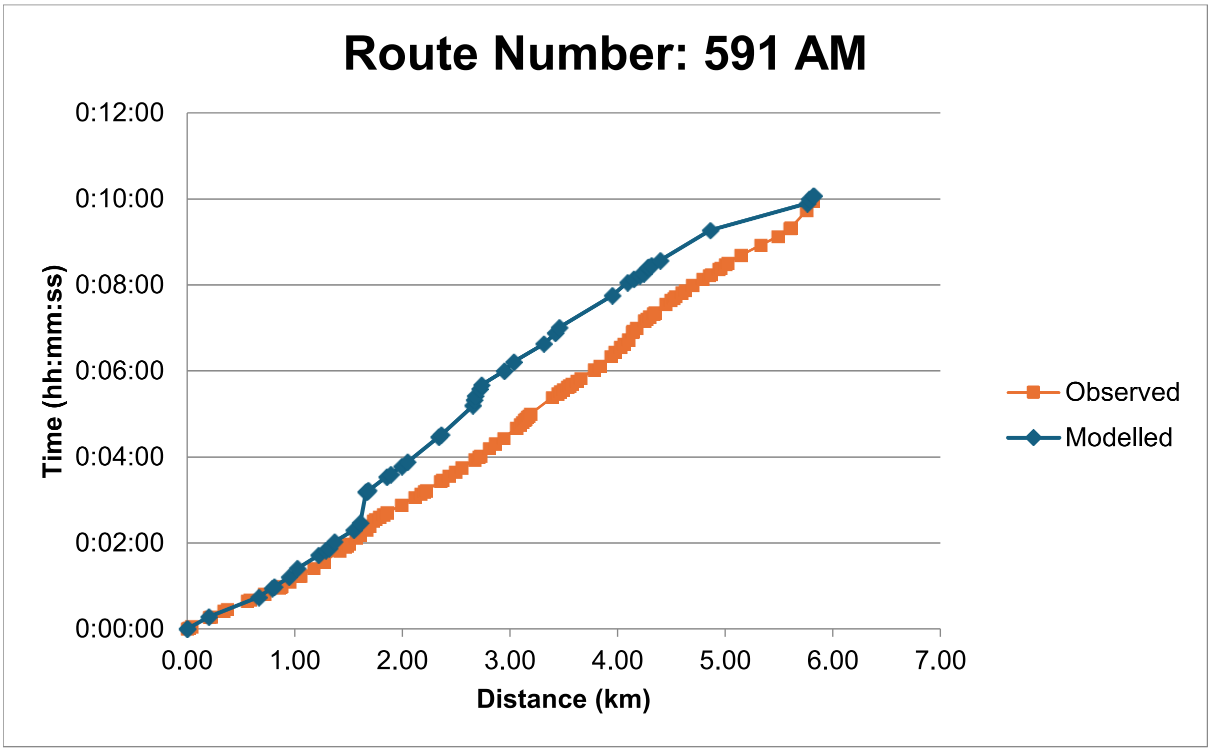
0:06:00
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled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Time (hh:mm:ss)
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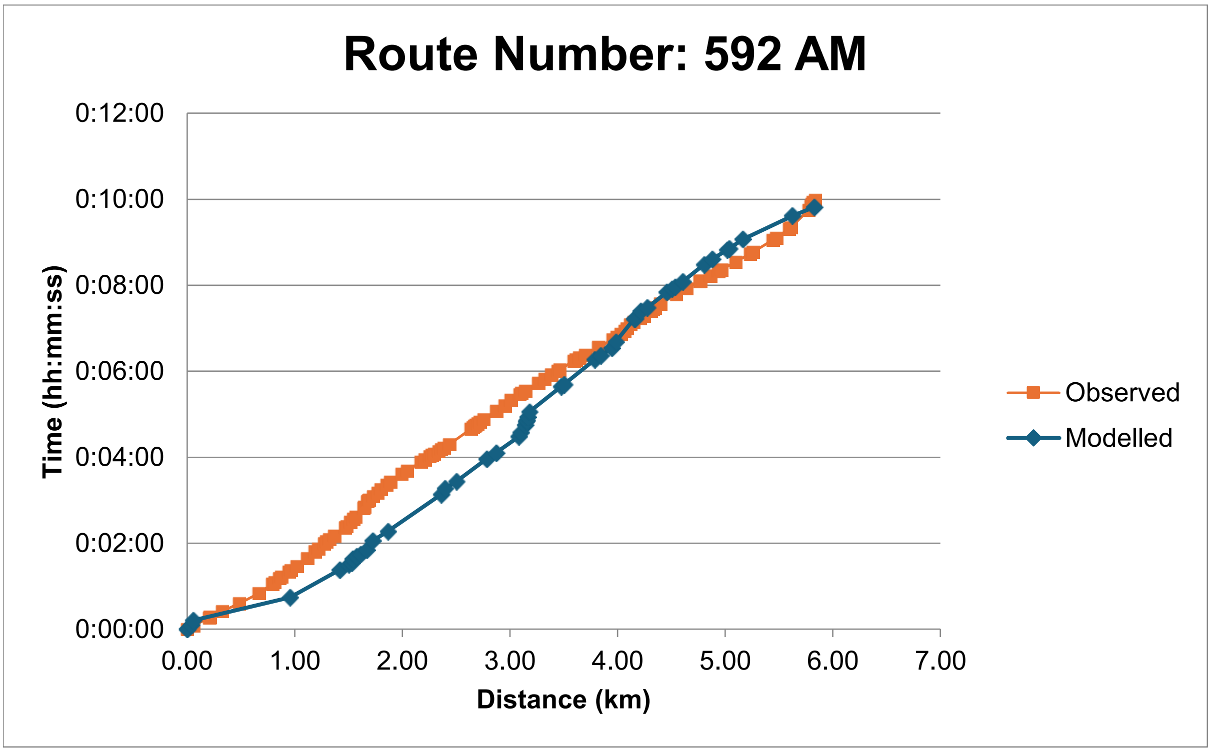
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled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0:00:00
Time (hh:mm:ss)
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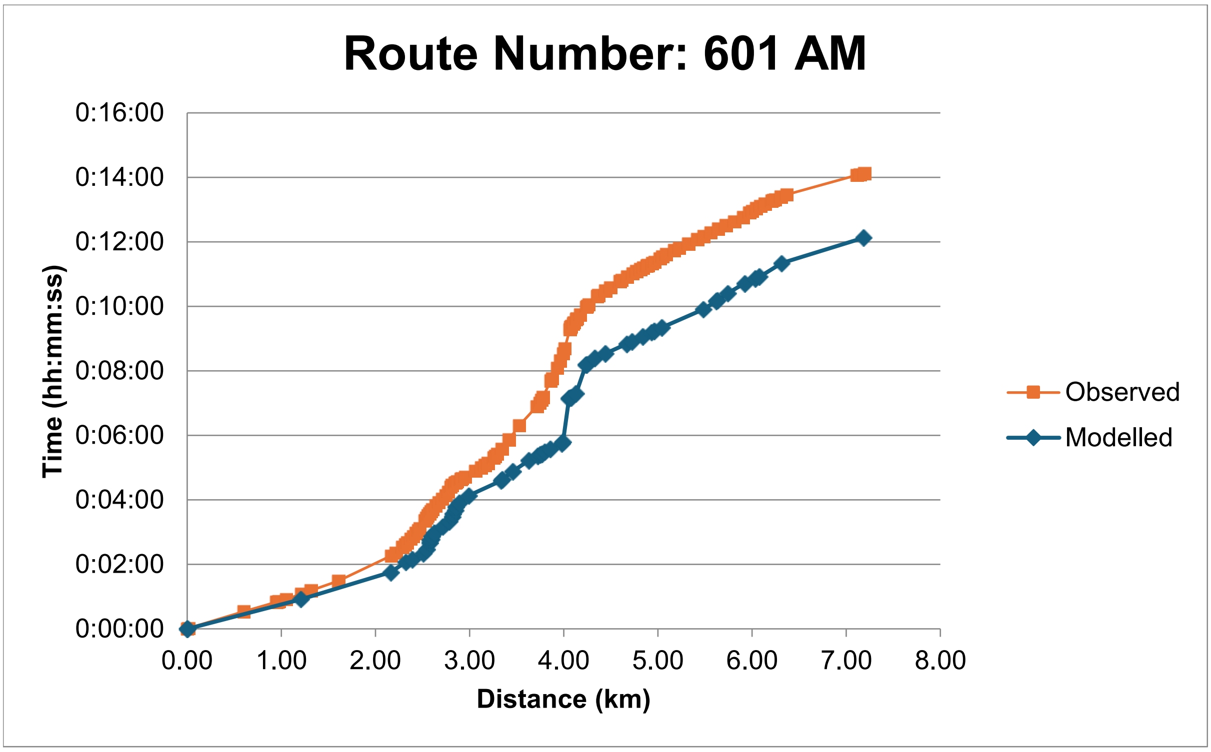
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled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Time (hh:mm:ss)
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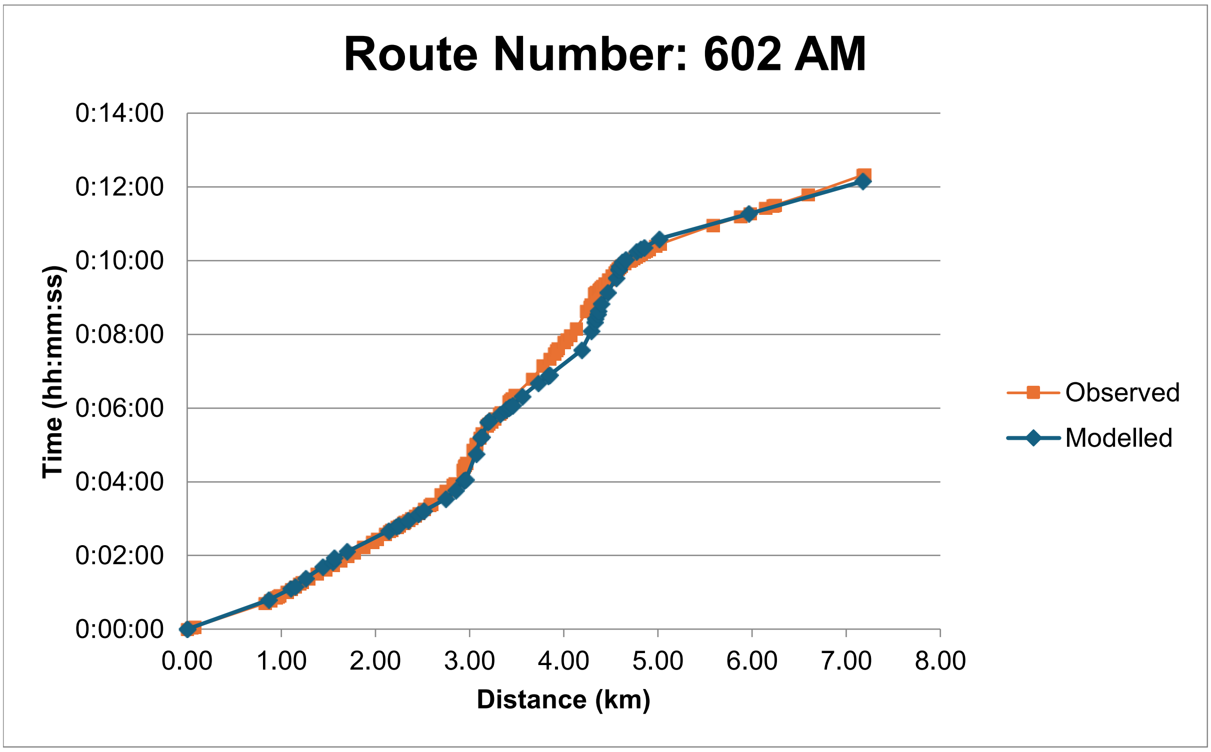
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
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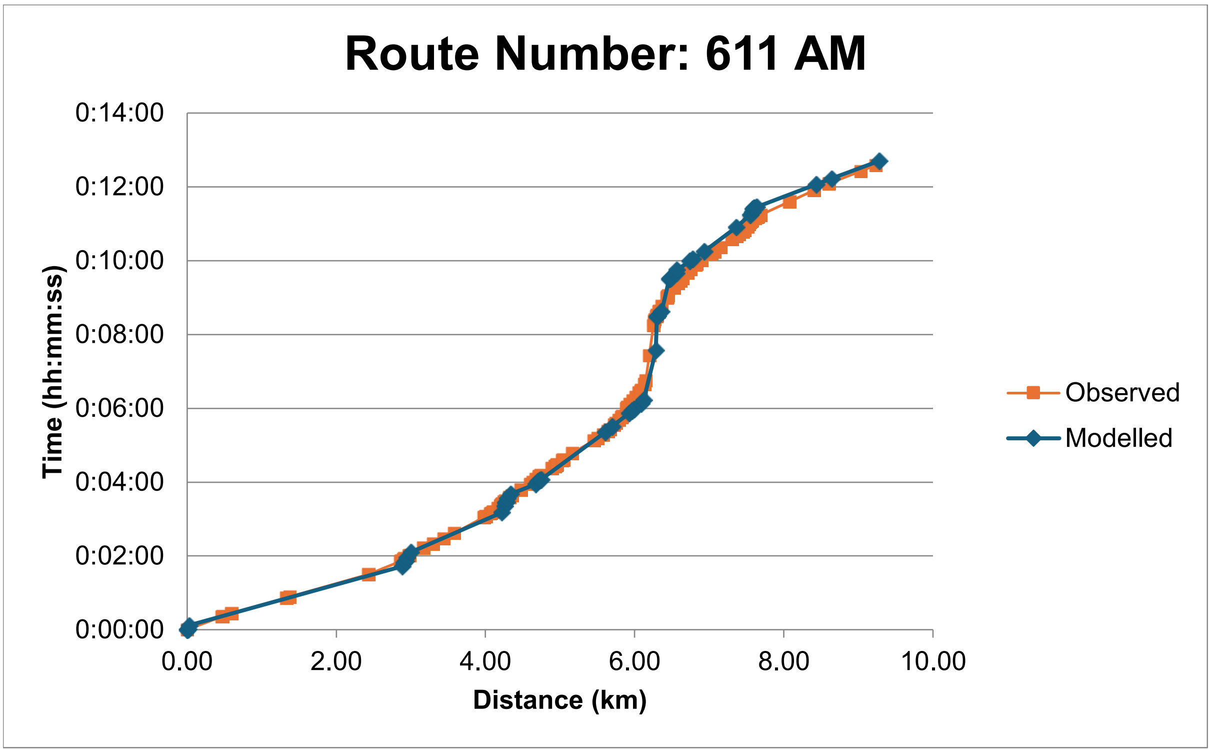
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled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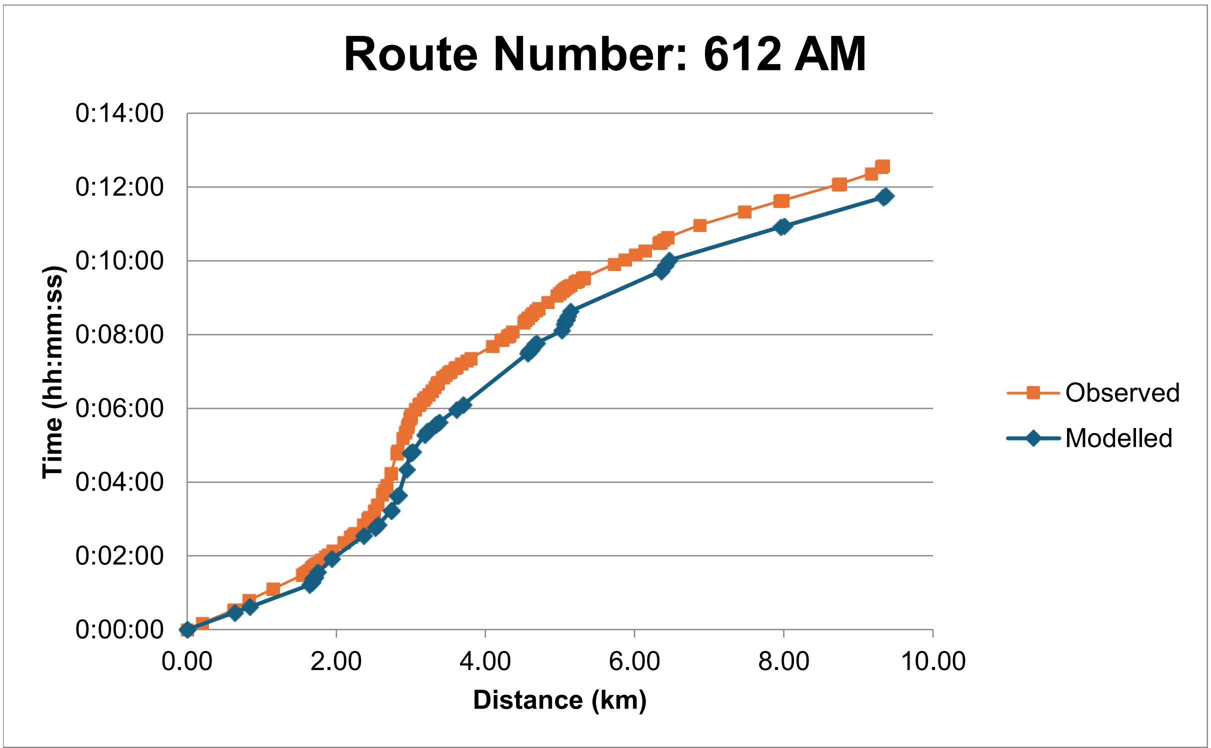
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled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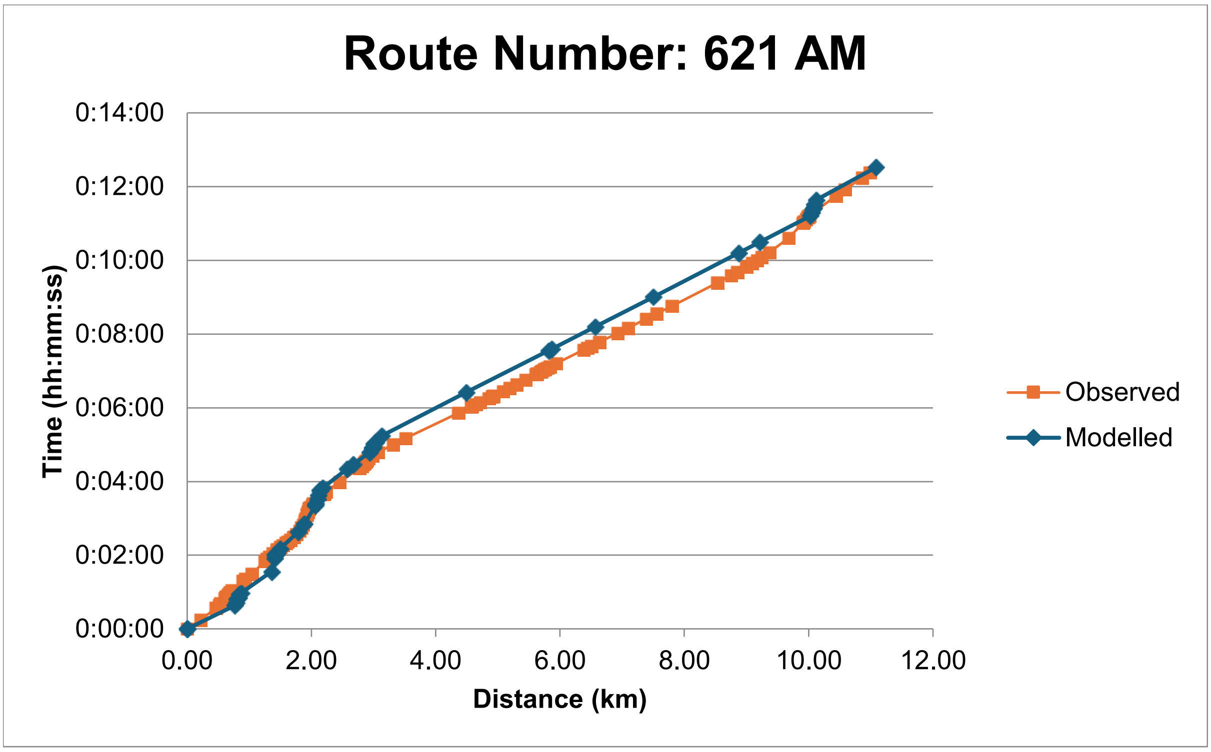
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled



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Time (hh:mm:ss)
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0:06:00
0:04:00
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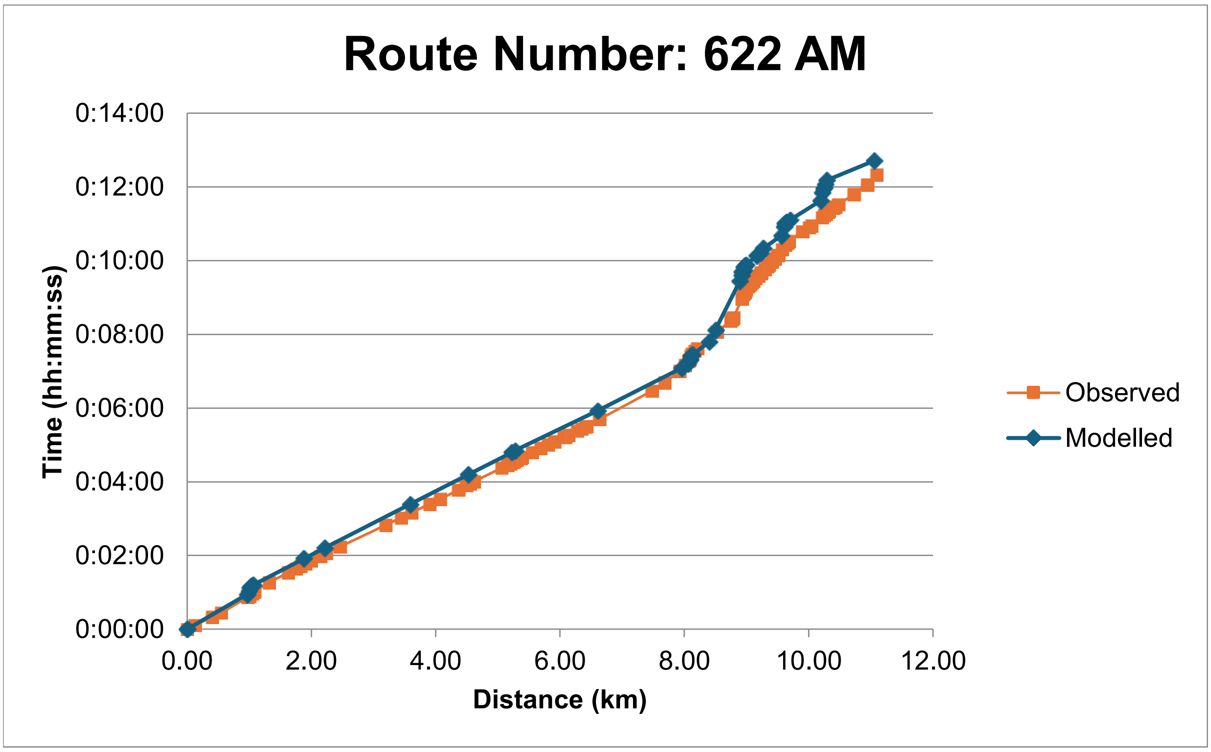
0:00:00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



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Time (hh:mm:ss)
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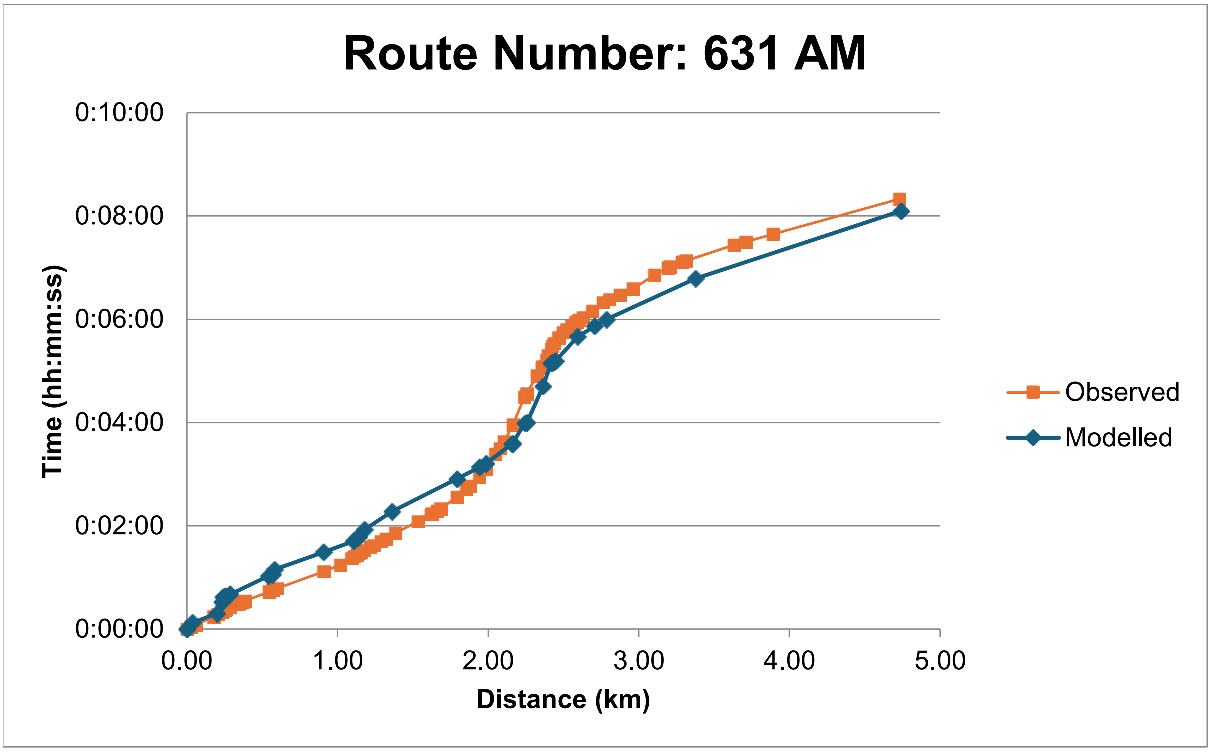
0:06:00
0:04:00
0:02:00
0:00:00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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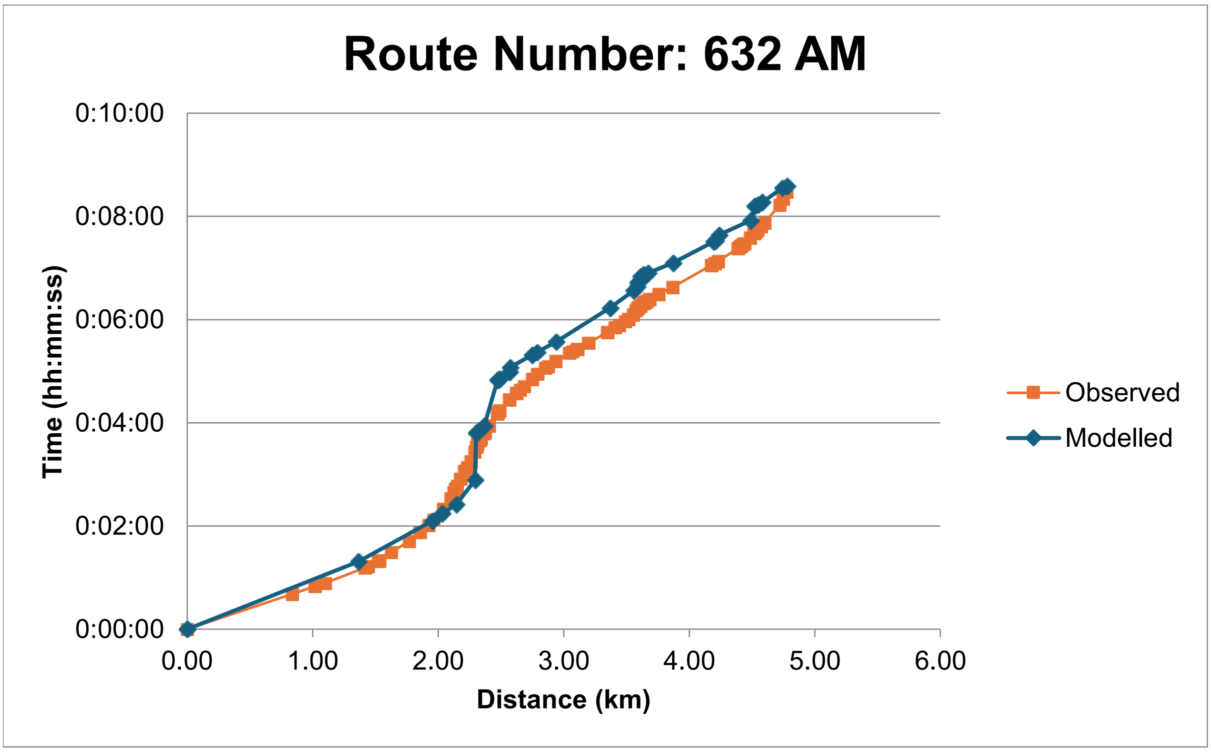
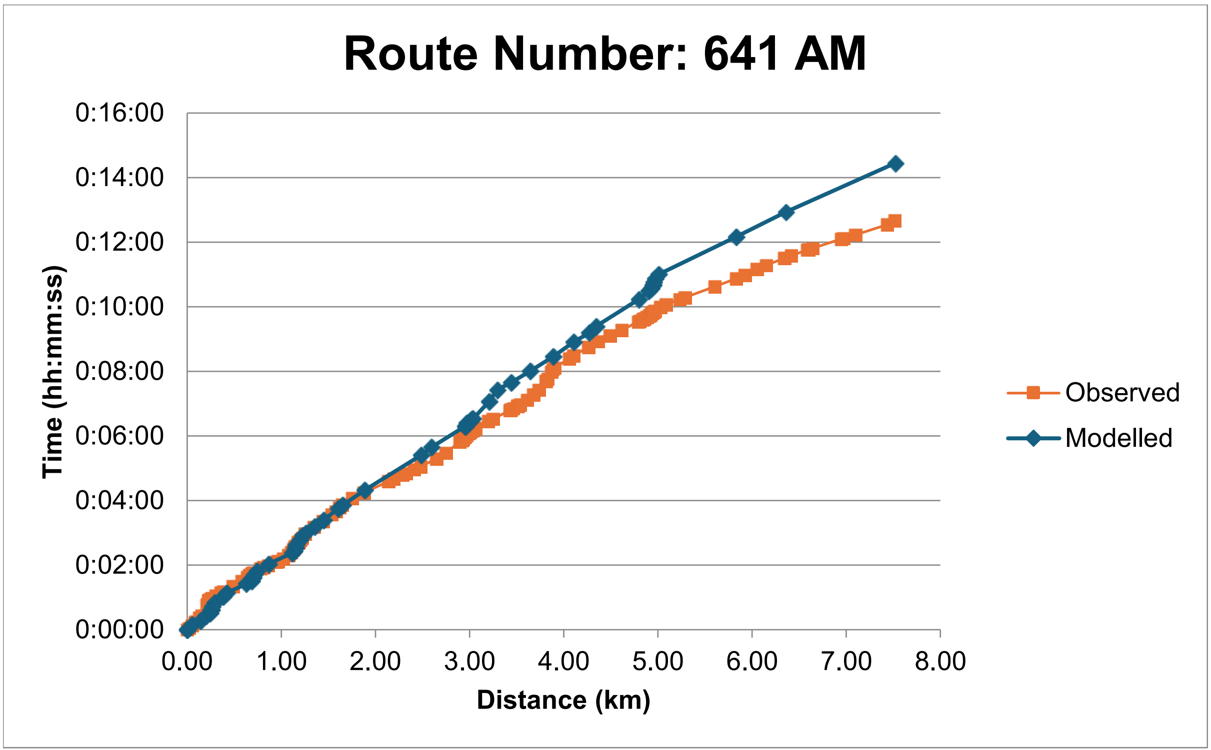
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 632 AM
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled



Route Number: 641 AM
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0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
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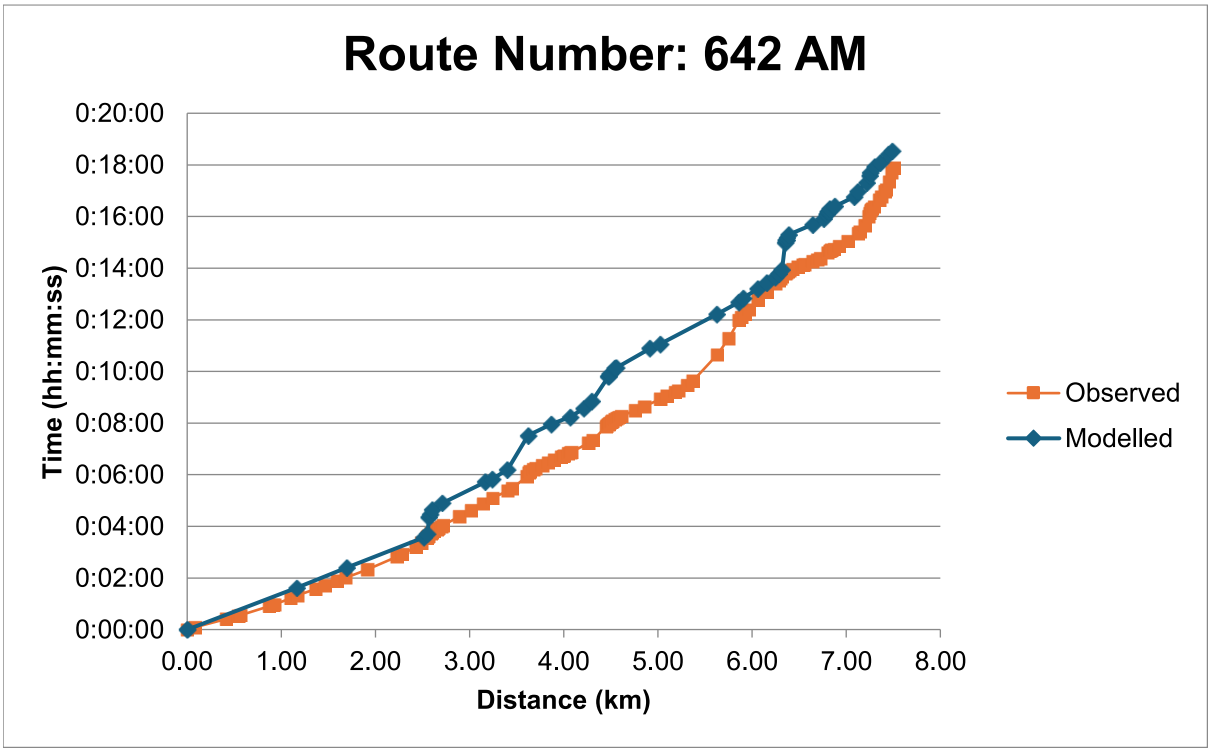
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled



Route Number: 642 AM
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0:12:00
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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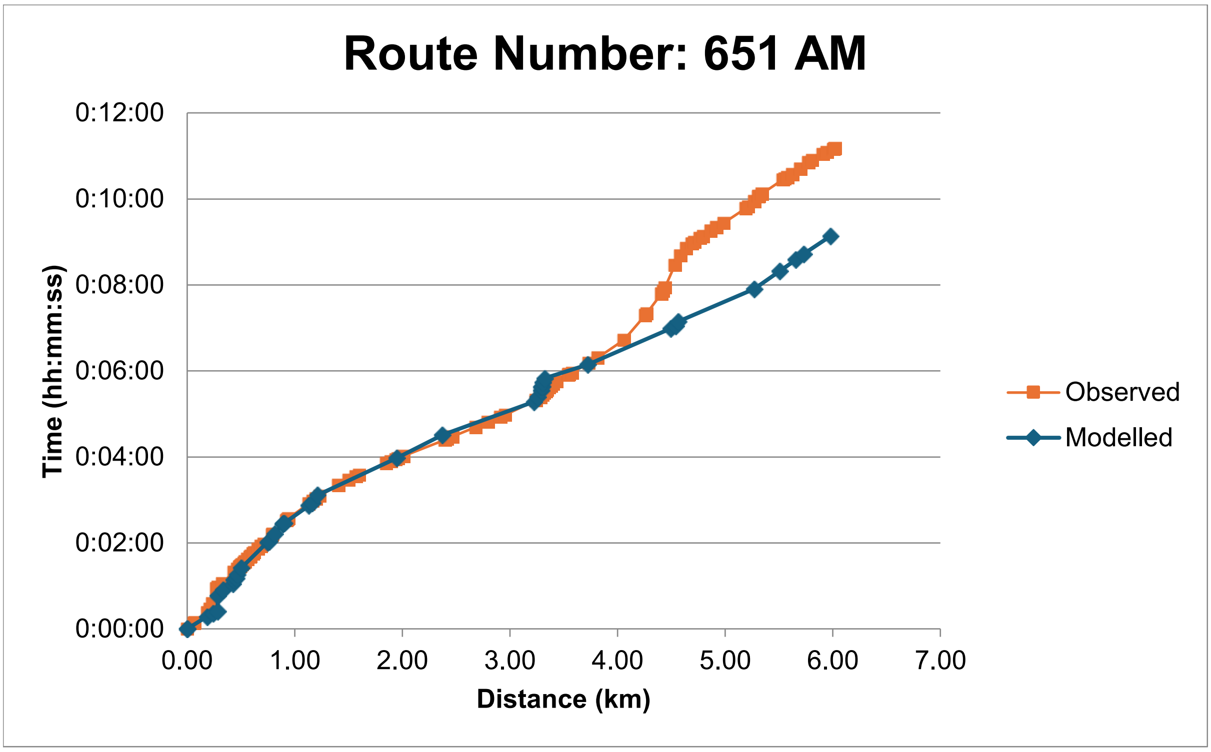
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled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0:00:00
Time (hh:mm:ss)
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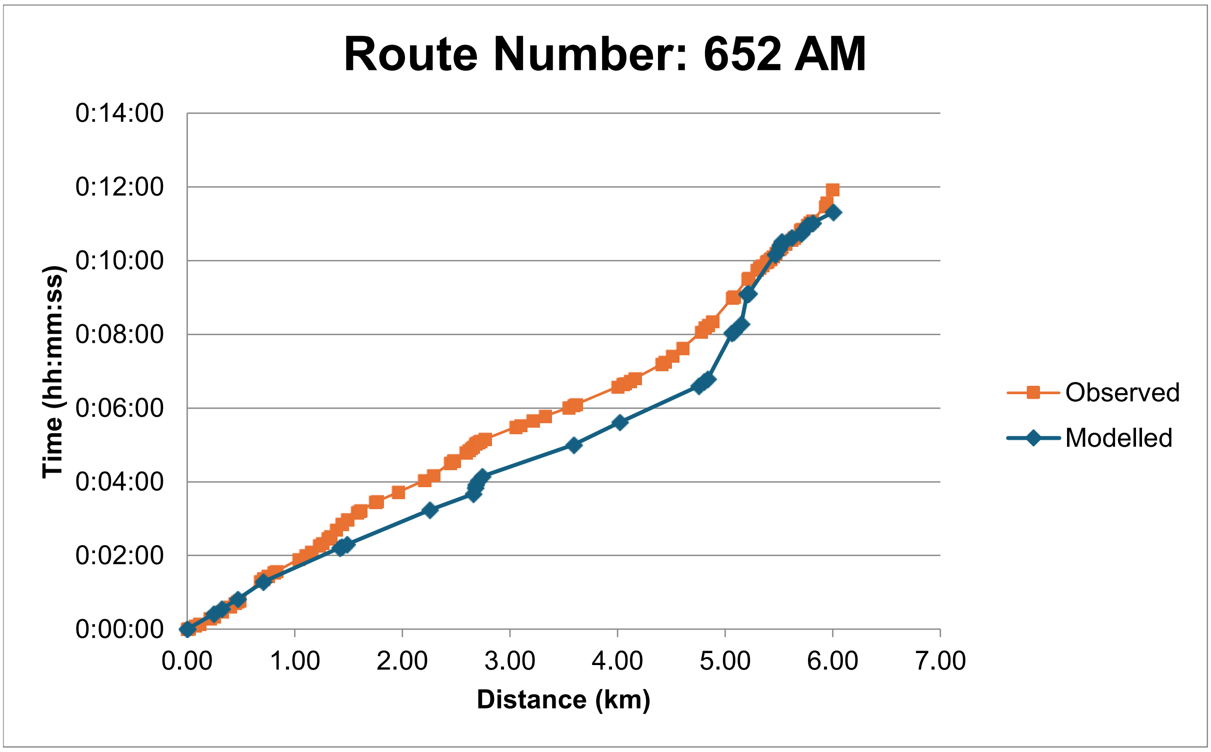
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled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0:06:00
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0:02:00
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Time (hh:mm:ss)
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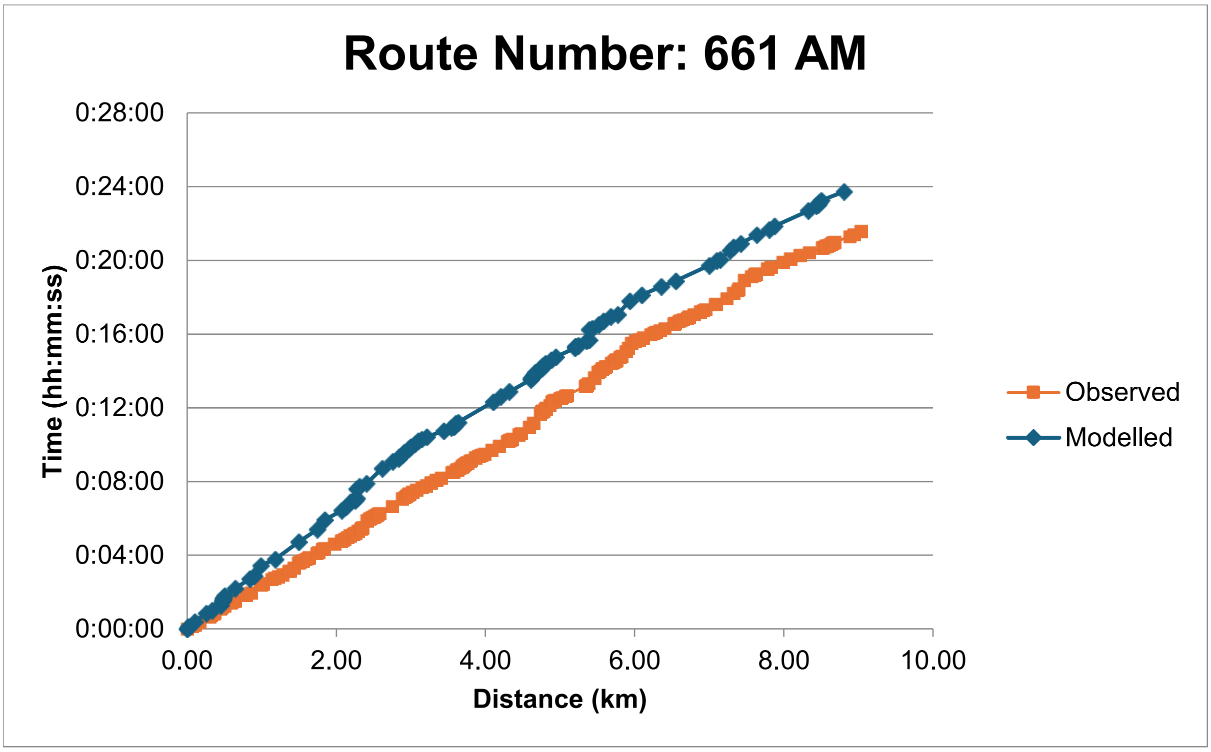
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 661 AM
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0:12:00
0:08:00
0:04:00
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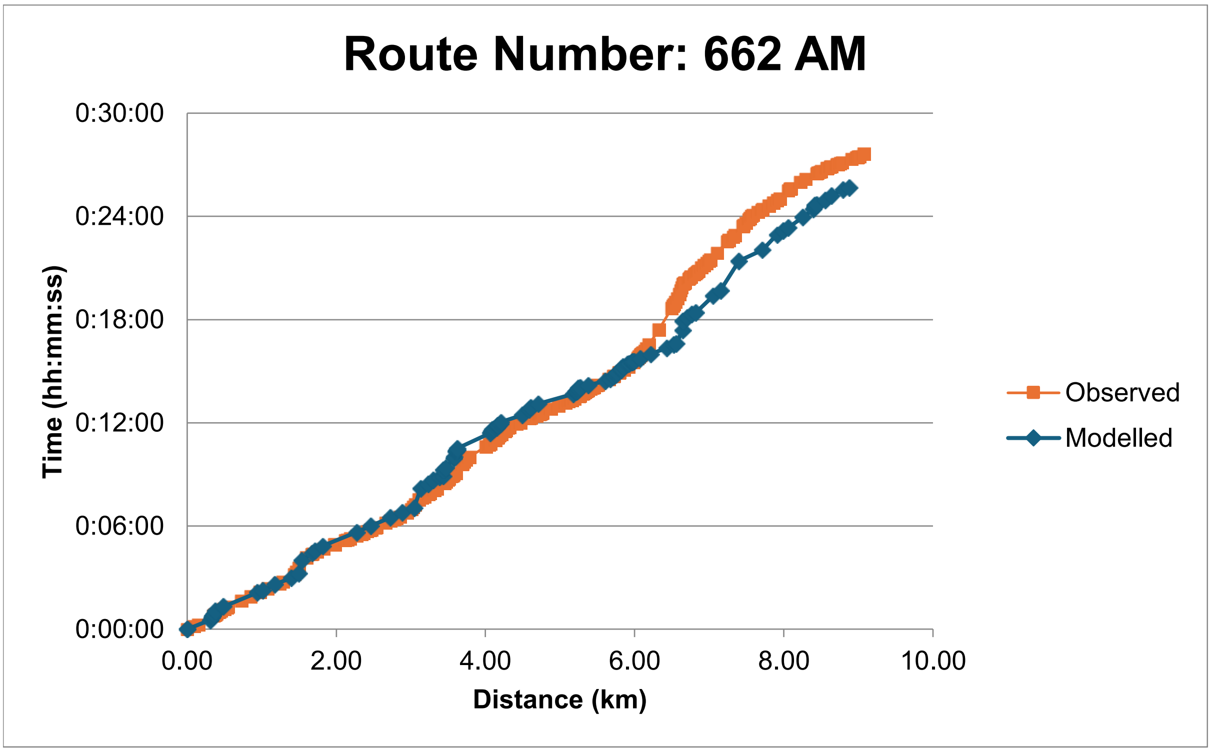
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 662 AM
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0:06:00
0:00:00
Time (hh:mm:ss)
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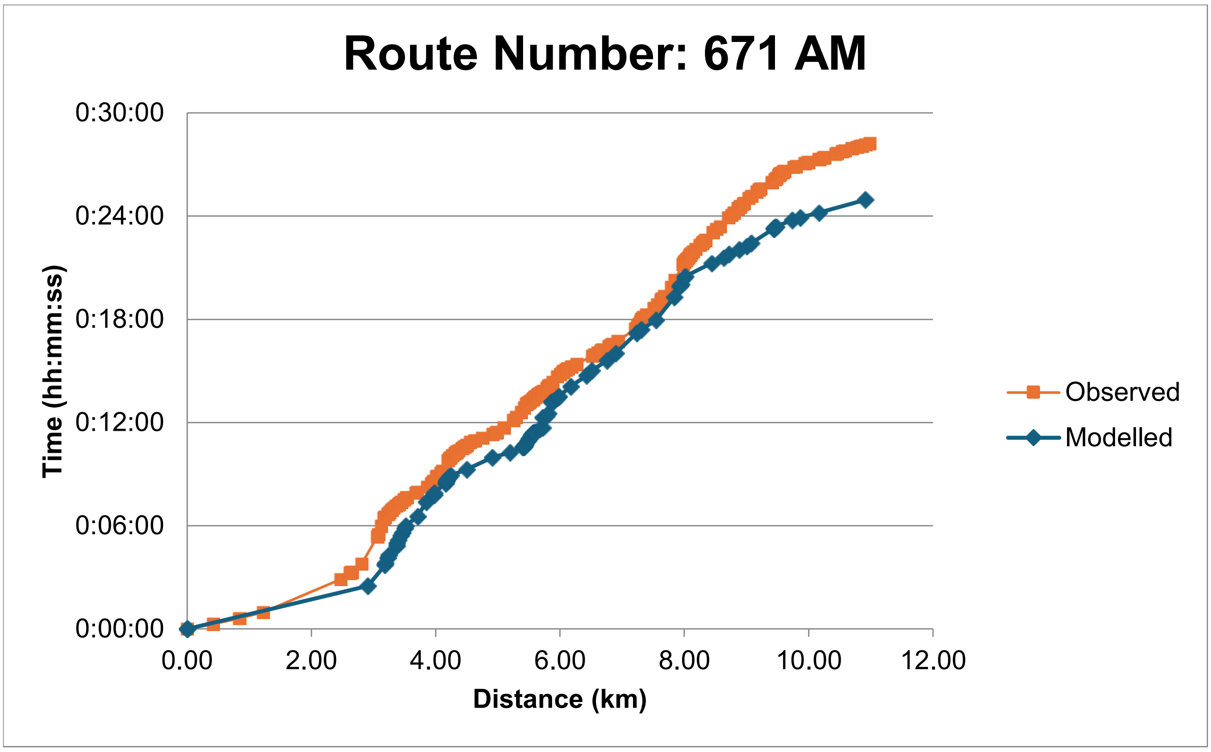
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled



Route Number: 671 AM
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0:18:00
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0:06:00
0:00:00
Time (hh:mm:ss)
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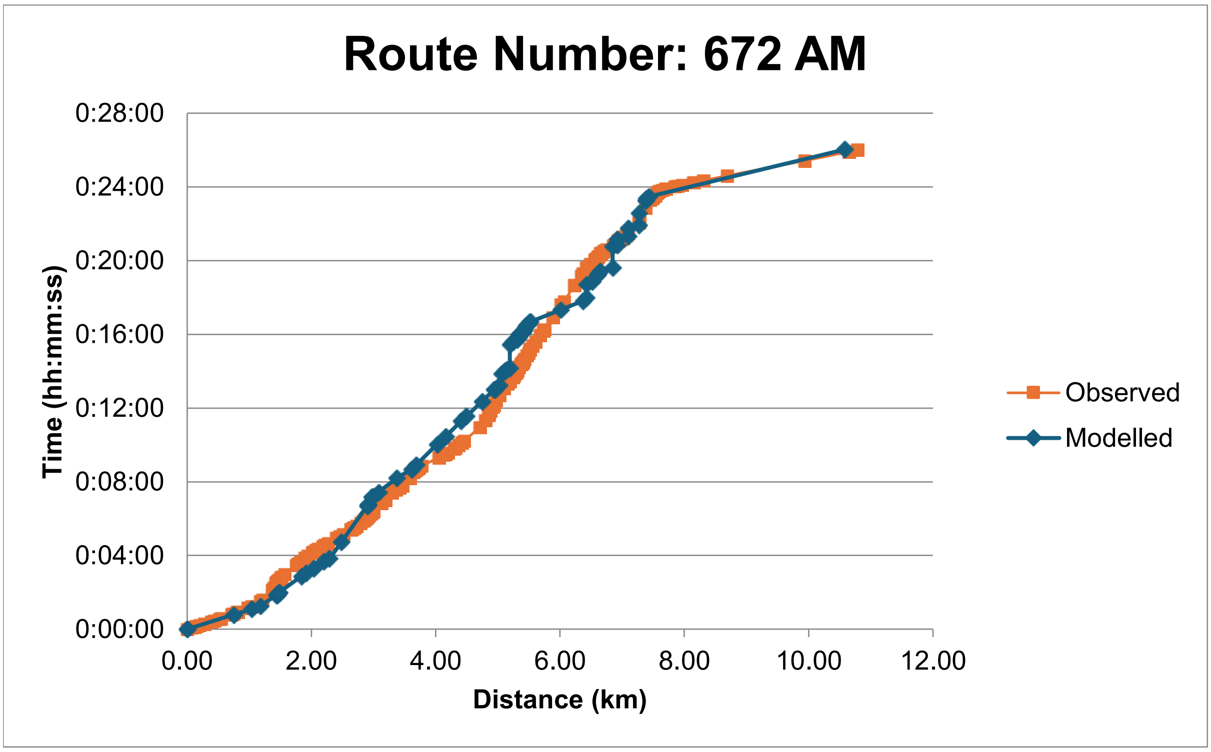
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



Route Number: 672 AM
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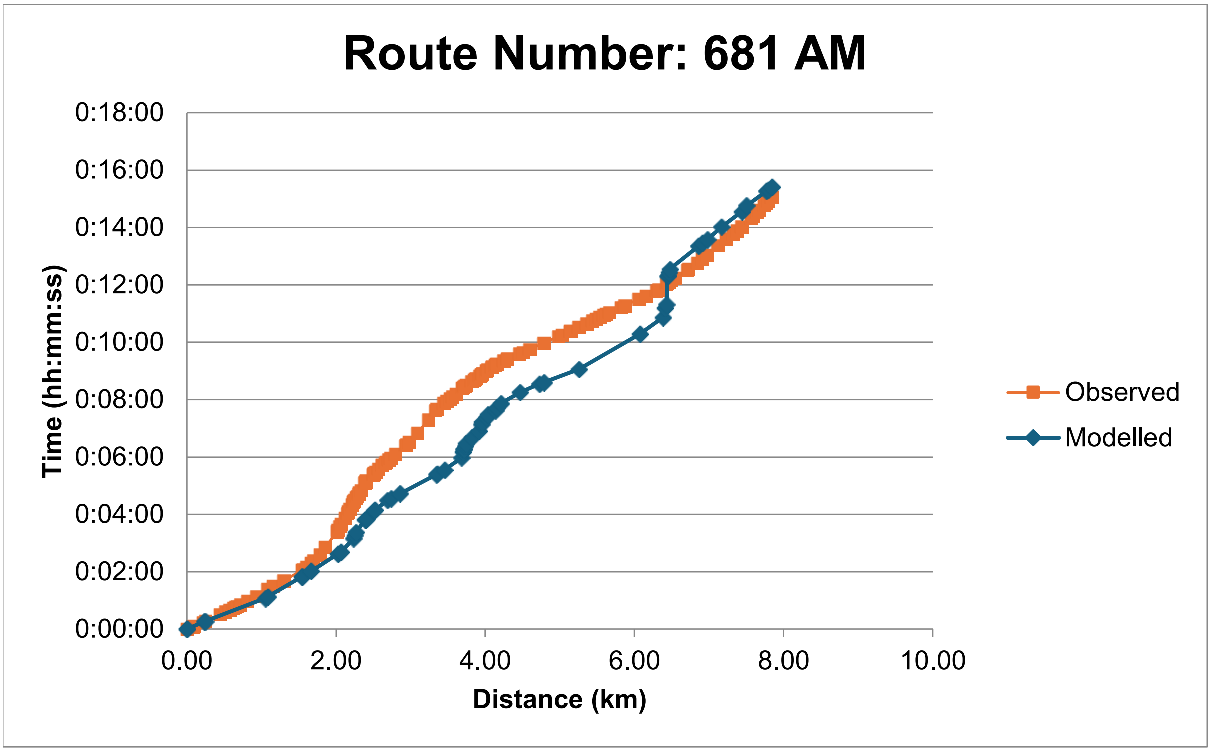
0:20:00
0:16:00
0:12:00
0:08:00
0:04:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 681 AM
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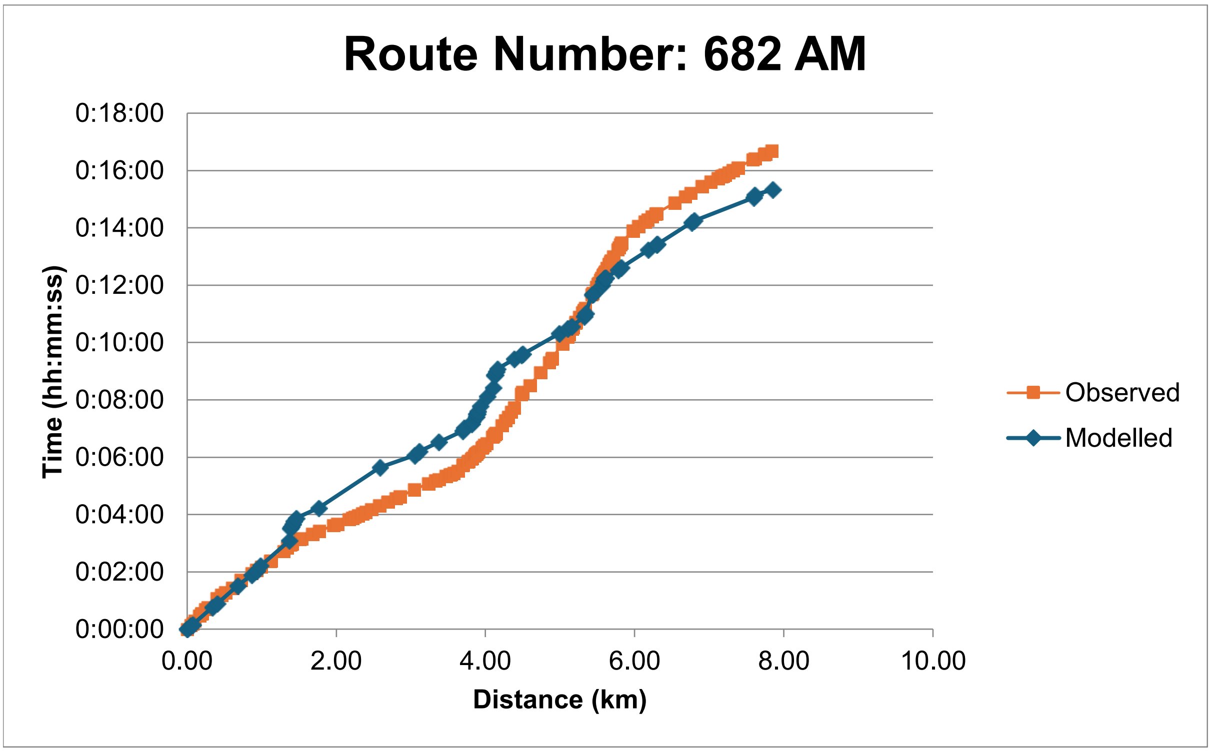
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 682 AM
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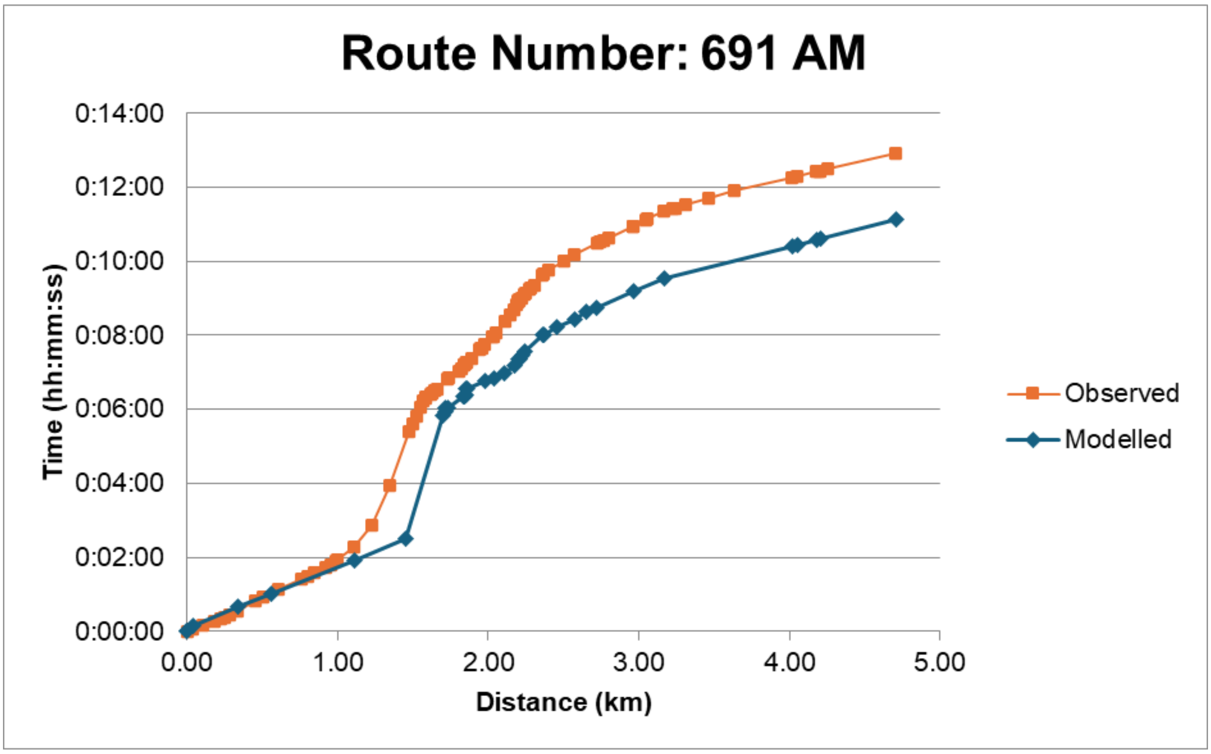
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 691 AM
Time (hh:mm:ss)
0:14:00
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0:10:00
0:08:00
0:06:00
0:04:00
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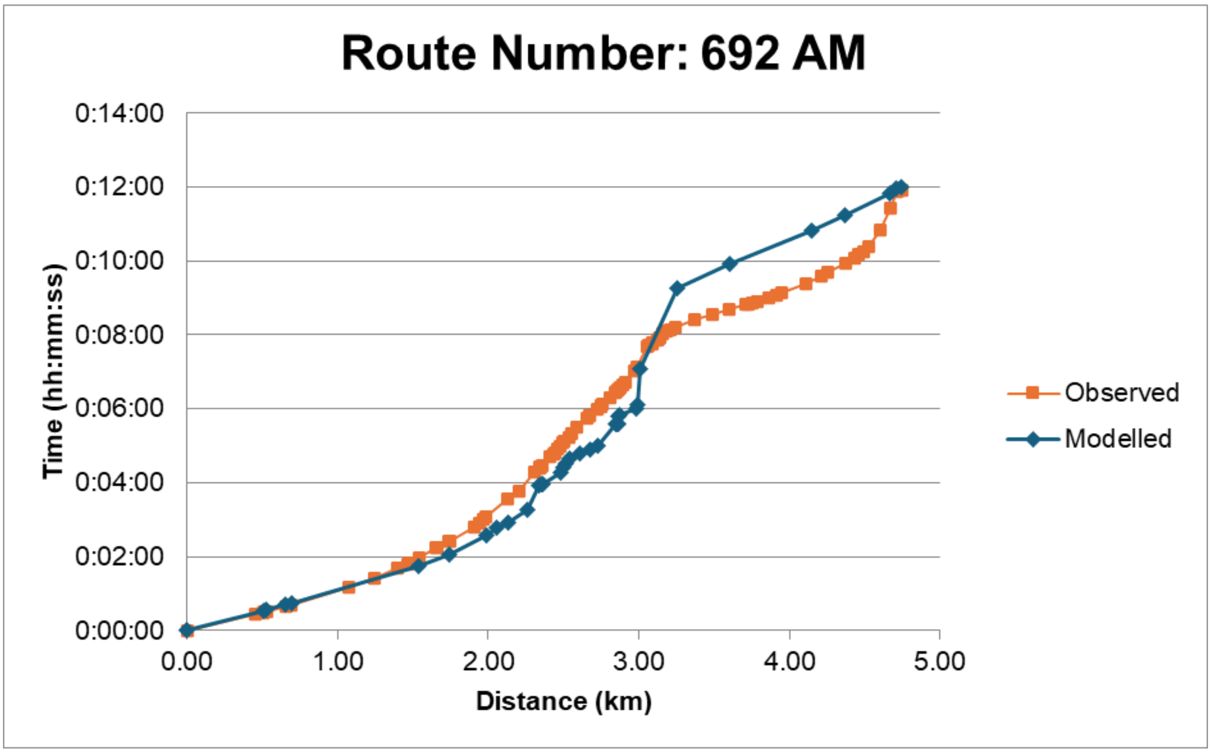
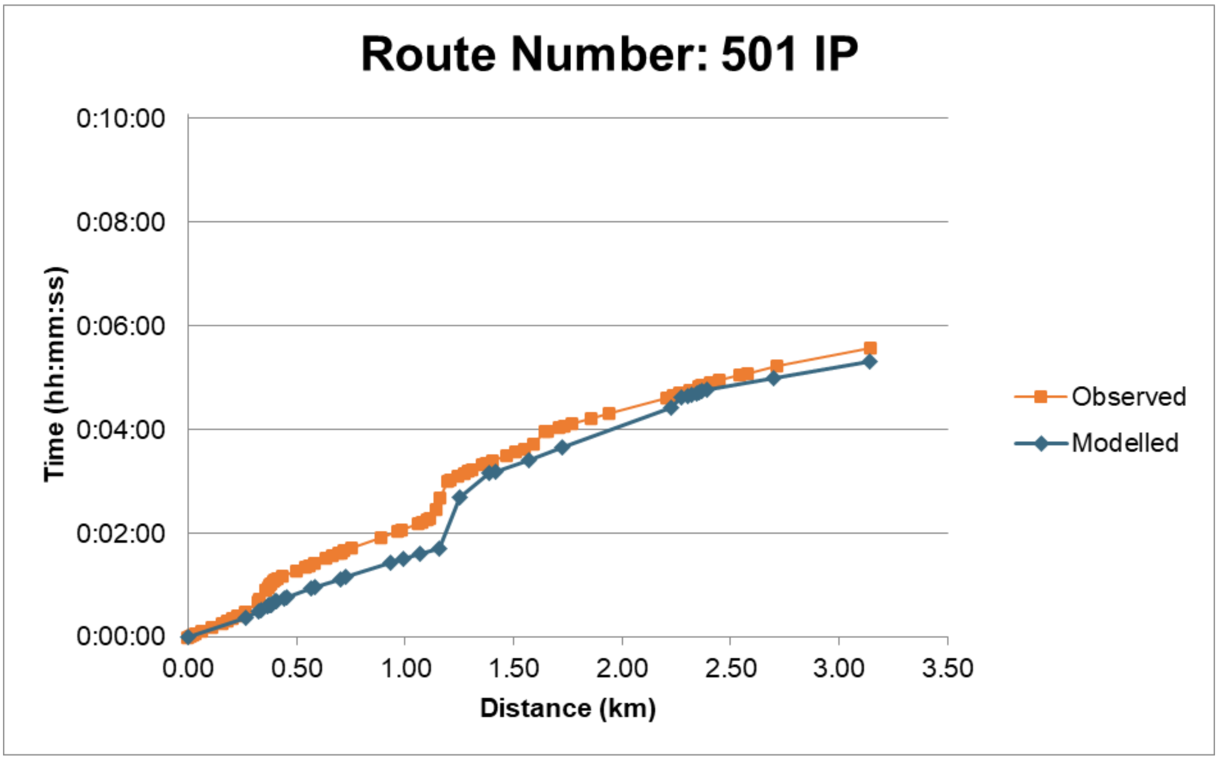
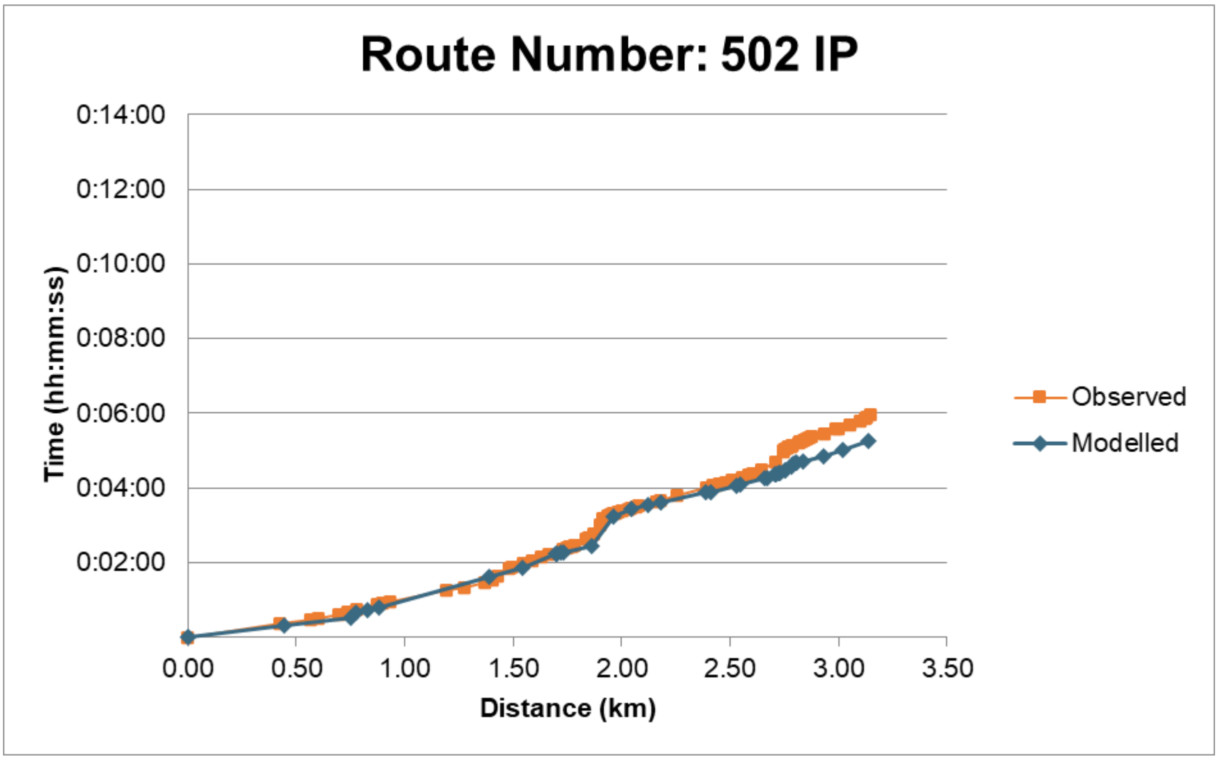
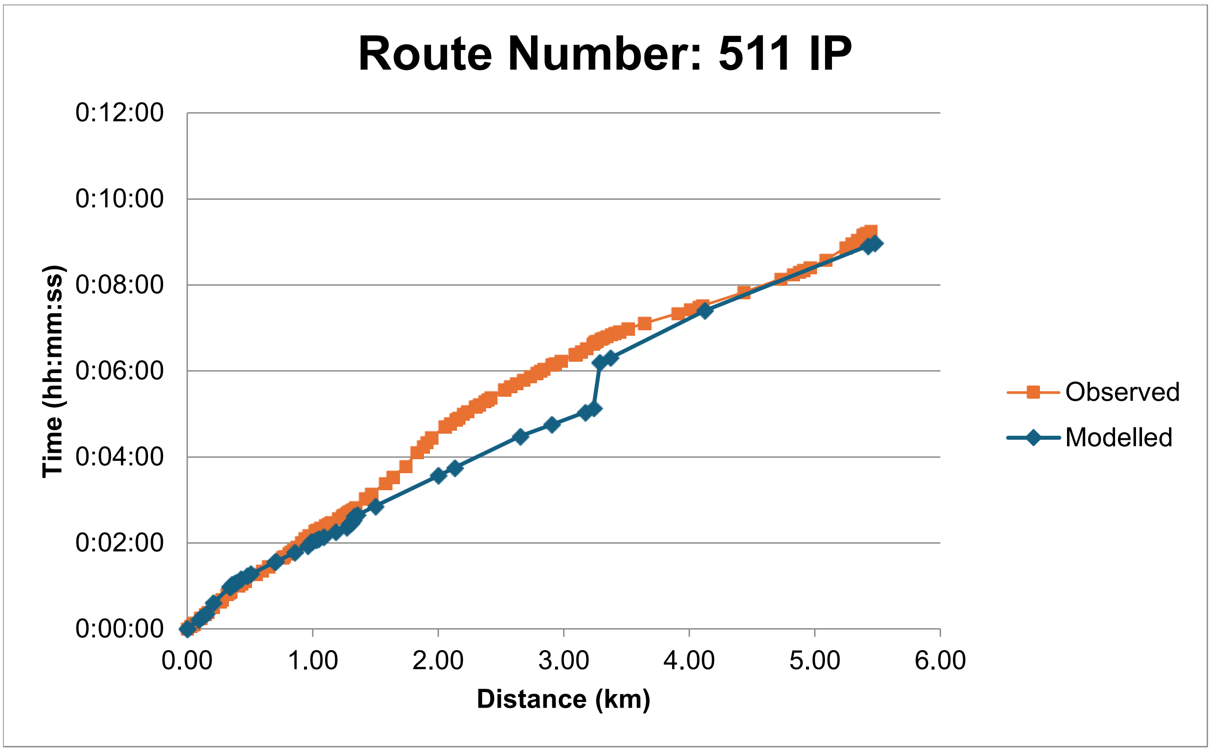
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 692 AM
Time (hh:mm:ss)
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled

A.2 IP JT plots







Route Number: 511 IP
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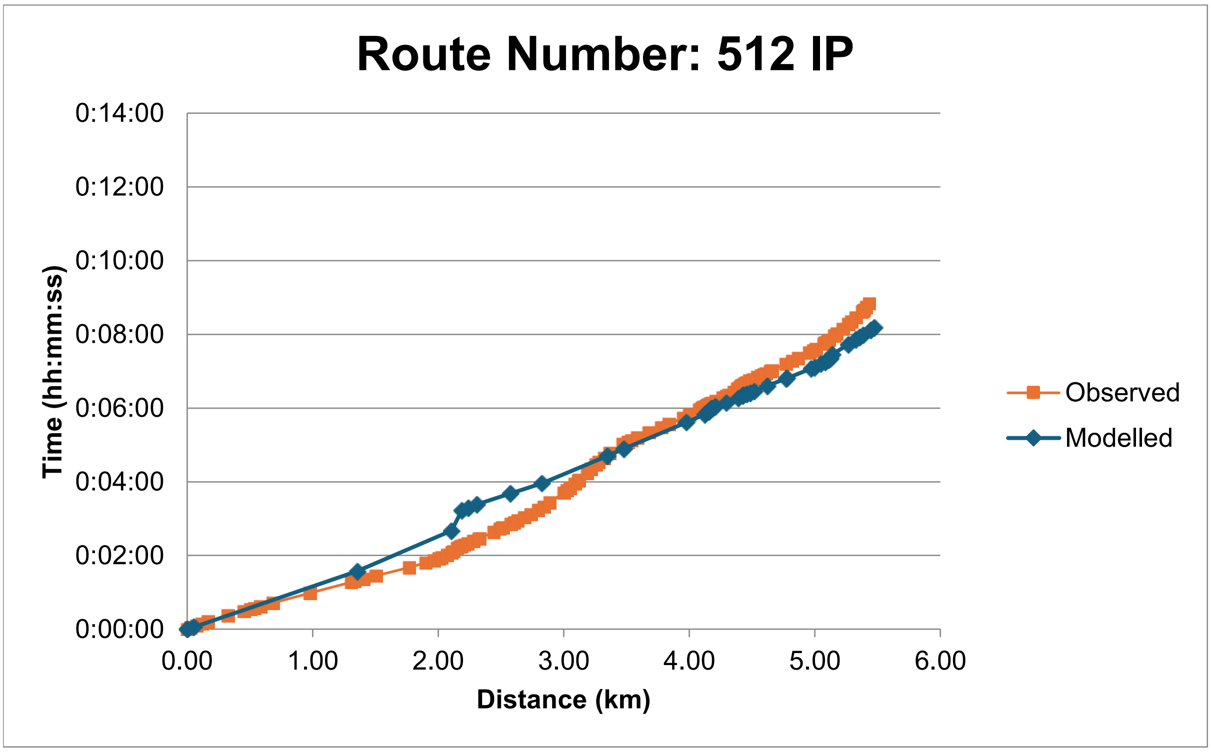
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled



Route Number: 512 IP
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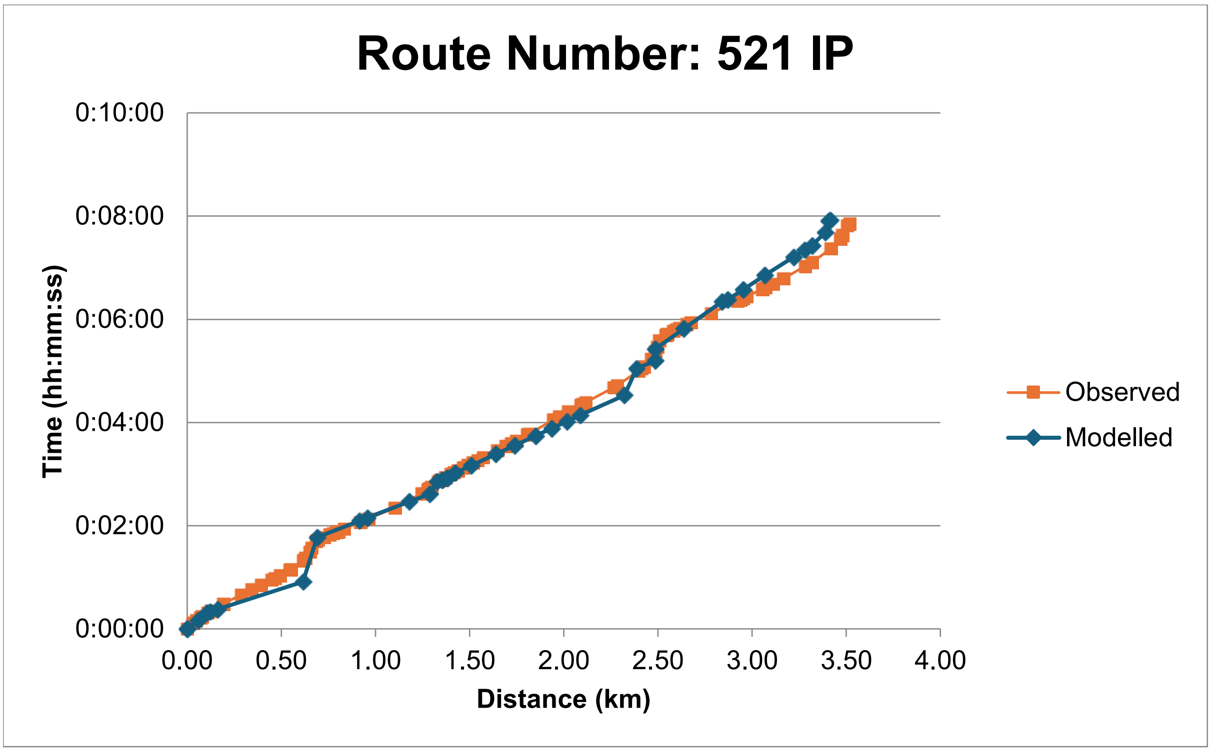
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled


Route Number: 521 IP
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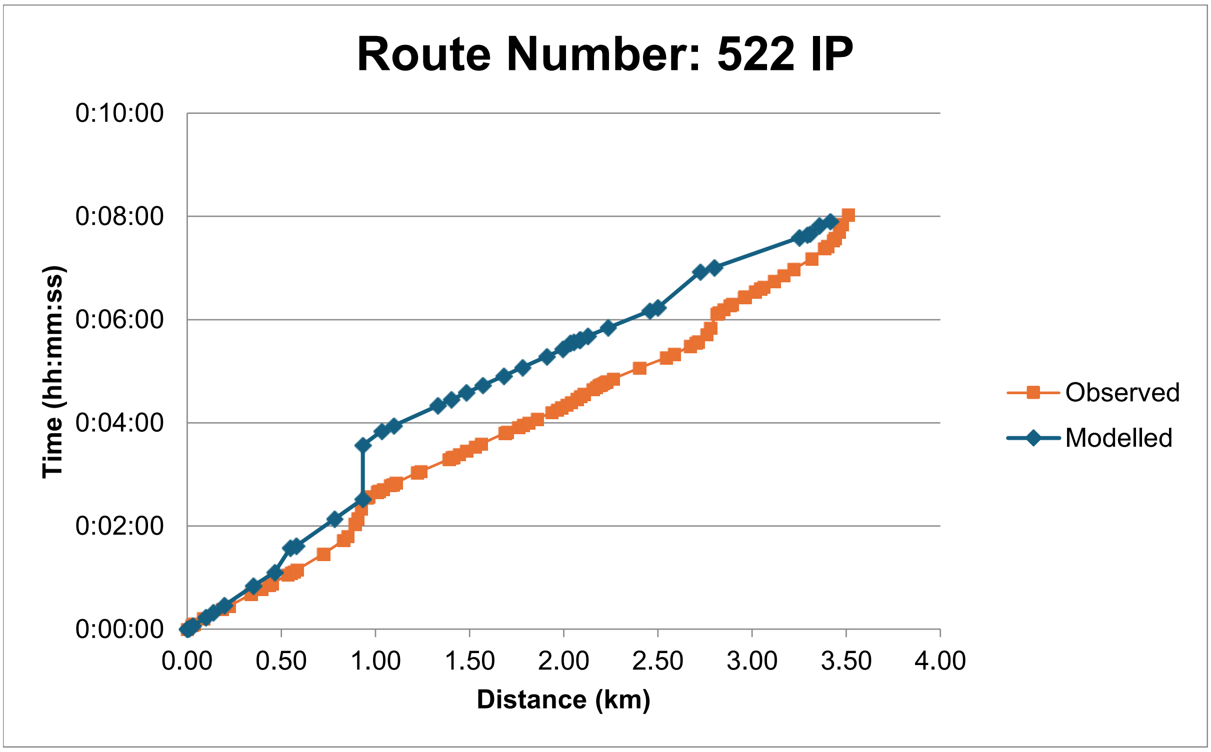
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled


Route Number: 522 IP
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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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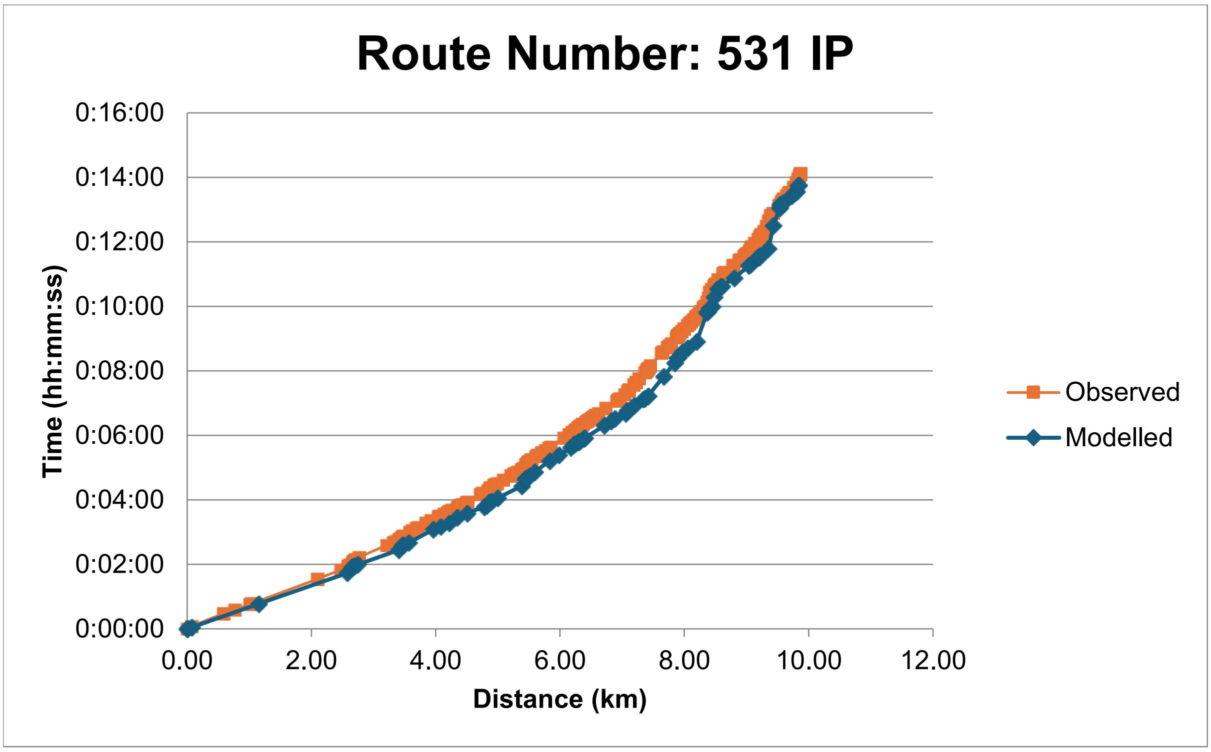
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled


Route Number: 531 IP
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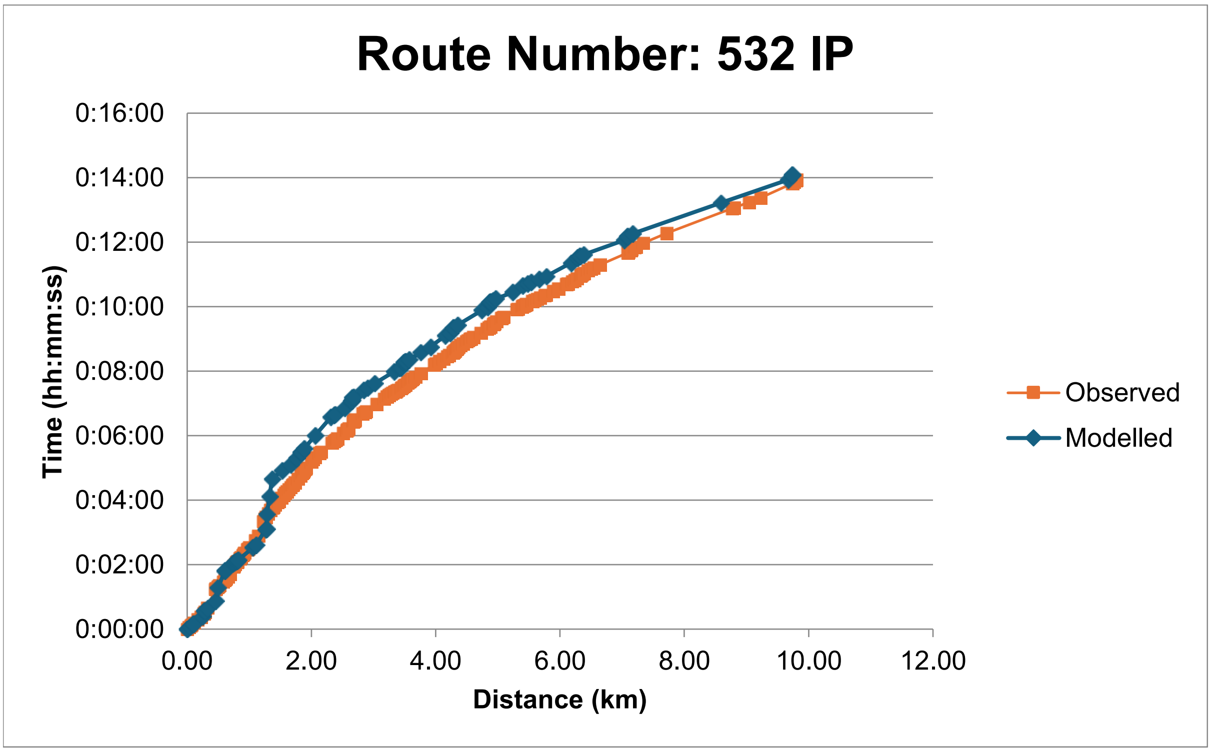
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 532 IP
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0:08:00
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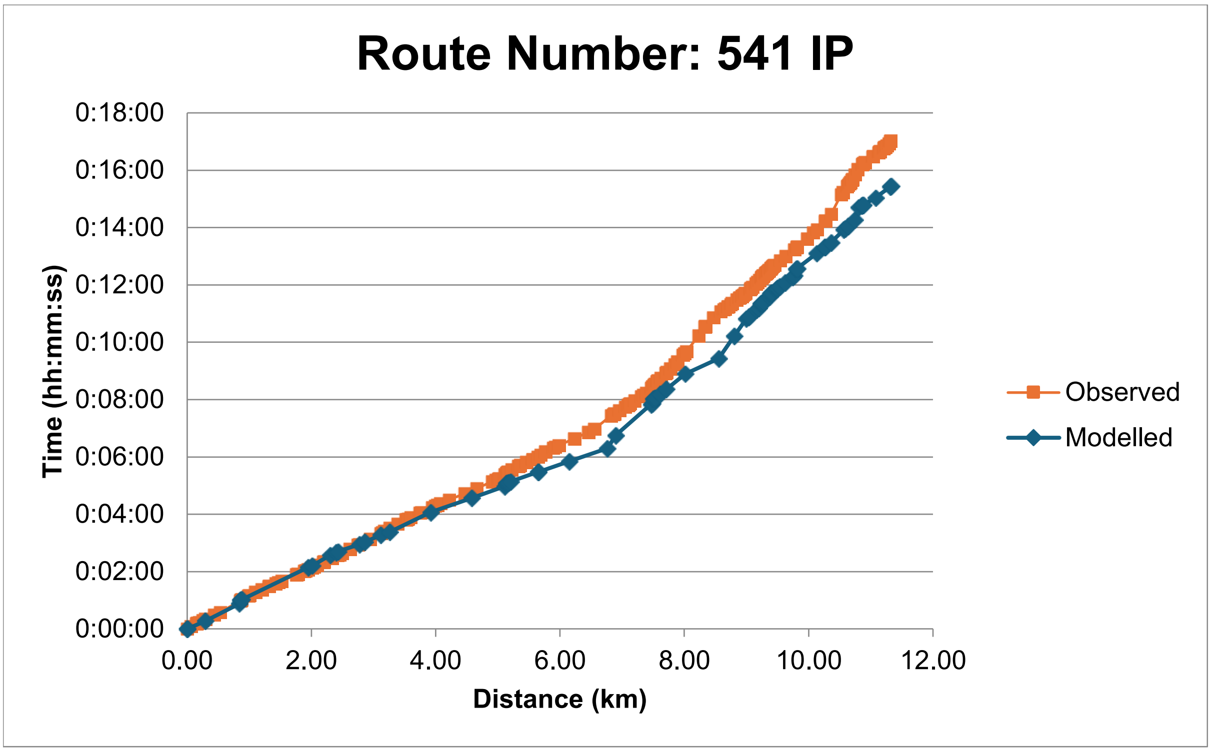
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



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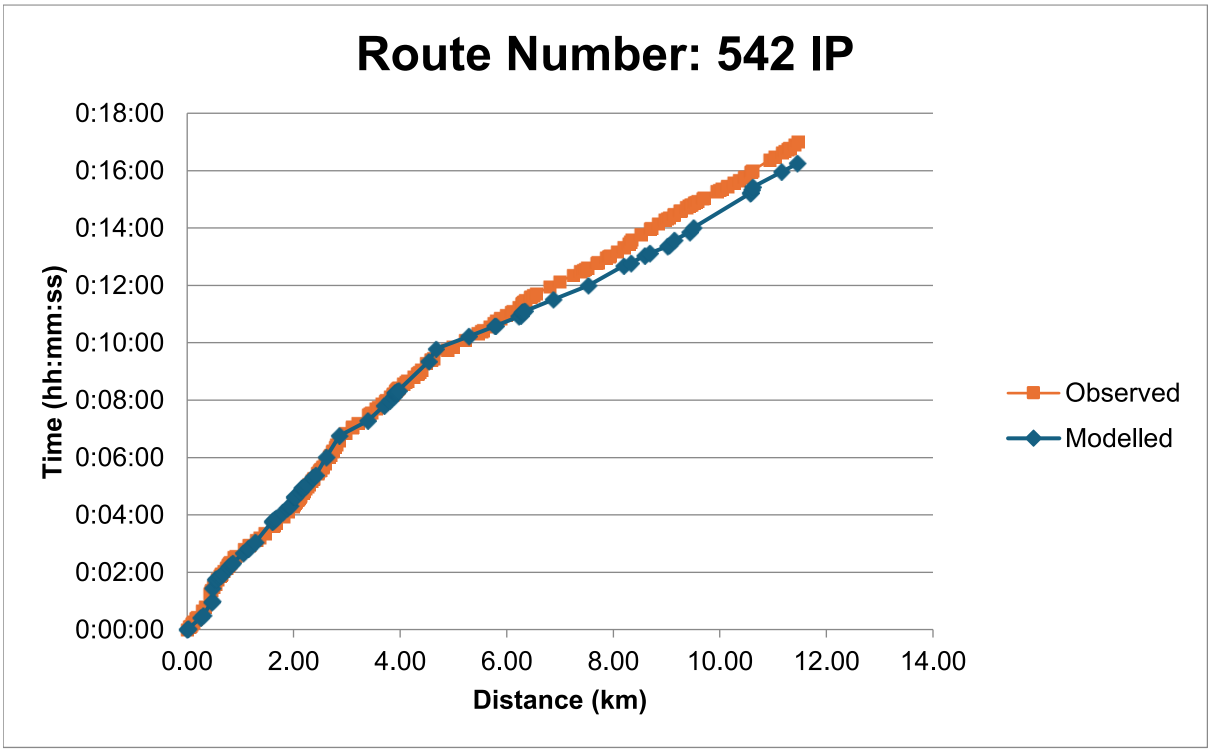
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



Route Number: 542 IP
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0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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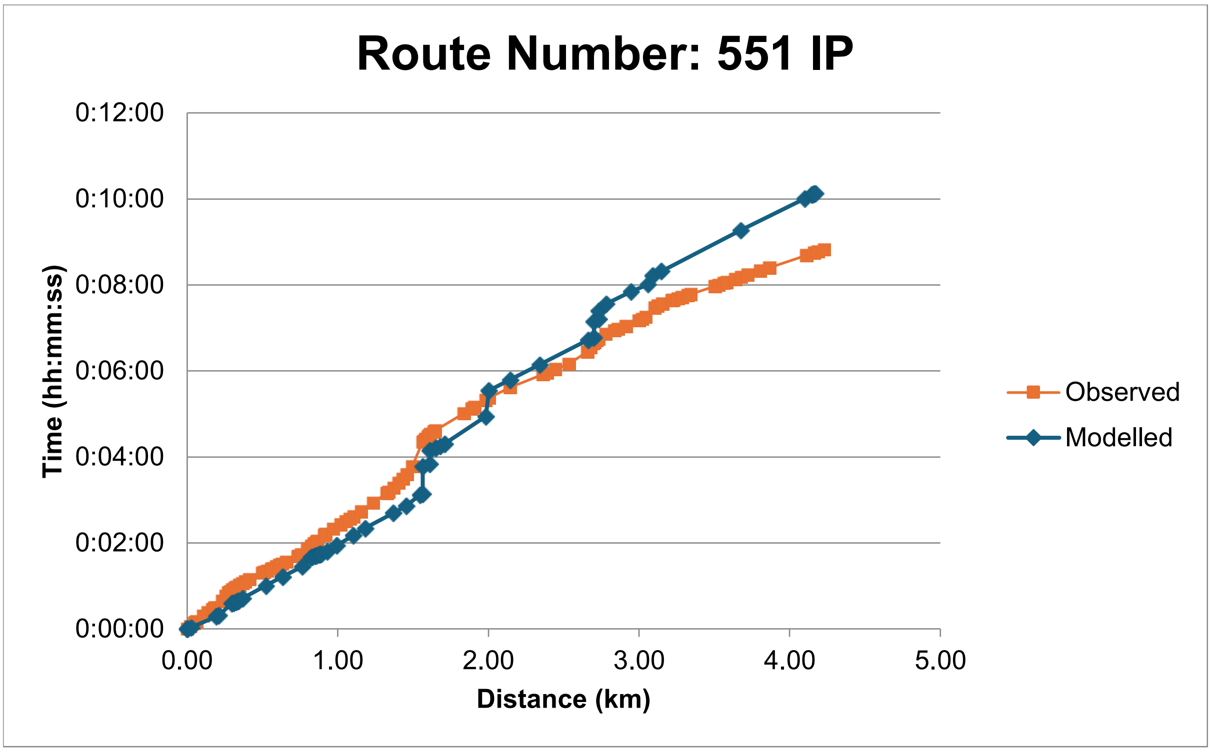
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance (km)
Observed
Modelled


Route Number: 551 IP
Time (hh:mm:ss)
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0:06:00
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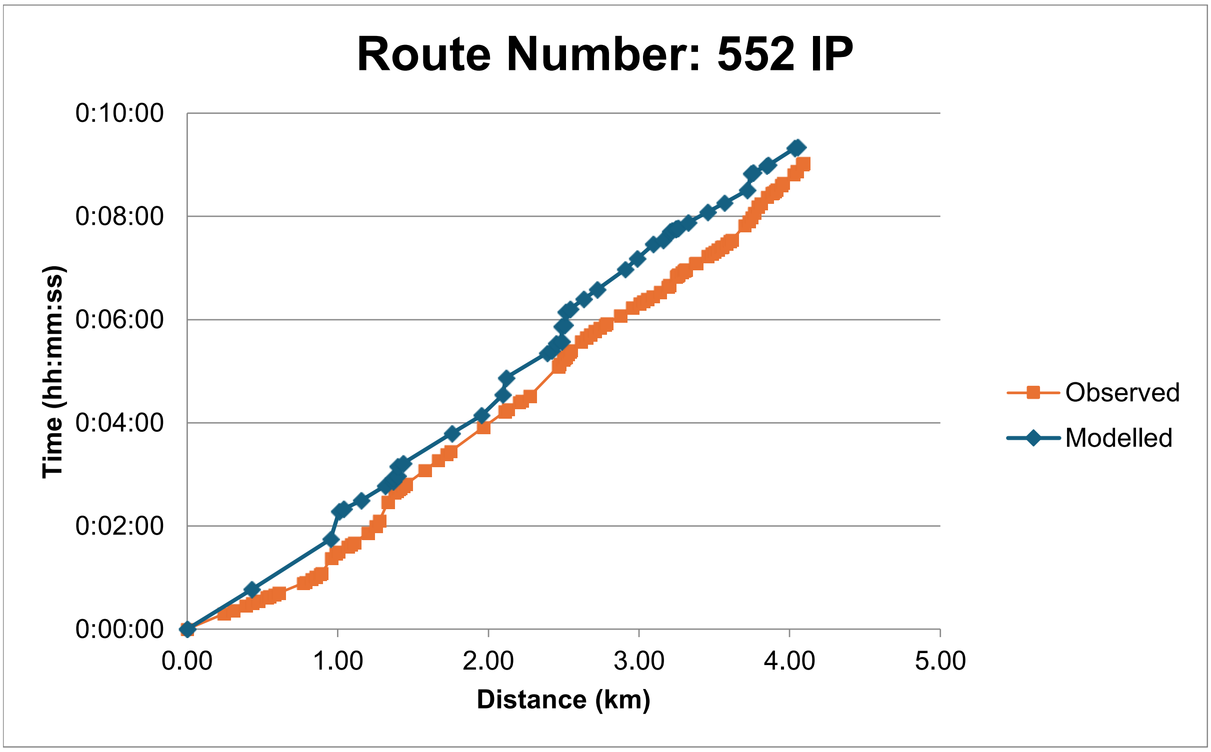
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 552 IP
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0:04:00
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0.00
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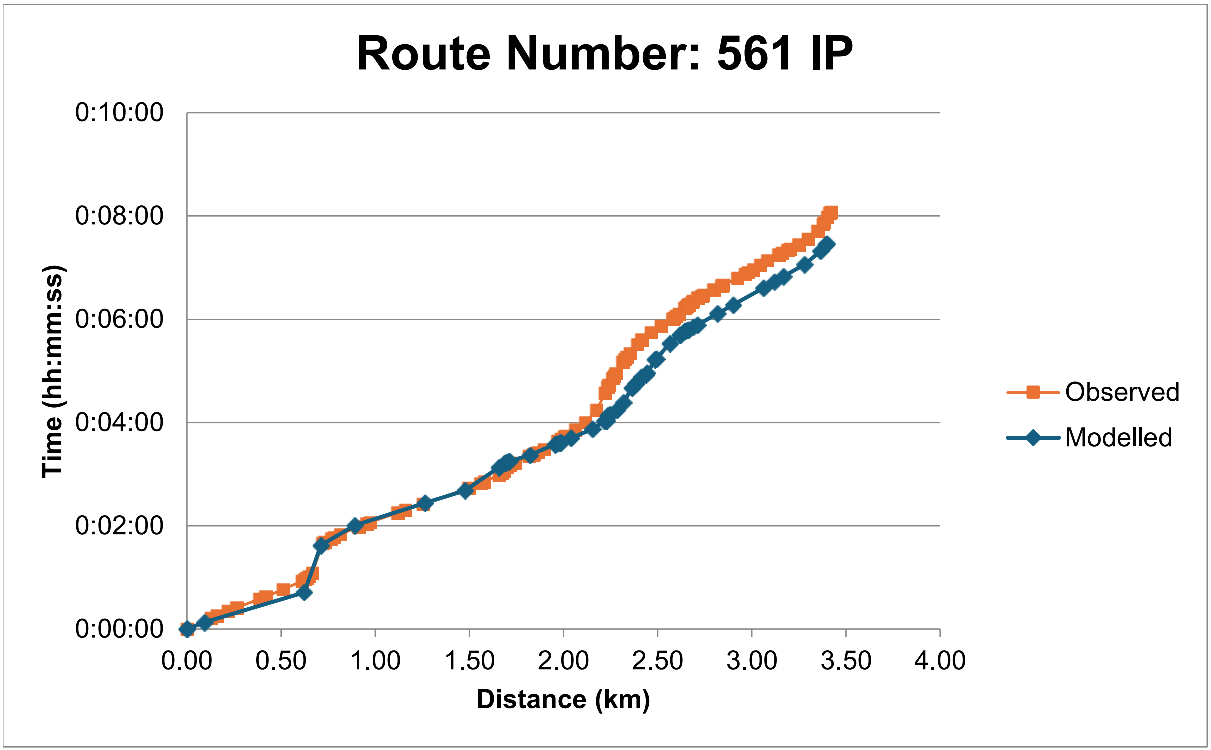
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 561 IP
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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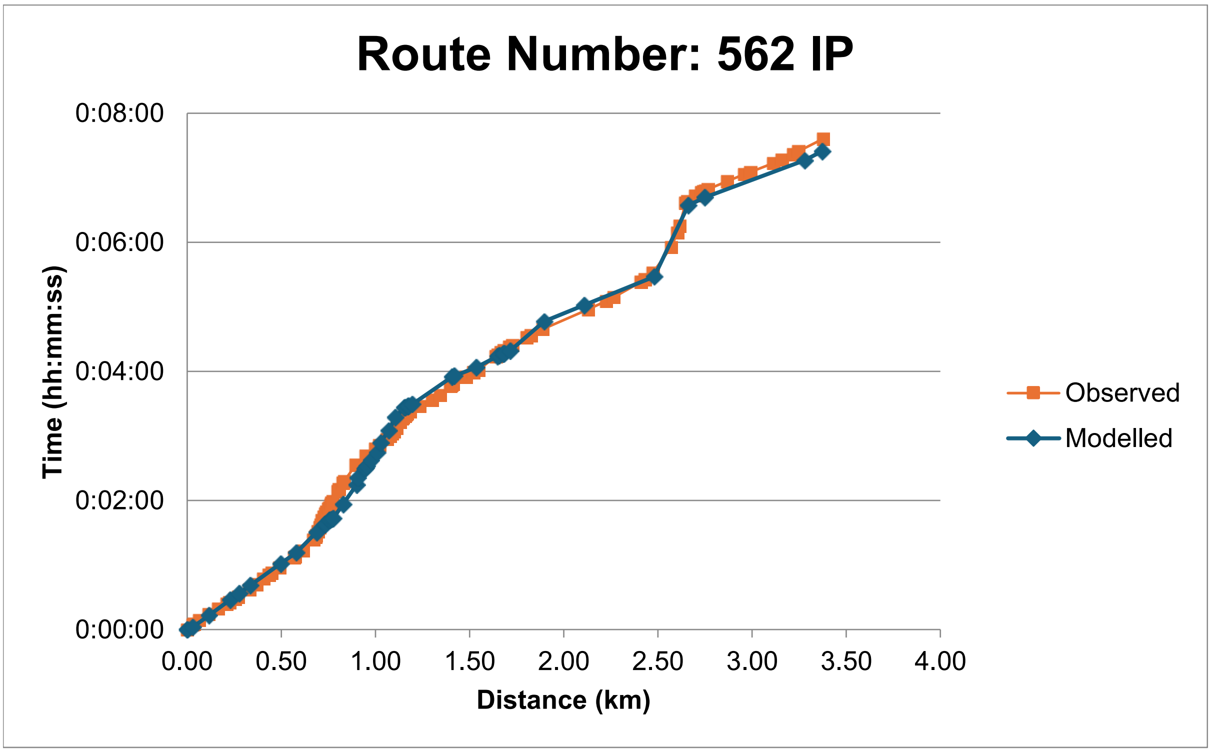
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled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0:00:00
Time (hh:mm:ss)
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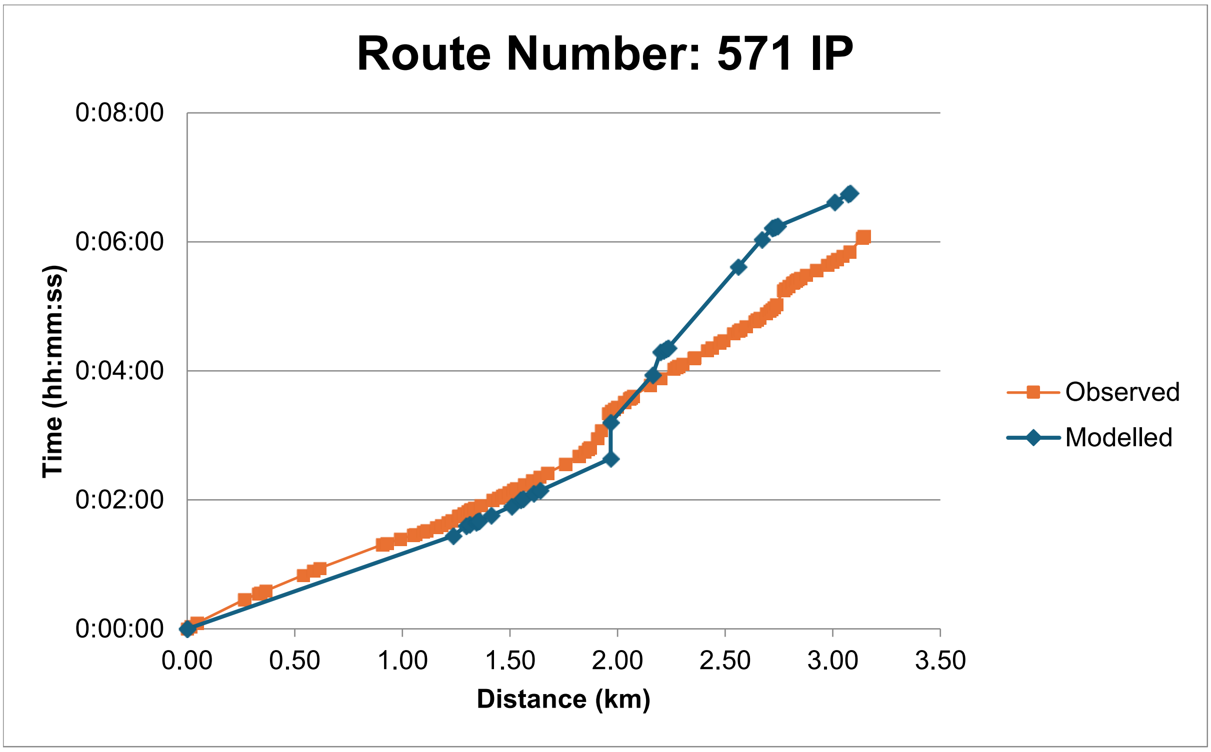
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled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Time (hh:mm:ss)
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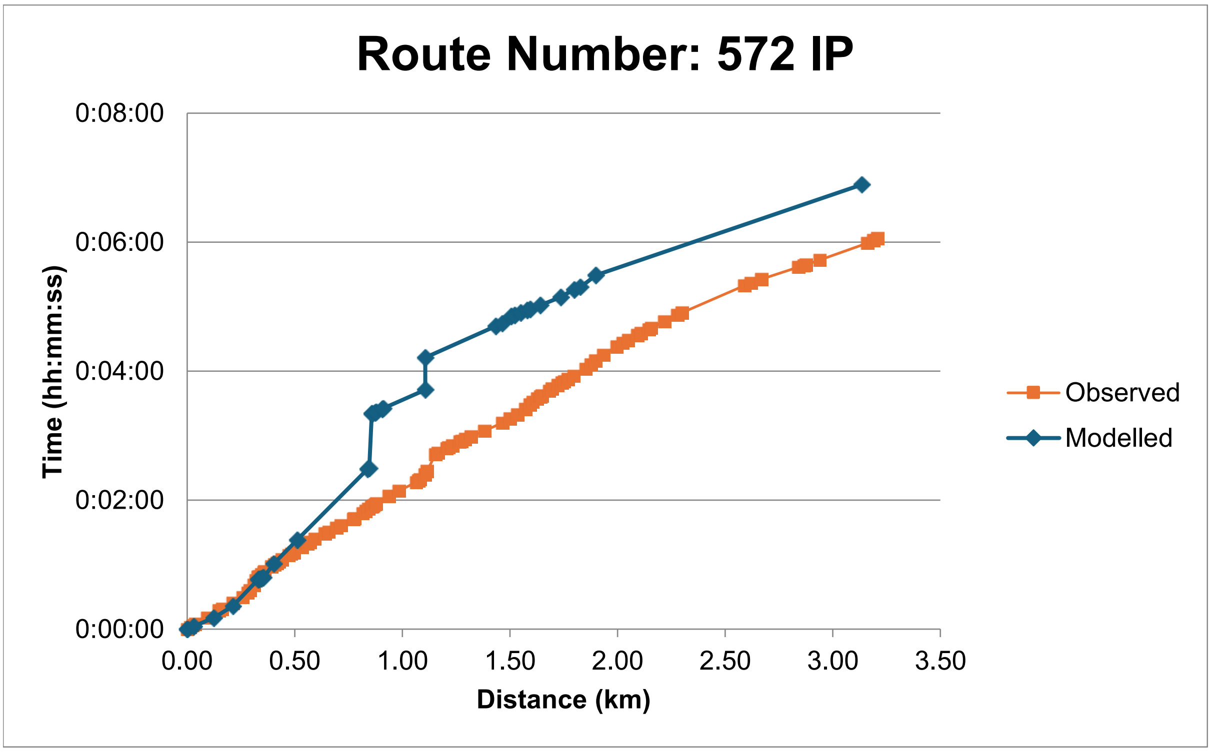
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled


Route Number: 572 IP
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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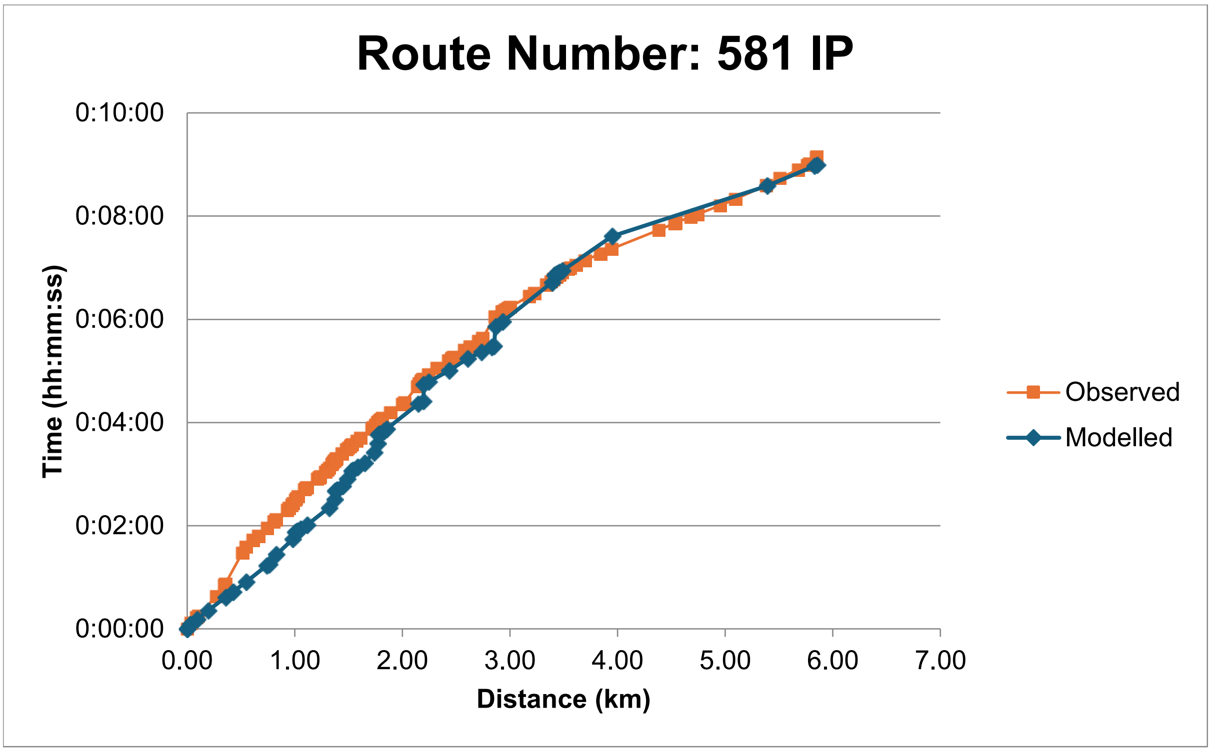
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled


Route Number: 581 IP
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0:02:00
0:00:00
Time (hh:mm:ss)
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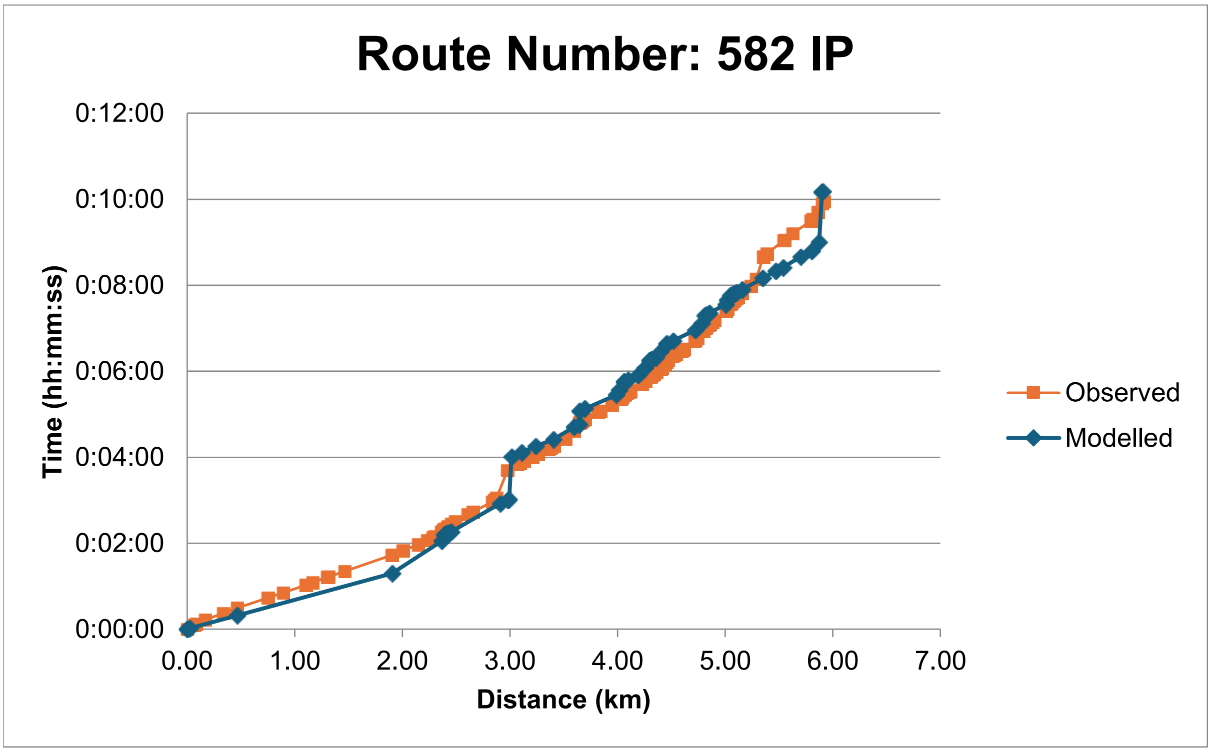
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 582 IP
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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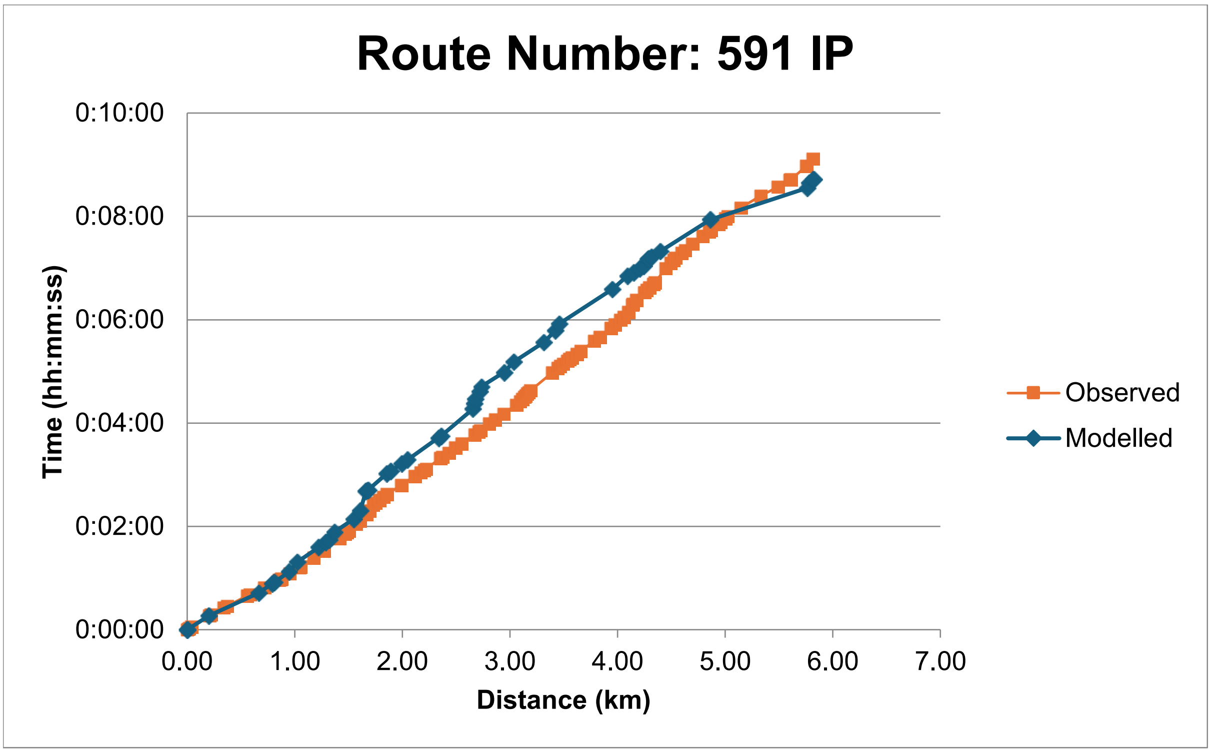
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 591 IP
Time (hh:mm:ss)
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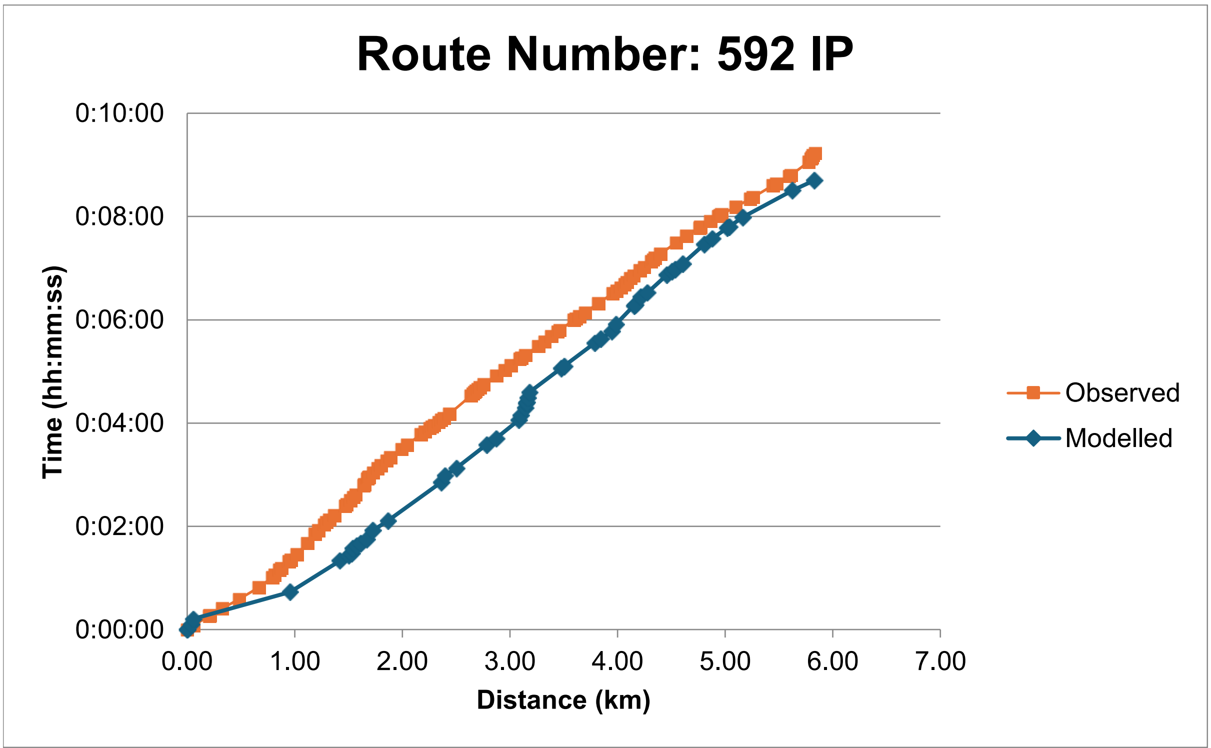
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 592 IP
Time (hh:mm:ss)
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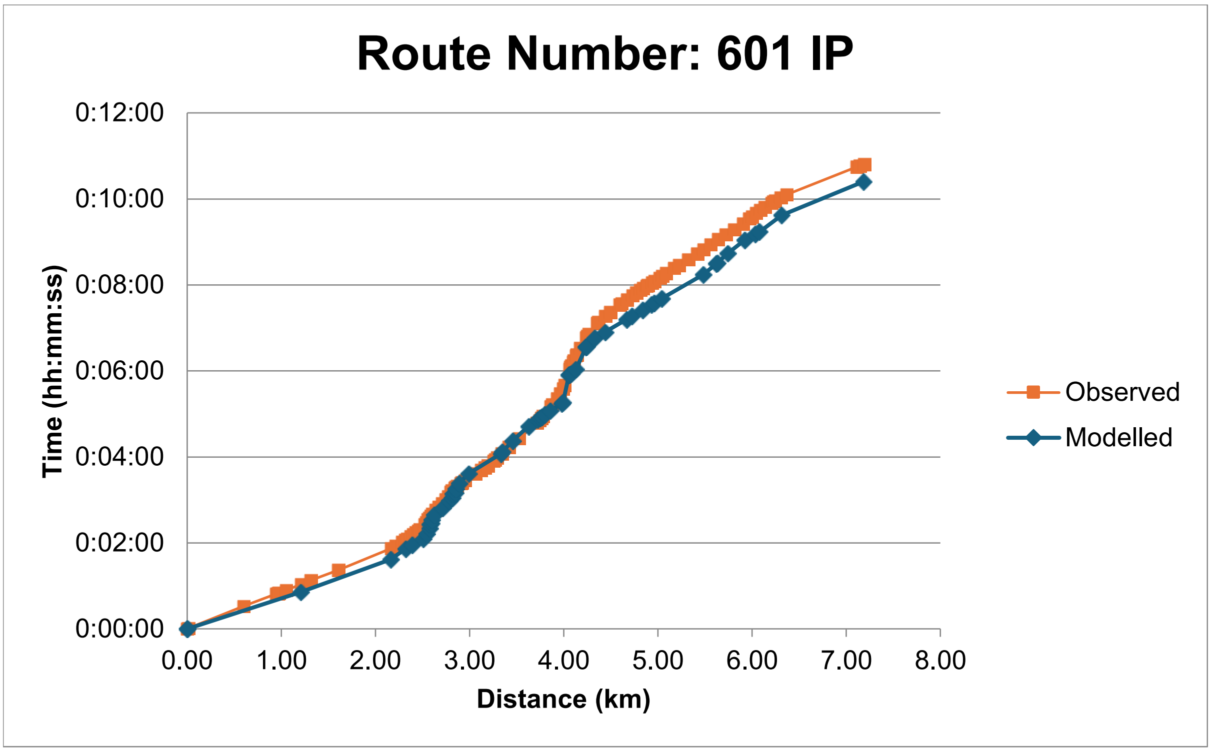
0:06:00
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 601 IP
0:12:00
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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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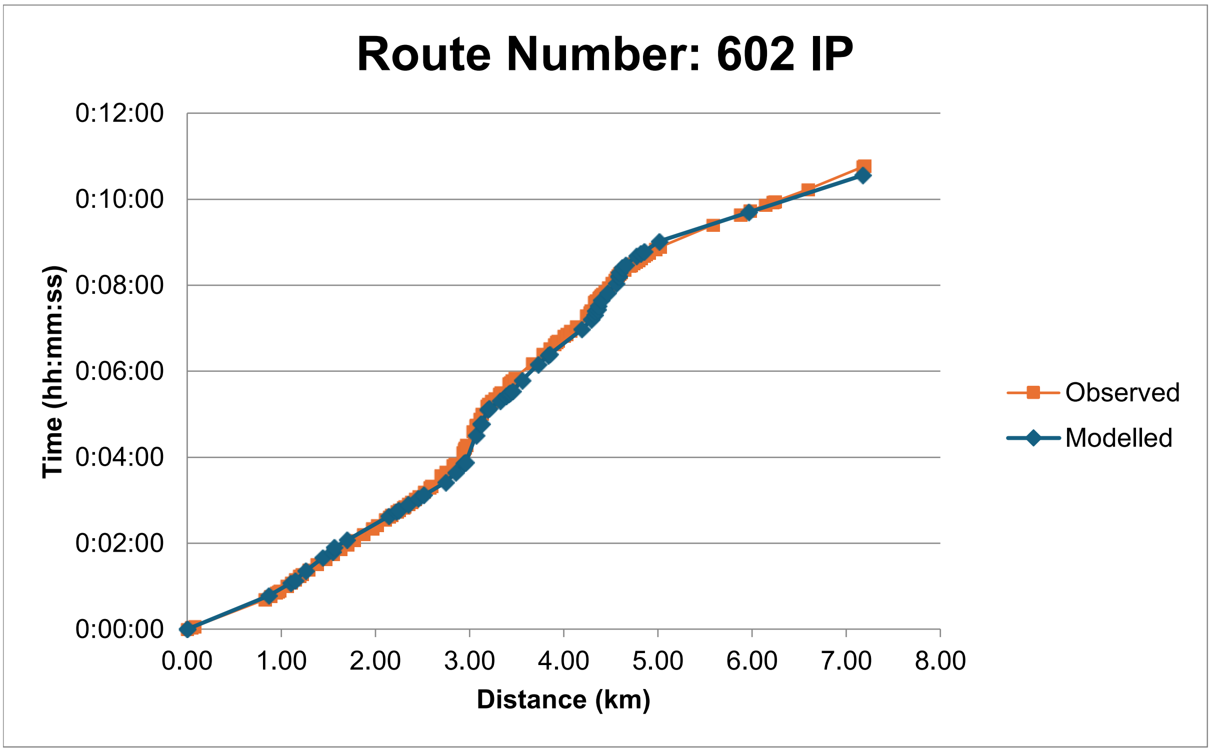
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled


Route Number: 602 IP
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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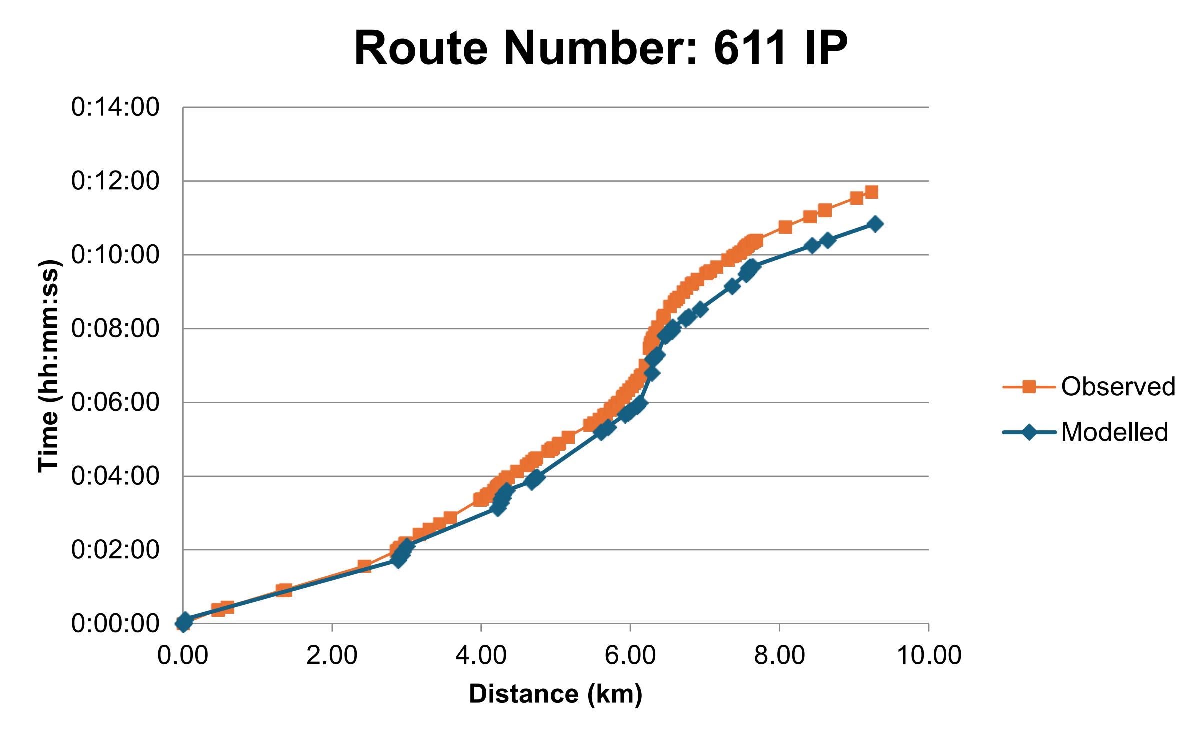
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled


Route Number: 611 IP
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0:06:00
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0:02:00
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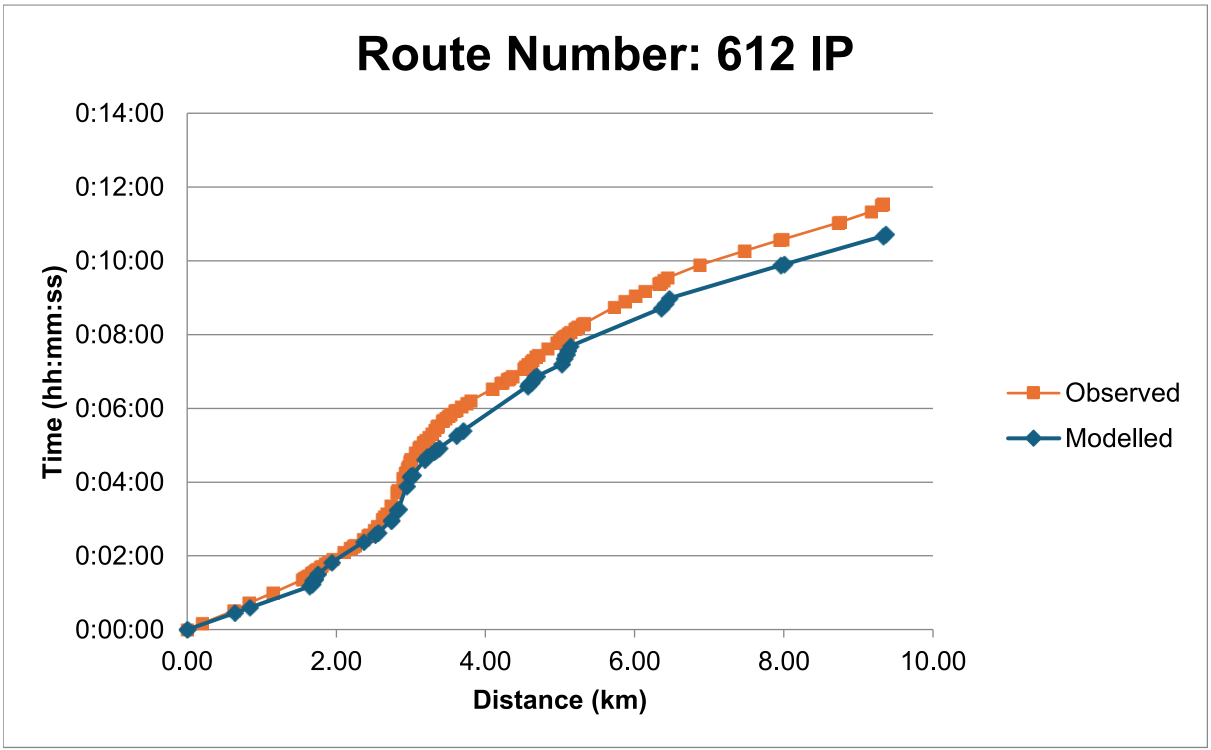
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled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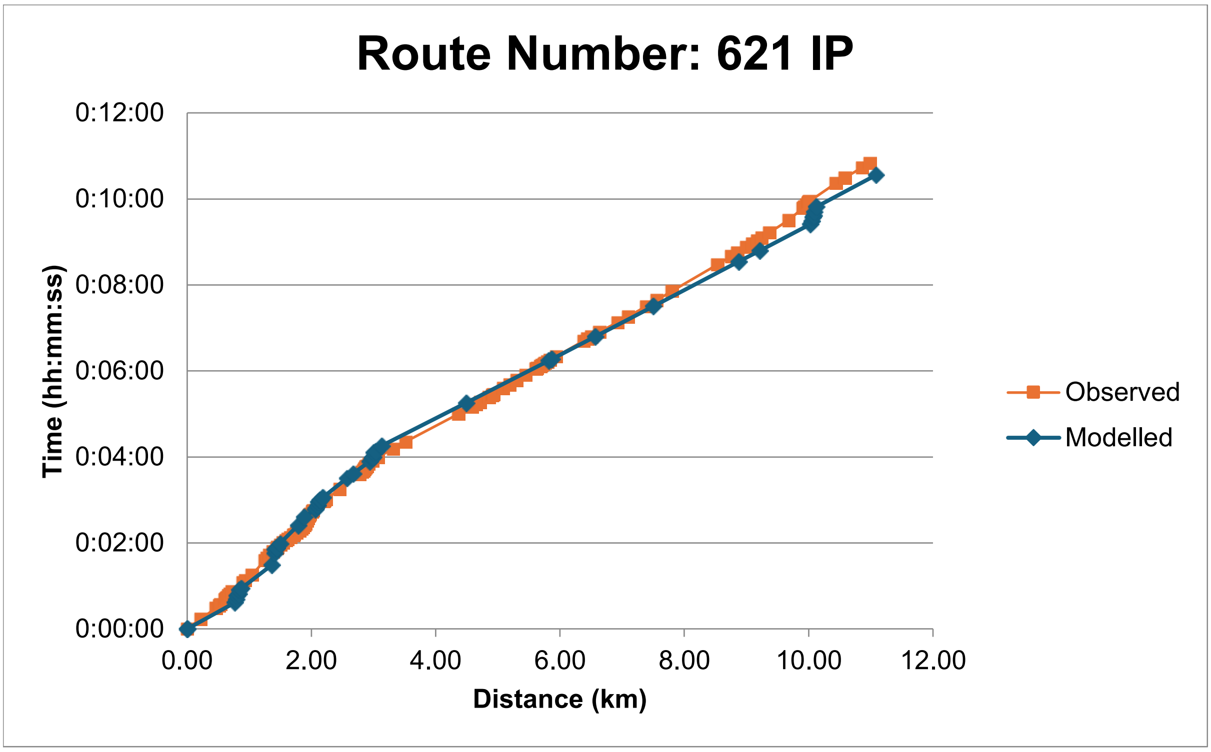
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 621 IP
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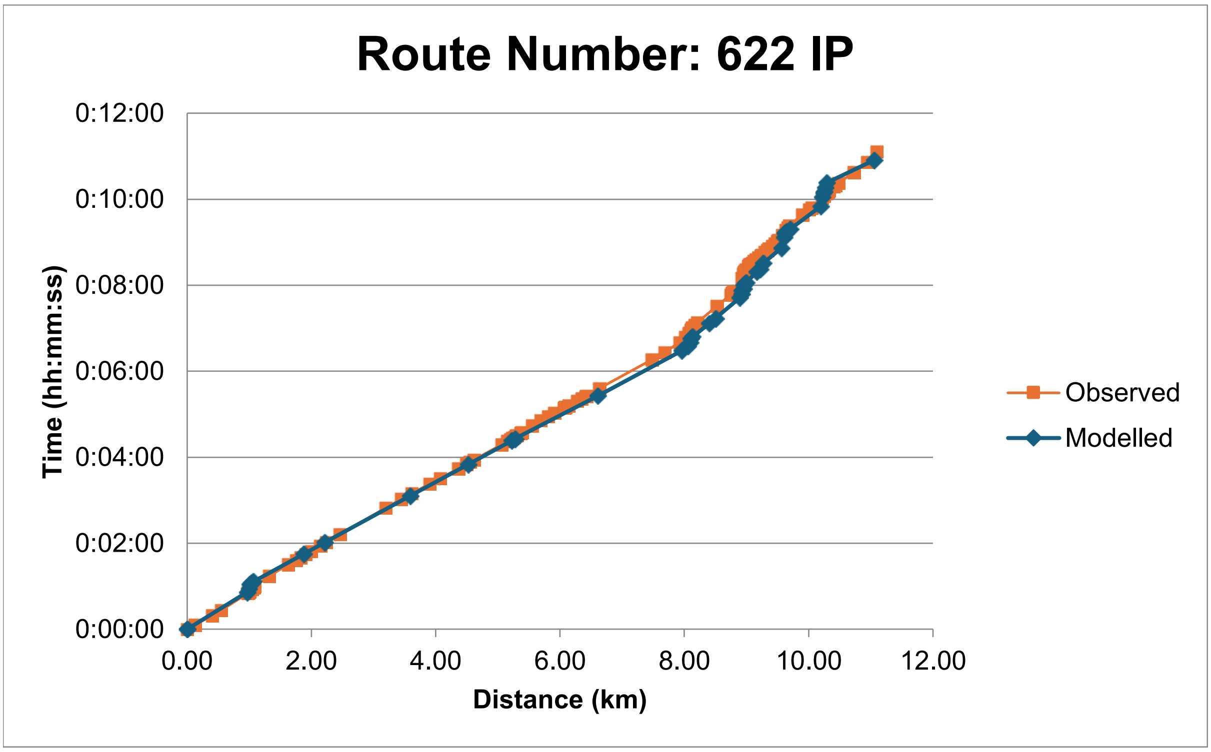
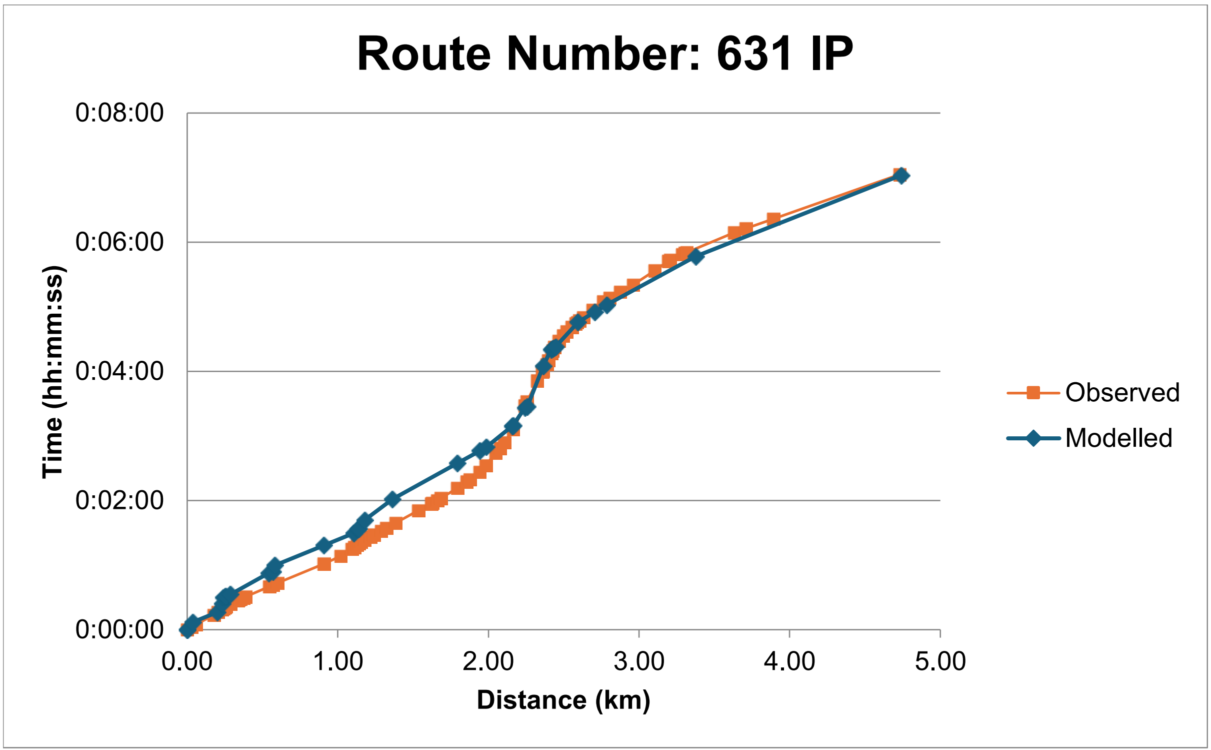
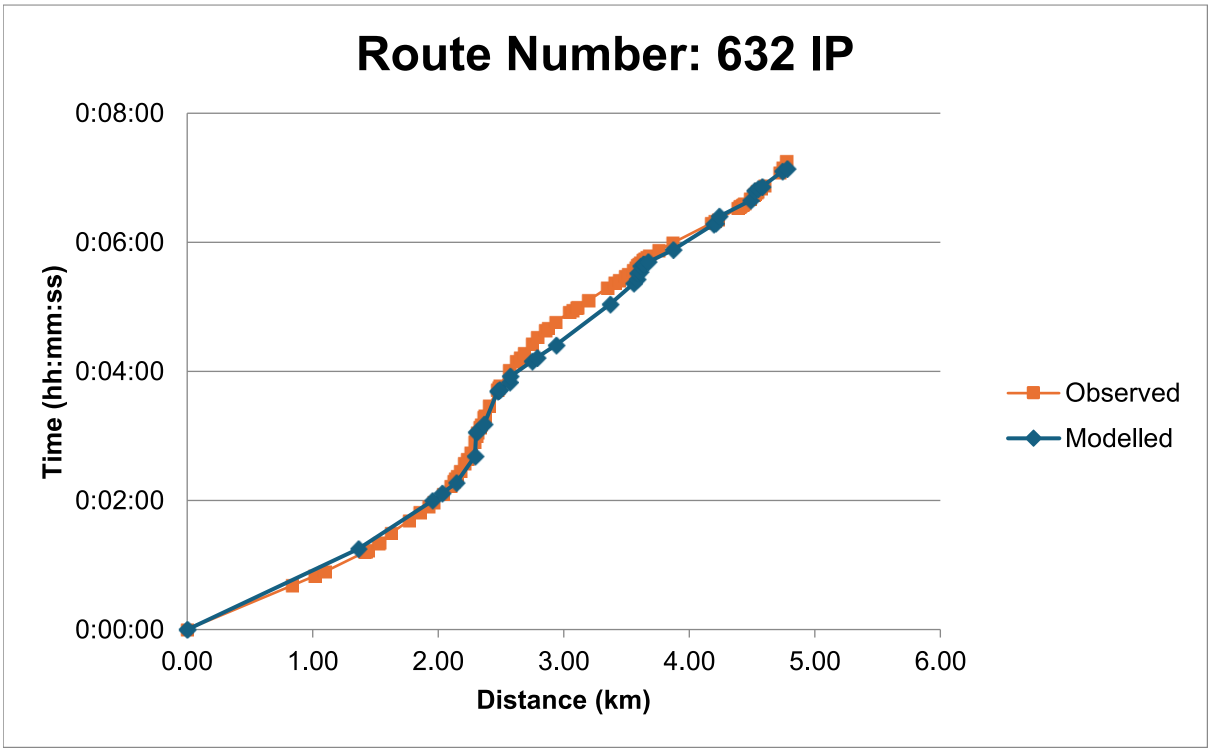
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 622 IP
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 631 IP
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 632 IP
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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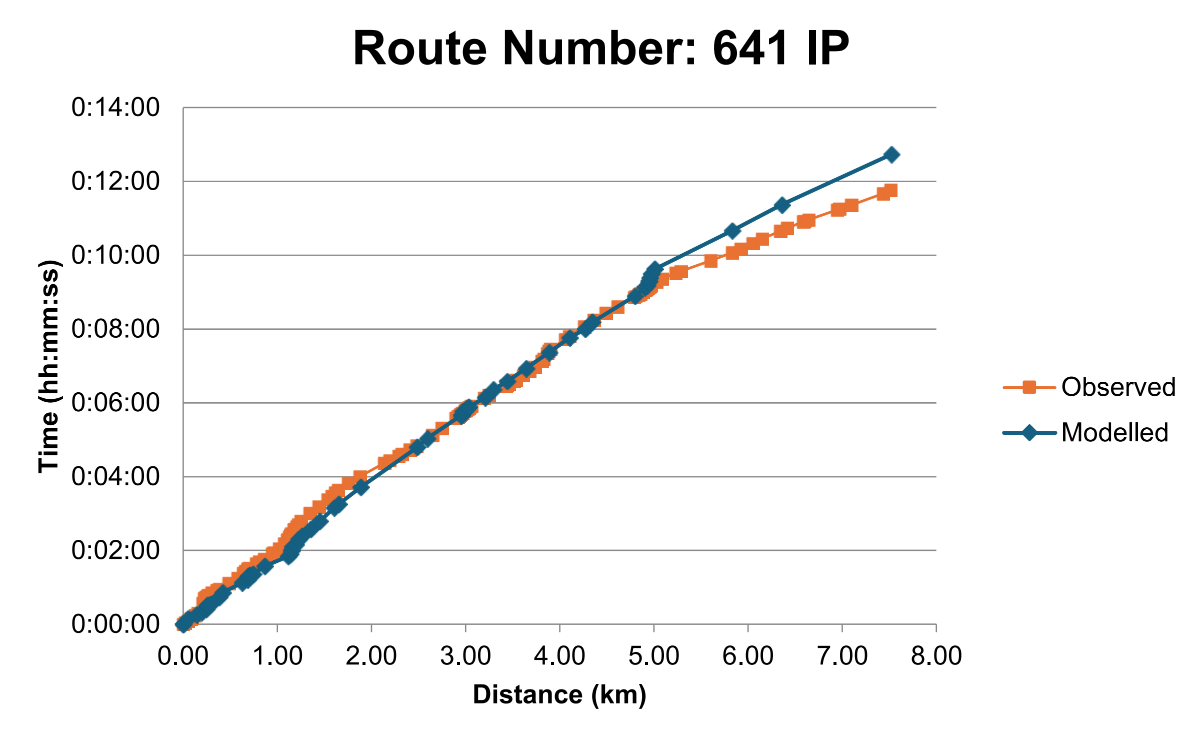
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled


Route Number: 641 IP
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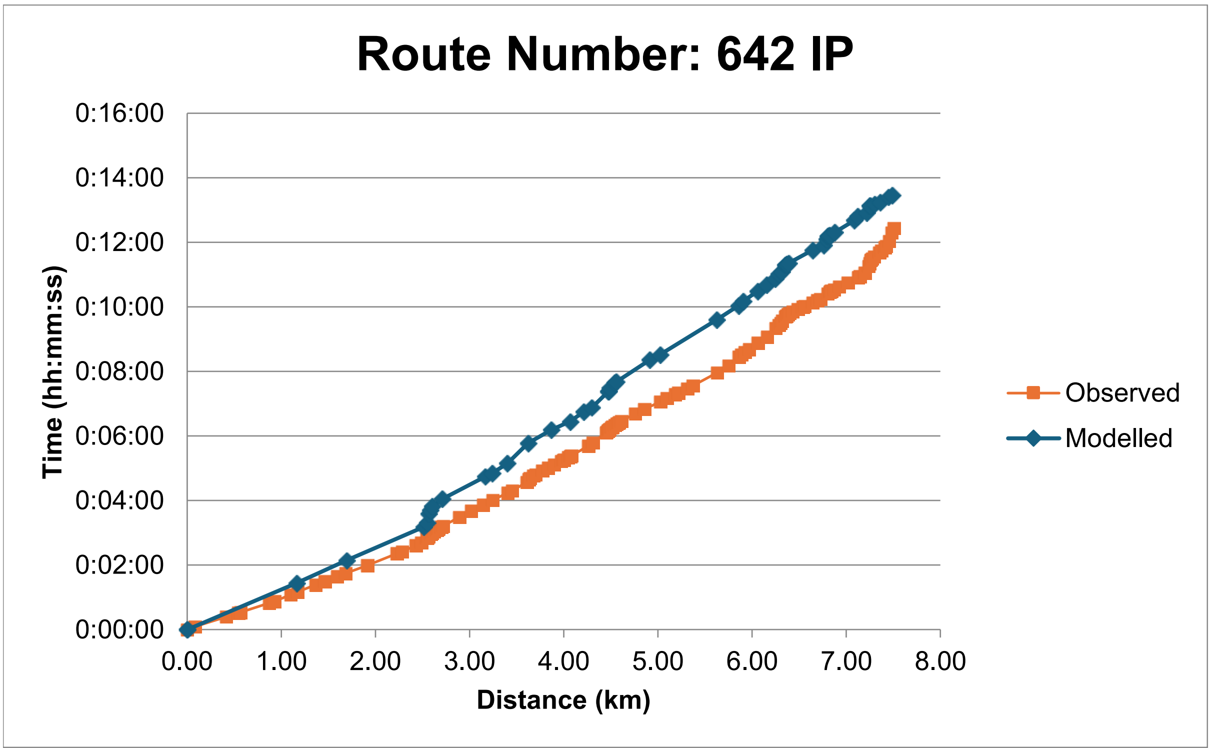
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled


Route Number: 642 IP
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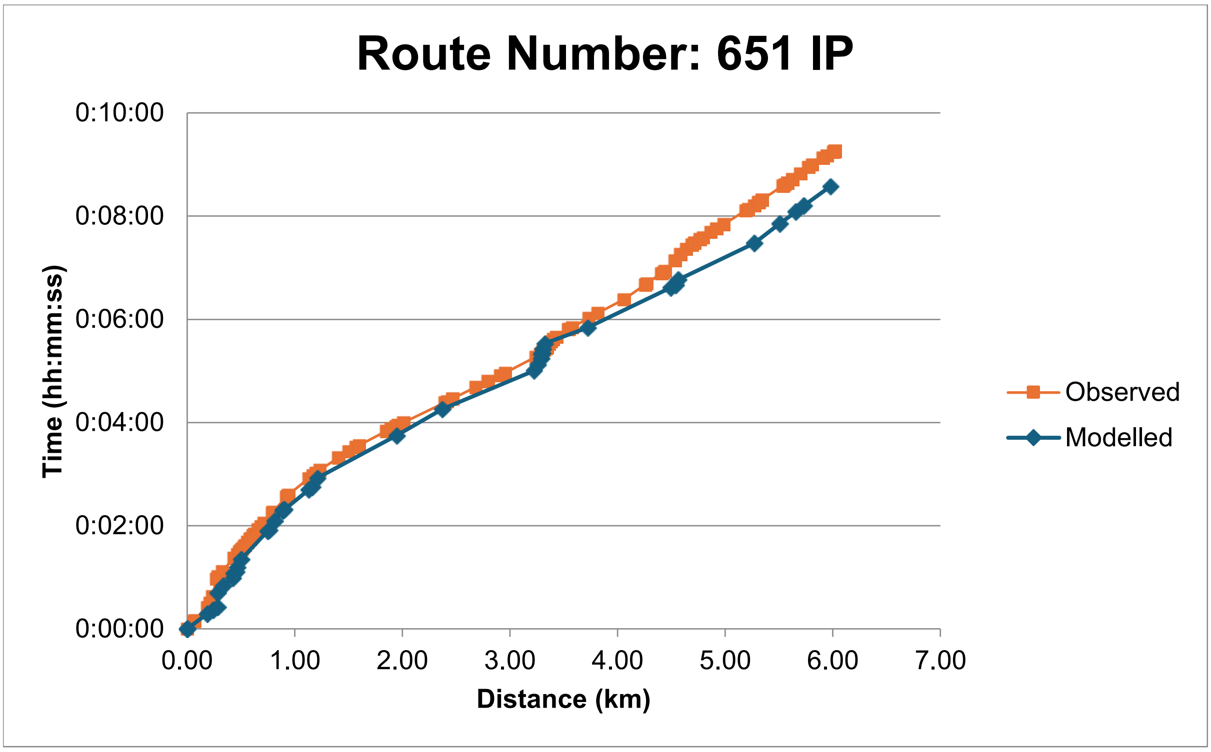
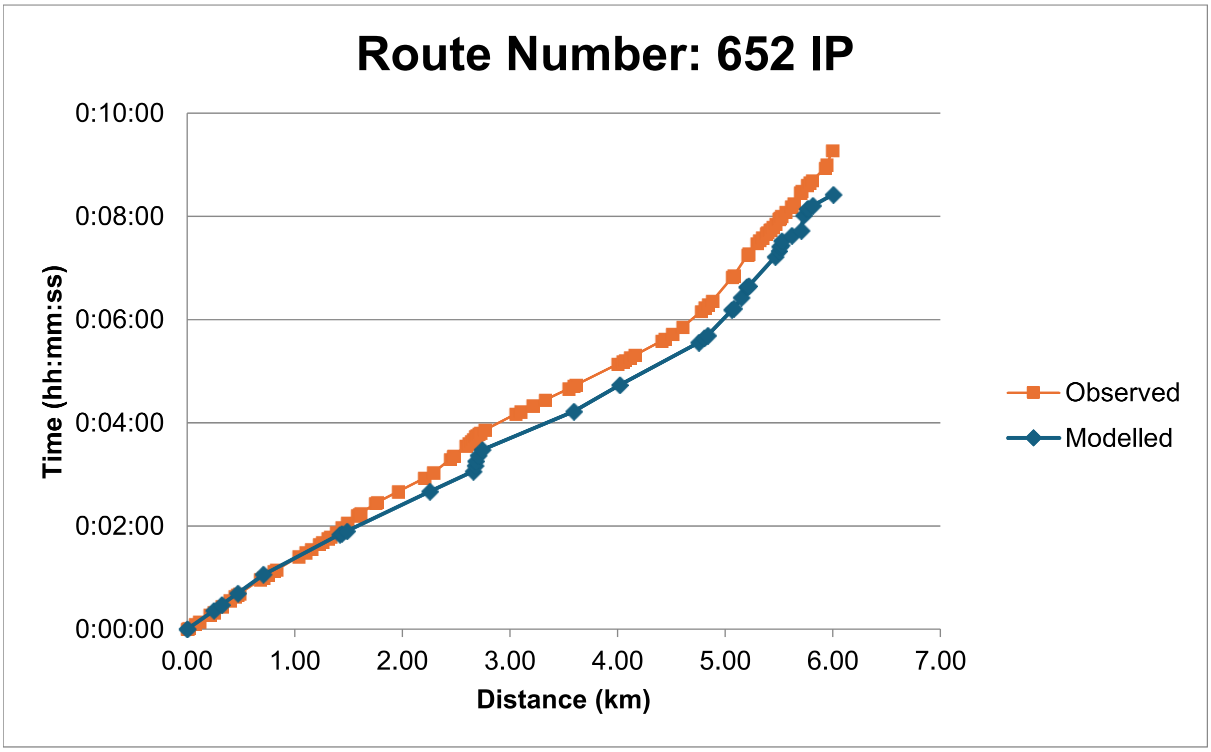
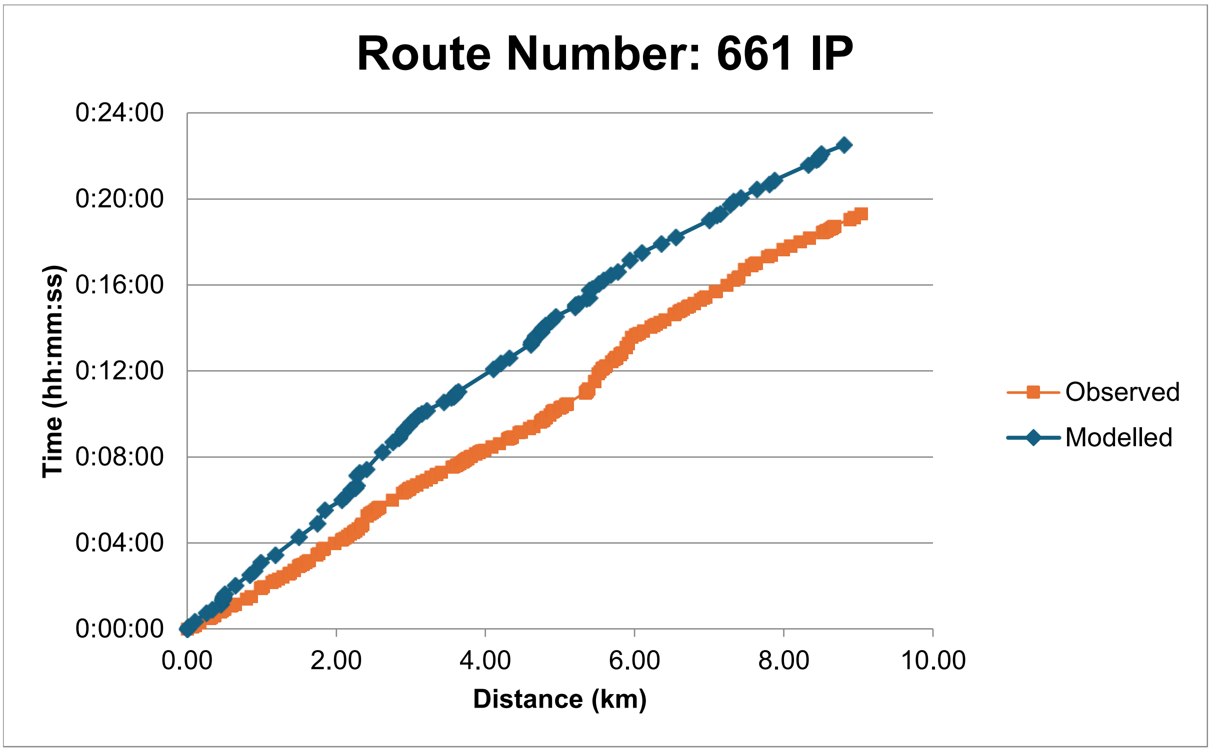
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled



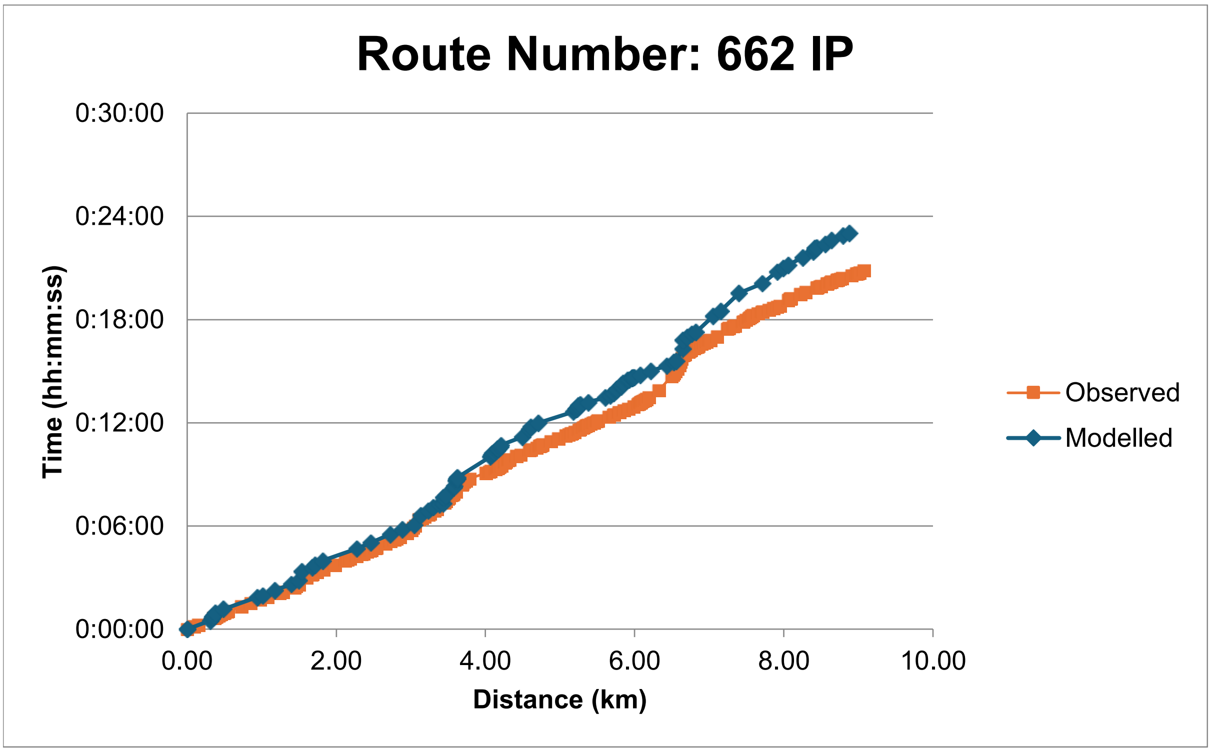
Route Number: 651 IP
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 652 IP
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 661 IP
0:24:00
0:20:00
0:16:00
0:12:00
0:08:00
0:04:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled



Route Number: 662 IP
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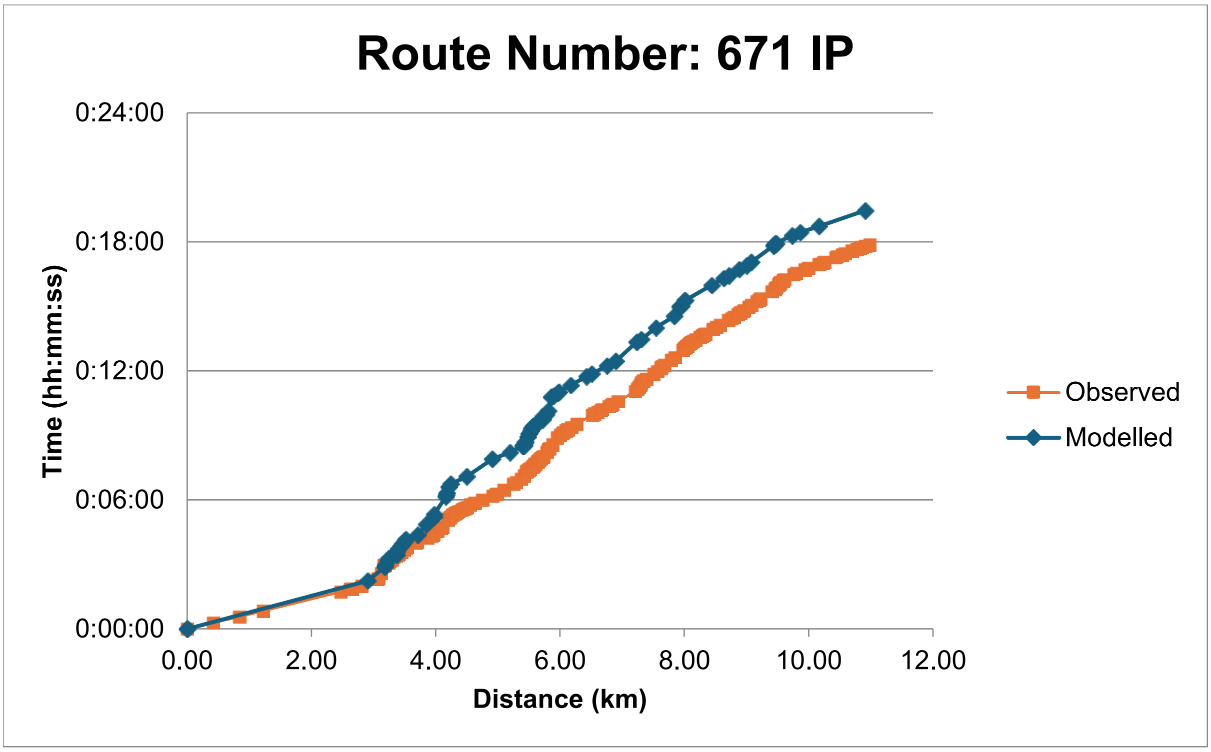
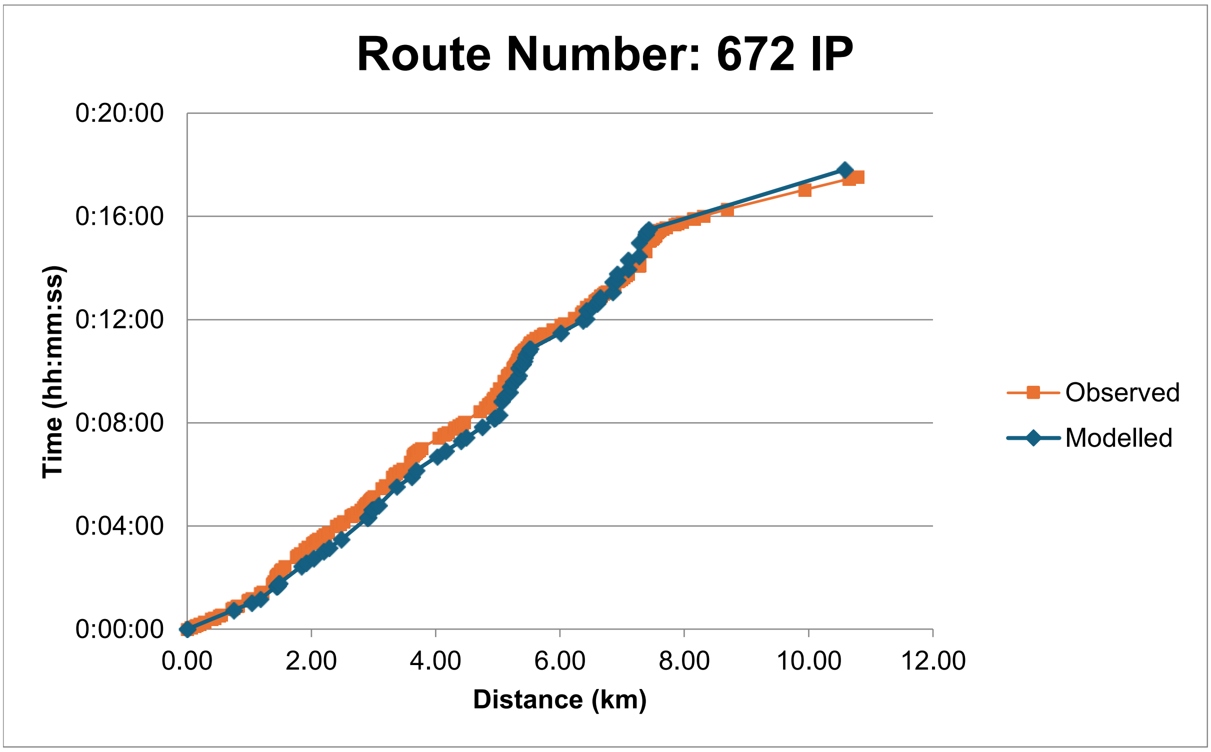
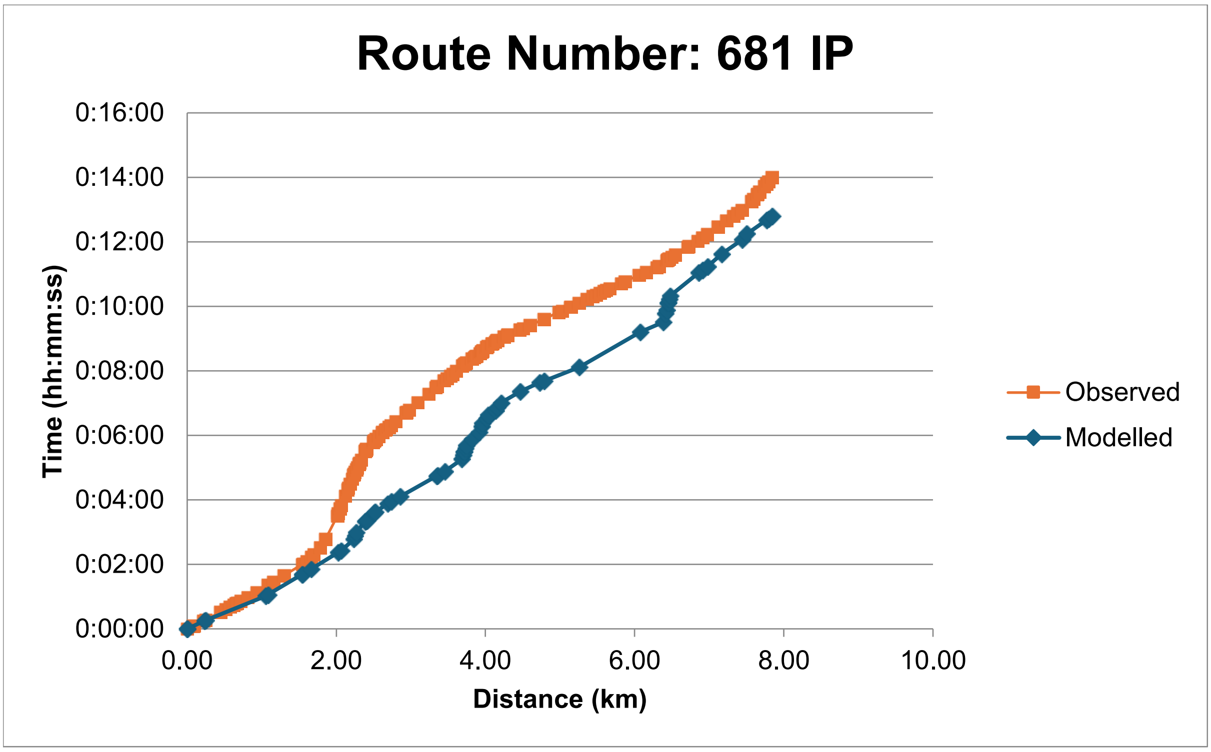
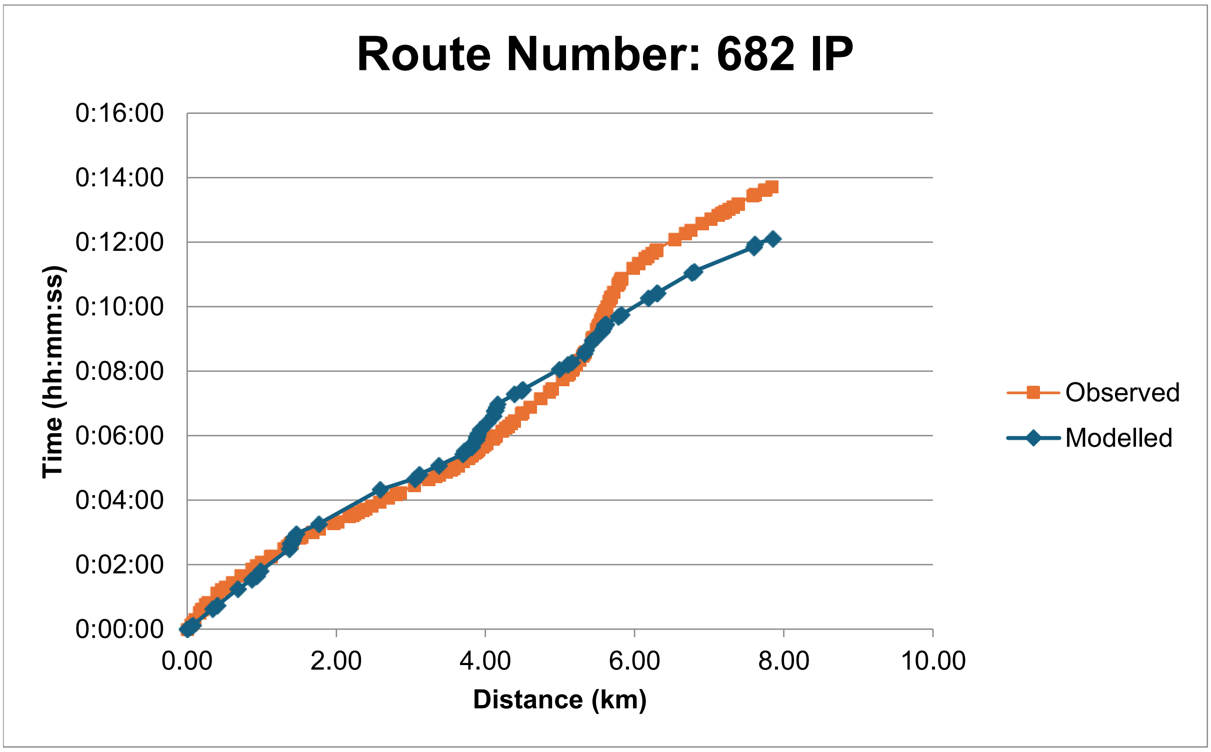
0:24:00
0:18:00
0:12:00
0:06:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 671 IP
0:24:00
0:18:00
0:12:00
0:06:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled

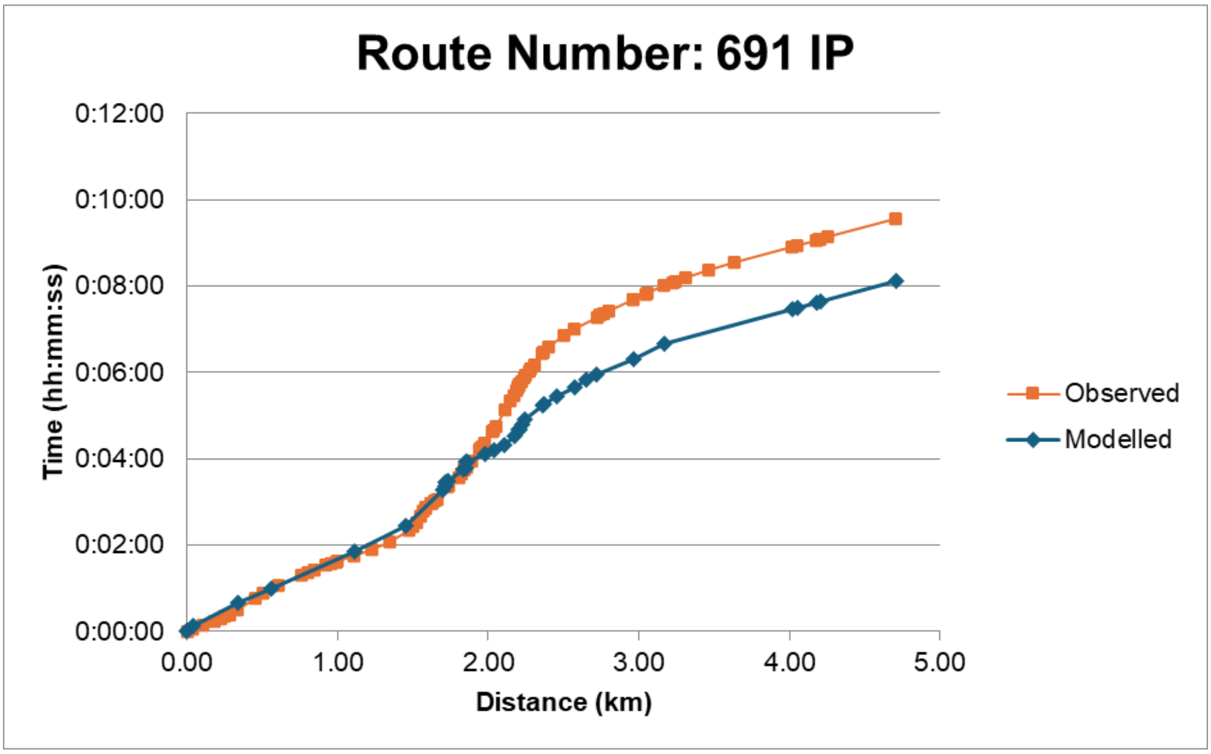

Route Number: 672 IP
0:20:00
0:16:00
0:12:00
0:08:00
0:04:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled

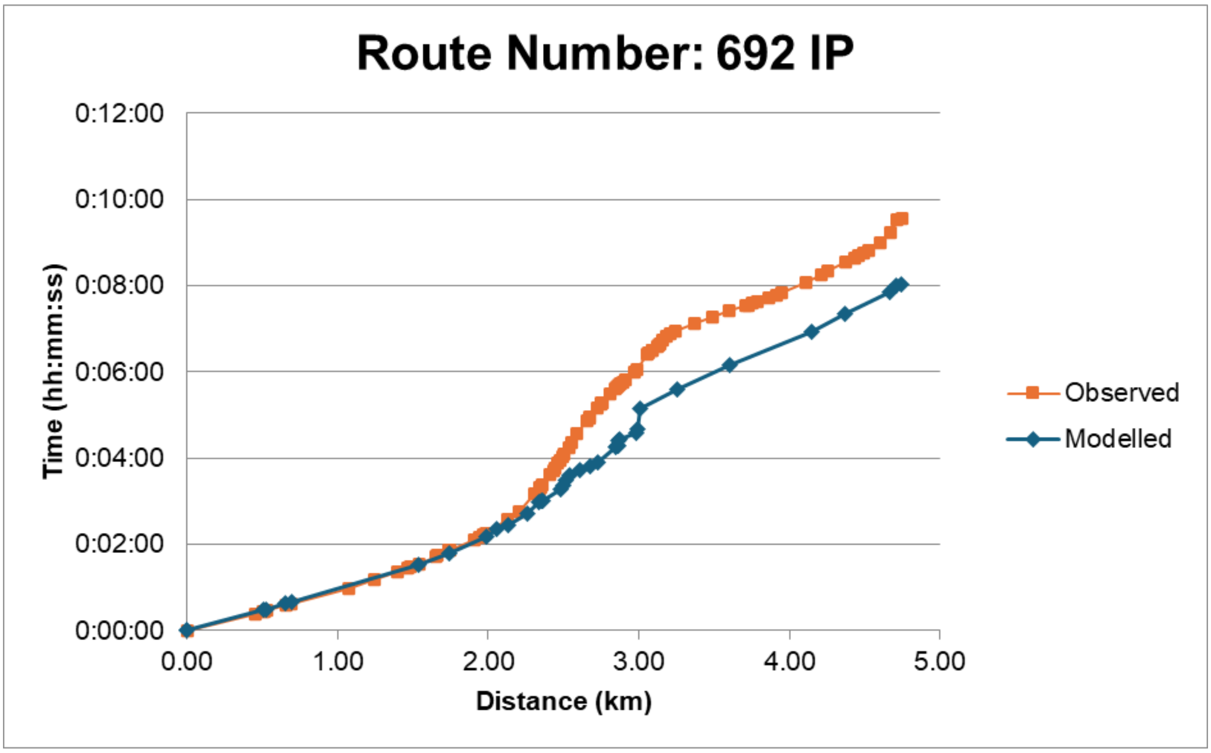


Route Number: 681 IP
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled

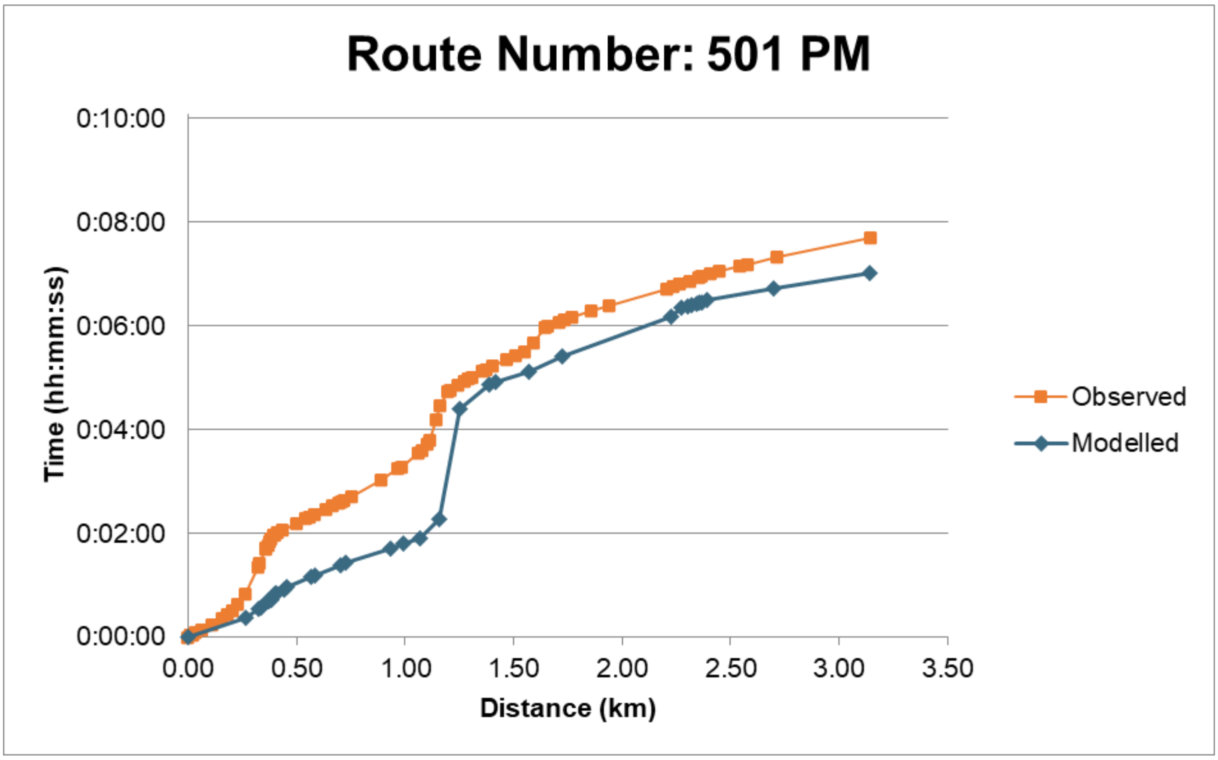


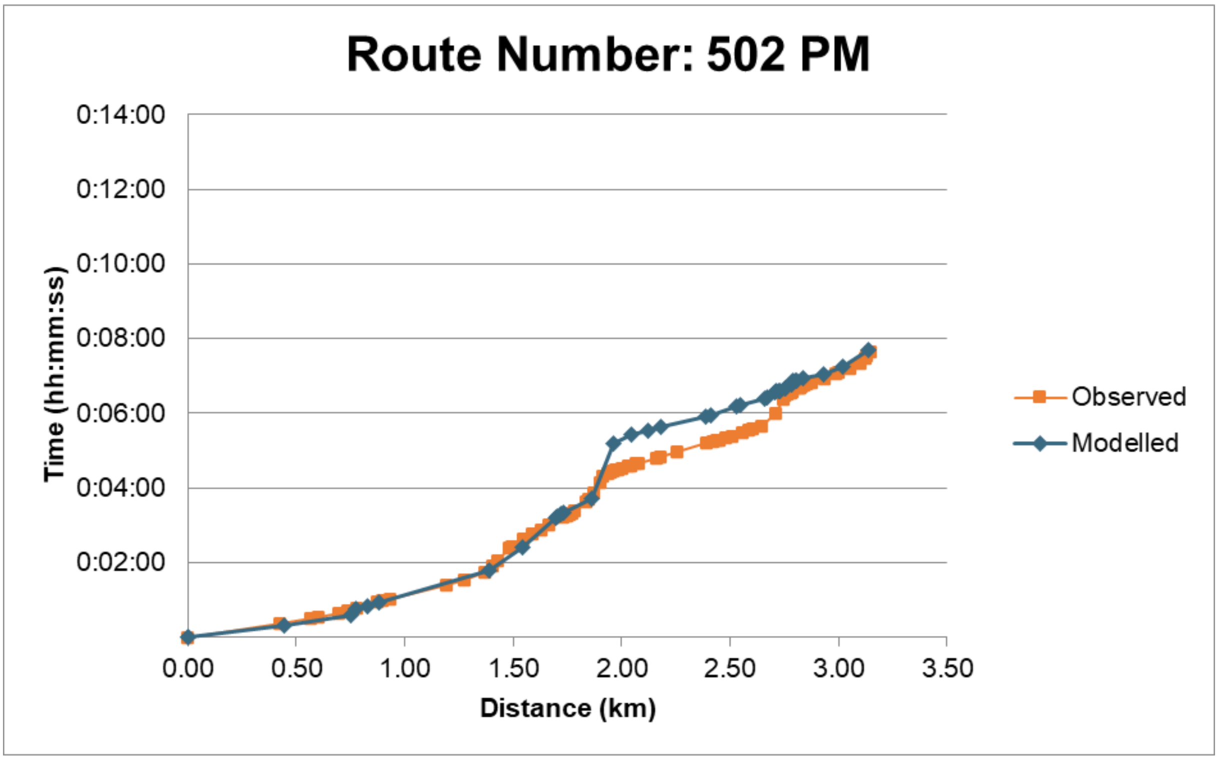
Route Number: 682 IP
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled

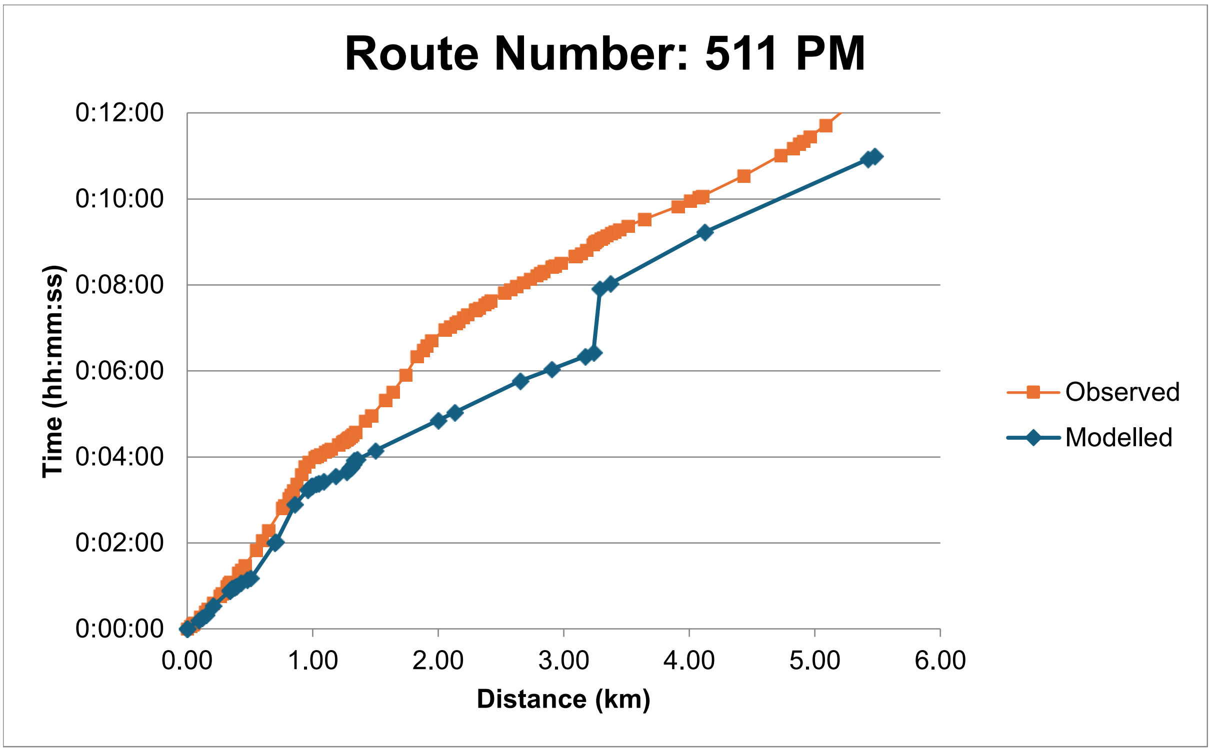

Route Number: 691 IP
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 692 IP
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled

A.3 PM JT plots







Route Number: 511 PM
Time (hh:mm:ss)
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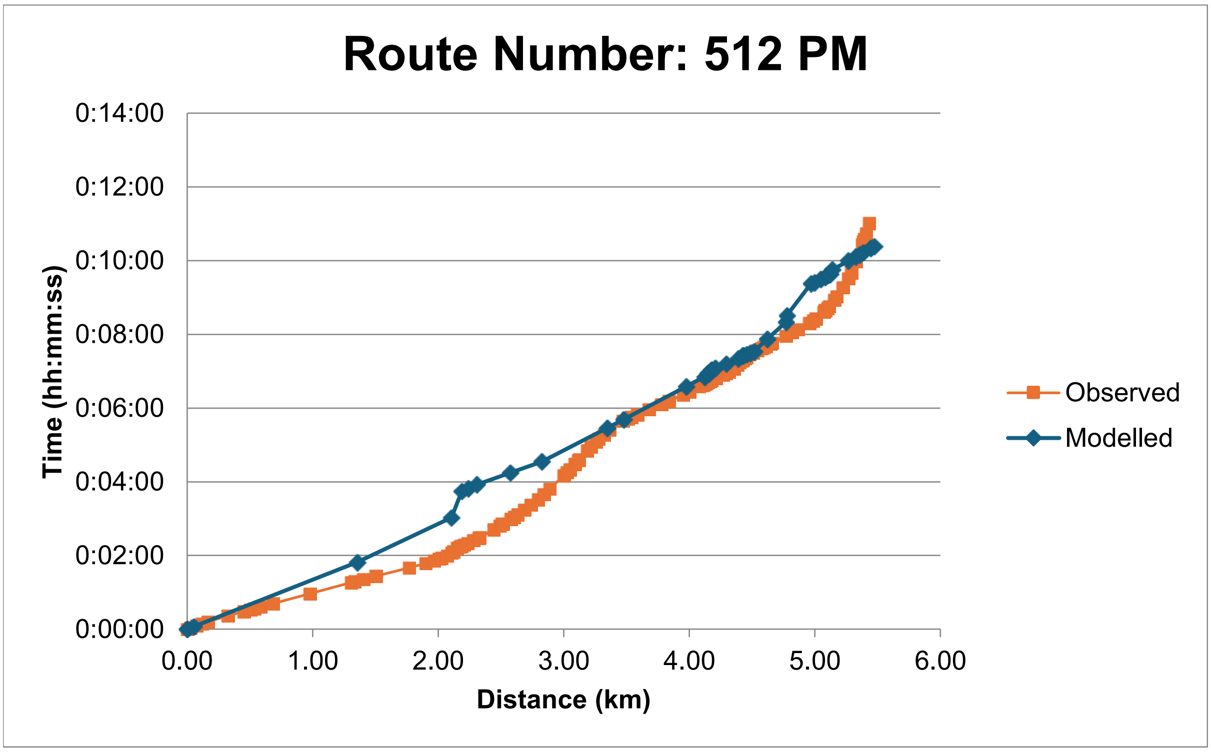
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled



Route Number: 512 PM
Time (hh:mm:ss)
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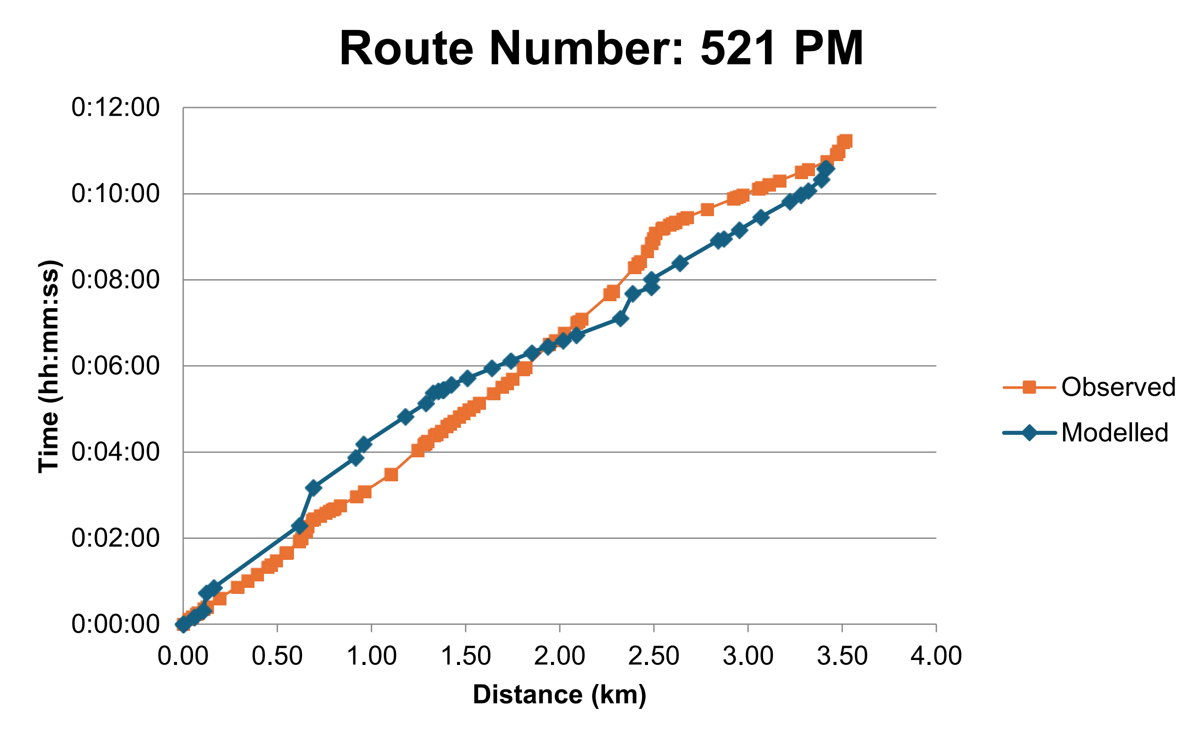
0:06:00
0:04:00
0:02:00
0:00:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled



Route Number: 521 PM
Time (hh:mm:ss)
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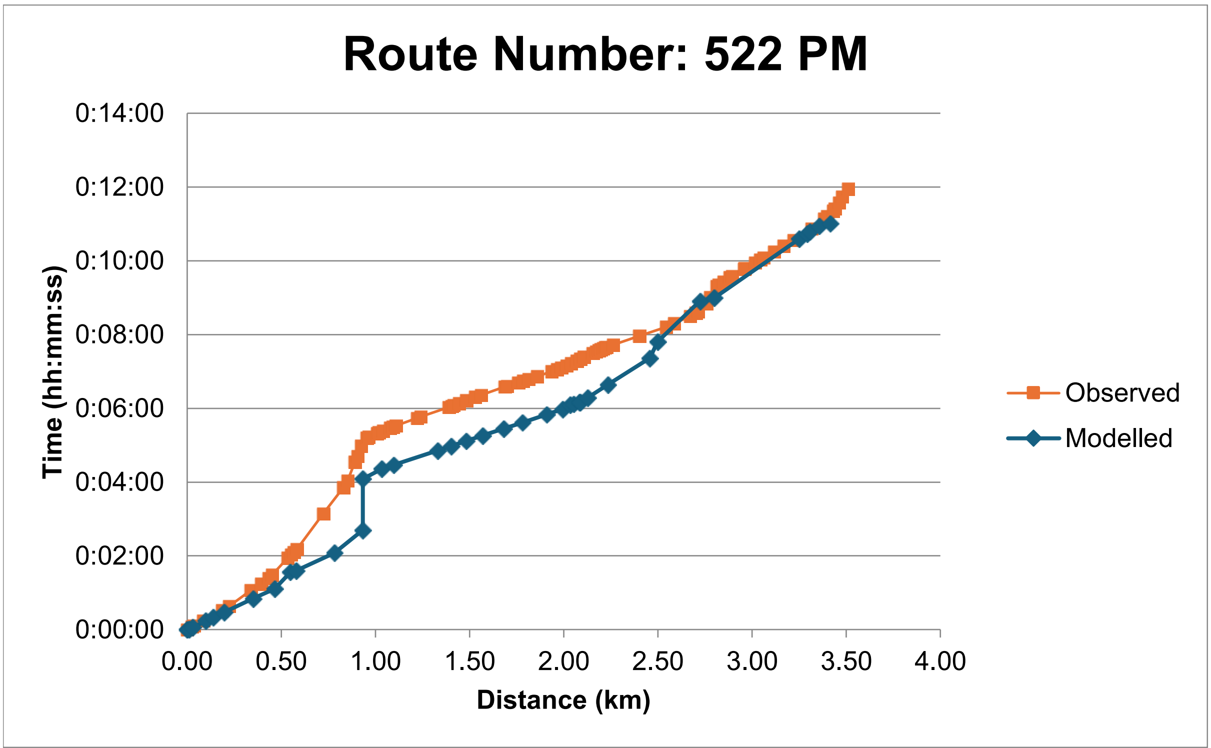
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled



Route Number: 522 PM
Time (hh:mm:ss)
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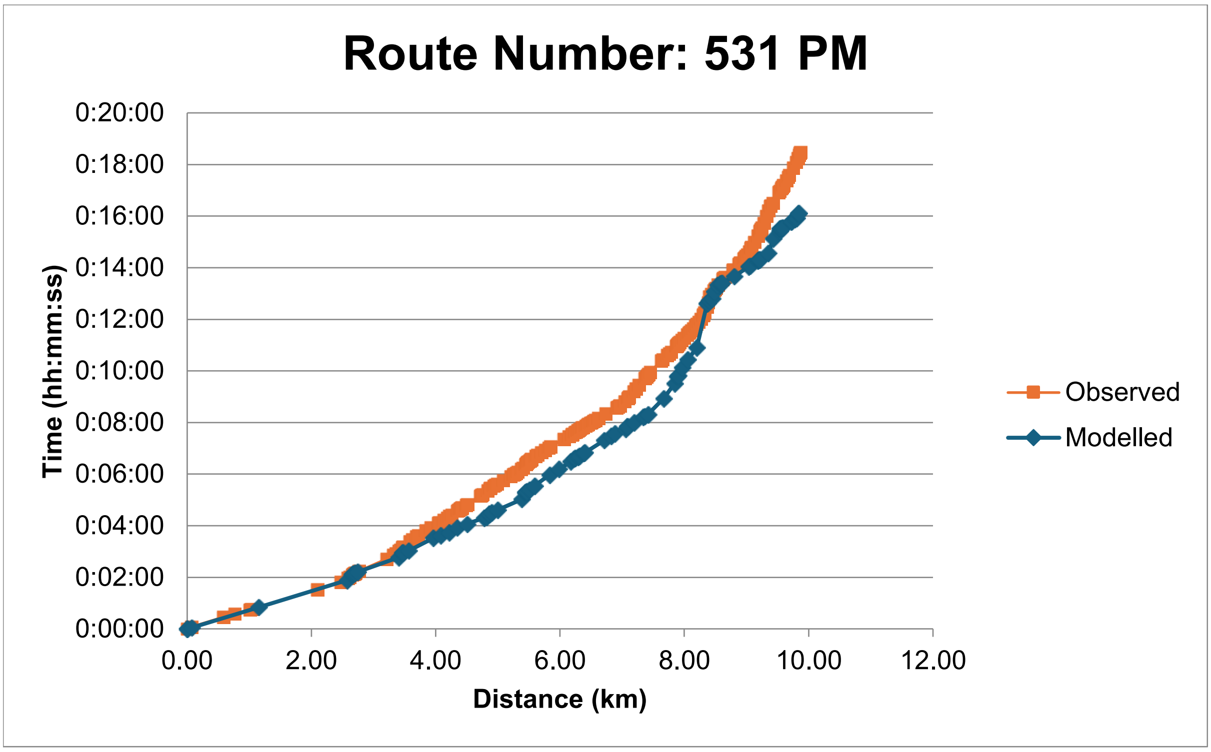
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled



Route Number: 531 PM
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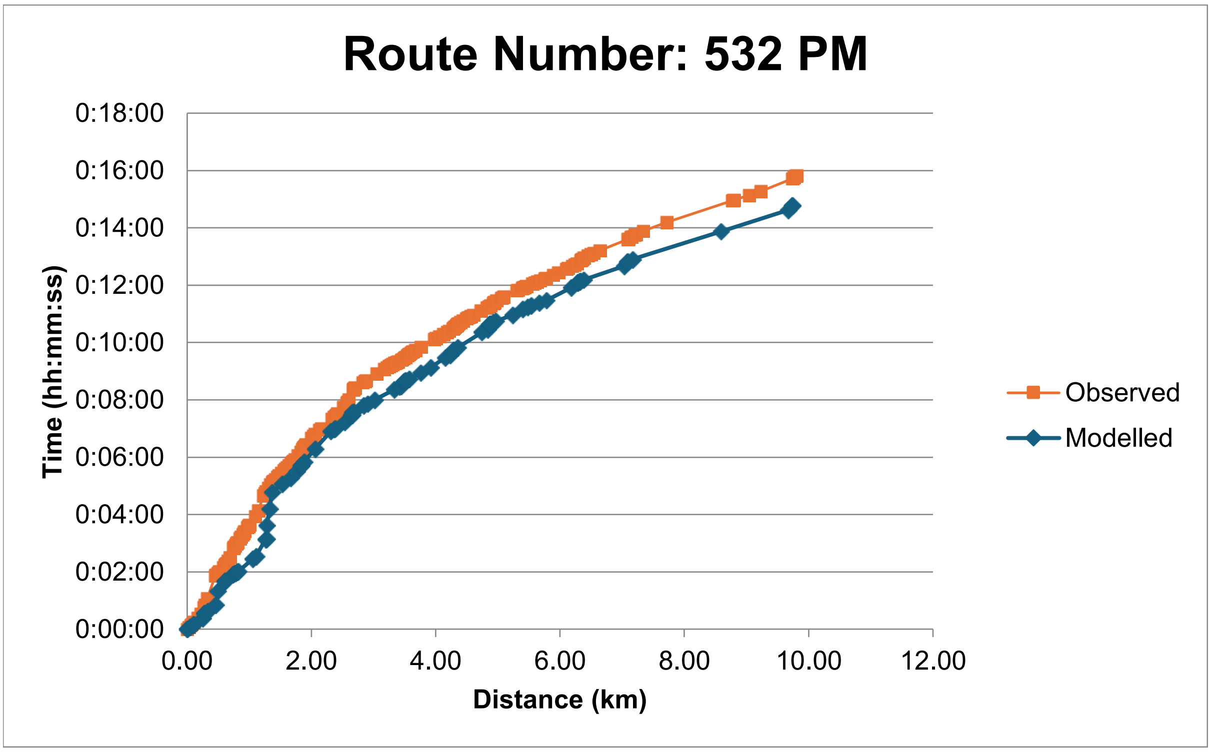
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled



Route Number: 532 PM
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0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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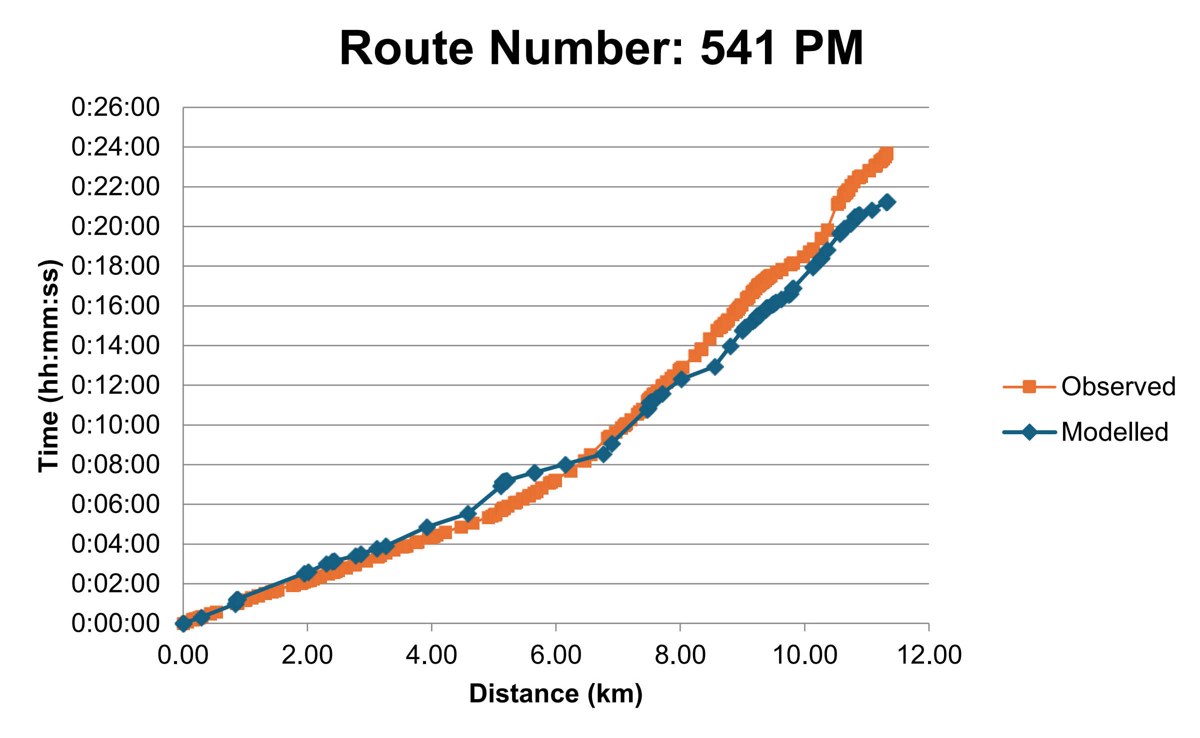
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 541 PM
Time (hh:mm:ss)
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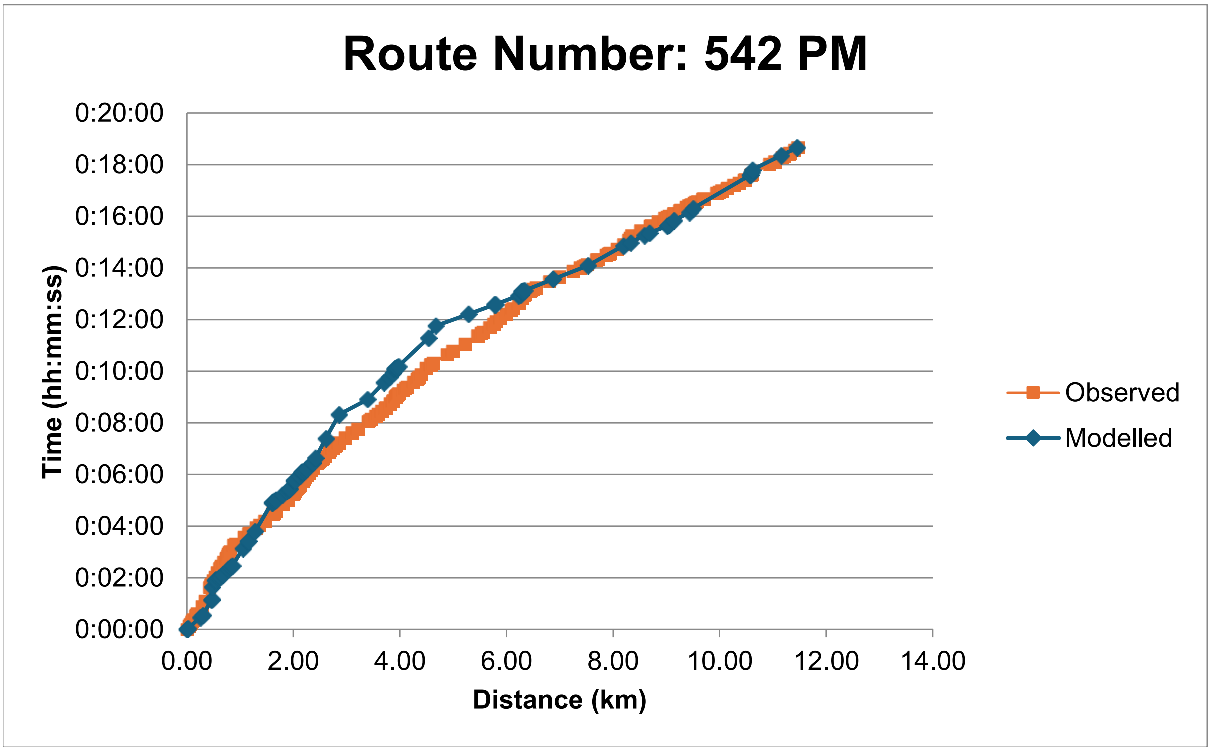
0:22:00
0:20:00
0:18:00
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 542 PM
Time (hh:mm:ss)
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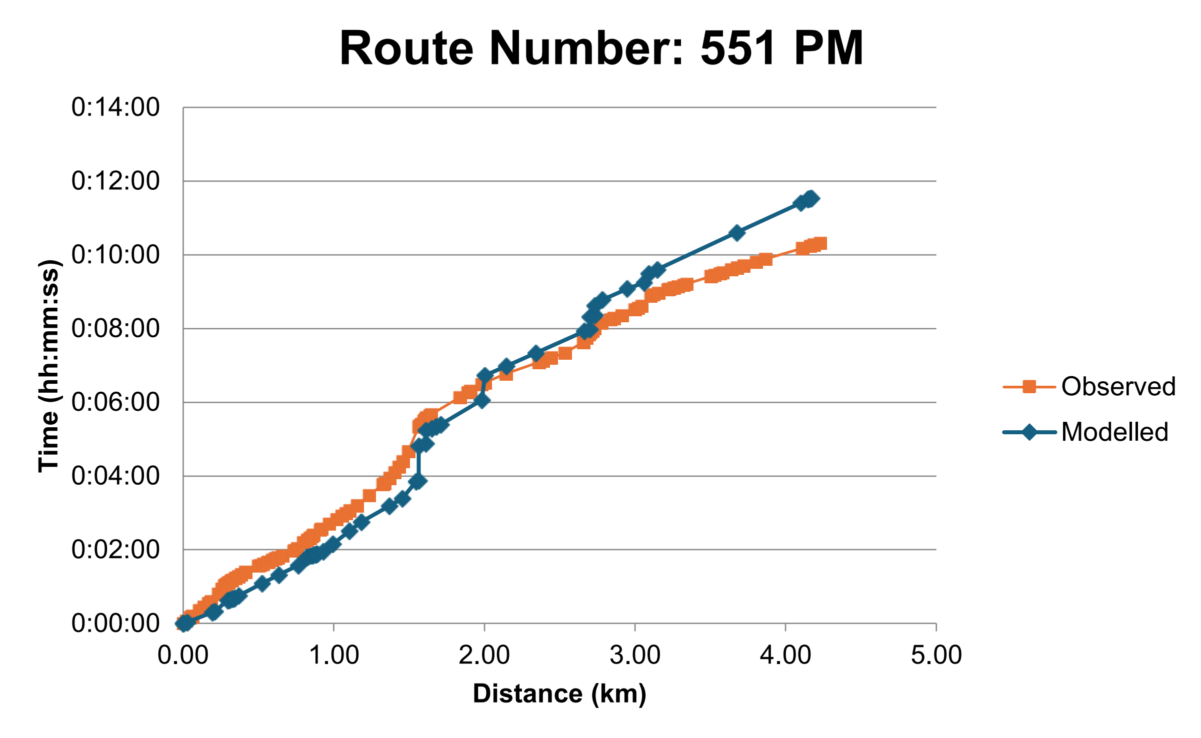
0:16:00
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance (km)
Observed
Modelled


Route Number: 551 PM
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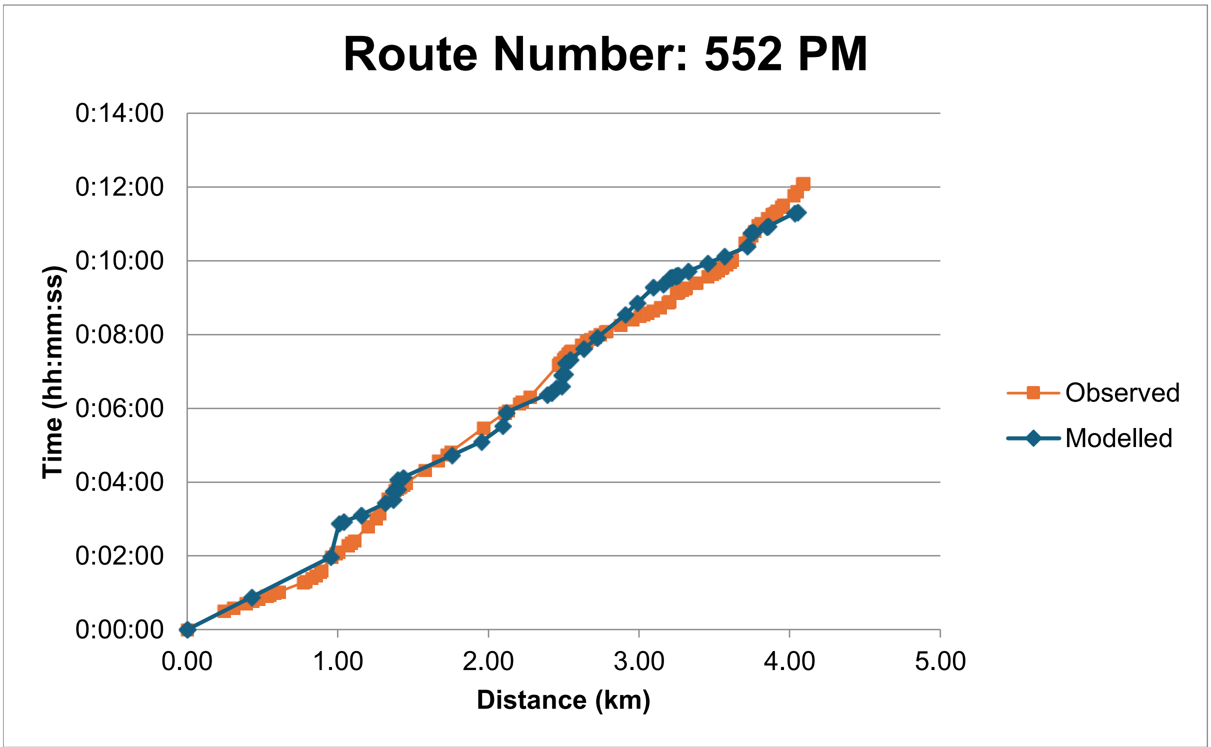
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 552 PM
0:14:00
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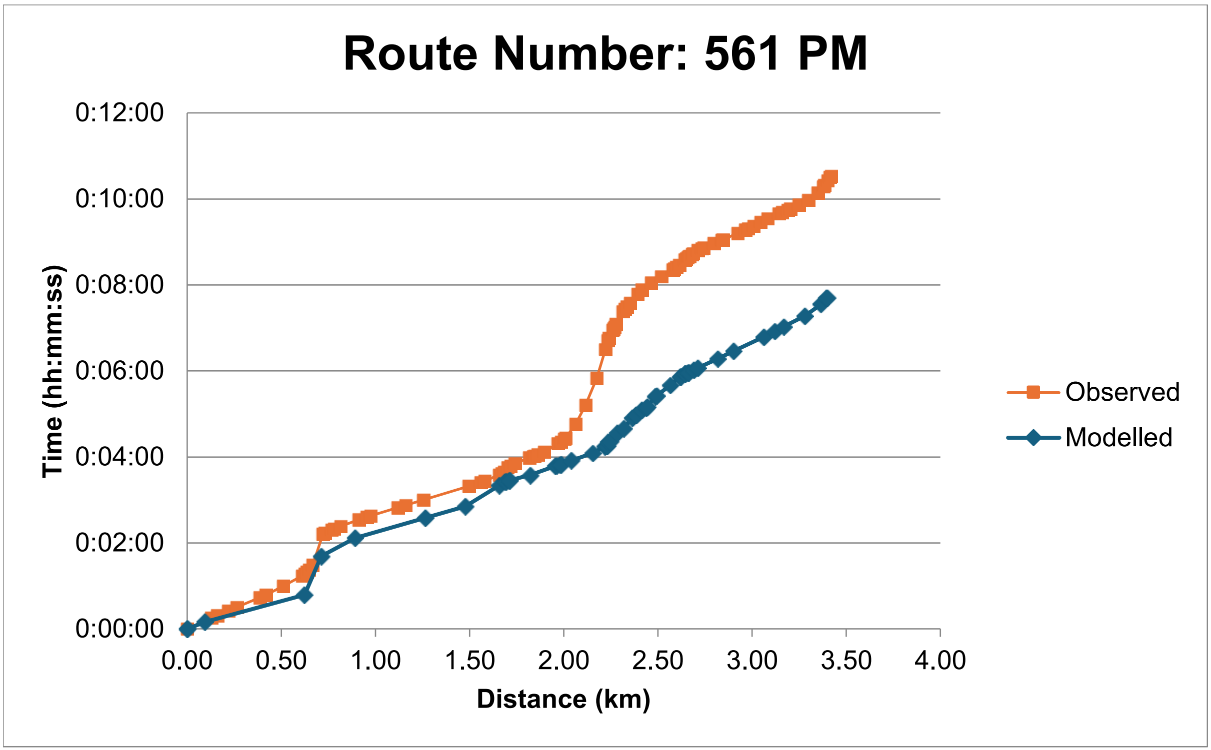
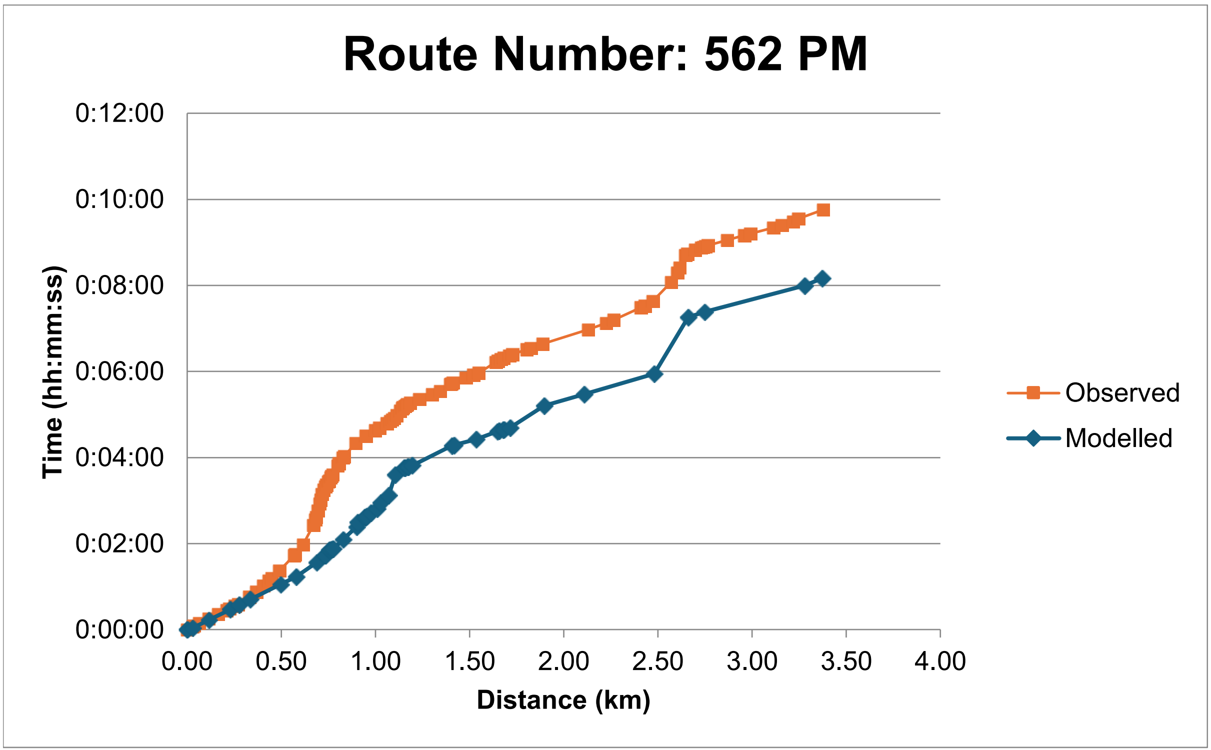
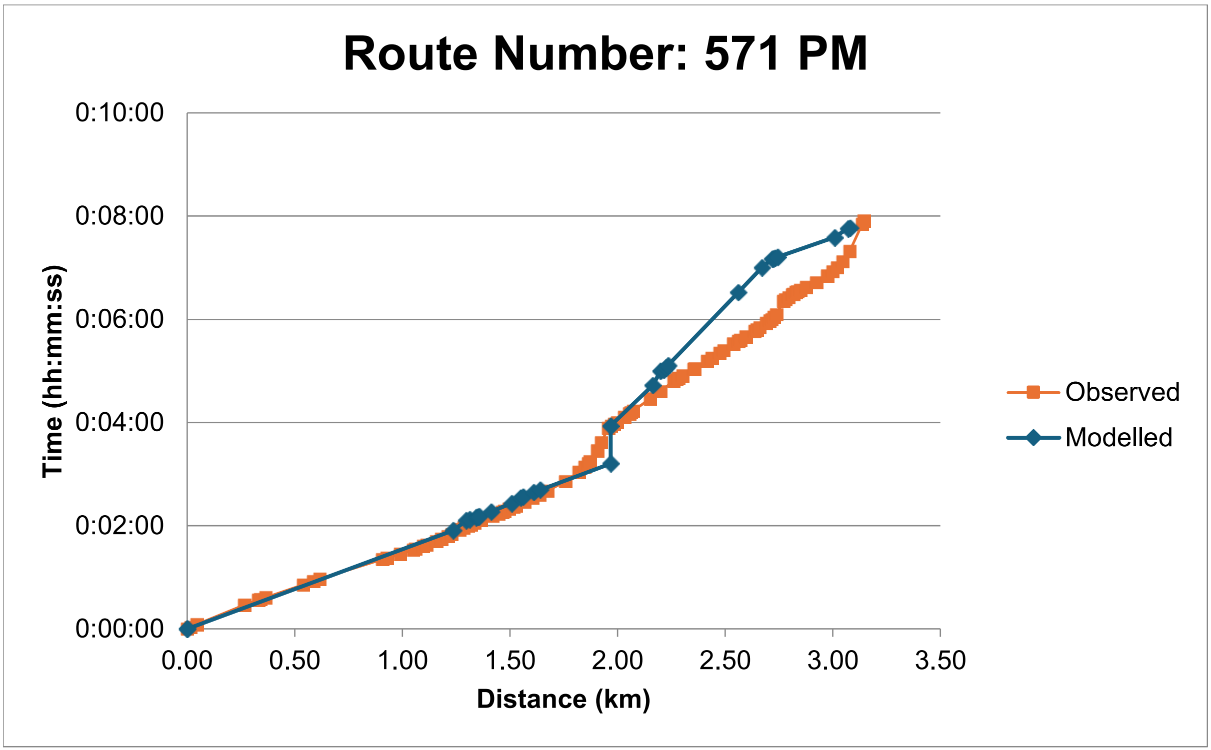
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 561 PM
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled


Route Number: 562 PM
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Distance (km)
Observed
Modelled


Route Number: 571 PM
Time (hh:mm:ss)
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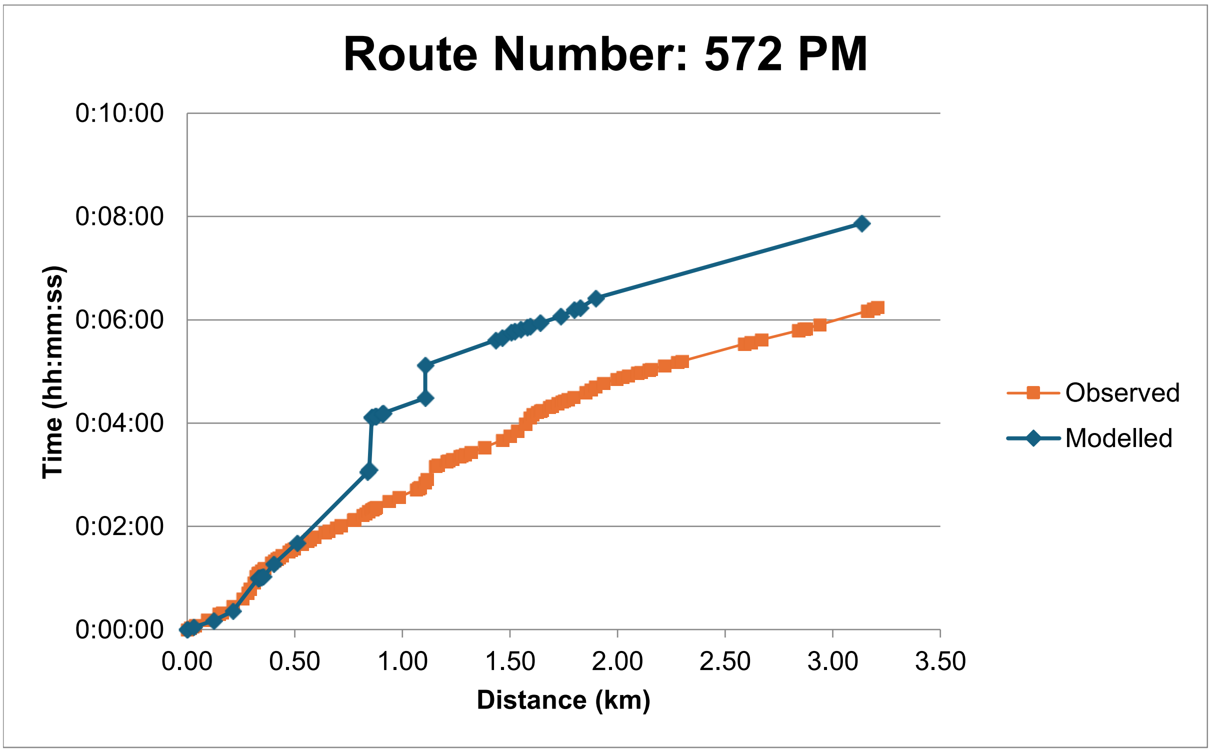
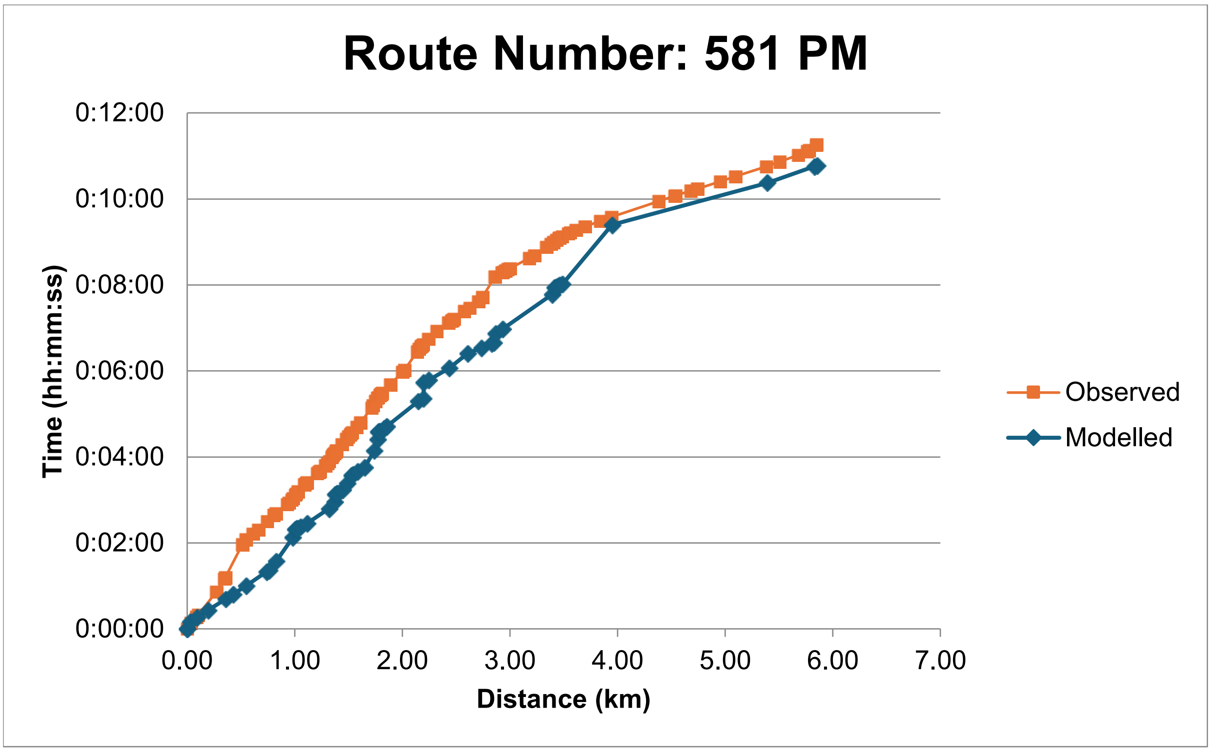
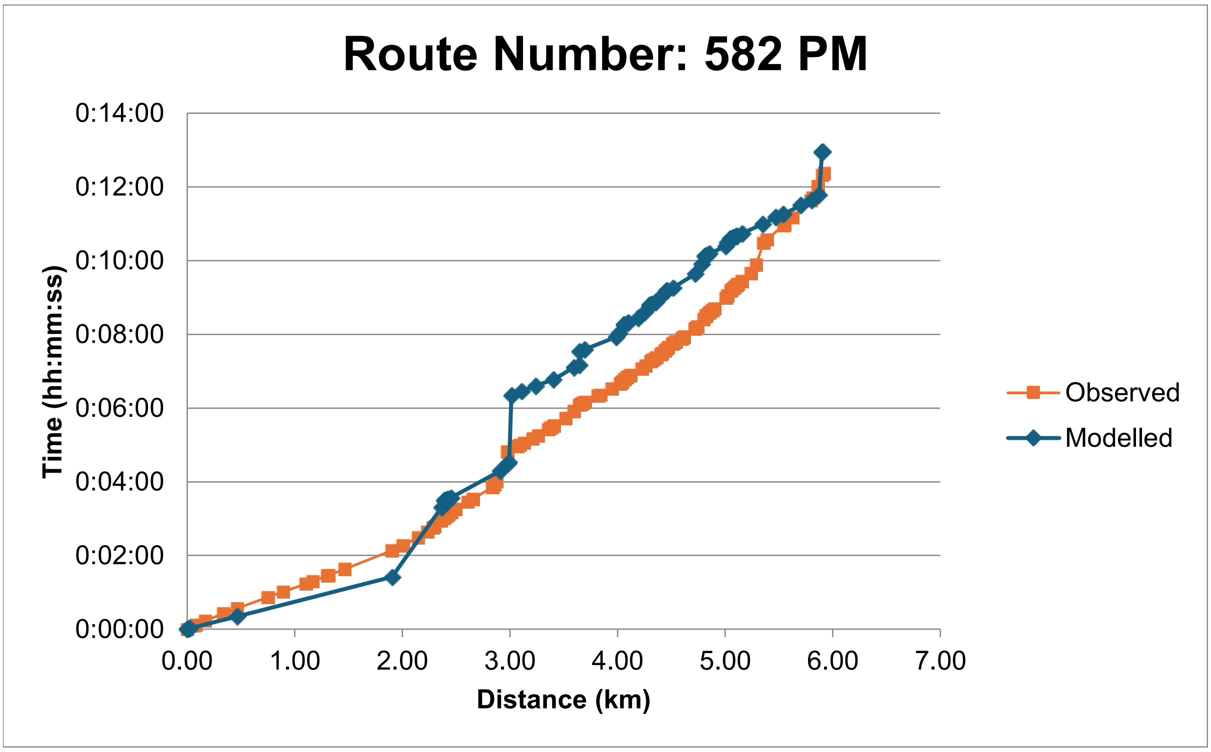
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled

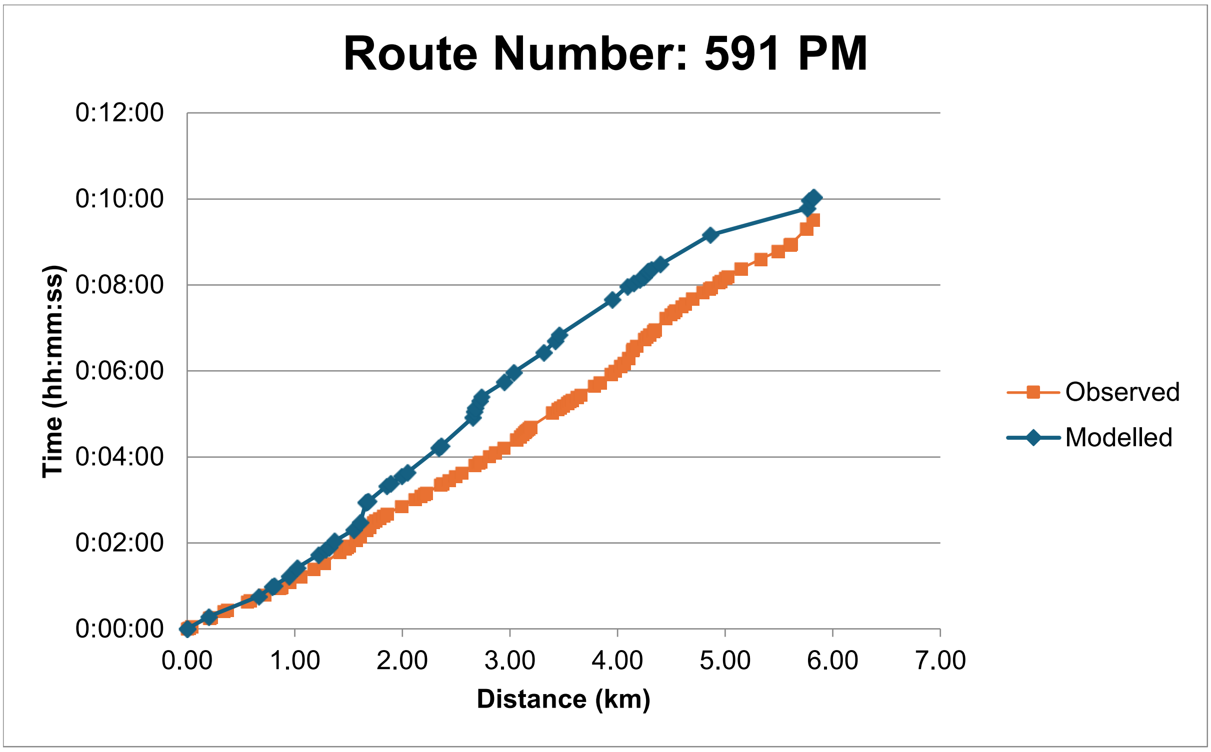

Route Number: 572 PM
Time (hh:mm:ss)
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance (km)
Observed
Modelled



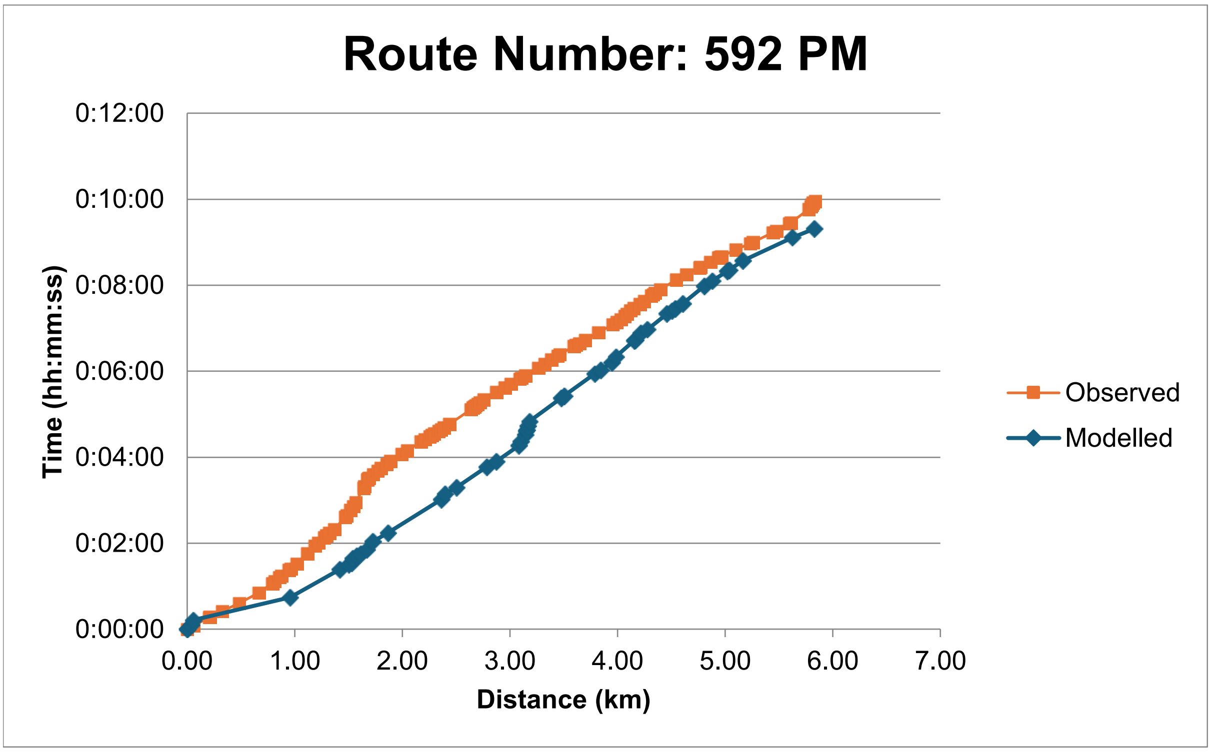
Route Number: 581 PM
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 582 PM
0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 591 PM
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 592 PM
0:12:00
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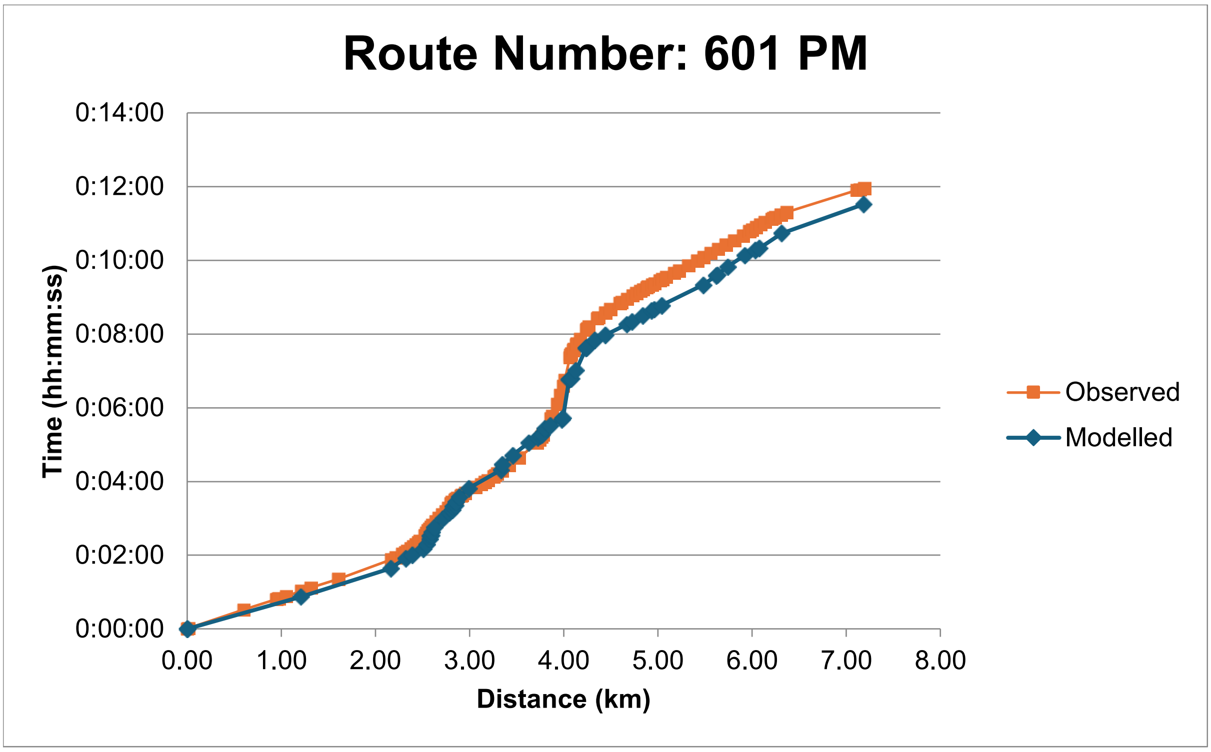
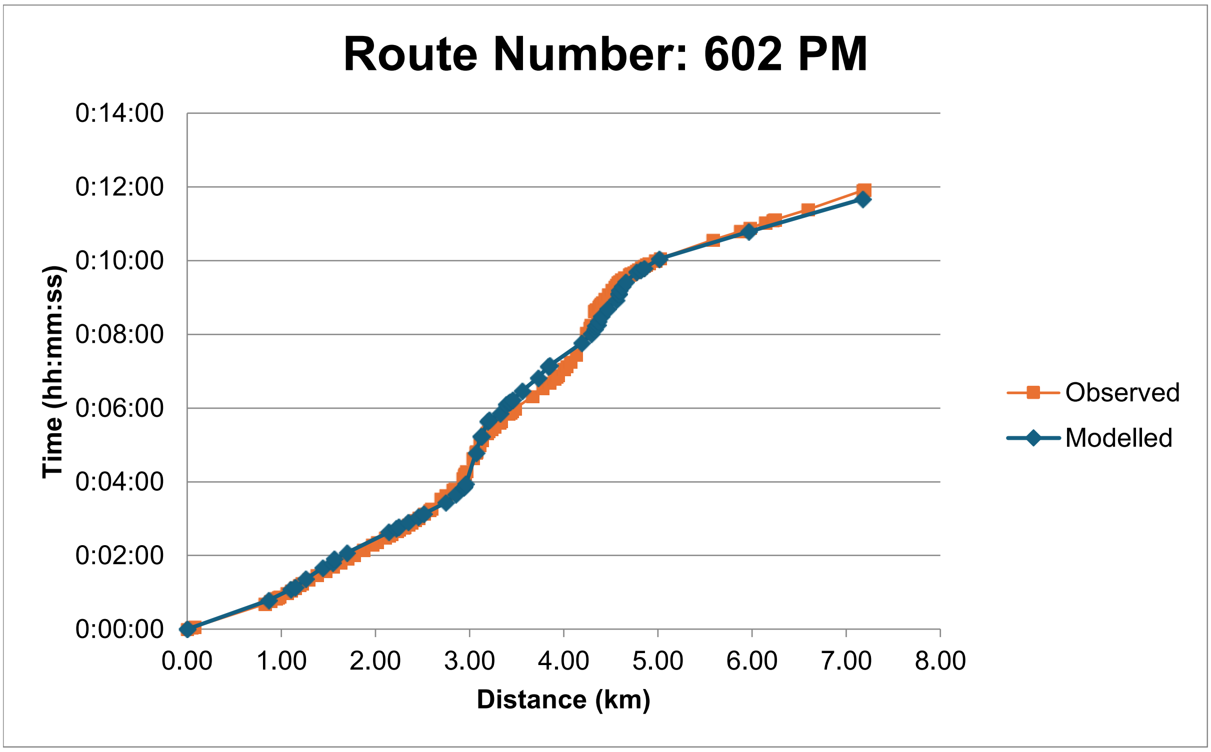
0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 601 PM
Time (hh:mm:ss)
0:00:00
0:02:00
0:04:00
0:06:00
0:08:00
0:10:00
0:12:00
0:14:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled


Route Number: 602 PM
Time (hh:mm:ss)
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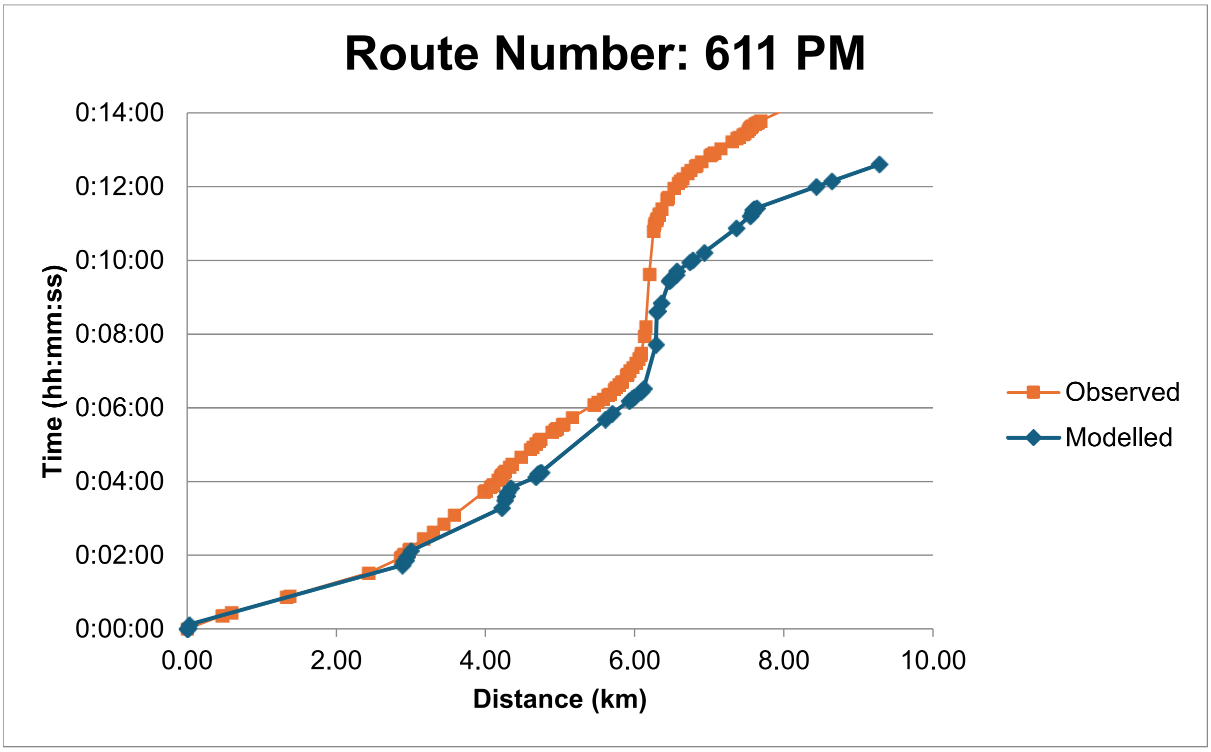
0:02:00
0:04:00
0:06:00
0:08:00
0:10:00
0:12:00
0:14:00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled


Route Number: 611 PM
Time (hh:mm:ss)
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0:12:00
0:10:00
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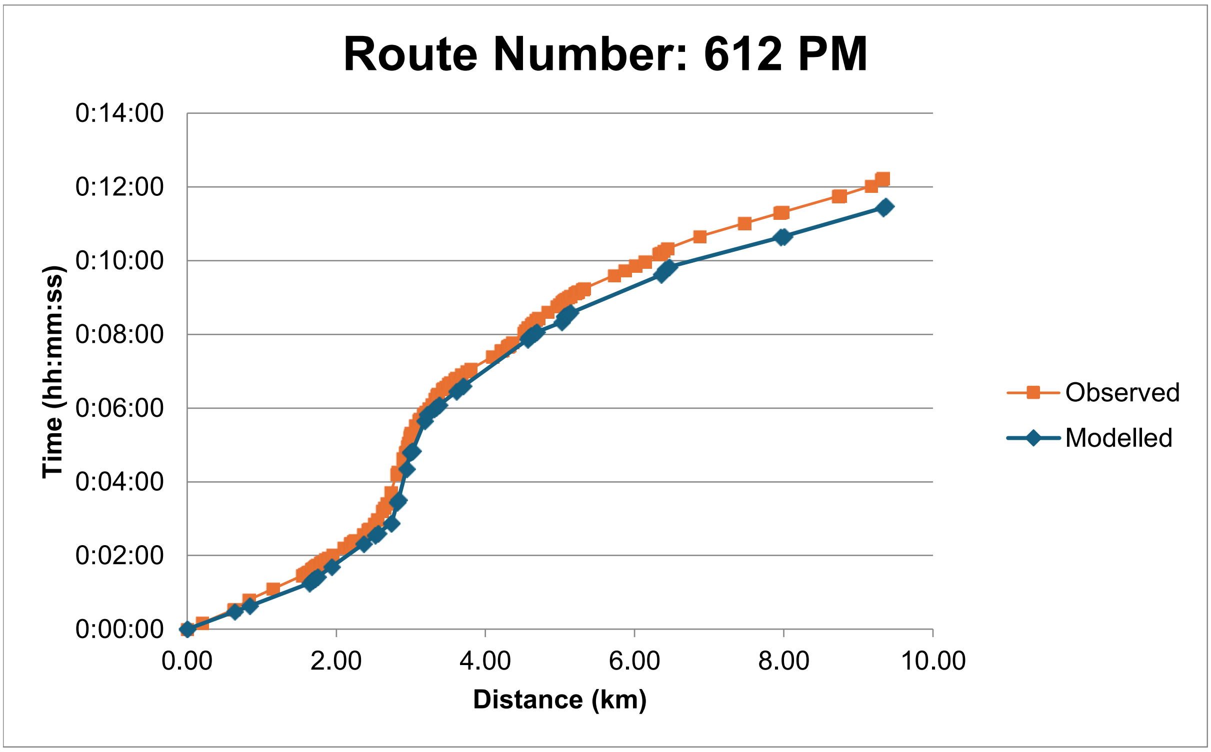
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 612 PM
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4.00
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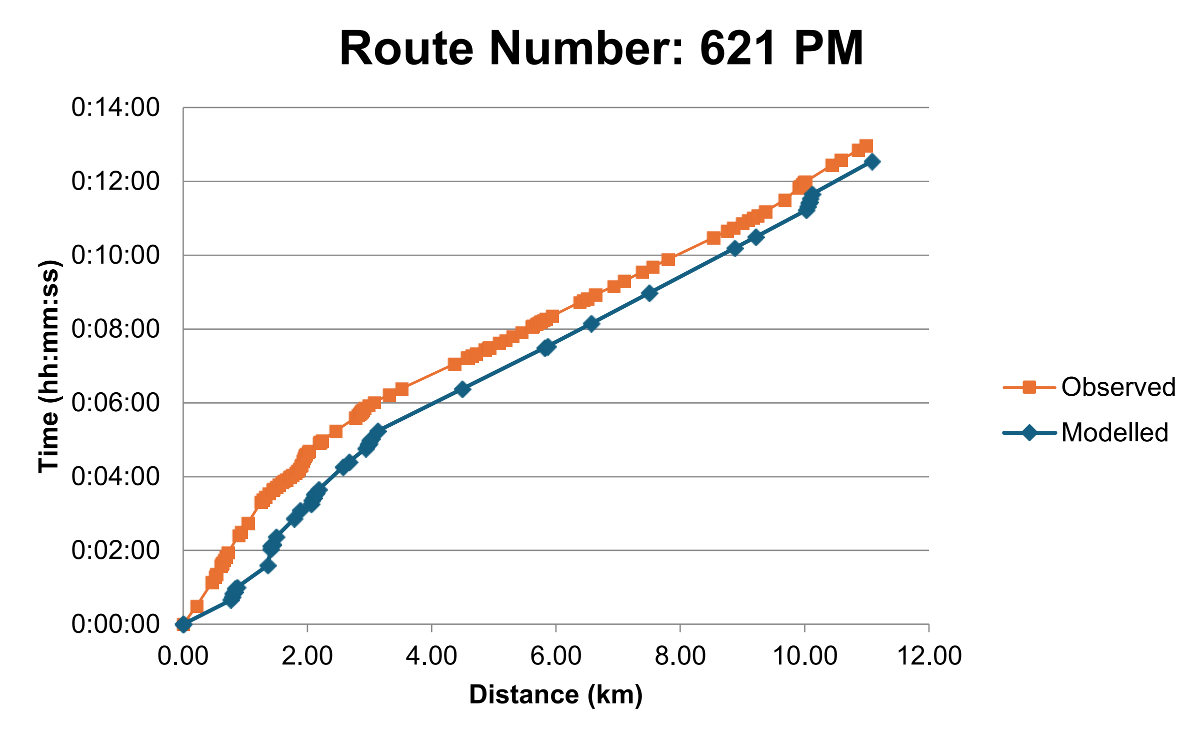
10.00
Distance (km)
Observed
Modelled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0:02:00
0:00:00
Time (hh:mm:ss)
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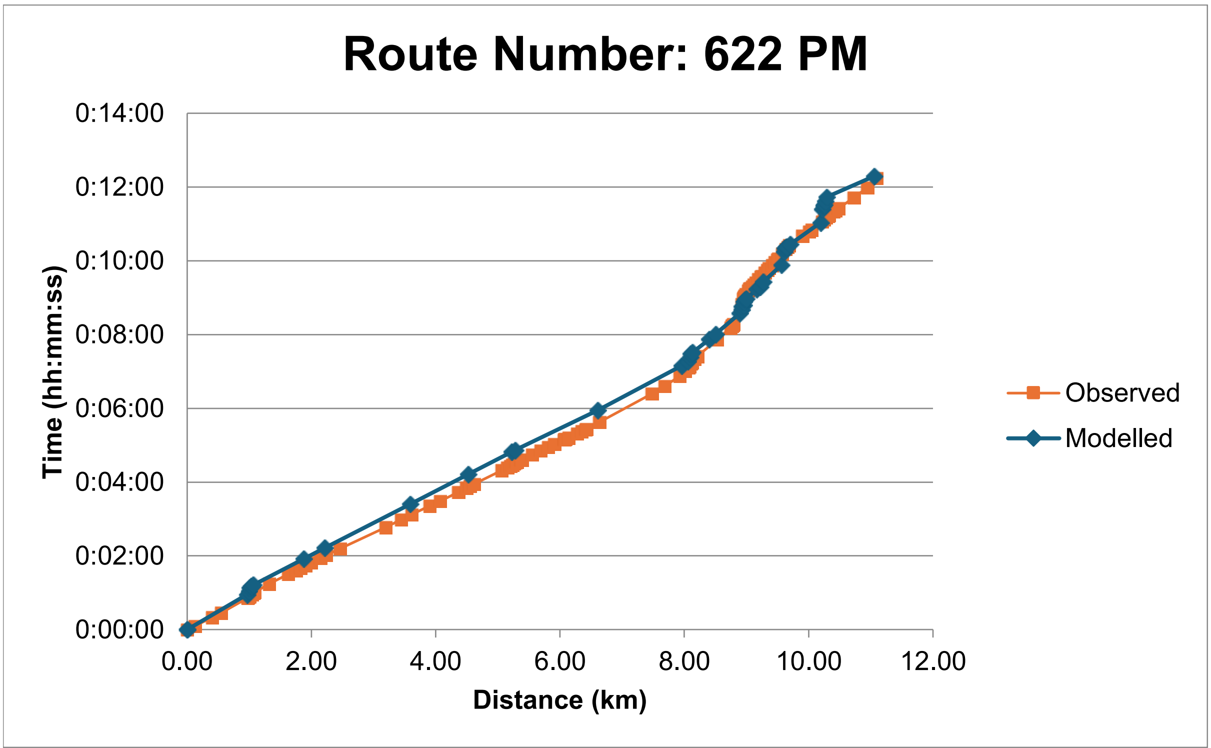
6.00
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 622 PM
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0:02:00
0:00:00
Time (hh:mm:ss)
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4.00
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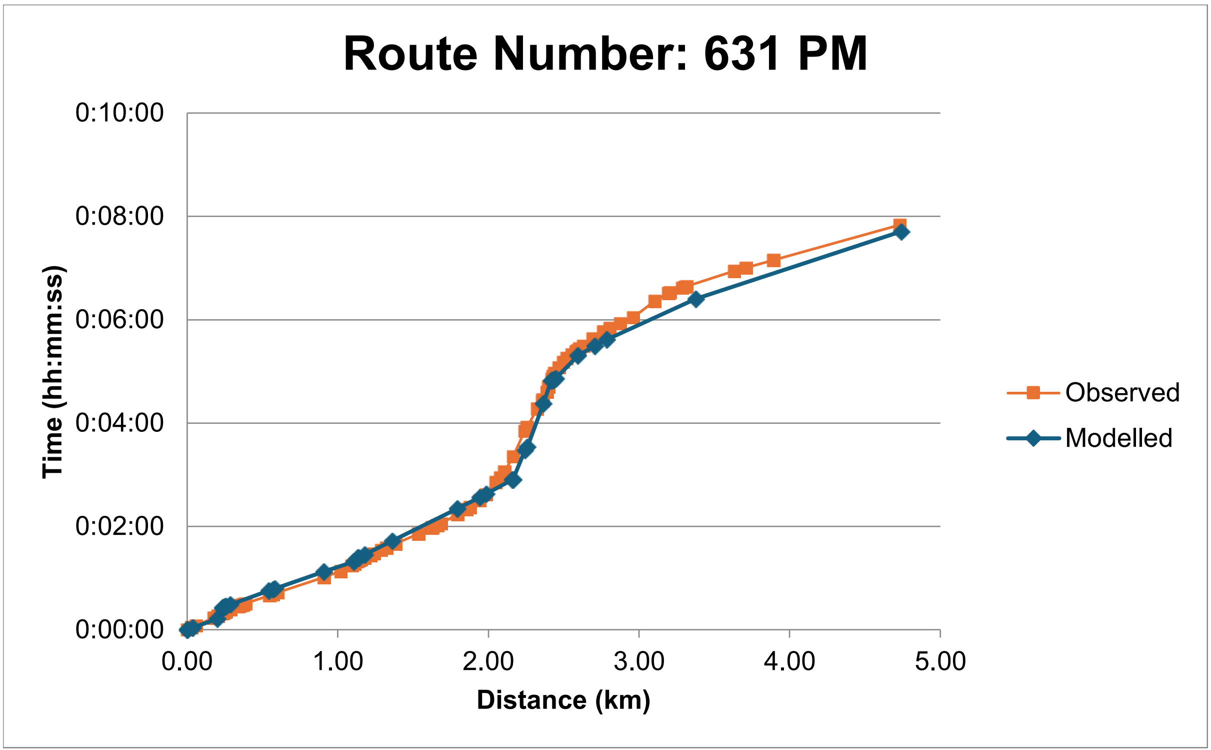
8.00
10.00
12.00
Distance (km)
Observed
Modelled


Route Number: 631 PM
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0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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1.00
2.00
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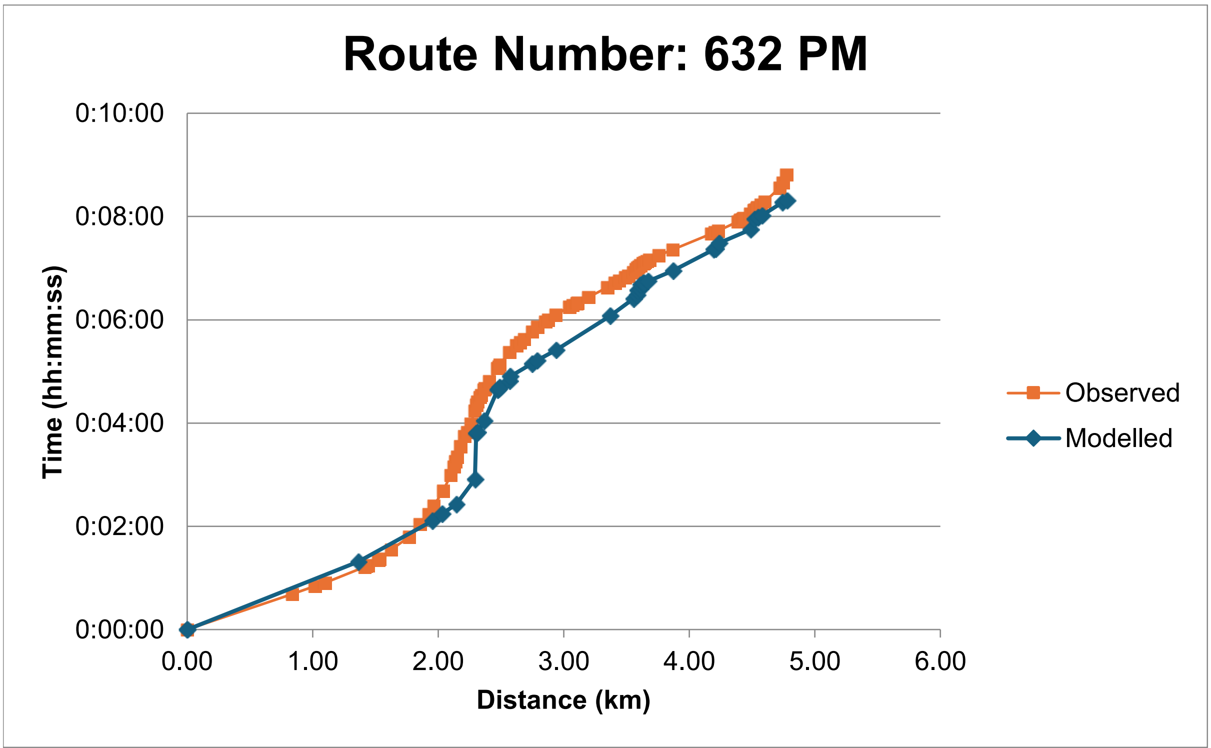
4.00
5.00
Distance (km)
Observed
Modelled


Route Number: 632 PM
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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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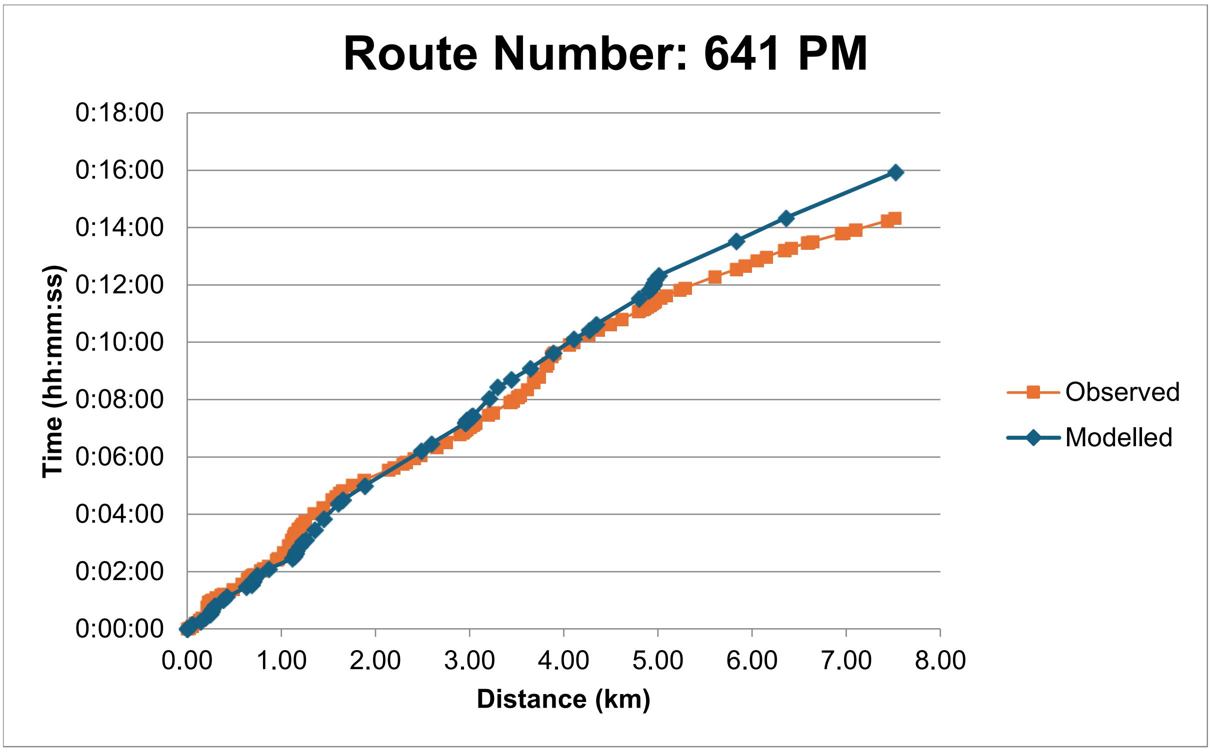
1.00
2.00
3.00
4.00
5.00
6.00
Distance (km)
Observed
Modelled



Route Number: 641 PM
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0:12:00
0:10:00
0:08:00
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Time (hh:mm:ss)
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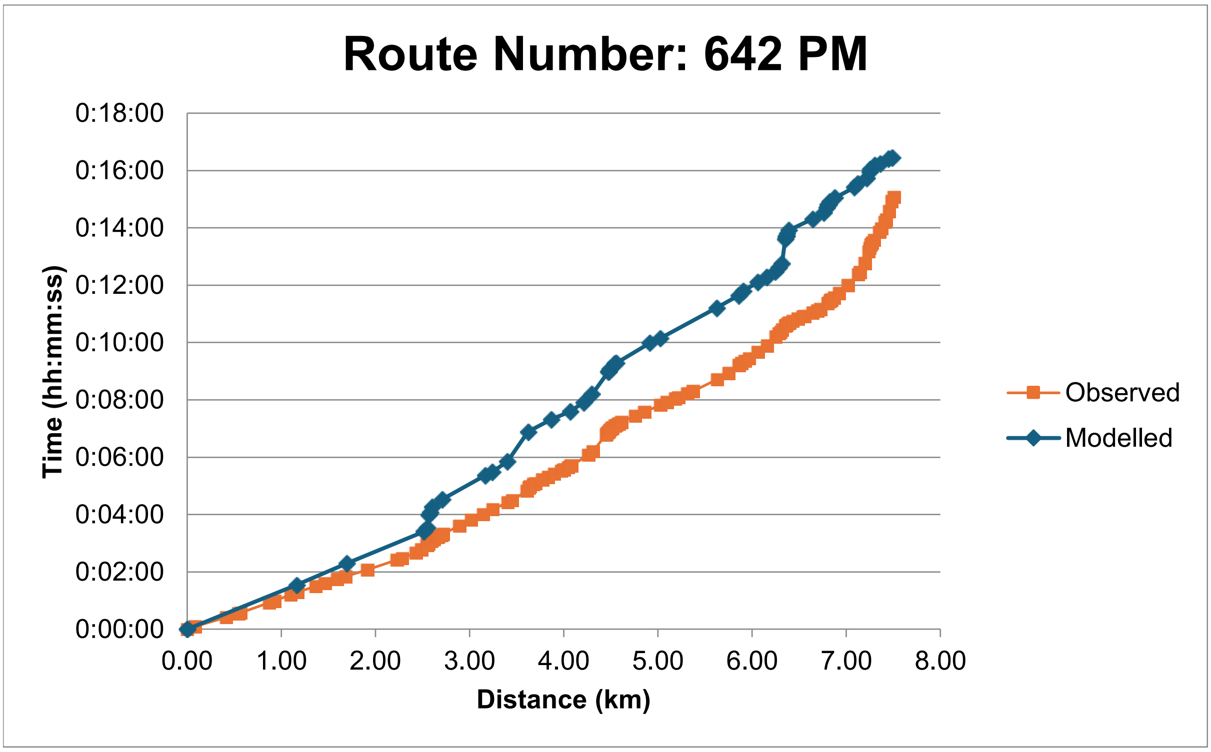
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled



Route Number: 642 PM
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0:14:00
0:12:00
0:10:00
0:08:00
0:06:00
0:04:00
0:02:00
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Time (hh:mm:ss)
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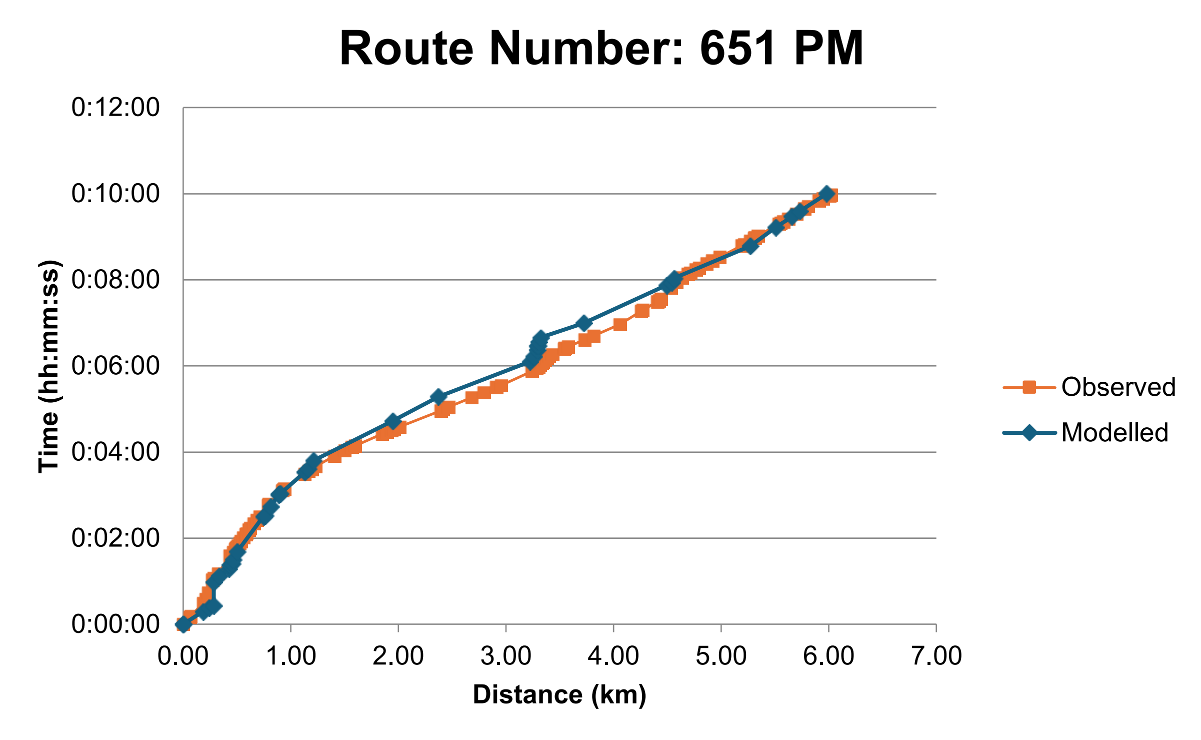
5.00
6.00
7.00
8.00
Distance (km)
Observed
Modelled



Route Number: 651 PM
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0:08:00
0:06:00
0:04:00
0:02:00
0:00:00
Time (hh:mm:ss)
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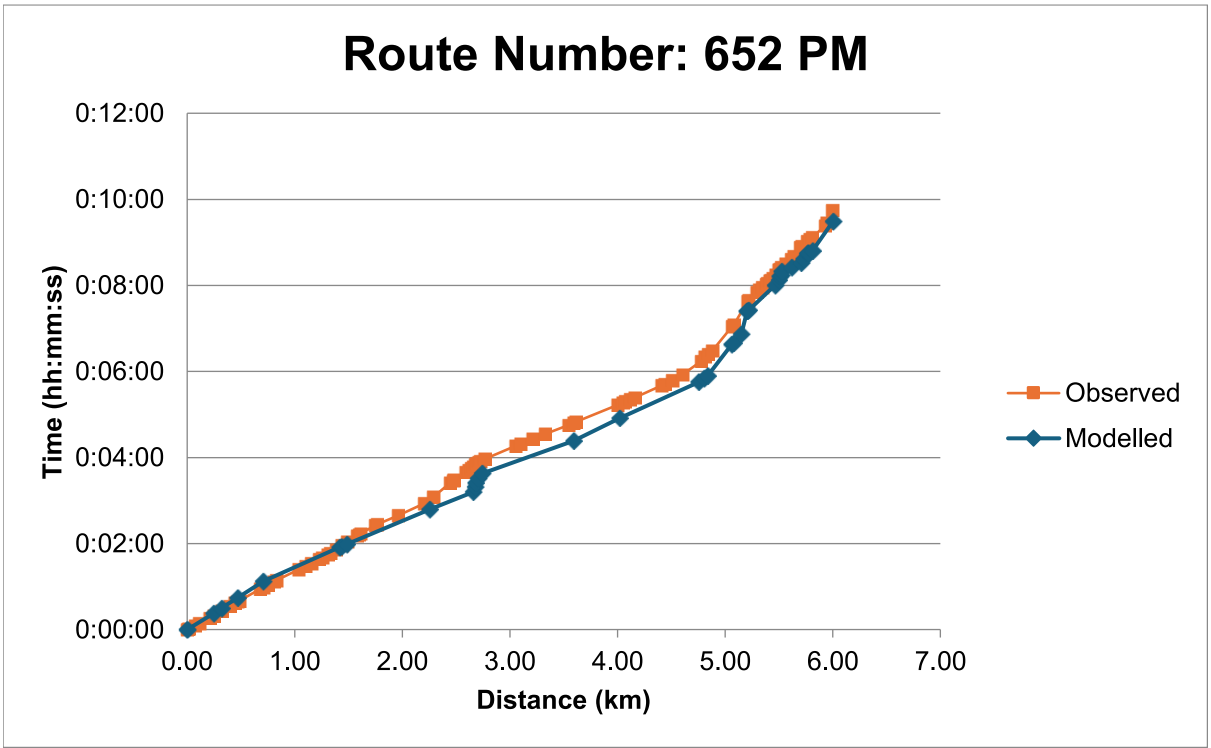
3.00
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled



Route Number: 652 PM
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0:04:00
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Time (hh:mm:ss)
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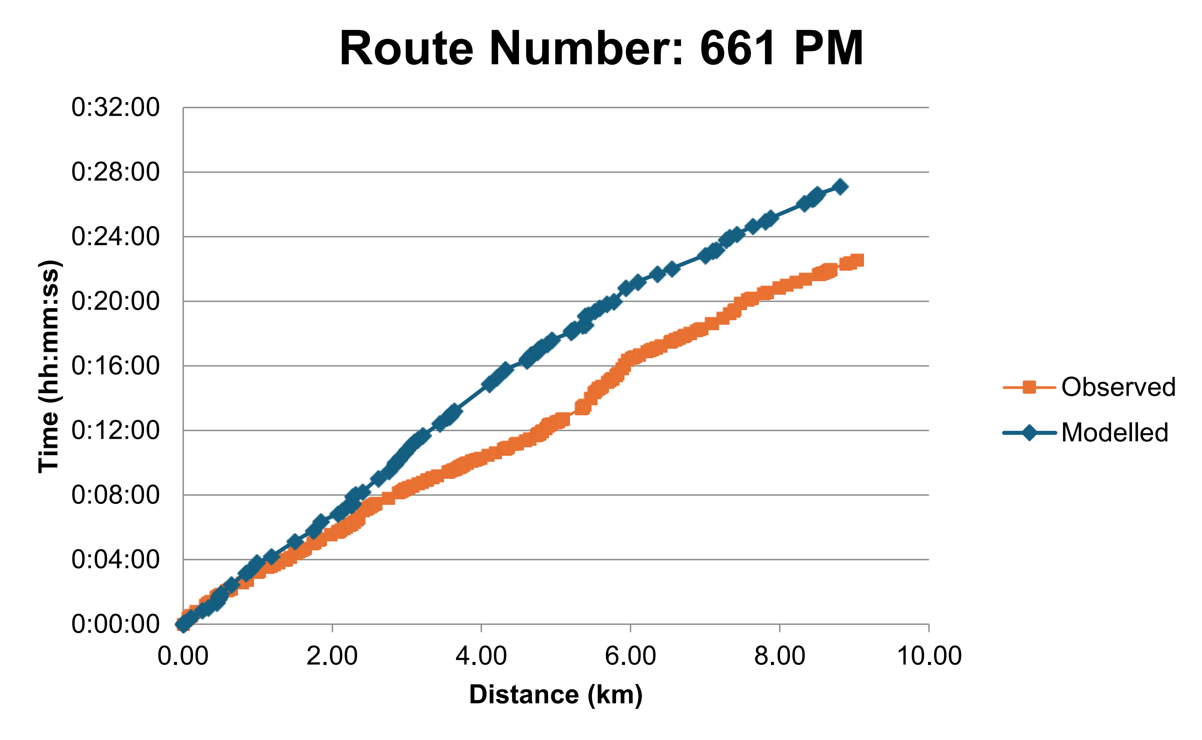
4.00
5.00
6.00
7.00
Distance (km)
Observed
Modelled


Route Number: 661 PM
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0:24:00
0:20:00
0:16:00
0:12:00
0:08:00
0:04:00
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Time (hh:mm:ss)
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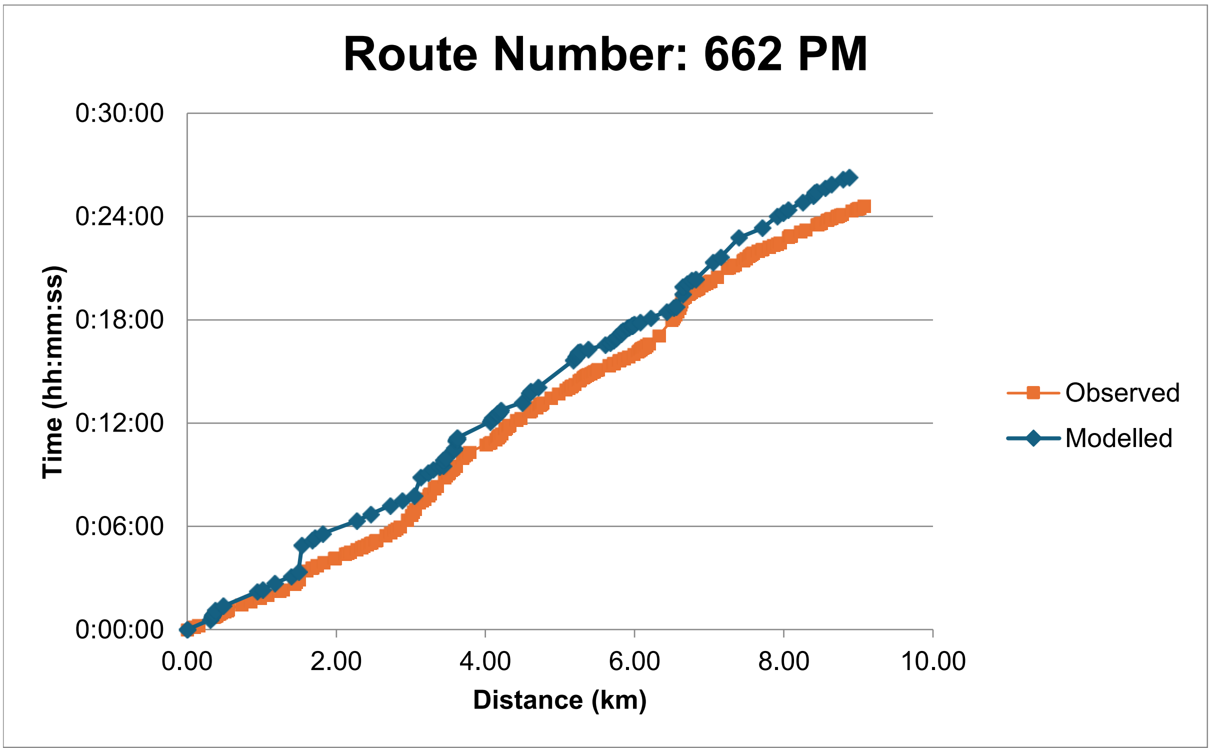
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 662 PM
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0:12:00
0:06:00
0:00:00
Time (hh:mm:ss)
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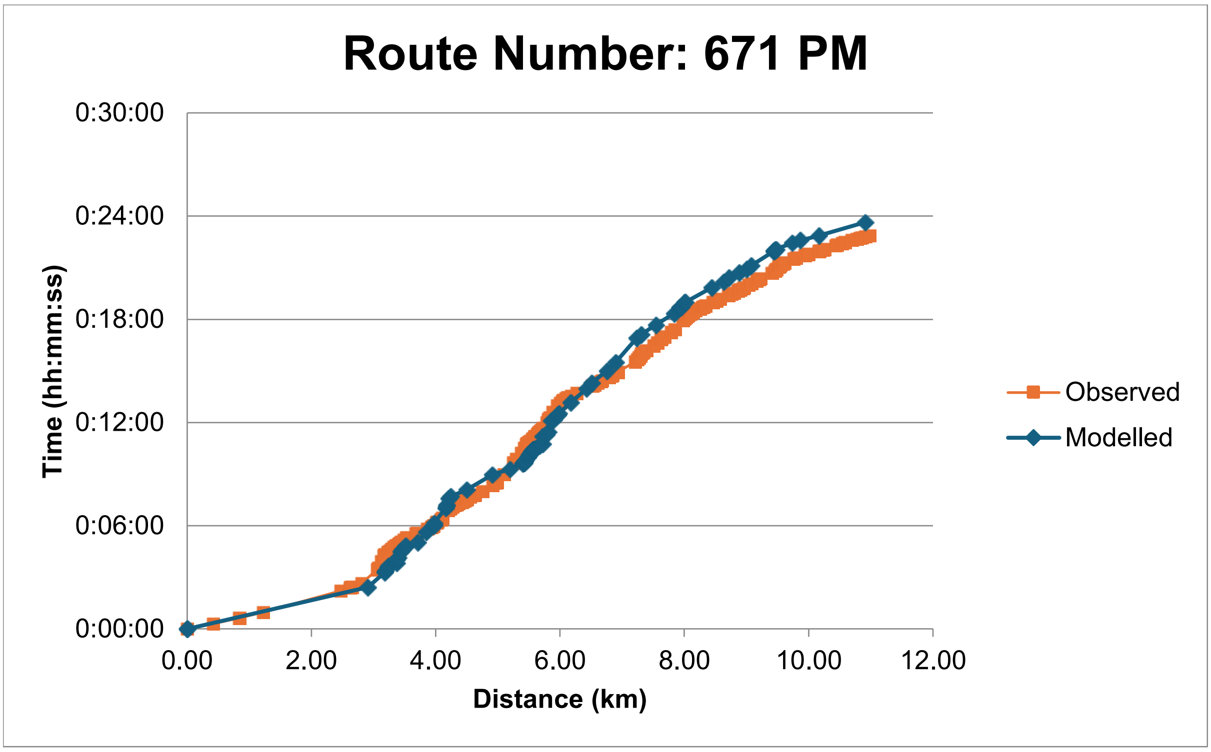
2.00
4.00
6.00
8.00
10.00
Distance (km)
Observed
Modelled


Route Number: 671 PM
0:30:00
0:24:00
0:18:00
0:12:00
0:06:00
0:00:00
Time (hh:mm:ss)
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6.00
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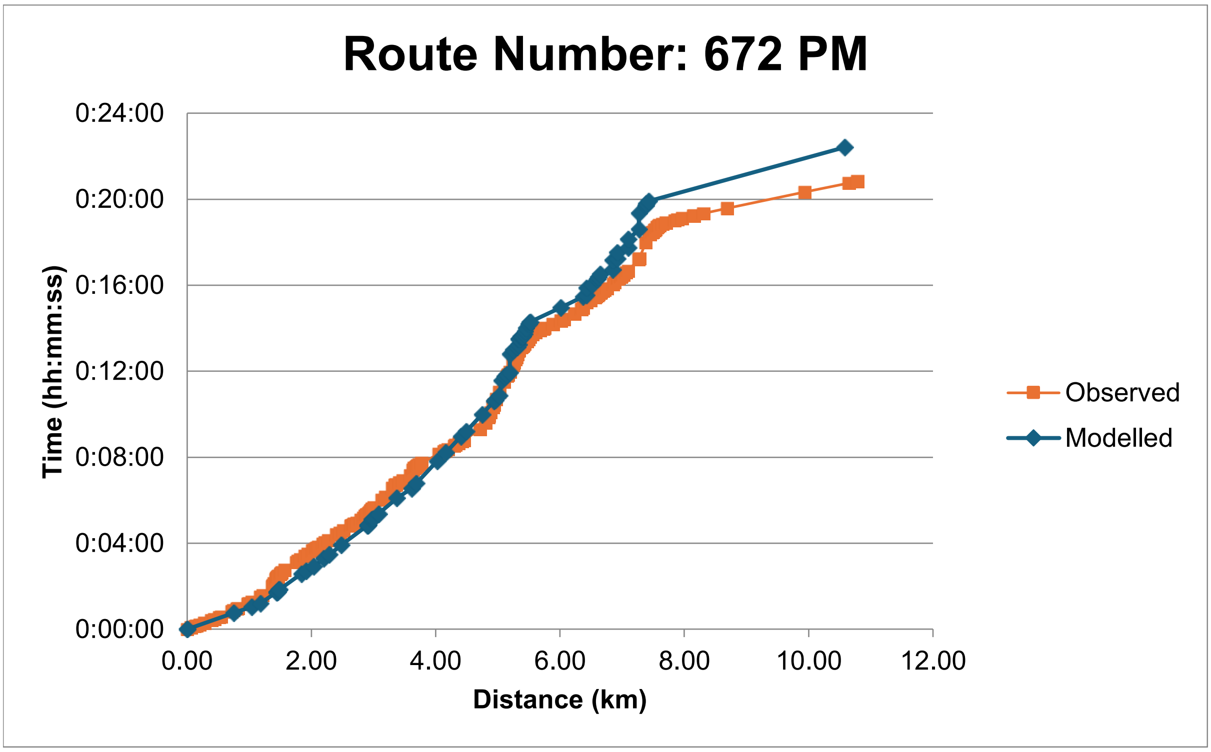
12.00
Distance (km)
Observed
Modelled


Route Number: 672 PM
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Time (hh:mm:ss)
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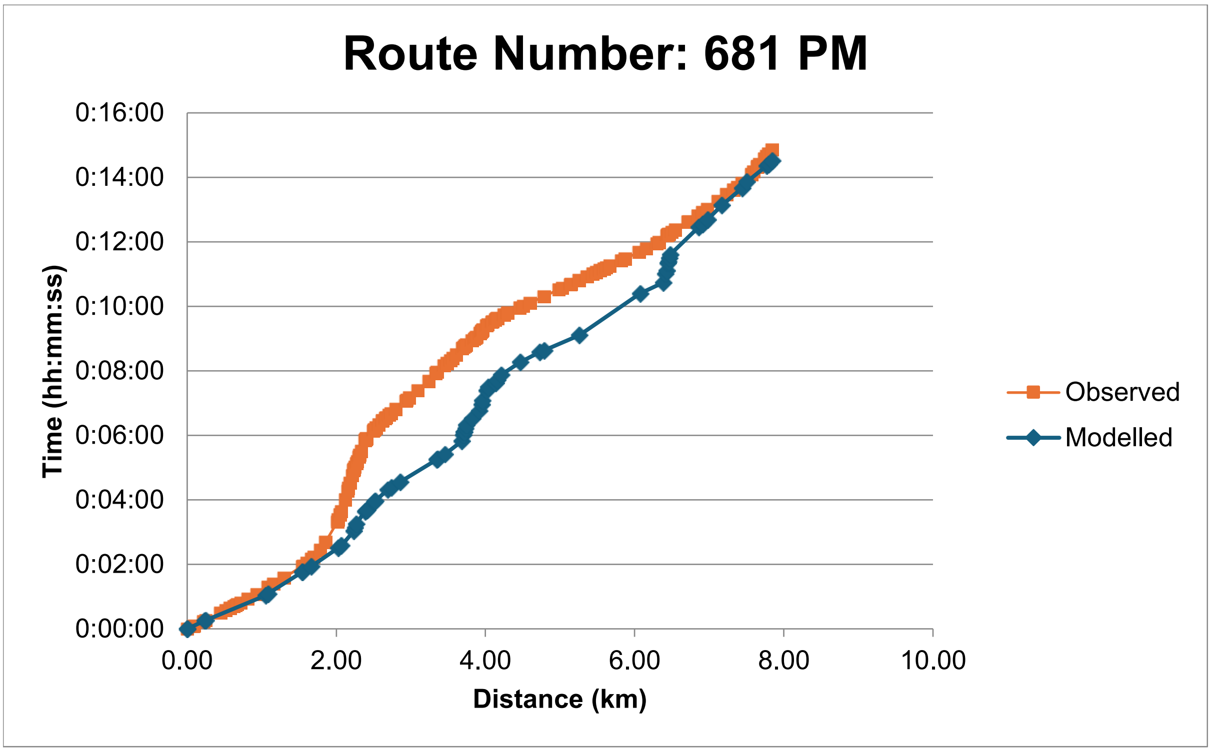
Distance (km)
Observed
Modelled


Route Number: 681 PM
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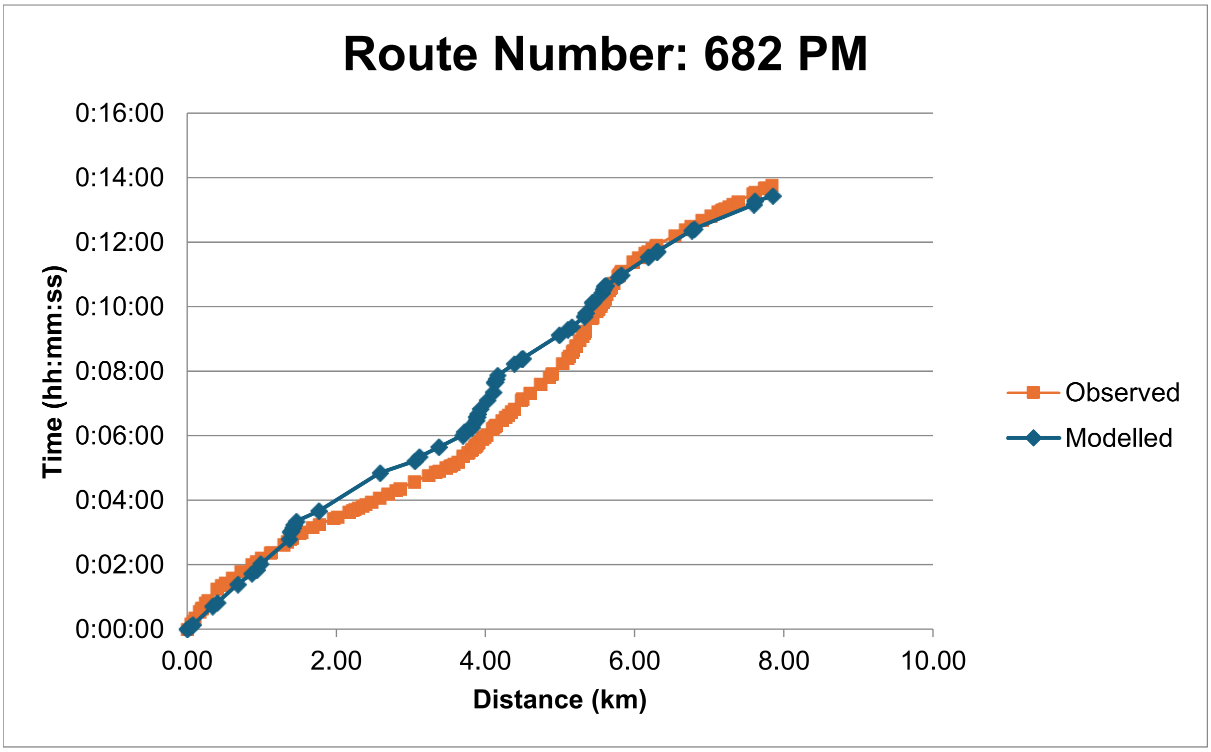
Distance (km)
Observed
Modelled


Route Number: 682 PM
0:16:00
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Time (hh:mm:ss)
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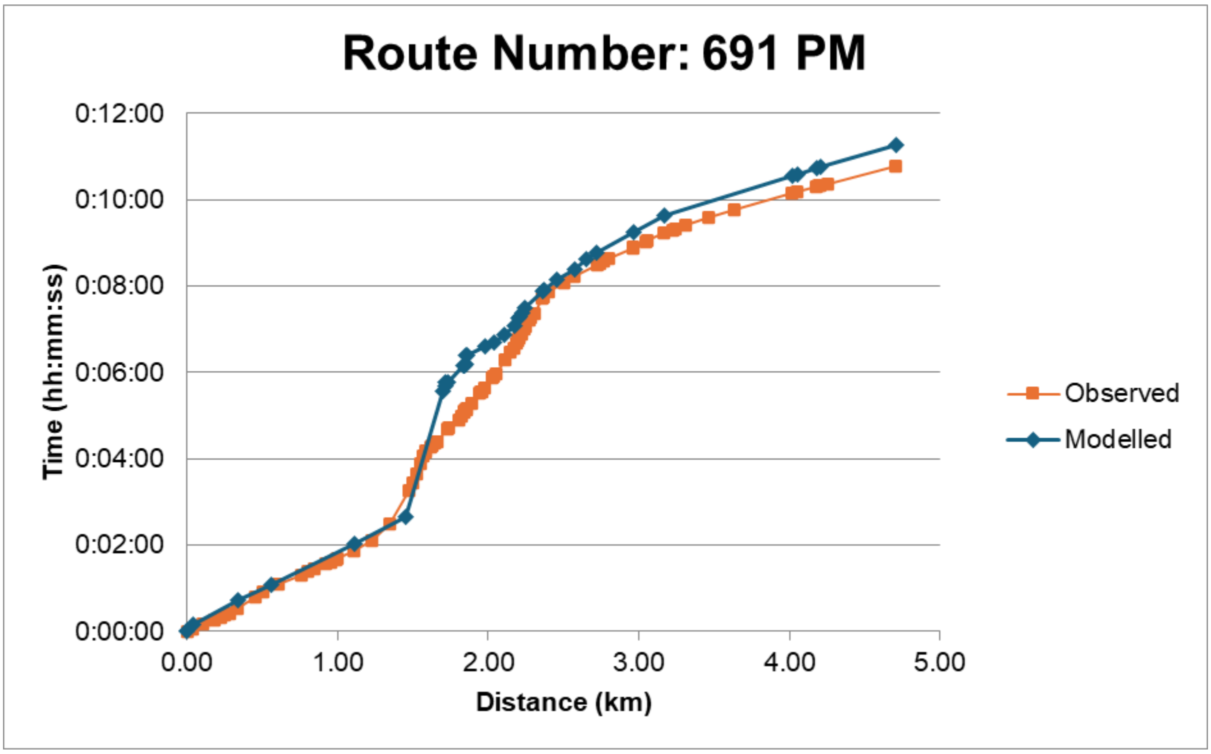
Distance (km)
Observed
Modelled


Route Number: 691 PM
Time (hh:mm:ss)
0:12:00
0:10:00
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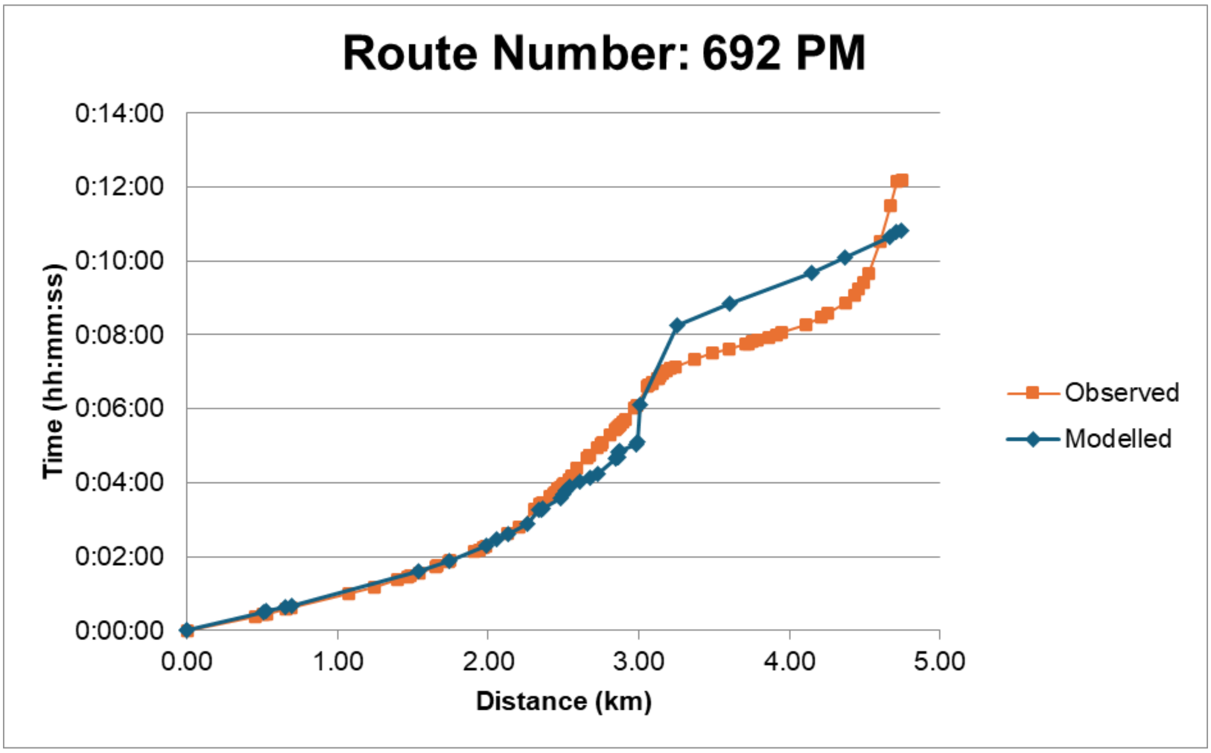
Distance (km)
Observed
Modelled


Route Number: 692 PM
Time (hh:mm:ss)
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0:12:00
0:10:00
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Distance (km)
Observed
Modelled

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