Resumen

Actualmente las grandes capitales en todo el mundo disponen de complejas redes de transporte público; normalmente operando de forma eficiente, con alta fiabilidad y una buena calidad del servicio. Sin embargo, el rendimiento del servicio puede verse modificado por diferentes factores, tales como atascos puntuales, obras de mantenimiento en el plan urbanístico, condiciones atmosféricas adversas, etc.

Hasta la fecha el efecto de las condiciones climatológicas sobre el transporte público no han recibido la atención necesaria por los investigadores del sector a pesar que éstas pueden tener una influencia importante sobre el tráfico en una ciudad. Des del punto de vista de una agencia de transporte, las condiciones climatológicas son consideradas factores exógenos con influencia indirecta en la demanda. Hoy en día, las operadores de buses urbanos no pueden aplicar modificaciones precisas en su planificación, ya que no pueden predecir correctamente la influencia de condiciones climatológicas adversas. La opinión popular sostiene que las inclemencias climatológicas tales como lluvias, nevadas, niebla o temperaturas extremas provocan cambios en la decisión del modo de transporte o incluso se evita viajar.

Así pues, el principal objetivo de este estudio es crear una metodología capaz de predecir los tiempos de viaje para poder trazar e incorporar medidas diariamente o semanalmente dependiendo de factores externos, centrándose en las condiciones climatológicas y flujo de tráfico. Se han desarrollado diferentes modelos de predicción para proporcionar una análisis completo y determinar las tendencias del tiempo de viaje del transporte público. El conjunto de datos ha sido obtenido del sistema AVL ("Automatic Vehicle Location"), del sistema Smartcard de recolección de datos de los pasajeros del caso de estudio, Brisbane (Queensland, Australia).

La mayor contribución de este estudio es el análisis de la variación del tiempo de viaje en transporte público parada-a-parada. Este informe extiende el debate utilizando grupo de datos más concretos para modelar los efectos climatológicos. Se utiliza un modelo predictivo del tiempo de viaje para estimar de forma precisa futuros viajes en transporte público. Los predictores más importantes encontrados resultan ser el índice de congestión de tráfico, las señales de tráfico; y la demanda de pasajeros en términos de la demora en paradas.

ETSEIB

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ETSEIB

1. Glossary of terms

AVL	Automatic Vehicle Location. It is a means for automatically determining and transmitting the geographic location of a vehicle.
Brisbane	The capital and most populous city in the Australian state of Queensland, the third most populous city in Australia (with a population of 2.24 million), located on the eastern coast of Australia.
BOM	Bureau of Meteorology. Executive agency of the Australian government responsible for providing weather services to Australia and surrounding areas.
CBD	Central Business District.
CityGlider	It is a high-frequency bus route operated by TransLink in Brisbane, Australia.
GoCard	Electronic smartcard ticketing system used on the TransLink public transport network in South East Queensland.
OLS	Ordinary Least Squares method for estimating the unknown parameters in a linear regression model.
NWS	National Weather Service is an agency of the United States government that is tasked with providing weather forecasts, warnings of hazardous weather, and other weather-related products to organizations and the public for the purposes of protection, safety, and general information.
RCI	Recurrent Congestion Index. It is capable to predict traffic flow variations depending on different traffic modifiers, such as, time of the day.
Running time	Operating time between two stops in a bus route, recovery time at time points is excluded.
Stop delay	Bus delay at any stop, lead time and dwell time at any stop.

TransLink	Agency of the department of transport and main roads first introduced by the Queensland Government in 2003. It provides public transport services in South East Queensland.
Travel time	Travel time between two consecutive stops in a bus route. It is the addition of running time and stop delay.

2. Preface

2.1. Present days

Nowadays public transport performance is mostly ruled by a set schedule which does not evolve day by day, independently from external factors that may have significant impact on its performance. Although most capital cities around the world have a complex public transport network; introducing dynamic schedules would optimise their service performance.

Adverse weather conditions and casual traffic congestions influence negatively on traffic congestion in big cities, therefore the performance of public transport networks may decrease unless the public transport operators incorporate appropriate changes into their planning, scheduling and management decisions.

Today, as adverse weather conditions and casual traffic congestions are difficult to predict, they are not considered in public transport scheduling and management decisions.

2.2. Motivation

Professor Luis Ferreira, from the School of Civil Engineering, University of Queensland (Australia), was contacted in order to specify a comprehensive topic, relevant to both parties, University of Queensland and me.

Professor Luis Ferreira, who supervised this research, has developed and delivered a large number of professional studies and lectures in transport over the last thirty years, such as *Measuring driver responses at railway level crossings* (2011), or *Planning single track rail operations* (1997). With thirty years in technical and managerial roles covering transport planning, research, management and consultancy. He has been closely involved with transport and traffic planning and modelling, evaluation and performance measurement of transport programs and projects as a practitioner, research and trainer.

Fortunately, during this project I had the inestimable collaboration of Mr. Luis Ferreira and PhD candidate Zhenliang Ma.

3. Introduction

3.1. Objectives

The main aim of this research is to create a methodology capable of predicting public transport travel times and draw whether or not measures on public transport should be incorporated daily or weekly depending on external factors, focusing on weather conditions and traffic flow. This paper emphasizes the importance of having theoretical framework encompassing weather, traffic flow and travel; a full analysis of travel time and stop delay variations on public transport depending on external variables is implemented. An accurate prediction of a full travel time in a real trip in Brisbane (Australia) is the main use of these predictive models.

An economic analysis of the study and viability of the implementation is necessary to determine the scope of the project.

3.2. Scope of the project

This paper intend to study the public transport network in Brisbane; full analysis of the actual status and an accurate modelling of travel times in Brisbane's public transport network are necessary. Meteorological conditions, demand data and traffic flow are highly important in this study. Then, few business recommendations of the implemented models are issued; such as, live updates of bus arrivals at any stop, timetables fitting, or adjustments on the focus of improvement strategies.

Future studies may improve the results of this paper, including into the models other modifiers. The extrapolation of models to other worldwide cities are out of the scope of this project. Other applications of this study may be examined by other researches; such as, improving live updating of buses approaching to any bus station.

4. Project stages

4.1. Literature review

Considerable effort has been made by planners to implement strategies related to advanced technologies capable of improving bus service reliability, these are likely to produce benefits for both passengers and operators. Some studies associated reliability with on-time performance [1], while others related it to travel time variability [2] or even waiting time [3].

On-time performance and headway regularity are the two mostly used operator-oriented service reliability measures. For routes characterized by low frequency services, on-time performance plays the most significant role, since passengers plan their arrivals to coordinate with the scheduled departures to minimize waiting time at stops with a tolerance probability of missing the expected trips [6]. On-time performance is defined as the percentage of trips that depart up to minutes late and minutes early from the scheduled departure time [7]. For routes characterized by high frequency services, headway regularity becomes important [8]. In these circumstances, passengers tend to arrive at stops randomly, and the aggregated waiting time is minimized when services are evenly spaced [9]. Although the operator-oriented measures often help to illustrate the level of service provided for passengers, they do not completely match their actual experienced service reliability. For instance, by altering the on-time tolerance interval from 5 minutes to 10 minutes, the measured reliability improves without any changes experienced by passengers [10]. Also, driving ahead or being late would have totally different impacts on passengers.

The variations of service operations can be derived from two main sources: terminal departure time variation and trip travel time variation [4]. Trip travel time variability is distinguished as one of the key elements of the mismatch between the schedule and actual operations. Many studies have focused on analysing different causes influencing such mismatch. Generally, the unreliability factors can be categorized as environmental, planning and operational [5]. Environmental factors include route characteristics, traffic conditions, weather, incident and road work. Planning factors include link length, schedules and service frequencies. Operational factors include departure delays, passenger activities (boardings and alightings), vehicle type, fare type and field supervision management.

In public bus transit, different factors have been identified as affecting bus running time, this is the amount of time that it takes for a bus to travel from two points excluding recovery time at stops. The main factors include segment length, boardings and alightings, signalized intersections, scheduled stops, actual stops made, bus delay, period of the year, day of the week, time of the day, directions, weather conditions or even drivers experience. Several researchers have investigated different strategies influencing running time [6; 7]. These strategies include smart fare card collection system, reserved bus lanes, limited-stop bus services, stop consolidation, articulated buses and transit signal priority. Diab and El-Geneidy [8] further investigated the impact of the implementation of various strategies on service variations.

Other studies have shown that the segment length can adversely influence service reliability, as well as number of scheduled stops, number of signalized intersections, variation of passenger activities or bus delay [9; 10]; nevertheless, the influence of adverse weather on reliability is controversial.

Little research has been conducted on the impacts of weather on public transport performance, although interest in the topic appears to have increased in recent years. Several research results on weather impact on traffic have been published, but none were directed towards incorporating the impact of weather conditions to a travel time prediction model.

The requirement of weather responsive traffic management was introduced by Pisano, Goodwin [11]. That study analysed the impacts of adverse weather on traffic flow and explained operational strategies which may have improved public transport performance with a presence of adverse weather conditions. Other studies concluded that a change in weather significantly influenced people’s choice in their transportation mode and the negative influence of adverse weather conditions on traffic flow. Basic weather conditions were included as one parameter of an analysis, since adverse weather conditions undoubtedly had an impact on public transport passenger behaviour and public transport service performance [12].

Although traffic condition is believed to be one of the main factors affecting public transport service reliability, only a small number of researchers have proposed an exhaustive analysis of the traffic flow influence on travel time. The congestion level could be calculated as the ratio or difference between actual and free flow travel times. Such measure can be comparable between links that differ in lengths and free flow traffic conditions.

The study also attempts to determine whether adverse weather conditions of the city of Brisbane have a significant impact on public transport travel time. Moreover, few applications are given to predict future bus arrangements depending on other environmental conditions, as well as several planning and operational factors. Otherwise, thanks to the provided methodology, it might be transferred to other cities.

4.2. Brisbane's public bus network actual status

Brisbane, capital of Queensland, is the third largest city in Australia. This cosmopolitan city is a mix of local people and people all over the world, with a population over 2 million of inhabitants. Brisbane disposes of a large public transport network with many possibilities for its inhabitants. Public buses are the most common choice; nevertheless, other options like CityTrain or CityFerry networks are growing fast.

Next SWOT analysis shows the internal and external factors that are favourable and unfavourable for public bus network in Brisbane, in terms of service, offer and demand.

Strengths	**Weaknesses**
Most extended and developed network. Proximity to any stop all around the city. Most introduced public way of transport. TransLink as the only agency allowed to operate in Brisbane.	High dependency to traffic conditions. Low capacity per bus in comparison to other modes of transport. Low on-time performance in certain routes. CBD area with high traffic flow. Fastest modes of transport, such as, subway.
Opportunities	**Threats**
Population shift of thinking in Australia regarding pollution and environmental points. Green technologies progress applicable to bus network; such as, 100% electric engines. Growth of researches aimed to improve public transport performance strategies.	Improvement of other public transport networks and their performance. Increment of traffic congestion that it would mean a drop in its performance. Public bicycle network project in Brisbane.

Figure 4.1: SWOT analysis for public bus network, Brisbane.

4.3. Methodology

Abstracting from literature review and previous analysis of the status of bus network in Brisbane; trip travel time variability is distinguished by bus operators as one of the key elements of the mismatch between the schedule and actual operations. Many studies have focused on analysing different causes influencing such mismatch.

Travel time is also key element for this study; the main objective of the study is to model the conduct of the public transport travel time at link level, with Brisbane (Queensland, Australia) as the location under study.

Thus, an analysis of actual performance of public transport network is necessary. The project database is based on data gathered from an urban bus operator (TransLink). Furthermore, only data from smartcard data boardings and alightings were available, since there are no records of casual boardings. By enriching the database with meteorological data originating from records stored by the Queensland Bureau of Meteorology, it was also possible to investigate the impact of adverse weather conditions on urban bus performance measures. The data were joined using the date and hour of both the passenger boarding and the meteorological data set.

Past papers were studied for the best qualitative approach, so as to provide a unified framework for understanding research design in causal analysis, aiming to satisfy certain fundamental criteria. Few prior assumptions were established based on the review. Data was collected from three different sources: AVL (Automatic Vehicle Location) system, smartcard ticketing systems and weather data from the case study location, Brisbane.

A data format was set in order to blend all the databases in a simple understood data set; so, the vast amount of transactional data from November 2012 to April 2013 (about 350,000 records) was moved from the TransLink database source to a single database. Before an in-depth analysis of all the information collected so far, an exhaustive data cleaning was implemented, achieving a consistent data assembling free from outliers and erroneous data.

As a first stage of an statistical analysis some assumptions were concluded. Subsequently, several prediction models were segregated due to a full regression analysis. Those models and results were studied to draw some conclusions. The final prediction models were subjected to a sensitivity test to evaluate their responses. Eventually, a few measures were proposed to be carried out by the urban public transport operator in order to optimize the performance of the public transport service in Brisbane.

Figure 1 shows a flow chart which summarizes the methodology followed.

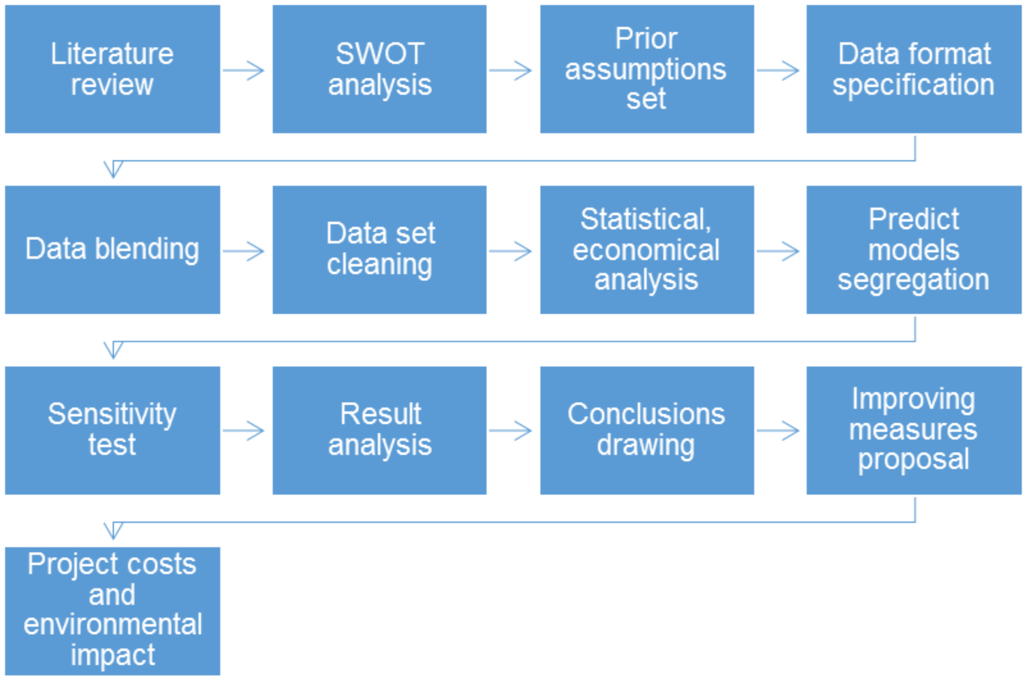

Figure 4.2: Research methodology flow chart.

5. Input data

The project provides insights into main factors that impact on the public transport travel time, running time and stop delay, with Brisbane as the location under study. Thus it was necessary to determine selection criteria for data set. It was collected from different sources of data. The raw data set was about 350,000 records, enough to outline all the different public transport network scenarios in terms of public transport performance.

A data set from GoCard system (smartcard ticketing system) was used; it is all the data collected from card readers installed on public buses from Brisbane during a period of six months (November 2012- April 2013). The ridership's way of recording their trip is touching the reader with their smartcards every time they enter and exit from the bus. However, only data from Gocard boardings were available, casual passengers were excluded from the analysis since there is no data available. Casual passengers influence is very low; most of the population in Brisbane dispose of a GoCard. Six month data set was considered enough to describe a pattern from the influence of the demand on public transport service performance; for the purpose of this project.

AVL (Automatic Vehicle Location) bus network data was processed during the project, TransLink yield AVL data set which was all data collected from AVL system during the same lapse of time. This data set was used to draw the different traffic scenarios.

Bureau of Meteorology (BOM) supplied data from Brisbane's weather from the year 2012 and 2013. It was necessary to study the influence of the weather on public transport performance. It was recorded following the next pattern: date, hour, rainfall (mm), temperature, mean wind speed, mean wind direction.

BRISBANE AREA

	Date/Time EST	Temp °C	App Temp °C	Dew Point °C	Rel Hum %	Delta T °C	Wind					Press hPa	Rain since 9 am mm	Low Temp °C time	High Temp °C time	Highest Wind Gust		
							Dir	Spd km/h	Gust km/h	Spd kts	Gust kts					Dir	km/h time	kts time
Brisbane	07/02:34pm	25.5	25.2	14.3	50	6.7	NNE	9	17	5	9	-	0.0	14.4 02:55am	26.9 12:58pm	ENE	28 11:07am	15 11:07am

Figure 5.1: Example of weather data recording.

In this study, a unique data set was built in order to characterize unreliability by integrating different sources of data, including Automatic Vehicle Location (AVL), smartcard transactions (GoCard) and Bureau of Meteorology (BOM) data. The integrated data set is able to provide detailed information of service characteristics, traffic conditions, route features, weather conditions and passenger demand.

By enriching the database with meteorological data originating from records stored by the Bureau of Meteorology of Queensland, it was possible to investigate the impact of adverse weather conditions on urban bus performances measures. The data were joined using the date and hour of both the passenger boarding/alighting; and vehicle location and the meteorological data set. Due to the difficulty of getting all the data from the different sources, the time of the study was delimited from November 2012 to April 2013; considered enough to carry out the project.

5.1. MySQL. Database management

Main data sources were supplied from three different institutions with very different data formats and lengths. Therefore and due to the extensive amount of data to treat, MySQL was used as main database management system. All data was saved in two large and unique files in order to access it in future stages of the research.

This step of the research was considered crucial due to the importance of getting appropriate and applicable information. The management of all the information was conducted with an elaborate process due to the large amount of data. Standard software was not enough to manage all the information; hence, MySQL was selected as a database management system. More than 350.000 observations were clustered in unique files. Data format is defined in posterior sections.

5.2. MATLAB. Data cleaning

Another essential process in early stages was the data cleaning from disturbances and outliers. Basic m-file functions were designed for the in-depth cleaning data. The MAD 3-delta criteria was used for outlier identification.

Public holidays were excluded from the analysis since they have different operation patterns. Cultural Centre bus station was excluded from the analysis since it had many disturbances, such as, bus bunching. 20% of data was excluded from the analysis in order to validate models in future stages.

6. Preliminary analysis and data format

6.1. Public transport mode assumptions

Most common public transports in main capitals of Australia are buses, ferries, trains, subways and tramways. Tramway is not present in Brisbane. Ferry and train networks were obviated due to lack of data and non-relevant influence of weather on their service performance. Nevertheless, reflecting past researches outcomes, adverse weather conditions have an impact on urban transit ridership, including subway, ferry and train passengers.

Blending the public bus network map and the weather observation stations maps from Brisbane area, a network/route selection criterion was drawn. Due to the large amount of data collected from the whole bus network, this project had non-necessary resources to process all data set. Thereby, it was analysed just a sample of routes that let study diverse and most significant scenarios in terms of traffic flow.

Routes selected were 555 and 60 (CityGlider). In fact, as premises set, there were non-relevant differences between studying at a network level or just a sample of significant routes. It is important to highlight that chosen routes were selected based on past studies of traffic development in the city of Brisbane. It was chosen few routes which show two very different scenarios in terms of traffic flow. It was already known that the Central Business District (CBD) is the part of Brisbane that has more traffic congestion issues both with and without adverse weather conditions.

It is highly important to understand the main differences between route 555 and 60. The first one crosses Brisbane through a bus way, which is intended to be a way just transited by public buses. The second one is a regular bus route. They both cross over the Central Business District (CBD) of Brisbane from different directions. CityGlider (route 60) is one of the highest frequency bus services in Brisbane; it runs every five minutes between 7-9am and 4-6pm on weekdays and every 10 to 15 minutes between all other hours of operation. 555 as a regular route runs every 15 minutes between 5:30am-9pm on weekdays and from 6-9pm on Saturdays; and every 30 minutes between all other hours of operation.

Route link was defined as the segment between two consecutive stops. The link length varies between 0.38km and 8.8km. Link travel time was defined as the arrival time difference between two consecutive stops. Running time was defined as the time difference between departure at the current stop and arrival at the next stop. Stop delay is the time difference between arrival and departure at a stop.

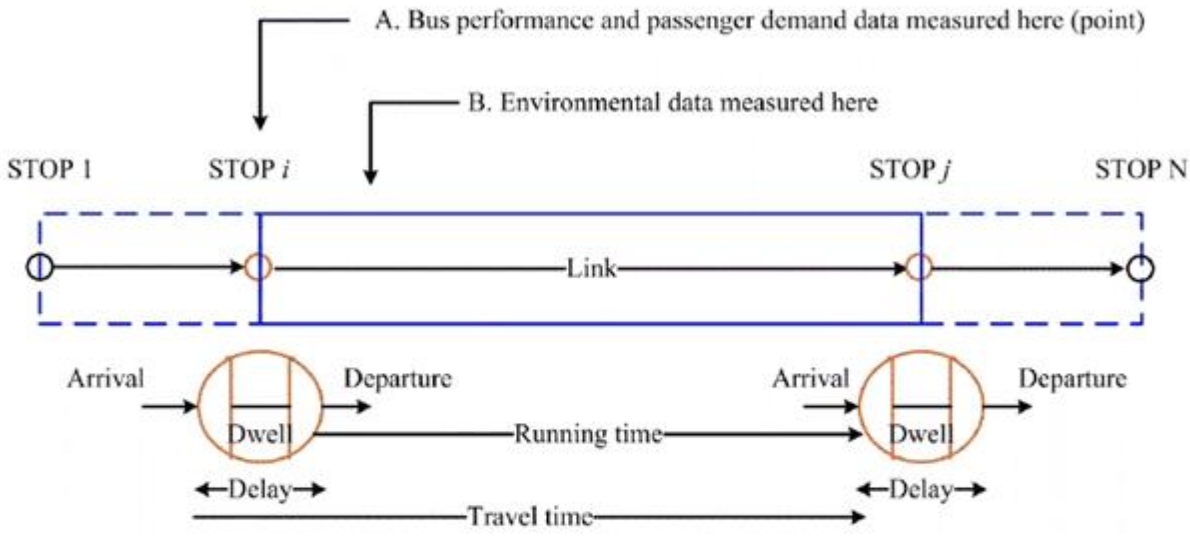

Figure 6.1: Time calculation scheme [2].

Following, detail of the public bus routes selected for this project.

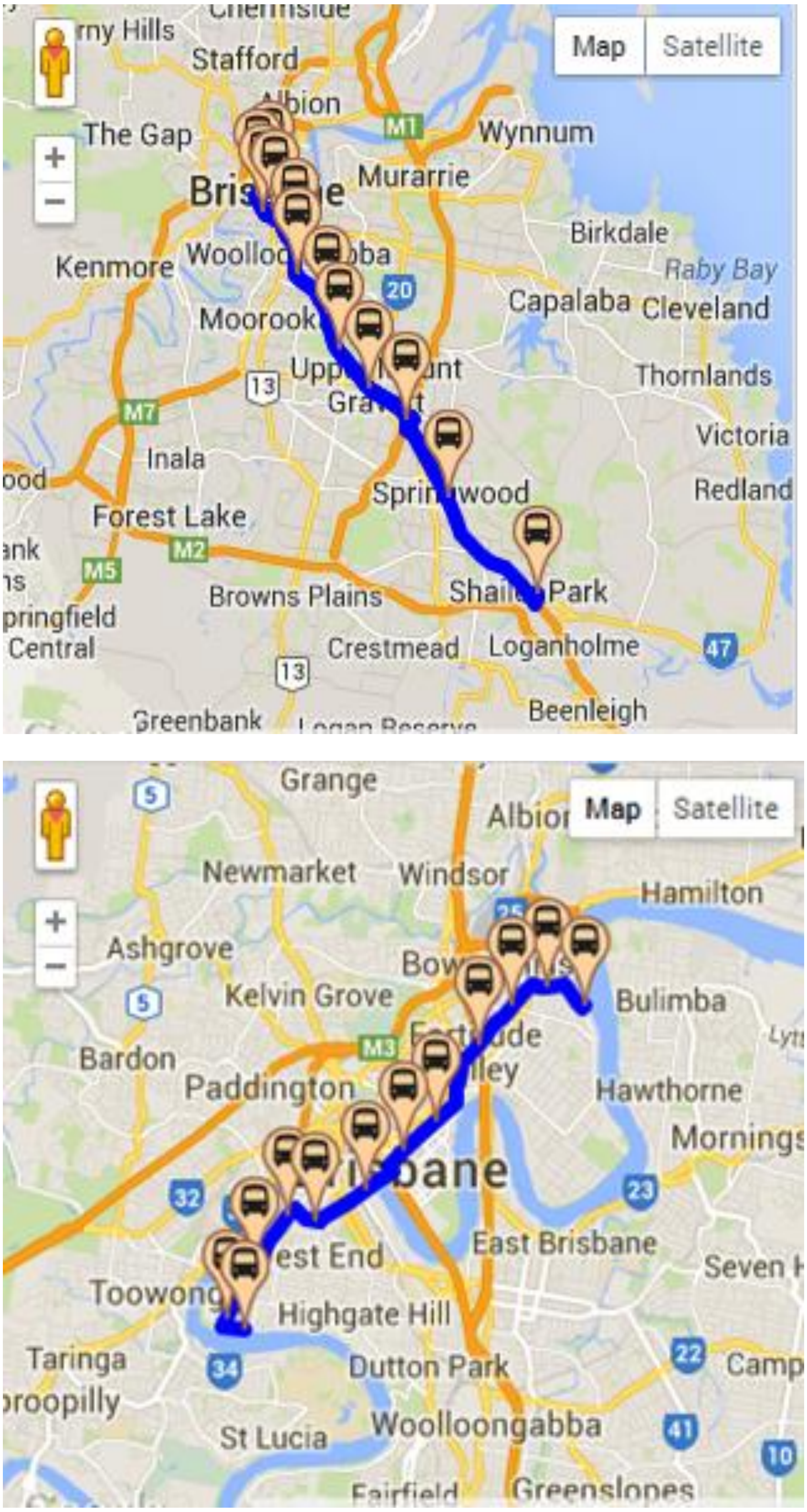

Figure 6.2: Up, bus route 555. Down, route 60, by TransLink, Brisbane [13].

6.2. Brisbane's weather observation stations election

Previous assumptions simplified the study to just a sample of two urban bus routes. Therefore, during the examination of weather observation station map from Brisbane area, a prior choice was just Brisbane's Weather Observation Station election, excluding all other meteorological stations from Brisbane area. For further studies, Brisbane airport weather observation station may be used to study an outer non-urban route. So, it was defined the same weather conditions in all urban routes studied.

Figure 6.3: Map of main weather observation stations, Brisbane area [13].

6.3. Weather data assumptions

Encompassing literature review, past beliefs and this previous study of weather conditions impact on public transport performance; they all suggest negative influences of adverse weather conditions. In the following stages, this paper extends that discussion by using more detailed hourly data to model the weather effects. Based on input dataset collected from BOM, there are different non-necessary records for the scope of this project.

Firstly, wind impact was excluded as a significant variable on traffic flow since non strong winds were recorded during the time studied. Below, wind speed records during those six months.

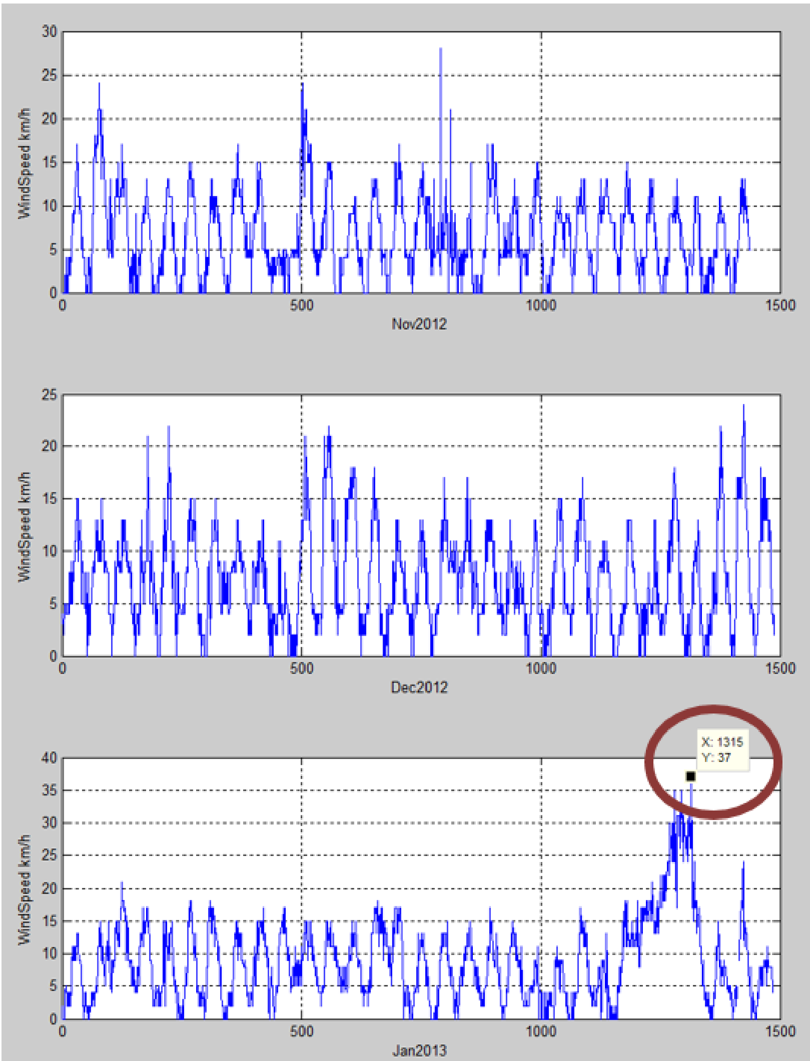

Figure 6.4: Wind records from Nov2012 to Jan2013 in Brisbane.

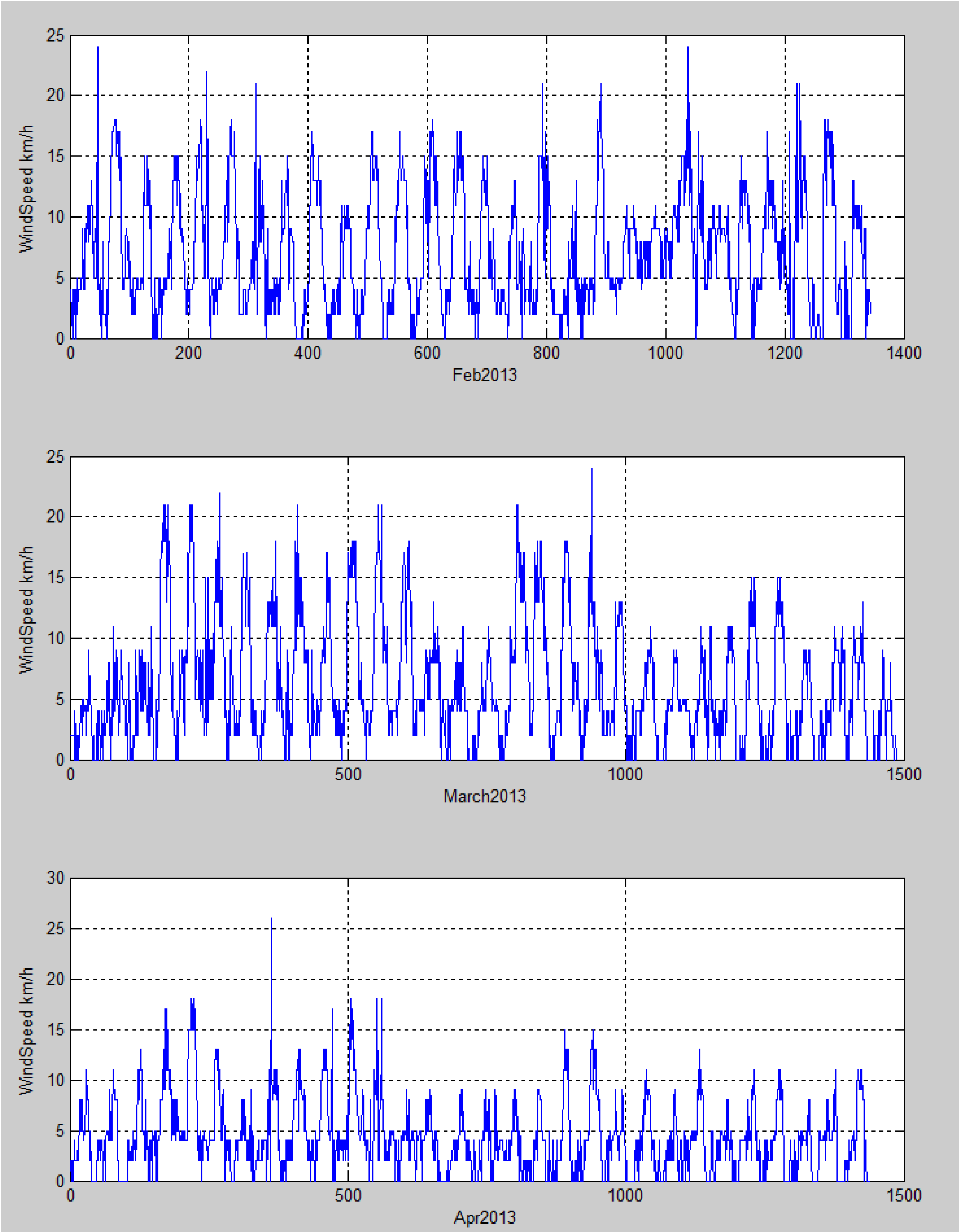

Figure 6.5: Wind records from Feb2013 to Apr2013 in Brisbane.

Wind speeds between 30 km/h and 39 km/h are defined as a fresh breeze, in accordance with National Weather Service (NWS) wind scale. The fastest wind speed registered during that period was 37km/h, registered the 28th of January 2013. Thereby wind was defined as a non-significant measure to study in this project.

In terms of temperature, there are few peaks of extreme temperatures during the analysed period. The highest one was registered the 4th of December 2013 (37.5°C); the lowest one was registered the 21st of April 2013 (12.2°C). Hence, these cases were studied separately. Nevertheless, none of both extremes of the sample were considered "extreme" temperatures for the city of Brisbane.

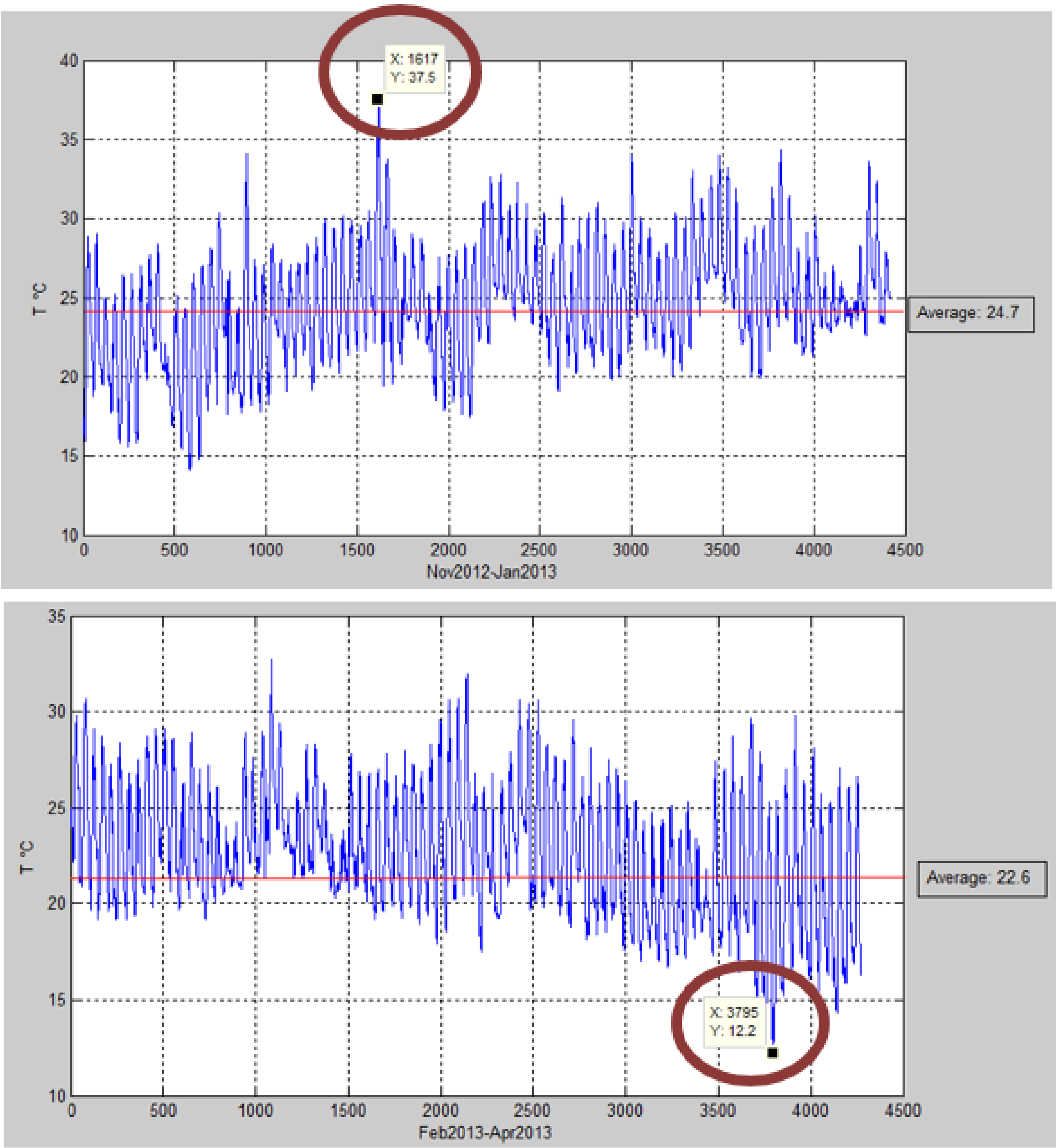

Figure 6.6: Brisbane temperature records Nov2012-Apr2013.

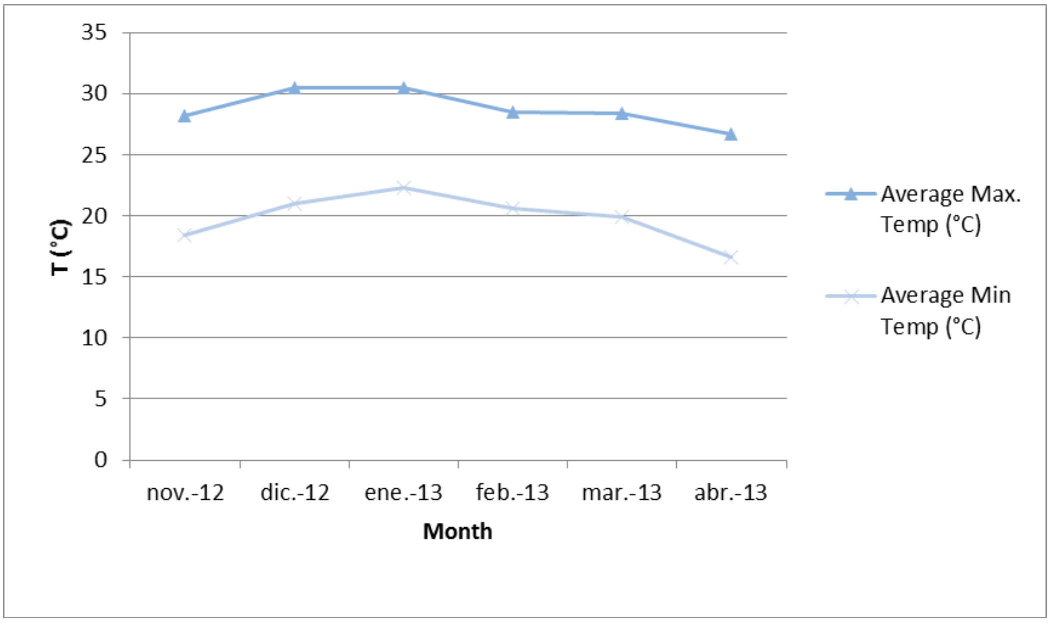

Figure 6.7: Brisbane average temperature records Nov2012-Apr2013.

Once dismissed the effect of winds and extreme temperatures and for the purpose of this study, the focus was mainly on the rainfall measure, which was collected hourly.

Next chart outlines the fluctuation of rain records during February and March 2013.

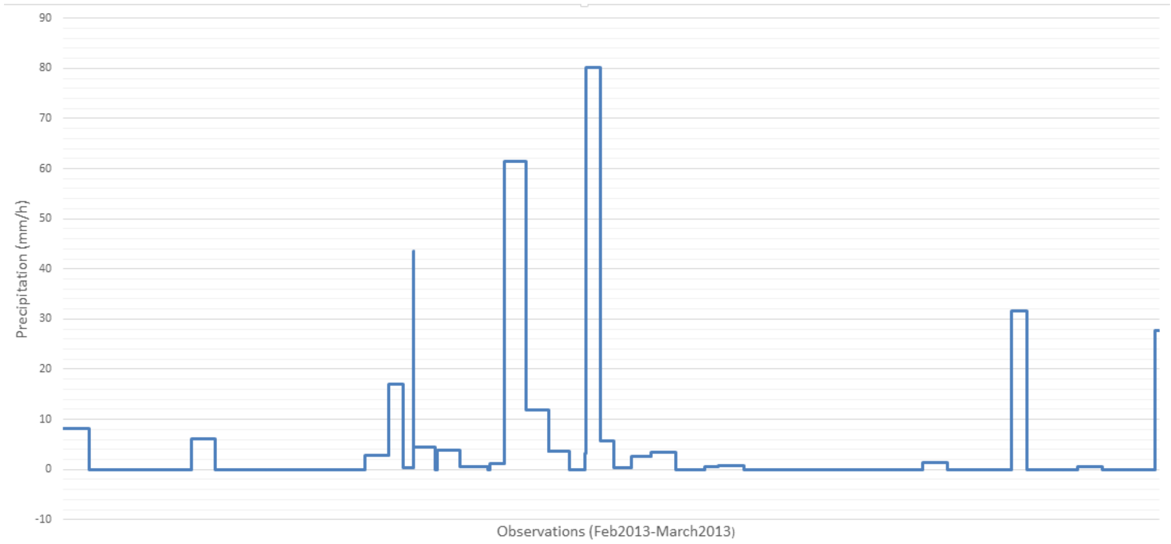

Figure 6.8: Brisbane station rainfall records February- March 203.

Next section confirms the importance of the rain in the behaviour of travel times for public buses in Brisbane.

6.4. Rain effects on bus travel time presumption

Several travel time observations were plotted as a first step of an in-depth study of the rain impact on public buses outcomes. This test was completed during two random Mondays, a rainy Monday and a non-rainy Monday. Both scenarios were recorded in successive weeks at the same time of the day in order to minimise the influence of other external factors. Each observation refers to the travel time used by a public bus during a segment in-between two consecutive stops.

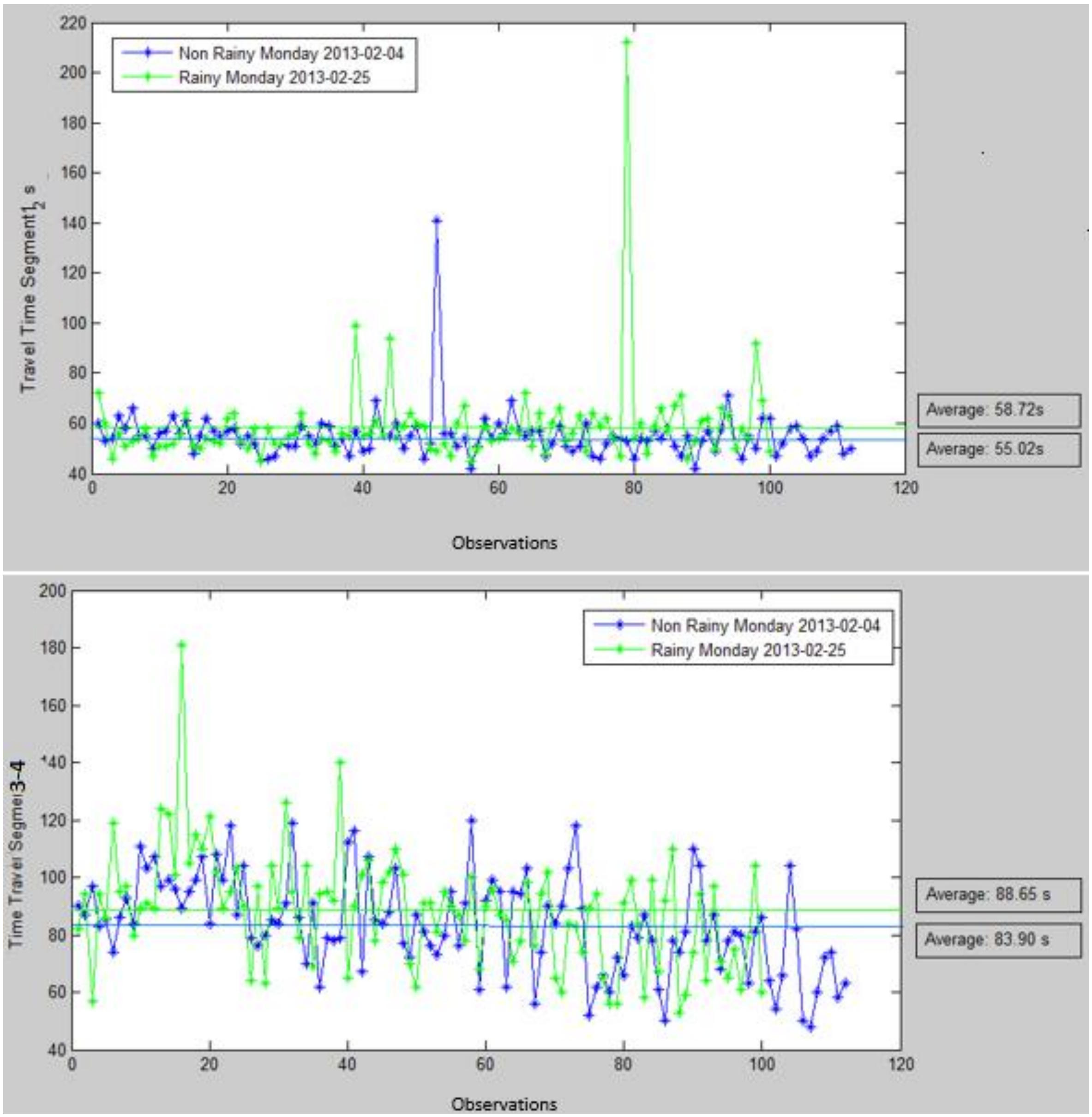

Figure 6.9: Travel time recording by links 1-2, route 60.

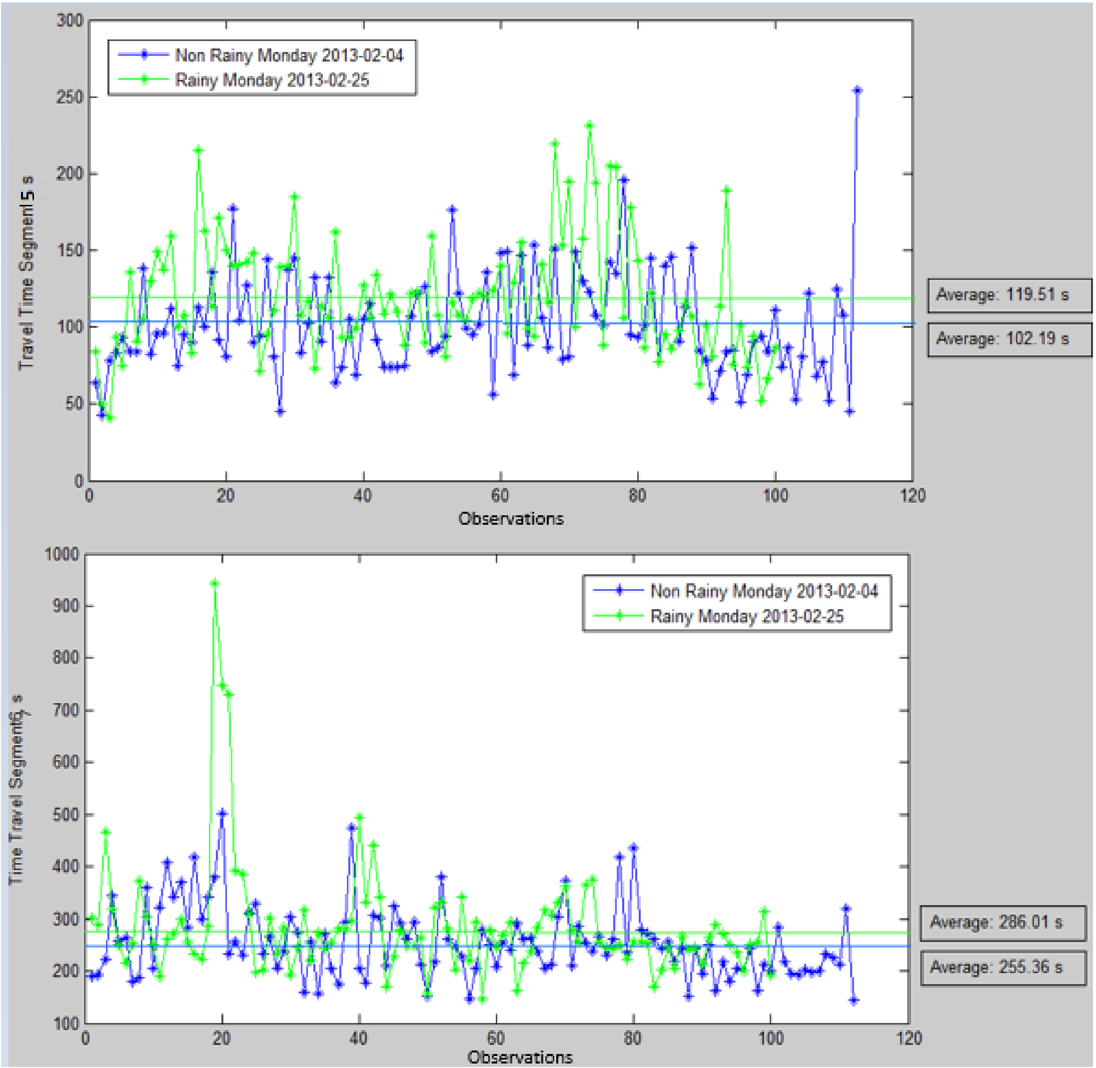

Figure 6.10: Travel time recording by links 3-4, route 60.

Once outliers were excluded and derived from previous plots, heavy rainfall might infer to travel time at bus performance in Brisbane, the travel time average by links in more than a hundred runs is slightly greater during that rainy day. As shown in *table 6.1* and *table 6.2*, the reliability of the travel time seems to be more unstable during rainy days. In any case, an in-depth statistical/ economical study was carried out in following stages of this study.

Travel time average (s)		
	Non-rainy day	*Rainy day*
Link 1	55.02	58.72
Link 2	83.90	88.65
Link 3	102.19	119.51
Link 4	255.36	286.01

Table 6.1: Travel time average by links, route 60.

Travel time standard deviation (s)		
	Non-rainy day	*Rainy day*
Link 1	17.987	9.838
Link 2	20.080	16.592
Link 3	38.494	33.961
Link 4	111.883	69.934

Table 6.2: Travel time standard deviation by links, route 60.

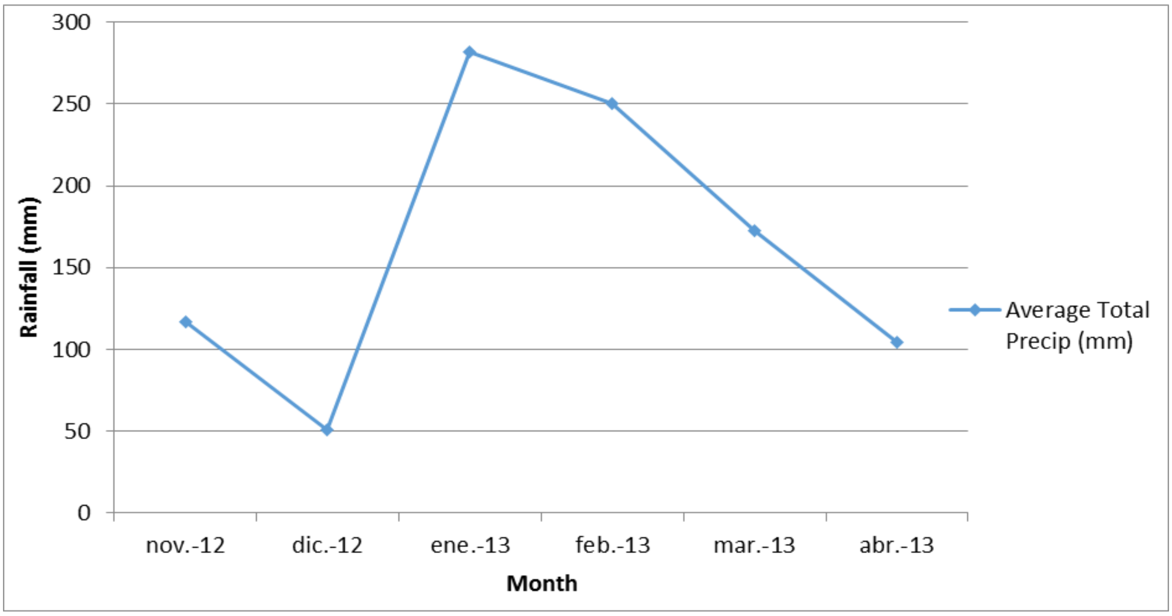

Figure 6.11 Average rainfall in Brisbane per month.

Wet season was selected for this study in order to have a big sample of observations with rains recorded. January as expected was the wetter month with almost 300mm of rainfall.

Australian Meteorological Institute classifies rain intensity in several groups; two adverse weather conditions for this study were distinguished: light rainy conditions (0.1 mm/h- 4 mm/h) and heavy rainy conditions (>4 mm/h); Afterwards, rainy conditions were subject to different statistical analysis in order to get accurate results.

On the other hand, other bus performance modifiers were defined in order to understand whether or not the adverse weather conditions influence on public transport performance. They are introduced in the following sections.

6.5. Planning variables

In addition to weather conditions variables, there are many other determinants which have a significant impact on public transport travel time.

Planning factors which depend on the calendar are considered significant in this study. Following ones were taken into account.

PLANNING VARIABLE	DESCRIPTION
1ST TERM	Nov 1st to Dec 12th.
2ND TERM	Dec 13th to Jan 26th.
3RD TERM	Jan 27th to Apr 30th.
SATURDAY	Saturday.
SUNDAY	Sunday.
EARLY MORNING (EM)	Time range from 05:30 to 07:00.
MORNING PEAK (AM)	Time range from 07:01 to 09:00.
MID-DAY (MD)	Time range from 09:01 to 13:30.
AFTERNOON PEAK (PM)	Time range from 13:31 to 18:00.
LATE EVENING (LE)	Time range from 18:01 to 23:59.
INBOUND	Bus directed to CBD.
OUTBOUND	Bus operating outbound across CBD.

Table 6.3: Planning modifiers.

Brisbane, as case of study, has steady traffic flow along the year with quite good behaviour of the city plan in terms of traffic congestion index. CBD is the most problematic area with a lot of traffic bunching.

Year terms were defined in order to distinguish the impact of public and school holiday on the traffic. Summer school holidays started the 13th of December in 2012 until January 26.

Passengers at Brisbane, with at least 5 trips in their GoCard during the week, have a free trip during the next weekend. Therefore Saturday was studied alone.

Different daily peaks are common in terms of traffic congestion in big cities. Based on past studies in the city of Brisbane, there were defined 5 time groups per day; with two peaks considering starting/finishing working times.

Inbound and outbound, as the two ways for a same route, were at first considered significant.

6.6. Operational variables

Most papers consider public transport demand relevant for timetables planning as stop delays will be longer with higher bus occupancy. Therefore, demand is important for this study. Following determinants were included in the study.

OPERATIONAL VARIABLE	DESCRIPTION
NUMBER OF BOARDINGS	Number of passengers boarding the bus at any stop.
BOARDINGS SQUARED	Number of passengers boarding the bus at any stop squared.
NUMBER OF ALIGHTINGS	Number of passengers alighting from the bus at any stop.
ALIGHTINGS SQUARED	Number of passengers alighting from the bus at any stop squared.
NUMBER OF PASSENGERS	Number of passengers on board.
DELAY AT FIRST STOP	Delay relative to schedule at the first stop (second) of the segment.
ACTUAL STOPS	The number of actual stops along the segment.

Table 6.4: Operational modifiers.

Quadratic equation is considered a legitimate approach to define time spent for passengers to board or alight from the bus. Therefore, boardings and alightings fit quadratic equations.

$$x^2 + px^2 + q = 0 \quad \text{(Eq. 6.1)}$$

Number of passenger on board may influence during stop delays or running times in-between stops.

Drivers should fit a pre-defined schedule, they will probably drive faster if they are late at the very first stop of the trip; so "delay at first stop" is defined as an operational variable.

Finally, *actual stops* is determined; there are a few buffer stops between consecutive stops, scheduled by transport agency. The reason is to avoid bus bunching; two or three buses coming at a time would cause longer period of time than scheduled for the following bus to arrive.

6.7. Traffic conditions

Public transport planners struggle considering traffic conditions in their schedules. There are many traffic modifiers and variables in the same bus route which have impact on the travel time.

Different traffic variables were considered in subsequent stages of the research. Nevertheless, most of them were discarded or clustered based on past studies.

The next chart shows all the amount of traffic variables which were considered at any stage of this study:

TRAFFIC CONDITIONS	DESCRIPTION
LENGTH	Length of the segment (km).
SIGNALS	Number of traffic signs at any intersection along the segment.
SIGNALS SQUARED	Number of traffic signs at any intersection along the segment squared.
ROUNDABOUTS	Number of roundabouts along the segment.
OTHER INTERSECTIONS	Number of other type of intersections along the segment.
SPEED LIMIT	Maximum speed allowed along two consecutive stops (km/h).
NUMBER OF LANES	Number of lanes of the road link along the segment.
MOTORWAY	Motorway road.
BUSWAY	Busway road.
ARTERIAL	Arterial road, high-capacity urban road.
CBD	Bus operating in CBD area; high traffic congestion in there.

Table 6.5: External variables.

Australian main cities have very different kind of routes depending on speeds and traffic congestion. CBD is a high traffic area as most of businesses are assembled there. Main Australian capitals have an specific roads just for public buses; so there is low traffic congestion in busways. Other roads include local, district and suburban roads.

Length between two consecutive stops, traffic signs, speed limits and number of lanes are considered as independent variables in this study.

6.8. Recurrent congestion index

There are many researches regarding traffic conditions in urban areas; as a first step, an in-depth literature review of this topic was done. Finally, a new variable was created in order to model the influence of traffic congestion.

Similar to the congestion index definition [14], the recurrent congestion index (RCI) was defined as the ratio of mode speed to free flow speed. To exclude stop delay influence, the link speed was calculated as length over running time (Eq. 6.2).

The free flow speed ($V_{freeflow}$) is the speed that could theoretically be achieved when the traffic is free flowing. It is usually less than the speed limit in order to allow for slowing down at intersections, stops and other alignment features. The free flow speed for each link has been derived from the maximum travel time using the cleaned dataset collected between 5:30 am and 23:30 pm.

The mode speed ($V_{scenario}$) for time period "*t*" on link "*x*" is the speed that mostly occurs under the recurrent service condition. In each scenario (basing on the speed profile the mean speed is been chosen).

$$RCI = \frac{V_{t,x}^{scenario}}{V_{x}^{free\,flow}} \qquad \text{(Eq. 6.2)}$$

Functions "GenerateSceanario_Aggregation" and "SceanariobasedClean" have been created in order to generate the different scenarios to treat them. Month, day of week, time of day, direction and weather conditions are the variables to define each scenario. Please see enclosed Annex A to check the whole list of functions.

```
function Result = GenerateSceanario_Aggregation
(Data,moy,dow,dir,tod,rain)

function output = sceanariobasedClean(Data,timecomponent)
```

Figure 6.12: Scenario generation function headers.

This variable is an index which approaches the traffic conditions for different scenarios created to fit the scope of the research. Scenarios with less than 30-trip observations was rejected as its robustness was not enough.

6.9. Data format definition

Once it was defined all the previous assumptions; the vast amount of transactional data was moved into a large database, for a later processing. Hereby, a data format was determined and enriched with meteorological data.

Both, bus route 555 and 60, were studied separately with two different data files. Afterwards, they were blended altogether in order to study them.

Data format created is:

Date	**Format: YearMonthDay. e.g. 20121101.**
Month	Month of the year. Numbering: 1 to 12.
Week	Day of the week. Numbering: 1 to 7.
Bus direction	Inbound or outbound.
Scheduled route starting	Format: HourMinuteSecond. e.g. 530000.
Segment	Segment between two consecutive stops. e.g. 1_2.
Scheduled bus stop departure	Expected time of departure from the bus stop. Format: HourMinuteSecond. e.g. 530000.
Actual arrival at the bus stop	Expected time of arrival at the bus stop.
Adherence	Actual bus stop arrival minus scheduled bus stop departure. Format: Seconds.
Scheduled travel time	Expected duration in seconds of the segment. Including the time stopped at the bus stop.
Actual travel time	Actual duration in seconds of the segment. Including the time stopped at the bus stop.

Actual running time	Actual duration in seconds of the run. The stop delay is not included
Stop delay	Time the bus is stopped at the stop, including the time it uses to approach and depart from the stop.
Stop dwell	Time passengers boarding and alighting.
Boarding passengers	Number of passengers boarding.
Alighting passengers	Number of passengers alighting.
On board passengers	Number of people in the bus during the run.
Route type	Type of road. Format: Motorway, busway, arterial, suburban, local or district.
Length	Kilometres between two consecutive stops.
Lane	Number of the same direction lanes of the road.
Speed limit	The post speed limit of the road link.
Signals	Number of signalized intersections.
Roundabouts	Number of roundabouts.
Other interceptions	Other type of traffic signs.
Station number	Number of bus platforms.
Rain	Precipitation (mm/h) recorded along the segment.

Table 6.6: Data format created for the database of this project.

7. Travel time, running time and stop delay

A preliminary view of the results was more meaningful once all the premises, assumptions and pre-testing were completed.

The main aim of the study was to quantify the determinants of bus travel time at the micro link level, including weather conditions as an independent variable. Three general models with respect to dependent variables were developed, namely, travel time (TT), running time (RT) and stop delay (SD). Travel time was defined as the addition of running time and stop delay, thus a comparison between could be completed and a final model was released.

Optimizing travel time is challenging for transit agencies because changes in travel time have large and usually conflicting influences on service reliability and total operating costs. The general guideline for establishing optimal travel times is to set travel time between two stop equal to the average observed travel time [4].

7.1. Operational, external and planning variables

The next table describes each of the dependent and independent variables used in the models developed here. During the in-depth analysis many variables were tested, some were excluded from the analysis during the very first steps of it, others were tested as different types of variables or classifications.

Rain was studied as a continuous variable (mm/h) and as categorical variable. Finally, it was represented as an indicator variable due to the ease of working with it and it was still as powerful as working as a continuous variable.

A simple three-factor definition was used to define weather conditions, based on past studies reviewed in section 4.1 [12]:

Very light rain or no rain: Precipitation rate < 0.4 mm/h

Light rain: Precipitation rate is between 0.4 mm/h and 4.0 mm/h

Heavy rain: Precipitation rate > 4.0 mm/h

VARIABLE	DESCRIPTION	MODEL		
	DEPENDENT VARIABLES	TT	RT	SD
TRAVEL TIME (TT)	Travel time between two stops, running time plus stop delay (second).	X		
RUNNING TIME (RT)	Operation time between two stops, time on the stop not included (second).		X	
STOP DELAY (SD)	Time that the bus is stopped at any stop (second).			X
	INDEPENDENT VARIABLES			
OPERATIONAL VARIABLES				
NUMBER OF BOARDINGS	Number of passengers boarding the bus at any stop.	X		X
BOARDINGS SQUARED	Number of passengers boarding the bus at any stop squared.	X		X
NUMBER OF ALIGHTINGS	Number of passengers alighting from the bus at any stop.	X		X
ALIGHTINGS SQUARED	Number of passengers alighting from the bus at any stop squared.	X		X
NUMBER OF PASSENGERS	Number of passengers on board.	X	X	X
DELAY AT FIRST STOP	Delay relative to schedule at the first stop (second) of the segment.	X	X	X
ACTUAL STOPS	The number of actual stops along the segment.	X	X	X
EXTERNAL VARIABLES				
LENGTH	Length of the segment (km).	X	X	X
SIGNALS	Number of traffic signs at any intersection along the segment.	X	X	
SIGNALS SQUARED	Number of traffic signs at any intersection along the segment squared.	X	X	
ROUNDABOUTS	Number of roundabouts and other intersections along the segment.	X	X	
OTHER INTERSECTIONS	Number of other type of intersections along the segment.	X	X	
SPEED LIMIT	Maximum speed allowed along two consecutive stops (km/h).	X	X	
NUMBER OF LANES	Number of lanes of the road link along the segment.	X	X	X
RECURRENT CONGESTION INDEX	Traffic congestion index per scenario depending on time of day, week of day…	X	X	X

MOTORWAY	Dummy variable equals one just if the bus operates along a motorway road.	X	X	X
BUSWAY	Dummy variable equals one just if the bus operates along a busway road.	X	X	X
ARTERIAL	Dummy variable equals one just if the bus operates along an arterial road.	X	X	X
CBD	Dummy variable equals one just if the bus operates in CBD area.	X	X	X
LIGHT RAIN	Dummy variable equals one if the rainfall is between 0.3 mm/h and 4.0 mm/h.	X	X	X
HEAVY RAIN	Dummy variable equals one if the rainfall is greater than 4.0 mm/h.	X	X	X
RAIN	Rainfall (mm/h).	X	X	X
PLANNING VARIABLES				
1ST TERM	Dummy variable equals one from Nov 1st to Dec 12th.	X	X	X
2ND TERM	Dummy variable equals one from Dec 13th to Jan 26th.	X	X	X
3RD TERM	Dummy variable equals one from Jan 27th to Apr 30th.	X	X	X
SATURDAY	Dummy variable equals one if it is Saturday.	X	X	X
SUNDAY	Dummy variable equals one if it is Sunday.	X	X	X
EARLY MORNING (EM)	Dummy variable equals one from 05:30 to 07:00.	X	X	X
MORNING PEAK (AM)	Dummy variable equals one from 07:01 to 09:00.	X	X	X
MID-DAY (MD)	Dummy variable equals one from 09:01 to 13:30.	X	X	X
AFTERNOON PEAK (PM)	Dummy variable equals one from 13:31 to 18:00.	X	X	X
LATE EVENING (LE)	Dummy variable equals one from 18:01 to 23:59.	X	X	X
AM PEAK	Dummy variable equals one if the bus started during the morning peak.	X	X	X
PM PEAK	Dummy variable equals one if the bus started during the afternoon peak.	X	X	X
INBOUND	Dummy variable equals one if the bus operates inbound to CBD.	X	X	X
OUTBOUND	Dummy variable equals one if the bus operates outbound across CBD.	X	X	X

Table 7.1: Description of variables and models.

7.2. Preliminary data programming

This stage was one of the most laborious of the project. Data treatment was necessary to proceed to statistical analysis and creation of final OLS models. An extensive programming exercise was implemented. Matlab software was necessary to complete different functions able to read, treat and modify the data already gathered and clustered altogether.

Main function ("*main.m*") was created, all other subfunctions were pointed there. More than fifteen functions were designed following statistical analysis requirements.

Scenario generation and RCI variable creation were the two most laborious functions programmed. As shown in section *Annex A.2*, *"GenerateScenario_aggregation"* and "*Vmode"* split all the dataset in different groups depending their features.

Most important Matlab functions are included in section *Annex A*. Testing plan and preliminary functions are not included due to their lack of importance for the scope of this research.

8. OLS models, results and analysis

The independent variables shown in table 7.1 were examined and pre-tested using statistical analysis. Some variables were excluded from further analysis because they were either insignificant (p> 0.05) or collinear with other variables (VIF>5). In particular, the effect of incorporating time and direction dummy variables on model's explanation power was tested using a hierarchical multiple regression, including inbound, outbound, weekday, AM peak and PM peak. These dummy variables were found to have negligible effects (effect size <0.007) on improving models' explanatory power since the proposed RCI had already captured the within-day variation of traffic conditions.

Preliminary models are included in section *Annex B*; different regression analysis were conducted with Minitab software. Stepwise regressions and Best Subsets regressions were implemented with all the independent variables. Some variables were excluded by the software, due to they were insignificant or they had hard collinearity with other variables; or due to a negligible effect on the models.

The general models were developed using the general dataset considering all road types and the alternative models were developed using road type specified dataset.

To choose appropriate regression models for TT, RT and SD equations, ordinary least squares (OLS) models were developed separately using the general dataset.

Descriptive statistic of definitive dependent and independent variables after significance and collinearity analysis:

Variable	Type of variable	Min	Max	Average
Dependent variables				
Travel time (TT)	Continuous	44.2	692.3	165.96
Running time (RT)	Continuous	41	652.1	139.99
Stop delay (SD)	Continuous	0	219	25.97
Independent variables				
Number of boardings	Continuous	0	22	1.78
*Boardings squared**	Continuous	0	484	9.02
Number of alightings	Continuous	0	23	1.9
*Alightings squared**	Continuous	0	529	10.89
Delay at first stop	Continuous	-394	1115.7	58.14
Actual stops	Continuous	0	2	0.66
Length	Continuous	0.38	8.53	1.69
Signals	Continuous	0	8	1.18
Recurrent congestion index	Continuous	9.88	96.57	64.33
*Motorway vs other roads**	Dummy	0	1	0.10
*Busway vs other roads**	Dummy	0	1	0.49
*Arterial vs other roads**	Dummy	0	1	0.09
*CBD vs non-CBD area**	Dummy	0	1	0.18
*Light rain vs good weather***	Dummy	0	1	0.14
*Heavy rain versus good weather***	Dummy	0	1	0.21

Table 8.1: Description of dependent and independent variables.

*Notes: * Other roads = road types including local, district and suburban roads. ** Good weather = no precipitation or very light rain.*

8.1. General models

Table 8.2 shows the OLS models for travel, running time and stop delay using the general dataset. Overall, they can explain 82%, 80% and 56% of the variations in travel time, running time and stop delay observations, respectively. The values shown in bold highlight the top three important factors impacting travel time, running time and stop delay.

PREDICTORS	***TRAVEL TIME***	***RUNNING TIME***	***STOP DELAY***
	Coef (*S Coef)	Coef (*S Coef)	Coef (*S Coef)
CONSTANT	184.362	165.953	25.231
NUMBER OF BOARDINGS	2.677 (0.084)	NA	**3.329 (0.930)**
BOARDINGS SQUARED	-	NA	-0.054 (-0.007)
NUMBER OF ALIGHTINGS	1.808 (0.076)	NA	1.246 (0.106)
ALIGHTINGS SQUARED	-0.022 (-0.024)	NA	-0.022 (-0.006)
DELAY AT FIRST STOP	-0.013 (-0.017)	-0.002 (-0.011)	-0.010 (-0.009)
ACTUAL STOPS	18.621 (0.031)	3.332 (0.059)	**15.704 (1.050)**
LENGTH	**71.497 (0.906)**	**65.339 (1.002)**	7.392 (0.080)
SIGNALS	**18.100 (0.502)**	**15.392 (0.141)**	NA
RECURRENT CONGESTION INDEX	**-1.947 (-0.480)**	**-1.299 (-0.525)**	**-0.442 (-0.215)**
MOTORWAY	-75.900 (-0.170)	-66.190 (-0.180)	-13.995 (-0.040)
BUSWAY	-34.017 (-0.123)	-34.388 (-0.090)	-1.013 (-0.076)
ARTERIAL	-98.823 (-0.241)	-88.560 (-0.205)	-4.379 (-0.183)
CBD	-46.808 (-0.191)	-31.753 (-0.136)	4.320 (0.154)
LIGHT RAIN	0.030 (0.006)**	0.069 (0.009)**	-
HEAVY RAIN	2.877 (0.074)	2.333 (0.080)	0.779 (0.116)
NUMBER OF CASES		182629	
ADJUSTED R^2	0.8218	0.8017	0.5602

Table 8.2: OLS models chosen with Coefs and SCoefs for each variable.

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Notes:

** S Coef or standardized coefficient measures the effect of the predictor on the model.*

*** p-value ≈0.05. Other predictors with p-values< 0.01. NA = Not applicable information. Symbol "-" = insignificant variable (p>0.05).*

Consistent with previous studies [1; 14], travel time increases with an increase in route length, number of signals, number of boardings, number of alightings, and number of actual stops. Route length has the largest positive effect. Delay at first stop has negative effect on travel time, which means bus drivers who have late departures have less travel times compared to those who depart on time or early. This could be explained by the fact that bus drivers aim to match a predefined timetables. As expected, travel time is adversely impacted by the RCI which means it takes less time to travel when traffic is less congested.

Compared to good weather, heavy rain will increase travel time. This can be attributed to a decrease in driving speed and increase in the gaps between vehicles for safety. Not very significant difference in travel time was found between light rain and good weather.

The coefficient of boarding (2.7 seconds) is relatively higher than alighting time (1.8 seconds), since passengers can only use the front door when boarding; while they can use both the front and back doors when alighting. The squared term for alighting indicates that the time associated with passenger alighting decreases with each additional passenger. It means that the first passenger takes and average of 1.8 seconds to alight, and the second passenger will take less time since they have already gotten their smart card and belongings ready. The test result by including the variable of boardings square showed that the boarding time associated with each additional passenger could also increase, since the subsequent passengers may need more time to find a seat when the bus is crowded; nevertheless the variable is insignificant ($p>0.05$). The response softens per extra passenger.

Stop delay has a low R^2 due to an unknown variable which makes the model less powerful, for example, change of driver, early running and wheel chair boarding. Travel time and running time models can explain 82% and 80% of the variations in actual travel time and running time, respectively.

Following figure assesses that OLS assumptions are met for TT with normal plot of residual, 99% of data without outliers, residuals with a constant variance and residuals are uncorrelated.

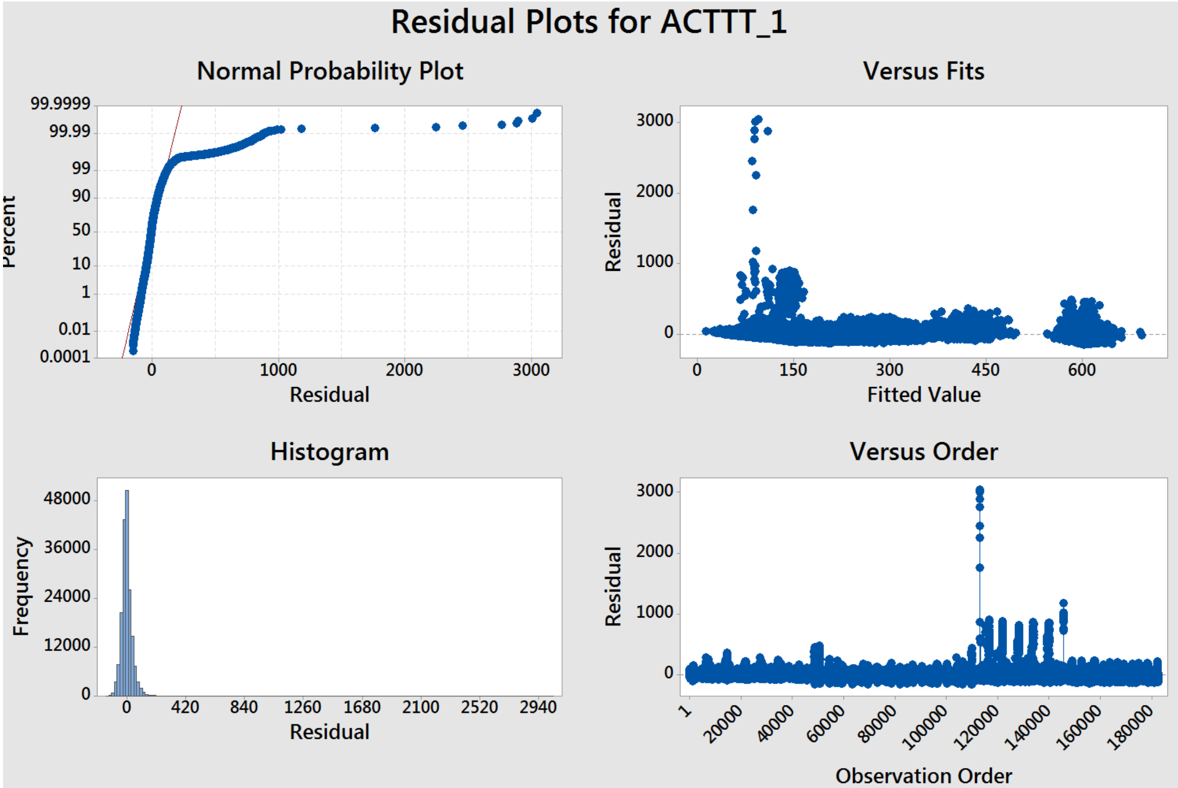

Figure 8.1: Alternative OLS models.

8.2. Alternative models

The service performance of bus operating on different type of roads can be compared directly in alternative models by excluding the influence of other covariant factors.

Next tables include these alternative models for travel time, running time and stop delay.

PREDICTORS	*ARTERIAL*	*MOTORWAY*	*BUSWAY*	*CBD*	*OTHERS*
	SE Coef (S Coef)	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*
CONSTANT	101.270	284.561	140.177	99.720	186.270
NUMBER OF BOARDINGS	0.400 (0.080)	**4.233 (0.102)**	**4.559 (0.255)**	4.674 (0.165)	1.400 (0.090)
BOARDINGS SQUARED*	-0.031 (-0.011)	-0.092 (-0.214)	-0.015 (-0.014)	-0.173 (-0.098)	-0.031 (-0.010)
NUMBER OF ALIGHTINGS	**5.741 (0.808)**	-5.714 (-0.106)	3.300 (0.199)	3.388 (0.174)	**5.741 (0.199)**
ALIGHTINGS SQUARED*	-0.031 (-0.007)	0.201 (0.009)	-0.129 (-0.036)	-0.105 (-0.008)	0.031 (0.011)
DELAY AT FIRST STOP	-0.068 (-0.095)	-0.008 (-0.010)	-0.001 (-0.022)	-0.046 (-0.090)	-0.017 (-0.100)
ACTUAL STOPS	22.031 (0.133)	56.39 (0.100)	16.881 (0.170)	**87.507 (0.601)**	-
LENGTH	**109.68 (0.440)**	**67.637 (0.504)**	**51.227 (0.828)**	**226.74 (1.077)**	**201.77 (0.444)**
SIGNALS	10.762 (0.431)	60.09 (0.152)	12.624 (0.031)	3.864 (0.080)	-
RECURRENT CONGESTION INDEX**	**-2.147 (-0.466)**	**-7.462 (-0. 331)**	**-1.773 (-0.511)**	**-2.681 (-0.311)**	**-2.946 (-0.677)**
LIGHT RAIN	0.069 (0.071)	-	-0.017 (-0.009)	4.525 (0.055)	-
HEAVY RAIN	2.360 (0.020)	0.024 (0.011)	0.011 (0.006)	7.551 (0.075)	-
ADJUSTED R^2	0.6570	0.8580	0.7900	0.7456	0.4567

Table 8.3: Alternative OLS models for travel time.

*Notes: * S Coef or standardized coefficient measures the effect of the predictor on the model. ** p-value ≈0.05. Other predictors with p-values< 0.01. NA = Not applicable information. Symbol "-" = insignificant variable (p>0.05).*

PREDICTORS	***ARTERIAL***	***MOTORWAY***	***BUSWAY***	***CBD***	***OTHERS***
	SE Coef (S Coef)	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*
CONSTANT	86.274	255.440	131.550	80.559	65.220
NUMBER OF BOARDINGS	NA	NA	NA	NA	NA
BOARDINGS SQUARED*	NA	NA	NA	NA	NA
NUMBER OF ALIGHTINGS	NA	NA	NA	NA	NA
ALIGHTINGS SQUARED*	NA	NA	NA	NA	NA
DELAY AT FIRST STOP	-0.009 (0.002)	-	-	-0.0436 (-0.005)	**-0.0068 (-0.002)**
ACTUAL STOPS	0.098 (0.018)	5.098 (0.027)	3.545 (0.055)	14.555 (0.020)	-
LENGTH	**99.001 (0.754)**	**55.111 (0.922)**	**40.227 (0.428)**	**227.11 (1.020)**	**200.00 (1.33)**
SIGNALS	7.898 (0.222)	**55.47 (0.101)**	**9.322 (0.088)**	**1.866 (0.100)**	-
RECURRENT CONGESTION INDEX**	**-1.899 (-0.188)**	**-6.111 (-0.433)**	**-1.566 (-0.458)**	**-1.800 (-0.210)**	**-3.9469 (-0.611)**
LIGHT RAIN	-	-0.255 (-0.008)	-0.067 (-0.080)	3.777 (0.070)	-
HEAVY RAIN	**1.99 (0.159)**	0.097 (0.055)	0.021 (0.018)	6.991 (0.065)	-
ADJUSTED R^2	0.5950	0.8470	0.7600	0.7400	0.2688

Table 8.4: Alternative OLS models for running time.

*Notes: * S Coef or standardized coefficient measures the effect of the predictor on the model. ** p-value ≈0.05. Other predictors with p-values< 0.01. NA = Not applicable information. Symbol "-" = insignificant variable (p>0.05).*

PREDICTORS	*ARTERIAL*	*MOTORWAY*	*BUSWAY*	*CBD*	*OTHERS*
	SE Coef (S Coef)	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*	*SE Coef (S Coef)*
CONSTANT	17.950	16.440	23.115	9.477	11.991
NUMBER OF BOARDINGS	**0.300 (0.871)**	**3.888 (1.010)**	**4.055 (0.867)**	**3.544 (0.777)**	**1.001 (0.110)**
BOARDINGS SQUARED*	-0.022 (-0.005)	-0.064 (-0.009)	-0.015 (-0.004)	-0.155 (-0.008)	-
NUMBER OF ALIGHTINGS	5.000 (0.111)	-4.777 (0.107)	2.819 (0.144)	3.388 (0.174)	**5.741 (0.239)**
ALIGHTINGS SQUARED*	-0.031 (-0.005)	0.101 (0.008)	-0.189 (-0.026)	-0.110 (-0.008)	0.022 (0.010)
DELAY AT FIRST STOP	-0.0061 (-0.005)	-0.005 (-0.010)	-0.001 (-0.005)	-0.032 (-0.005)	-0.009 (-0.009)
ACTUAL STOPS	**23.031 (0.633)**	**49.44 (0.511)**	**12.881 (0.972)**	**58.600 (0.710)**	-
LENGTH	3.980 (0.055)	6.444 (0.078)	7.814 (0.090)	2.77 (0.606)	1.678 (0.100)
SIGNALS	NA	NA	NA	NA	NA
RECURRENT CONGESTION INDEX**	-0.255 (0.249)	**-0.667 (-0.310)**	**-0.010 (-0.191)**	**-0.488 (-0.188)**	**-0.455 (-0.233)**
LIGHT RAIN	-	-	-	2.099 (0.010)	-
HEAVY RAIN	**0.554 (0.144)**	0.011 (0.099)	0.001 (0.187)	2.100 (0.159)	0.008 (0.005)
ADJUSTED R^2	0.3950	0.5110	0.4884	0.4600	0.1945

Table 8.5: Alternative OLS models for travel time for stop delay.

Notes:

** S Coef or standardized coefficient measures the effect of the predictor on the model.*

*** p-value ≈0.05. Other predictors with p-values< 0.01.*

NA = Not applicable information. Symbol "-" = insignificant variable (p>0.05).

Few interesting results are drawn from these tables; such as, busway could provide a faster and more reliable service than others, in terms of average travel time.

Buses travelling on busway experience less running time (40.227 seconds) than those travelling on other road types. Traffic congestion is supposed to be less important in busways. Stopping on CBD area means more wasting of time than other roads (87.5 seconds), as the high fluency of passengers.

Traffic lights are shorter in busway roads, therefore the signals influence is lower (12.62 seconds). Vehicles in the CBD area are less influenced by signal (3.8 seconds), possibly due to less cycle length and coordination of traffic signals.

CBD travels are more sensitive to rain (4.525 seconds for light rain and 7.551 seconds for heavy rain) than those travelling on other road types. The proposed RCIs are all negatively significant and greatly important in explaining the variations in travel time observations.

Boarding and alighting times will decrease with each additional passenger boarding and alighting, but some unexpected results. In busway, boardings have more importance than the number of actual stops, so it means that finding a strategy to speed up the boarding could be more efficient than find ways to decrease stop delays.

Stop delays in alternative models have also low R^2 due to an unknown variable which makes the model not that accurate, for example, change of driver, early running and wheel chair boarding. They are not as powerful as travel time and running time models; hence, travel time estimation as the sum of running time and stop delay is not recommended.

8.3. Study of sensibility

Past beliefs and many studies sustain that there are five main factors which impact to travel time: traffic congestion, weather conditions, route type, public demand and traffic accidents. Traffic accident and route type switching were discarded for the study of sensibility. Thus, three scenarios were created to understand the performance of public transport in case three external factors would switch in the future. Adverse weather, passengers demand and congestion were modified. The following charts show these sensibility tests.

	+10% rain	***+50% rain***
Travel time	0.0336%	0.1688%
Running time	0.0283%	0.1416%
Stop delay	0.0648%	0.3238%

	+10% demand	***+50% demand***
Travel time	0.4422%	2.2123%
Running time	0%	0%
Stop delay	2.9928%	14.9637%

	+10% congestion	***+50% congestion***
Travel time	6.9639%	34.8208%
Running time	4.7350%	23.6747%
Stop delay	11.2564%	56.2818%

Table 8.6: Sensibility analysis of the general models.

Based on this sensibility study, rainfall has low impact on the performance of public buses travel times, running times and stop delays. Nevertheless, these results have to be validated with a further statistical analysis and other input data; since there are too many factors which may perform completely different with an increment of precipitation. For example, public buses demand would probably descend significantly; traffic flow would be different as well.

An hypothetical increment of demand impacts significantly to stop delays; nonetheless, the travel time. Boarding and alightings fit quadratic equations which influence negatively with every extra passenger boarding or alighting. Travel time is not affected since drivers would drive faster in order to match predefined timetables.

An increment of traffic congestion would have significant influence on the models. Recurrent congestion index standardized coefficients are great in all the cases. Stop delay is also affected as time to slow down and accelerate the bus will be lower.

8.3.1. Study of sensibility per type of road

Travel time:

	Arterial	***Motorway***	***Busway***	***CBD***	***Others***
+10% rain	-0.1248%	0.0021%	0%	0.0577%	0%
+50% rain	-0.0147%	0.0103%	0%	0.2887%	0%
+10% demand	0.4470%	-0.7999%	0.3966%	0.3136%	0.3842%
+50% demand	2.8443%	-3.9996%	1.9831%	1.5680%	1.9202%
+10% congestion	7.3709%	95.6291%	-1.7999%	4.4872%	5.4082%
+50% congestion	37.4639%	117.1457%	-8.9995%	22.4362%	27.0412%

Table 8.7: Sensibility of travel time differentiated per type of road.

Running time:

	Arterial	***Motorway***	***Busway***	***CBD***	***Others***
+10% rain	0.0297%	-0.0022%	0%	0.0554%	0%
+50% rain	0.1485%	-0.0275%	-0.0021%	0.2774%	0%
+10% demand	0%	0%	0%	0%	0%
+50% demand	0%	0%	0%	0%	0%
+10% congestion	8.6824%	82.0494%	8.9845%	3.2178%	17.0496%
+50% congestion	43.4119%	110.2306%	44.9224%	16.0892%	85.2481%

Table 8.8: Sensibility of running time differentiated per type of road.

Stop delay:

	Arterial	***Motorway***	***Busway***	***CBD***	***Others***
+10% rain	0.0356%	0.0015%	0%	0.2412%	0%
+50% rain	0.1777%	0.0076%	0%	3.3315%	0%
+10% demand	2.9017%	-1.079%	1.9046%	3.3315%	25.7280%
+50% demand	14.5086%	-1.0793%	9.5232%	16.6576%	31.7568%
+10% congestion	5.0116%	28.3574%	0.1180%	10.3046%	-10.8635%
+50% congestion	25.0582%	111.7868%	0.5902%	51.5229%	119.9430%

Table 8.9: Sensibility of stop delay differentiated per type of road.

Congestion has the most impact on Motorway and CBD, in regard to travel time. It is understandable as any traffic jam is critical in a Motorway.

Non important decisions have to be done by transport agencies with increments on adverse weather or demand. Nevertheless, an increment of congestion has significative impacts on travel time reliability.

9. Economic analysis

Costs of this research have been estimated as a first stage; transport agency will bear these costs and those belonging to a future implementation of the research in order to optimise the public transport network. A second stage of this research would be the implementation of recommendations issued by the consultants.

9.1. Human and material resources

This research was taken over by two consultant engineers and one PFC student. The next table shows an estimation of human resources utilized.

	TOTAL AMOUNT OF HOURS (H)	UNITARY COST (EUR/H)*	COST (EUR)
HEAD ENGINEER- SENIOR CONSULTANT	40	78.00	3,120.00
PHD ENGINEER- JUNIOR CONSULTANT	80	55.00	4,400.00
PFC STUDENT	450	25.00	11,250.00
			18,770.00€

Table 9.1: Human resources costs

**An estimation of cost were calculated based on standard consultant fee rates. Costs were estimated in Australian Dollars (AUD) and converted to Euro (EUR) using a mean exchange rate for 2013.*

Amount of hours are estimated as a weekly meeting between a junior consultant and PFC student during the 20 weeks of the project. The whole teamwork meeting was conducted every two weeks. Holidays and day-off are not included.

This section also includes the office equipment used to conduct the project. Software's licenses for, Matlab, Microsoft Office, Minitab and MySQL. Besides, it has been into account the amortization of these licenses and the computer used.

Regarding to the amortization of the computer, it is supposed a cost of 3,000€ and a lineal amortization of 5 years. It is also supposed that in this computer 2 projects are executed every year.

Similarly, regarding to the amortization of the licenses: it is estimated a price of 3,000€ for Matlab, a price of 5,500€ for Minitab, Microsoft Office Proffesional for 350€ and 4,000€ for MySQL. Four years lineal amortization for all the licenses was supposed, two projects per year are executed in the PC requiring Office and only one project per year require the other programs. Eight in a row computers were using Matlab, MySQL and Minitab licenses. Hence, the cost of material resources are shown in Table 9.2.

MATERIAL RESOURCES	**COST (EUR)**
COMPUTER	300.00
MATLAB LICENSE	93.75
MICROSOFT OFFICE LICENSE	43.75
MINITAB LICENSE	171.88
MYSQL LICENSE	125.00
PAPERWORK	100.00
	834.38€

Table 9.2: Material resources costs

Total costs of the project are shown in the next table.

Human and material costs	**EUR 19,604.30**
15% overhead	EUR 2,940.65
Subtotal before VAT	EUR 22,544.95
10% VAT	EUR 2,254.50
TOTAL	**EUR 24,799.45**

Table 9.3: Total costs of the research.

10. Environmental impact

The target of this project is aimed to optimise the public transport network performance for both parties, the transport agency and the passengers. All the benefits are targeted on schedule optimisations. Therefore, no important environmental impacts are modified.

Nevertheless, suggested action plan to the transport agency includes buses reinforcements or weakening of the sources depending on certain modifiers. Environmental impacts are mainly divided in atmospheric pollution, acoustic pollution and smell generation.

10.1. Significant traffic congestion worsening scenario

As a hypothetical scenario with an increment of traffic congestion during a week; transport agency would include extra buses per route, based in this studio.

Official buses timetables were taken from the official Translink website [13]; buses drivers have 10min break per trip. Routes 555 and 60 have a total of 28.3km and 8.7km per trip, respectively. 40 min and 24min are the average inbound travel times. Stop delay increment of +11.257% and a +4.735% running time increment have been supposed with regard to scheduled times.

In terms of environmental impact means a clear negative impact as modifications are purely focused on backup buses in order to fit schedules. Down below, some numbers of emissions from each extra bus per trip (inbound or outbound).

Emissions shown on *table 10.1* were taken from the official Translink website [13]. Standard bus model were chosen (M.A.N A69 18.310 powered by 12.81 L Turbocharged 6 cylinder CNG EEV).

Pollutant	*Urban diesel buses emissions while being driven (g/km)*	*Urban diesel buses average idle emissions (g/hour)*
VOC	0.217	2.700
THC	0.219	2.735
CO	2.098	37.430
NOx	9.194	61.113
$PM_{2.5}$	0.046	1.069
PM_{10}	0.185	1.161

Table 10.1: Average emissions by Translink public buses.

Next tables show the environmental impact in terms of pollutants.

Bus route 555	*VOC*	*THC*	*CO*	*NOx*	*$PM_{2.5}$*	*PM_{10}*
Running time emissions	6.141	6.198	59.373	260.190	1.032	5.236
Idle emissions	0.026	0,026	0,254	1,112	0,006	0,022
Total	6.167	6.224	59.627	261.302	1.038	5.258

Table 10.2: Emissions by a bus in a trip; bus route 555

Bus route 60	*VOC*	*THC*	*CO*	*NOx*	*$PM_{2.5}$*	*PM_{10}*
Running time emissions	1.888	1.905	18.253	79.988	0.400	1.610
Idle emissions	0.012	0.012	0.119	0.520	0.003	0.010
Total	1.900	1.917	18.372	80.508	0.403	1.620

Table 10.3: Emissions by a bus in a trip; bus route 60

*Notes: *Each bus is able to travel 11-12 trips per day as average.*

11. Conclusions and recommendations

The concern with making effective strategies to improve service reliability brings about the need to quantify causes of unreliability in public transit. This research aims to draw one of the most important factors that influence the service attributes concerned by passengers and operators, based on which effective and efficient strategies could be made to fit scheduled travel times of public transport.

Optimizing travel time is challenging for transit agencies because changes in travel time have large and usually conflicting influence on service reliability and total operating costs. The general optimal travel times is to set travel time equal to the average observed travel time.

A comprehensive set of reliability causes associated with planning, operational and environmental categories, has been estimated and tested using six months data on two bus routes in Brisbane. A recurrent congestion index was developed here to reflect within-day variation of traffic conditions using historical travel time observations. The statistical tests suggest that the congestion index is highly significant in reliability models. Heavy rain was found to be significant for travel time predictions.

Blending travel time models found, together with weather and traffic forecasts can estimate the number of support buses needed (per route). These adjustments may be done weekly, or even daily, in order to match timetables. On the other hand, transport agency may decide to update on-line timetables regularly (for example, some on-line gadgets capable to predict travel time in a trip with some transfers); depending on the development of different modifiers; such as, traffic or weather conditions.

OLS models found are a powerful tool to forecast buses travel times in order to comply with timetables. Official public transport timetables are not modified regularly as modifying them will not be effective and viable.

Real-time updating bus arrival data at any stop is a strong application which probably will improve the reliability of electronic display at any stop. Running time models will approach the reality to displays’ indications; AVL source data is also needed for this application. The viability of this application needs an in-depth study.

Based on general and alternative models of this study, travel agencies may want to improve some strategies or others. For example, in busway travel time model, the impact of the number of actual stops is less important than the number of boarding. It implies that making strategies to speed the boarding could be more efficient than finding ways to decrease stop delays. However, this practical implication may influence on service reliability and operating costs.

Findings of this paper offer a new perspective to model trave time reliability in public transit; other groups of reliability measures (e.g. on-time performance and regularity headway) could be modelled using the approach proposed here. Future research may focus on aggregating the link level reliability into segment, route and network levels.

12. Acknowledgement

The author would like to acknowledge Professor Luis Ferreira for his support on all the implementation and development of this project. Moreover, he was the person who achieved my approval in the University of Queensland research program.

The author would like to thank Zhenliang Ma for his endless patience during all the stages of the project; including his boosts during difficult phases of the research. Otherwise, his knowledge in advanced programming and data treatment were more than useful.

The author would like to thank Laia Ferrer for her support during the time in Australia and later in Barcelona. Her global point of view regarding the research and her promptness responses at any time have been key determinant in the project.

The author would like to acknowledge the University of Queensland, the TransLink Division of Queensland and Bureau of Meteorology for their help in providing sources and tools to create this paper.

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APPENDIXES

A. Matlab functions and headers

GenerateSceanario_Aggregation.m:

```
function Result = GenerateSceanario_Aggregation
(Data,moy,dow,dir,tod,rain)

global colMOY;
global colDOW;
global colDIR;
global colTOD;
global colRAIN;
% global colSEG;

% if ~isempty(seg)
%     SEG = Data(:,colSEG);
%     index_seg = strcmp(seg,SEG);
%     Data = Data(index_seg,:);
% end

if ~isempty(moy)
    DATE = cell2mat(Data(:,colMOY));
    index_moy = DATE >= moy(1)  & DATE < moy(2);
    Data = Data(index_moy,:);
end

if ~isempty(dow)
    WI = cell2mat(Data(:,colDOW));
    if strcmp(dow,'WD')
        index_dow = WI > 1 & WI < 7;
        Data = Data(index_dow,:);
    elseif strcmp(dow,'WE')
        index_dow = WI == 1 | WI == 7;
        Data = Data(index_dow,:);
    elseif isnumeric(dow)
        index_dow = WI == dow;
        Data = Data(index_dow,:);
    end
end

if ~isempty(dir)
    DIR = cell2mat(Data(:,colDIR));
    index_dir = DIR == dir;
    Data = Data(index_dir,:);
end

if ~isempty(tod)
    timelist = cell2mat(Data(:,colTOD));
    time_low = tod(1);
    time_up = tod(2);
    index = timelist>=time_low & timelist<time_up;
    Data = Data(index,:);
end

if ~isempty(rain)
```

```
    RAIN = cell2mat(Data(:,colRAIN));
    index_rain = RAIN >= rain(1) & RAIN < rain(2);
    Data = Data(index_rain,:);
end
Result = Data;
```

Vmode.m:

```
function vmode
[~,~,SourceData1] = xlsread('SourceData4Model_555_link.xlsx');
[~,~,SourceData2] = xlsread('Stat_555.xlsx');

i = 2;
j = 2;

for j = 2: 5265
    for i = 2:202839
            if SourceData1(i,1) <= 20121212 &&
strcmp(SourceData2(j,3),'20121101_20121212')
               if SourceData1(i,3) = SourceData2(j,4)
                  if SourceData1(i,4) = SourceData2(j,2)
                     if SourceData1(i,5) <= 70000 &&
strcmp(SourceData2(j,5),'53000_70000')
                        if strcmp(SourceData1(i,6),SourceData2(j,1))
                           if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           elseif SourceData1(i,31) > 0.2 &&&&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           else
                               continue
                           end
                        else
                            continue;
                        end
                      elseif SourceData1(i,5) > 70000 && SourceData1(i,5)
<= 90000 && strcmp(SourceData2(j,5),'70000_90000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                    continue
                                end
```

```
                           else
                                continue;
                           end
                      elseif SourceData1(i,5) > 90000 && SourceData1(i,5)
<= 160000 && strcmp(SourceData2(j,5),'90000_160000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                               if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               else
                                   continue
                               end
                           else
                               continue;
                           end
                      elseif SourceData1(i,5) > 160000 && SourceData1(i,5)
<= 190000 && strcmp(SourceData2(j,5),'160000_190000')
                             if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                   continue
                                end
                             else
                                 continue;
                              end
                      elseif SourceData1(i,5) > 190000 &&
strcmp(SourceData2(j,5),'190000_235959')
                             if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                    continue
```

```
                                end
                            else
                               continue;
                            end
                      end
                 else
                     continue;
                 end
            else
                 continue;
            end
            elseif SourceData1(i,1) > 20121212 && SourceData1(i,1) <=
20130126 && strcmp(SourceData2(j,3),'20121213_20130126')
                 if SourceData1(i,3) = SourceData2(j,4)
                  if SourceData1(i,4) = SourceData2(j,2)
                     if SourceData1(i,5) <= 70000 &&
strcmp(SourceData2(j,5),'53000_70000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                              if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                       vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                       vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                       vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              else
                                  continue
                              end
                           else
                               continue;
                           end
                      elseif SourceData1(i,5) > 70000 && SourceData1(i,5)
<= 90000 && strcmp(SourceData2(j,5),'70000_90000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                    continue
                                end
                           else
                                continue;
                           end
                      elseif SourceData1(i,5) > 90000 && SourceData1(i,5)
<= 160000 && strcmp(SourceData2(j,5),'90000_160000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                               if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
```

```
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                              else
                                  continue
                              end
                          else
                              continue;
                          end
                     elseif SourceData1(i,5) > 160000 && SourceData1(i,5)
<= 190000 && strcmp(SourceData2(j,5),'160000_190000')
                            if strcmp(SourceData1(i,6),SourceData2(j,1))
                               if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               else
                                  continue
                               end
                            else
                                continue;
                             end
                     elseif SourceData1(i,5) > 190000 &&
strcmp(SourceData2(j,5),'190000_235959')
                            if strcmp(SourceData1(i,6),SourceData2(j,1))
                               if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                   vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               else
                                   continue
                               end
                           else
                              continue;
                           end
                     end
                else
                    continue;
                end
```

```
            else
                 continue;
            end
            elseif SourceData1(i,1)> 20130126 &&
strcmp(SourceData2(j,3),'20130127_20130430')
                 if SourceData1(i,3) = SourceData2(j,4)
                  if SourceData1(i,4) = SourceData2(j,2)
                     if SourceData1(i,5) <= 70000 &&
strcmp(SourceData2(j,5),'53000_70000')
                        if strcmp(SourceData1(i,6),SourceData2(j,1))
                           if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                           else
                               continue
                           end
                        else
                            continue;
                        end
                      elseif SourceData1(i,5) > 70000 && SourceData1(i,5)
<= 90000 && strcmp(SourceData2(j,5),'70000_90000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                    continue
                                end
                           else
                                continue;
                           end
                      elseif SourceData1(i,5) > 90000 && SourceData1(i,5)
<= 160000 && strcmp(SourceData2(j,5),'90000_160000')
                           if strcmp(SourceData1(i,6),SourceData2(j,1))
                               if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
```

```
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                               else
                                   continue
                               end
                           else
                               continue;
                           end
                      elseif SourceData1(i,5) > 160000 && SourceData1(i,5)
<= 190000 && strcmp(SourceData2(j,5),'160000_190000')
                             if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                   continue
                                end
                             else
                                 continue;
                              end
                      elseif SourceData1(i,5) > 190000 &&
strcmp(SourceData2(j,5),'190000_235959')
                             if strcmp(SourceData1(i,6),SourceData2(j,1))
                                if SourceData1(i,31) <= 0.2 &&
strcmp(SourceData2(j,6),'0_0.2')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 0.2 &&
SourceData1(i,31) <= 4 && strcmp(SourceData2(j,6),'0.2_4')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                elseif SourceData1(i,31) > 4 &&
strcmp(SourceData2(j,6),'4_10000000')
                                    vmode =
SourceData1(i,22)/(SourceData2(j,7)/3600;
                                else
                                    continue
                                end
                            else
                               continue;
                            end
                      end
                 else
                     continue;
                 end
            else
                 continue;
            end
            else
                continue;
            end
    end
```

Main.m:

```
%% For statistical analysis
defineglobalvar();

disp('Reading source file...')
tic;
filename = 'SourceData4Model_555_link.xlsx';
[~,~,SourceData] = xlsread(filename);
Data = SourceData(2:end,:);
toc;

disp('Calculating statistics for running time...')
tic;
Stat_555 = calStat4RT_all(Data);
toc

disp('Writing the statistical results to Excel...')
xlswrite('Stat_555.xlsx',Stat_555);
disp('All finished!')


%% For data cleanning
defineglobalvar();

disp('Reading source file...')
tic;
filename = 'SourceData4Model_555_link.xlsx';
[~,~,SourceData] = xlsread(filename);
Data = SourceData(2:end,:);
toc;

cldoutput = sceanariobasedClean(Data,'RT');
cldoutput = sceanariobasedClean(cldoutput,'TT');
xlswrite('cld555.xlsx',SourceData(1,:),'sheet1','A1');
xlswrite('cld555.xlsx',cldoutput,'sheet1','A2');
```

ATT555.m:

```
M = [605.95 636.00; 423.45 439.10; 152.68 149.63; 173.18 175.90; 119.74
121.85; 144.07 140.39; 103.29 101.67];
N = [2382.67 2380.15; 2456.59 2374.23];
O = [2306.024 2348.283 2287.52; 2334.21 2436.30 2416.18];
Q = [2 2; 4 4; 5 5; 126.60 128.43; 103.88 105.53; 128.05 127.39; 90.90
91.78];
figure
subplot(2,2,1);
bar(M,0.4)
title('TTAverage Route555 Nov12 Inbound OffPeak')
xlabel('Segments')
ylabel('Travel Time (s)')
legend('No rain','Heavy rain')
subplot(2,2,2);
bar(N,0.4)
title('TTAverage Route555 Trip Nov12 Inbound')
xlabel('1:Offpeak 2:Peak')
ylabel('Travel Time (s)')
legend('No rain','Heavy rain')
subplot(2,2,3);
bar(O,0.4)
title('TTAverage Route555 Trip Dec-Jan Inbound')
xlabel('1:Offpeak 2:Peak')
ylabel('Travel Time (s)')
legend('No rain','Moderate Rain','Heavy rain')
subplot(2,2,4);
bar(Q,0.4)
title('RTAverage Route555 Trip Dec-Jan Inbound')
xlabel('Segments')
ylabel('Travel Time (s)')
legend('No rain','Heavy rain')
filename = 'Dataset555NovOffPeakSeg.xlsx';
range1 = 'L2:L773';
range2 = 'K2:K773';
range3 = 'L2:L154';
ACTTTN7= xlsread(filename, 'NRL7', range1);
SCHTT7= xlsread(filename, 'NRL7', range2);
ACTTTH7= xlsread(filename, 'HRL7', range3);
figure
plot(ACTTTN7)
hold on
plot(SCHTT7,'--r')
hold on
plot(ACTTTH7,'g')
title('RTAverage Route555 Nov12 Inbound OffPeak Seg1')
xlabel('Runs')
ylabel('Travel Time (s)')
legend('No rain','SchedTT','Heavy rain' )
hold off
```

Other headers:

ATT555.m; ATT60.m; AverageMaxMinT.m; calStat4RT_all.m; MADfilter.m; cleandata.m; ClusterOnAttri.m; Defineglovar.m; Rainfall.m; Temperature.m; WindSpeed.m…

B. Preliminary statistical regression models

TT with Rain as dummy var (non- standardized coefs.)

Regression Analysis: ACTTT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, BOARDING_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	14	2045836526	146131180	60146.66	0.000
LENGTH_1	1	291477980	291477980	119970.47	0.000
ADHERENCE_seg1_1	1	1414913	1414913	582.37	0.000
ACTSTOP_1	1	8959002	8959002	3687.47	0.000
BOARDING_1	1	9086312	9086312	3739.87	0.000
ALIGHTING_1	1	1354944	1354944	557.69	0.000
Alig Sq_1	1	93509	93509	38.49	0.000
RCI_1	1	20244352	20244352	8332.45	0.000
SIGNAL_1	1	34471349	34471349	14188.19	0.000
CBD_1	1	1098212	1098212	452.02	0.000
Arterial_1	1	14112857	14112857	5808.76	0.000
Busway_1	1	39539990	39539990	16274.41	0.000
Motorway_1	1	10248326	10248326	4218.15	0.000
Light Rain_1	1	134961	134961	55.55	0.000
Heavy Rain_1	1	83843	83843	34.51	0.000
Error	182614	443675531	2430		
Lack-of-Fit	167054	433659139	2596	4.03	0.000
Pure Error	15560	10016392	644		
Total	182628	2489512057			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
49.2908	82.18%	82.18%	82.17%

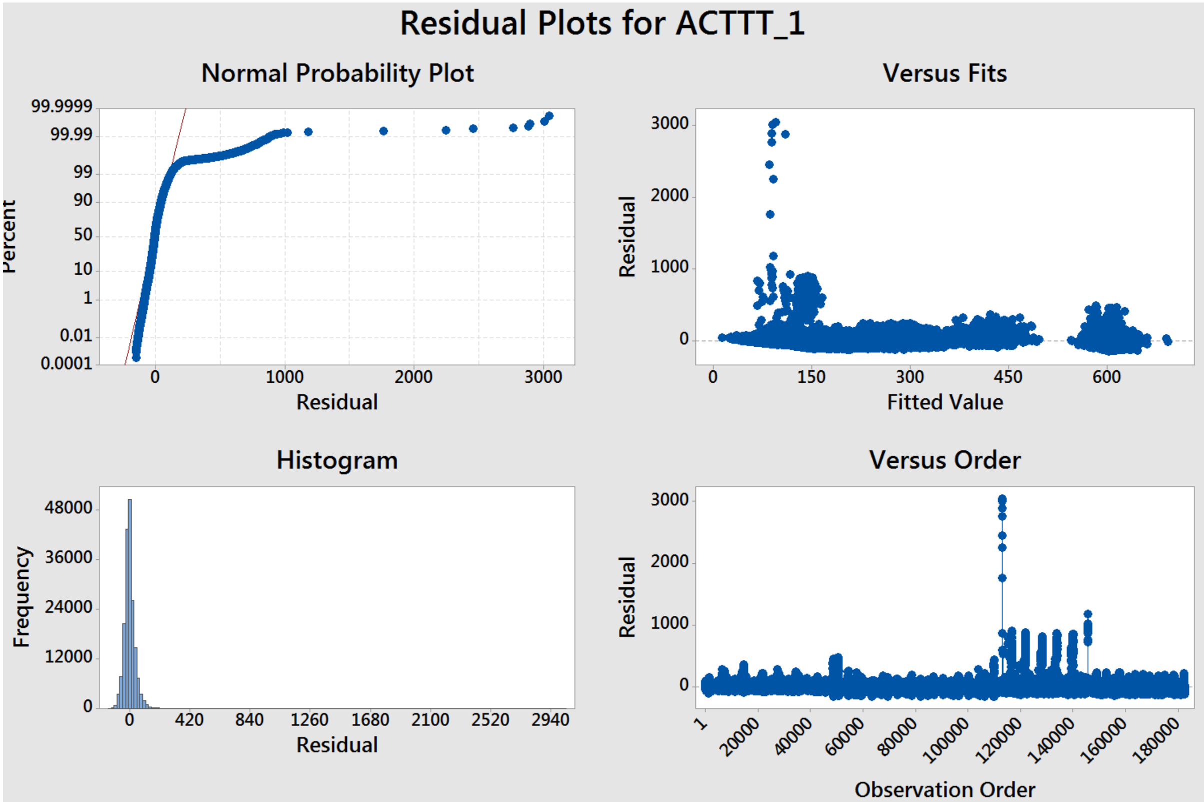
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	184.362	0.907	122.75	0.000	
LENGTH_1	71.497	0.206	346.37	0.000	9.34
ADHERENCE_seg1_1	-0.013093	0.000543	-24.13	0.000	1.11
ACTSTOP_1	18.621	0.307	60.72	0.000	1.58
BOARDING_1	2.6770	0.0435	61.15	0.000	1.26
ALIGHTING_1	1.8083	0.0746	23.62	0.000	4.56
Alig Sq_1	-0.02230	0.00359	-6.20	0.000	3.71
RCI_1	-1.9468	0.0137	-91.28	0.000	3.25
SIGNAL_1	18.100	0.152	119.11	0.000	6.36
CBD_1					
1	-46.808	0.788	-21.26	0.000	3.13
Arterial_1					

```
  1                 -98.823     0.641    -76.22    0.000   2.66
Busway_1
  1                 -34.017     0.423   -127.57    0.000   3.37
Motorway_1
  1                 -75.900     1.170    -64.95    0.000   9.15
Light Rain_1
  1                   0.303     0.309      7.45    0.000   1.06
Heavy Rain_1
  1                   2.877     0.337      5.87    0.000   1.04


Regression Equation

ACTTT_1 = 184.362 + 71.497 LENGTH_1 - 0.013093 ADHERENCE_seg1_1 + 18.621 ACTSTOP_1
          + 2.6770 BOARDING_1 + 1.8083 ALIGHTING_1 - 0.02230 Alig Sq_1 -
 1.2468 RCI_1
          + 18.100 SIGNAL_1 + 0.0 CBD_1_0 - 16.808 CBD_1_1 + 0.0 Arterial_1_0
          - 98.823 Arterial_1_1 + 0.0 Busway_1_0 - 34.017 Busway_1_1
+ 0.0 Motorway_1_0
          - 34.017 Motorway_1_1 + 0.0 Light Rain_1_0 + 2.303 Light Rain_1_1
          + 0.303 Heavy Rain_1_0 + 2.877 Heavy Rain_1_1
```



TT with Rain as continuous var (non- standardized coefs.):

Regression Analysis: ACTTT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, BOARDING_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	13	2045704294	157361869	64750.19	0.000
LENGTH_1	1	291504717	291504717	119946.38	0.000
ADHERENCE_seg1_1	1	1370340	1370340	563.86	0.000
ACTSTOP_1	1	8972971	8972971	3692.14	0.000
RCI_1	1	20270394	20270394	8340.72	0.000
BOARDING_1	1	9101921	9101921	3745.20	0.000
ALIGHTING_1	1	1361725	1361725	560.31	0.000
Alig Sq_1	1	94017	94017	38.69	0.000
SIGNAL_1	1	34505160	34505160	14197.95	0.000
RAIN_1	1	52133	52133	21.45	0.000
CBD_1	1	1113973	1113973	458.37	0.000
Arterial_1	1	14133272	14133272	5815.46	0.000
Busway_1	1	40181573	40181573	16533.64	0.000
Motorway_1	1	10346935	10346935	4257.49	0.000
Error	182615	443807763	2430		
Lack-of-Fit	169638	438907268	2587	6.85	0.000
Pure Error	12977	4900495	378		
Total	182628	2489512057			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
49.2980	82.17%	82.17%	82.17%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	172.083	0.903	124.16	0.000	
LENGTH_1	71.503	0.206	346.33	0.000	9.34
ADHERENCE_seg1_1	-0.012864	0.000542	-23.75	0.000	1.10
ACTSTOP_1	18.635	0.307	60.76	0.000	1.58
RCI_1	-1.2479	0.0137	-91.33	0.000	3.25
BOARDING_1	2.6793	0.0438	61.20	0.000	1.26
ALIGHTING_1	1.8128	0.0766	23.67	0.000	4.56
Alig Sq_1	-0.02236	0.00360	-6.22	0.000	3.71
SIGNAL_1	18.109	0.152	119.16	0.000	6.36
RAIN_1	0.4186	0.0105	4.63	0.000	1.00
CBD_1					
1	-16.925	0.791	-21.41	0.000	6.13
Arterial_1					
1	-48.858	0.641	-76.26	0.000	2.66
Busway_1					
1	-54.268	0.422	-128.58	0.000	3.34
Motorway_1					
1	-76.21	1.17	-65.25	0.000	9.13

Regression Equation

```
ACTTT_1 = 112.083 + 71.503 LENGTH_1 - 0.012864 ADHERENCE_seg1_1 + 18.635 ACTSTOP_1
          - 1.2479 RCI_1 + 2.6793 BOARDING_1 + 1.8128 ALIGHTING_1 -
 0.02236 Alig Sq_1
          + 18.109 SIGNAL_1 + 0.0486 RAIN_1 + 0.0 CBD_1_0 - 16.925 CBD_1_1
+ 0.0 Arterial_1_0
          - 48.858 Arterial_1_1 + 0.0 Busway_1_0 - 54.268 Busway_1_1
+ 0.0 Motorway_1_0
          - 76.21 Motorway_1_1
```

RT no demand (non- standardized coefs.):

Regression Analysis: ACTRT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, SIGNAL_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	11	1605411927	145946539	67106.74	0.000
LENGTH_1	1	267432798	267432798	122966.56	0.000
ADHERENCE_seg1_1	1	42953	42953	19.75	0.000
ACTSTOP_1	1	388609	388609	178.68	0.000
RCI_1	1	11305168	11305168	5198.16	0.000
SIGNAL_1	1	25869155	25869155	11894.73	0.000
CBD_1	1	554316	554316	254.88	0.000
Arterial_1	1	8832589	8832589	4061.26	0.000
Busway_1	1	42362731	42362731	19478.54	0.000
Motorway_1	1	8231173	8231173	3784.72	0.000
Light Rain_1	1	73228	73228	33.67	0.000
Heavy Rain_1	1	32620	32620	15.00	0.000
Error	182617	397163060	2175		
Lack-of-Fit	148187	372804513	2516	3.56	0.000
Pure Error	34430	24358548	707		
Total	182628	2002574988			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
46.6352	80.17%	80.17%	80.16%

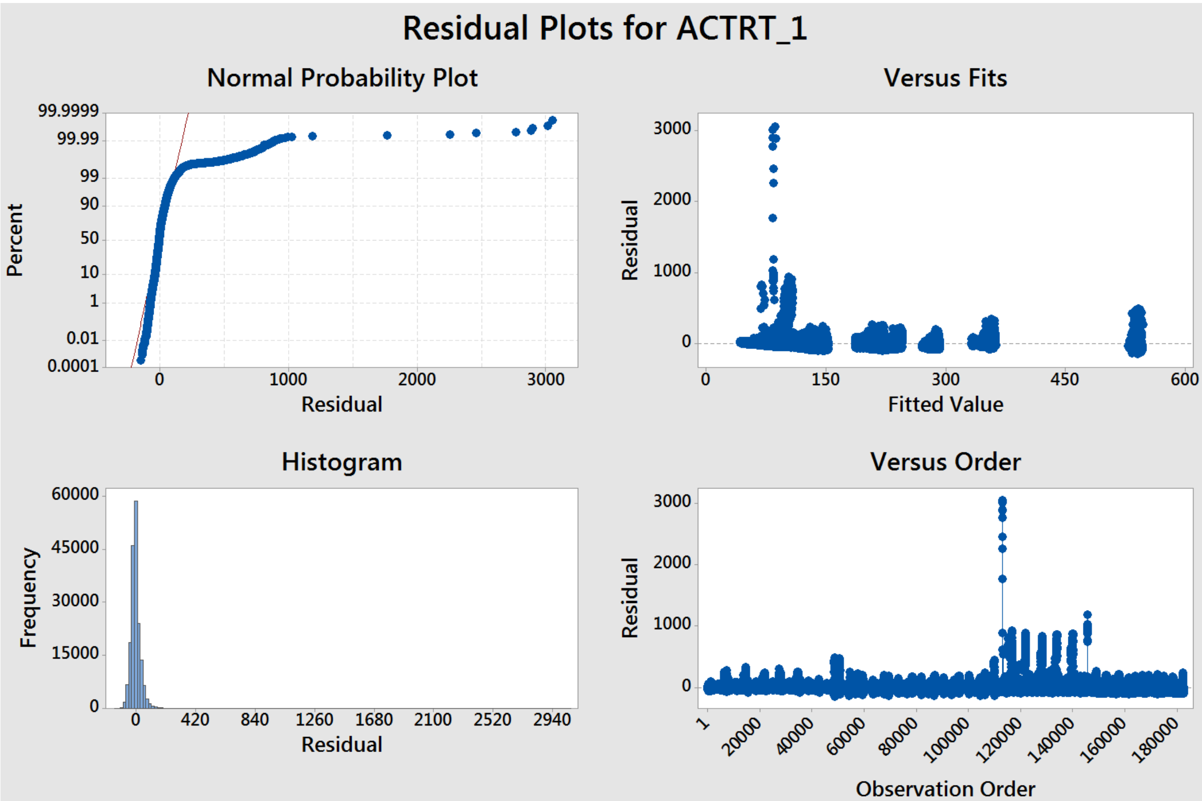
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	165.953	0.837	109.88	0.000	
LENGTH_1	65.339	0.186	350.67	0.000	4.50
ADHERENCE_seg1_1	-0.002269	0.00051	-4.44	0.000	1.10
ACTSTOP_1	3.332	0.249	13.37	0.000	1.16
RCI_1	-1.299	0.0125	-72.10	0.000	3.02
SIGNAL_1	15.392	0.199	109.06	0.000	3.13
CBD_1					
1	-31.753	0.736	-15.96	0.000	4.94
Arterial_1					

```
  1                  -88.560     0.608   -63.73     0.000  2.65
Busway_1
  1                  -34.388     0.388  -139.57     0.000  3.19
Motorway_1
  1                  -66.190      1.08   -61.52     0.000  4.66
Light Rain_1
  1                   0.0696     0.292     5.80     0.000  1.06
Heavy Rain_1
  1                    2.233     0.318     3.87     0.000  1.04


Regression Equation

ACTRT_1 = 165.953 + 65.339 LENGTH_1 - 0.002269 ADHERENCE_seg1_1 + 3.332 ACTSTOP_1
          - 0.8985 RCI_1 + 15.392 SIGNAL_1 + 0.0 CBD_1_0 - 31.753 CBD_1_1
+ 0.0 Arterial_1_0
          - 38.560 Arterial_1_1 + 0.0 Busway_1_0 - 34.388 Busway_1_1
+ 0.0 Motorway_1_0
          - 66.190 Motorway_1_1 + 0.0 Light Rain_1_0 + 0.0696 Light Rain_1_1
          + 0.0 Heavy Rain_1_0 + 2.233 Heavy Rain_1_1
```



RT, on board included:

Regression Analysis: ACTRT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, SIGNAL_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	12	1605961846	133830154	61620.57	0.000
LENGTH_1	1	263583378	263583378	121363.96	0.000
ADHERENCE_seg1_1	1	163611	163611	75.33	0.000
ACTSTOP_1	1	124472	124472	57.31	0.000
RCI_1	1	11252153	11252153	5180.93	0.000
SIGNAL_1	1	25894178	25894178	11922.68	0.000
ONBOARD_1	1	549918	549918	253.20	0.000
CBD_1	1	612585	612585	282.06	0.000
Arterial_1	1	9121708	9121708	4199.99	0.000
Busway_1	1	42633623	42633623	19630.17	0.000
Motorway_1	1	8195953	8195953	3773.73	0.000
Light Rain_1	1	67280	67280	30.98	0.000
Heavy Rain_1	1	38164	38164	17.57	0.000
Error	182616	396613142	2172		
Lack-of-Fit	173172	393135659	2270	6.17	0.000
Pure Error	9444	3477483	368		
Total	182628	2002574988			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
46.6030	80.19%	80.19%	80.19%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	92.065	0.836	110.09	0.000	
LENGTH_1	65.092	0.187	348.37	0.000	8.56
ADHERENCE_seg1_1	-0.004609	0.000531	-8.68	0.000	1.19
ACTSTOP_1	1.991	0.263	7.57	0.000	1.30
RCI_1	-0.8964	0.0125	-71.98	0.000	3.02
SIGNAL_1	15.400	0.141	109.19	0.000	6.13
ONBOARD_1	0.1840	0.0116	15.91	0.000	1.39
CBD_1					
1	-12.372	0.737	-16.79	0.000	5.96
Arterial_1					
1	-39.302	0.606	-64.81	0.000	2.67
Busway_1					
1	-55.606	0.397	-140.11	0.000	3.31
Motorway_1					
1	-66.06	1.08	-61.43	0.000	8.66
Light Rain_1					
1	1.626	0.292	5.57	0.000	1.06
Heavy Rain_1					
1	1.334	0.318	4.19	0.000	1.04

Regression Equation

```
ACTRT_1 = 92.065 + 65.092 LENGTH_1 - 0.004609 ADHERENCE_seg1_1 + 1.991 ACTSTOP_1
          - 0.8964 RCI_1 + 15.400 SIGNAL_1 + 0.1840 ONBOARD_1 + 0.0 CBD_1_0 -
 12.372 CBD_1_1
          + 0.0 Arterial_1_0 - 39.302 Arterial_1_1 + 0.0 Busway_1_0 -
 55.606 Busway_1_1
          + 0.0 Motorway_1_0 - 66.06 Motorway_1_1 + 0.0 Light Rain_1_0
+ 1.626 Light Rain_1_1
          + 0.0 Heavy Rain_1_0 + 1.334 Heavy Rain_1_1
```

RT with external variables:

Regression Analysis: ACTRT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, SIGNAL_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	14	1638795441	117056817	58761.45	0.000
LENGTH_1	1	269143392	269143392	135107.52	0.000
ACTSTOP_1	1	81048	81048	40.69	0.000
RCI_1	1	23433346	23433346	11763.33	0.000
SIGNAL_1	1	16939984	16939984	8503.72	0.000
ONBOARD_1	1	525044	525044	263.57	0.000
SPEEDLIMIT_1	1	8907938	8907938	4471.70	0.000
LANE_1	1	21488224	21488224	10786.89	0.000
OTHERINTER_1	1	7996502	7996502	4014.17	0.000
CBD_1	1	2223766	2223766	1116.31	0.000
Arterial_1	1	19752214	19752214	9915.43	0.000
Busway_1	1	3489747	3489747	1751.82	0.000
Motorway_1	1	2214262	2214262	1111.54	0.000
Light Rain_1	1	21147	21147	10.62	0.001
Heavy Rain_1	1	29584	29584	14.85	0.000
Error	182614	363779546	1992		
Lack-of-Fit	173170	360302063	2081	5.65	0.000
Pure Error	9444	3477483	368		
Total	182628	2002574988			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
44.6326	81.83%	81.83%	81.83%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	213.21	3.17	67.17	0.000	
LENGTH_1	66.522	0.181	367.57	0.000	8.76
ACTSTOP_1	-1.637	0.257	-6.38	0.000	1.35
RCI_1	-1.3516	0.0125	-108.46	0.000	3.30
SIGNAL_1	15.261	0.165	92.22	0.000	9.20
ONBOARD_1	0.1729	0.0106	16.23	0.000	1.29

```
SPEEDLIMIT_1  -3.7435   0.0560   -66.87    0.000   70.34
LANE_1         84.929    0.818   103.86    0.000   86.03
OTHERINTER_1   5.6402   0.0890    63.36    0.000    5.04
CBD_1
  1            -34.20     1.02   -33.41    0.000   12.54
Arterial_1
  1           -272.68     2.74   -99.58    0.000   59.27
Busway_1
  1             70.02     1.67    41.85    0.000   64.08
Motorway_1
  1           -127.24     3.82   -33.34    0.000  118.95
Light Rain_1
  1             0.911    0.280     3.26    0.001    1.06
Heavy Rain_1
  1             1.173    0.304     3.85    0.000    1.04

Regression Equation

ACTRT_1 = 213.21 + 66.522 LENGTH_1 - 1.637 ACTSTOP_1 - 1.3516 RCI_1
+ 15.261 SIGNAL_1
          + 0.1729 ONBOARD_1 - 3.7435 SPEEDLIMIT_1 + 84.929 LANE_1
+ 5.6402 OTHERINTER_1
          + 0.0 CBD_1_0 - 34.20 CBD_1_1 + 0.0 Arterial_1_0 - 272.68 Arterial_1_1
          + 0.0 Busway_1_0 + 70.02 Busway_1_1 + 0.0 Motorway_1_0 -
 127.24 Motorway_1_1
          + 0.0 Light Rain_1_0 + 0.911 Light Rain_1_1 + 0.0 Heavy Rain_1_0
          + 1.173 Heavy Rain_1_1
```

RT with other intersections included:

Regression Analysis: ACTRT_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, SIGNAL_1, ...

```
Method

Categorical predictor coding  (1, 0)


Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15


Analysis of Variance
```

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	13	1609526641	123809742	57523.50	0.000
LENGTH_1	1	252246534	252246534	117196.78	0.000
ADHERENCE_seg1_1	1	149819	149819	69.61	0.000
ACTSTOP_1	1	159814	159814	74.25	0.000
RCI_1	1	12086781	12086781	5615.66	0.000
SIGNAL_1	1	11688642	11688642	5430.68	0.000
ONBOARD_1	1	635460	635460	295.24	0.000
OTHERINTER_1	1	3564795	3564795	1656.25	0.000
CBD_1	1	432059	432059	200.74	0.000
Arterial_1	1	2117666	2117666	983.89	0.000
Busway_1	1	5784671	5784671	2687.63	0.000
Motorway_1	1	2096080	2096080	973.86	0.000
Light Rain_1	1	58977	58977	27.40	0.000
Heavy Rain_1	1	37667	37667	17.50	0.000
Error	182615	393048347	2152		
Lack-of-Fit	173171	389570864	2250	6.11	0.000
Pure Error	9444	3477483	368		

```
Total              182628  2002574988


Model Summary

      S    R-sq  R-sq(adj)  R-sq(pred)
46.3932  80.37%     80.37%      80.37%


Coefficients

Term                    Coef   SE Coef  T-Value  P-Value    VIF
Constant              75.178     0.930    80.82    0.000
LENGTH_1              64.159     0.187   342.34    0.000   8.69
ADHERENCE_seg1_1   -0.004411  0.000529    -8.34    0.000   1.19
ACTSTOP_1              2.256     0.262     8.62    0.000   1.30
RCI_1                -0.9313    0.0124   -74.94    0.000   3.04
SIGNAL_1              12.021     0.163    73.69    0.000   8.27
ONBOARD_1             0.1979    0.0115    17.18    0.000   1.39
OTHERINTER_1          3.5162    0.0864    40.70    0.000   4.40
CBD_1
  1                   13.826     0.976    14.17    0.000  10.55
Arterial_1
  1                  -22.808     0.727   -31.37    0.000   3.87
Busway_1
  1                  -34.153     0.659   -51.84    0.000   9.20
Motorway_1
  1                   -39.23      1.26   -31.21    0.000  11.95
Light Rain_1
  1                    1.523     0.291     5.23    0.000   1.06
Heavy Rain_1
  1                    1.325     0.317     4.18    0.000   1.04


Regression Equation

ACTRT_1 = 75.178 + 64.159 LENGTH_1 - 0.004411 ADHERENCE_seg1_1 + 2.256 ACTSTOP_1
          - 0.9313 RCI_1 + 12.021 SIGNAL_1 + 0.1979 ONBOARD_1 + 3.5162 OTHERINTER_1
          + 0.0 CBD_1_0 + 13.826 CBD_1_1 + 0.0 Arterial_1_0 - 22.808 Arterial_1_1
          + 0.0 Busway_1_0 - 34.153 Busway_1_1 + 0.0 Motorway_1_0 -
 39.23 Motorway_1_1
          + 0.0 Light Rain_1_0 + 1.523 Light Rain_1_1 + 0.0 Heavy Rain_1_0
          + 1.325 Heavy Rain_1_1
```

SD no signals:

Regression Analysis: STOPDELAY_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	14	66930987	4780785	16612.16	0.000
LENGTH_1	1	3229733	3229733	11222.60	0.000
ADHERENCE_seg1_1	1	899515	899515	3125.62	0.000
ACTSTOP_1	1	5759403	5759403	20012.64	0.000
RCI_1	1	2759900	2759900	9590.04	0.000
BOARDING_1	1	3684751	3684751	12803.69	0.000
Bd Sq_1	1	277288	277288	963.51	0.000
ALIGHTING_1	1	651484	651484	2263.76	0.000
Alig Sq_1	1	94120	94120	327.05	0.000
CBD_1	1	487520	487520	1694.02	0.000
Arterial_1	1	163912	163912	569.56	0.000
Busway_1	1	13928	13928	48.40	0.000
Motorway_1	1	351422	351422	1221.11	0.000
Light Rain_1	1	12443	12443	43.24	0.000
Heavy Rain_1	1	13030	13030	45.28	0.000
Error	182614	52554165	288		
Lack-of-Fit	167054	51485101	308	4.49	0.000
Pure Error	15560	1069064	69		
Total	182628	119485152			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
16.9643	56.02%	56.01%	56.00%

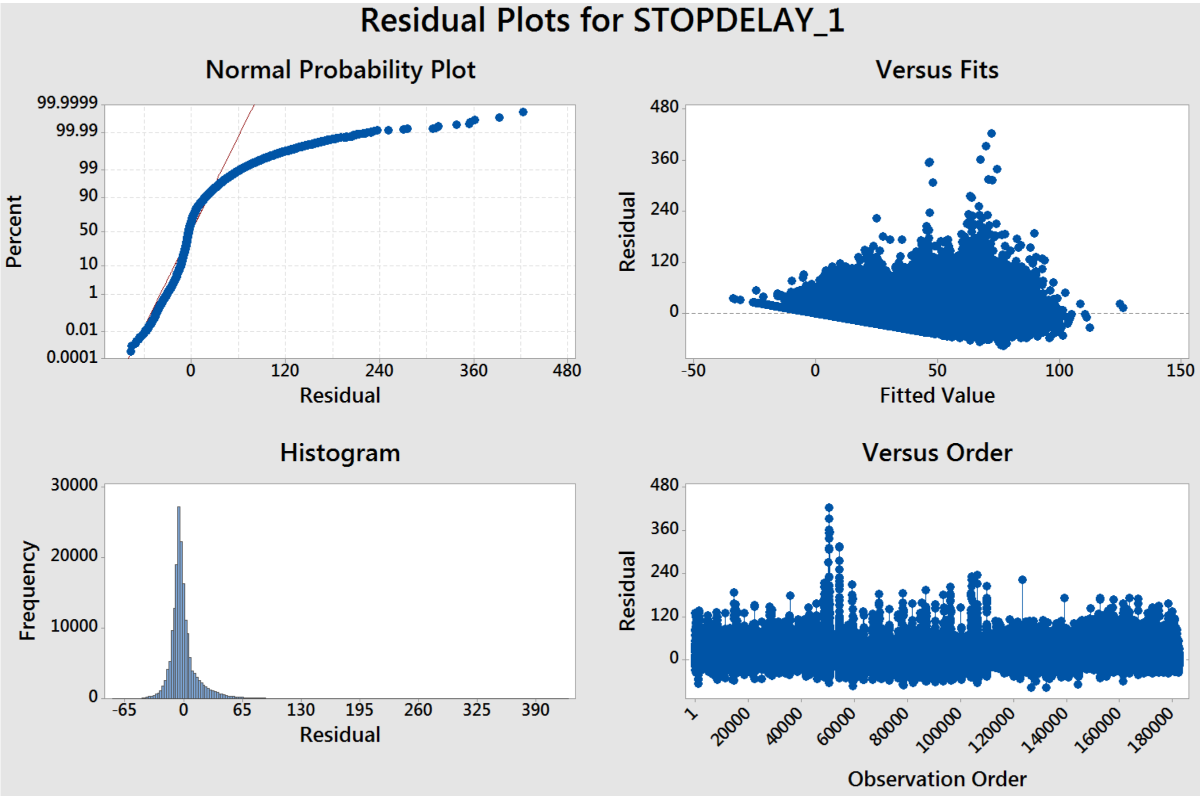
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	25.231	0.301	83.87	0.000	
LENGTH_1	7.3917	0.0698	105.94	0.000	9.01
ADHERENCE_seg1_1	-0.010434	0.00187	-55.91	0.000	1.11
ACTSTOP_1	15.704	0.111	141.47	0.000	1.75
RCI_1	-0.44198	0.00451	-97.93	0.000	3.00
BOARDING_1	3.3293	0.0294	113.15	0.000	4.82
Bd Sq_1	-0.05425	0.00175	-31.04	0.000	4.07
ALIGHTING_1	1.2453	0.0262	47.58	0.000	4.50
Alig Sq_1	-0.02235	0.00124	-18.08	0.000	3.70
CBD_1					
1	4.320	0.154	41.16	0.000	1.95
Arterial_1					
1	-4.379	0.183	-23.87	0.000	1.84
Busway_1					
1	-1.013	0.146	-6.96	0.000	3.36
Motorway_1					

```
  1                 -13.995     0.400    -34.94     0.000   4.07
Heavy Rain_1
  1                   0.779     0.0111     6.73     0.000   1.04


Regression Equation

STOPDELAY_1 = 25.231 + 7.3917 LENGTH_1 - 0.010434 ADHERENCE_seg1_1
+ 15.704 ACTSTOP_1
              - 0.44198 RCI_1 + 3.3293 BOARDING_1 - 0.05425 Bd Sq_1
+ 1.2453 ALIGHTING_1
              - 0.02235 Alig Sq_1 + 0.0 CBD_1_0 + 6.320 CBD_1_1 + 0.0 Arterial_1_0
              - 4.379 Arterial_1_1 + 0.0 Busway_1_0 - 1.013 Busway_1_1
+ 0.0 Motorway_1_0
              - 13.995 Motorway_1_1 + 0.0 Light Rain_1_0
+ 0.0 Heavy Rain_1_0 + 0.779 Heavy Rain_1_1
```



SD with signals:

Regression Analysis: STOPDELAY_1 versus LENGTH_1, ADHERENCE_se, ACTSTOP_1, RCI_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	15	67530748	4502050	15824.12	0.000
LENGTH_1	1	2595814	2595814	9123.95	0.000
ADHERENCE_seg1_1	1	851151	851151	2991.69	0.000
ACTSTOP_1	1	5491590	5491590	19302.23	0.000
RCI_1	1	1882919	1882919	6618.22	0.000
BOARDING_1	1	3704197	3704197	13019.77	0.000
Bd Sq_1	1	272768	272768	958.74	0.000
ALIGHTING_1	1	842713	842713	2962.03	0.000
Alig Sq_1	1	131089	131089	460.76	0.000
SIGNAL_1	1	599761	599761	2108.08	0.000
CBD_1	1	60460	60460	212.51	0.000
Arterial_1	1	587311	587311	2064.32	0.000
Busway_1	1	6032	6032	21.20	0.000
Motorway_1	1	264262	264262	928.85	0.000
Light Rain_1	1	10716	10716	37.67	0.000
Heavy Rain_1	1	11809	11809	41.51	0.000
Error	182613	51954404	285		
Lack-of-Fit	167053	50885340	305	4.43	0.000
Pure Error	15560	1069064	69		
Total	182628	119485152			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
16.8673	56.52%	56.51%	56.51%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	21.394	0.311	68.89	0.000	
LENGTH_1	6.7570	0.0707	95.52	0.000	9.37
ADHERENCE_seg1_1	-0.010155	0.000186	-54.70	0.000	1.11
ACTSTOP_1	15.368	0.111	138.93	0.000	1.75
RCI_1	-0.38081	0.00468	-81.35	0.000	3.26
BOARDING_1	3.3381	0.0293	114.10	0.000	4.82
Bd Sq_1	-0.05380	0.00174	-30.96	0.000	4.07
ALIGHTING_1	1.4338	0.0263	54.42	0.000	4.61
Alig Sq_1	-0.02645	0.00123	-21.47	0.000	3.72
SIGNAL_1	2.3875	0.0520	45.91	0.000	6.36
CBD_1					
1	-3.947	0.271	-14.58	0.000	6.14
Arterial_1					
1	-9.961	0.219	-45.43	0.000	2.66
Busway_1					

```
  1                -0.667     0.145    -4.60    0.000  3.37
Motorway_1
  1               -12.194     0.400   -30.48    0.000  9.15
Light Rain_1
  1                 0.649     0.106     6.14    0.000  1.06
Heavy Rain_1
  1                 0.742     0.115     6.44    0.000  1.04
```

Regression Equation

```
STOPDELAY_1 = 21.394 + 6.7570 LENGTH_1 - 0.010155 ADHERENCE_seg1_1
+ 15.368 ACTSTOP_1
              - 0.38081 RCI_1 + 3.3381 BOARDING_1 - 0.05380 Bd Sq_1
+ 1.4338 ALIGHTING_1
              - 0.02645 Alig Sq_1 + 2.3875 SIGNAL_1 + 0.0 CBD_1_0 - 3.947 CBD_1_1
              + 0.0 Arterial_1_0 - 9.961 Arterial_1_1 + 0.0 Busway_1_0 -
 0.667 Busway_1_1
              + 0.0 Motorway_1_0 - 12.194 Motorway_1_1 + 0.0 Light Rain_1_0
              + 0.649 Light Rain_1_1 + 0.0 Heavy Rain_1_0 + 0.742 Heavy Rain_1_1
```

TT vs CBD:

Regression Analysis: ACTTT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	11	162991951	14817450	7504.10	0.000
LENGTH_1_1	1	32547749	32547749	16483.38	0.000
ADHERENCE_seg1_1_1	1	1267597	1267597	641.96	0.000
ACTSTOP_1_1	1	3441129	3441129	1742.71	0.000
BOARDING_1_1	1	201992	201992	102.30	0.000
Bd Sq_1_1	1	4724	4724	2.39	0.122
ALIGHTING_1_1	1	748371	748371	379.00	0.000
Alig Sq_1_1	1	305805	305805	154.87	0.000
RCI_1_1	1	5754459	5754459	2914.27	0.000
SIGNAL_1_1	1	15426	15426	7.81	0.005
Light Rain_1_1	1	56960	56960	28.85	0.000
Heavy Rain_1_1	1	41402	41402	20.97	0.000
Error	28184	55651566	1975		
Lack-of-Fit	25604	54329567	2122	4.14	0.000
Pure Error	2580	1321998	512		
Total	28195	218643517			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
44.4362	74.55%	74.54%	74.52%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	79.72	1.89	42.23	0.000	
LENGTH_1_1	226.74	1.77	128.39	0.000	4.49
ADHERENCE_seg1_1_1	-0.04357	0.00172	-25.34	0.000	1.26
ACTSTOP_1_1	37.507	0.898	41.75	0.000	2.43
BOARDING_1_1	1.674	0.165	10.11	0.000	5.82
Bd Sq_1_1	-0.01261	0.00815	-1.55	0.122	4.64
ALIGHTING_1_1	3.388	0.174	19.47	0.000	6.85
Alig Sq_1_1	-0.10531	0.00846	-12.44	0.000	5.26
RCI_1_1	-1.6809	0.0311	-53.98	0.000	1.97
SIGNAL_1_1	-0.864	0.309	-2.80	0.005	3.56
Light Rain_1_1					
1	3.525	0.656	5.37	0.000	1.06
Heavy Rain_1_1					
1	3.551	0.775	4.58	0.000	1.05

Regression Equation

```
ACTTT_1_1 = 79.72 + 226.74 LENGTH_1_1 - 0.04357 ADHERENCE_seg1_1_1
+ 37.507 ACTSTOP_1_1
            + 1.674 BOARDING_1_1 - 0.01261 Bd Sq_1_1 + 3.388 ALIGHTING_1_1
            - 0.10531 Alig Sq_1_1 - 1.6809 RCI_1_1 - 0.864 SIGNAL_1_1
+ 0.0 Light Rain_1_1_0
            + 3.525 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 3.551 Heavy Rain_1_1_1
```

TT vs Motorway:

Regression Analysis: ACTTT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	334347521	41793440	13630.97	0.000
LENGTH_1_1	1	55215481	55215481	18008.58	0.000
ACTSTOP_1_1	1	134758	134758	43.95	0.000
RCI_1_1	1	7056229	7056229	2301.40	0.000
BOARDING_1_1	1	167061	167061	54.49	0.000
ALIGHTING_1_1	1	140143	140143	45.71	0.000
Bd Sq_1_1	1	25077	25077	8.18	0.004
SIGNAL_1_1	1	4795811	4795811	1564.16	0.000
Heavy Rain_1_1	1	135885	135885	44.32	0.000
Error	18045	55327140	3066		
Lack-of-Fit	17309	54605642	3155	3.22	0.000
Pure Error	736	721498	980		
Total	18053	389674661			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
55.3721	85.80%	85.80%	85.79%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	264.56	7.35	35.99	0.000	
LENGTH_1_1	67.637	0.504	134.20	0.000	3.52
ACTSTOP_1_1	8.39	1.27	6.63	0.000	1.64
RCI_1_1	-4.4652	0.0931	-47.97	0.000	1.79
BOARDING_1_1	2.233	0.302	7.38	0.000	9.23
ALIGHTING_1_1	0.714	0.106	6.76	0.000	1.68
Bd Sq_1_1	0.0421	0.0147	2.86	0.004	6.32
SIGNAL_1_1	60.09	1.52	39.55	0.000	3.17
Heavy Rain_1_1					
1	7.84	1.18	6.66	0.000	1.00

Regression Equation

```
ACTTT_1_1 = 264.56 + 67.637 LENGTH_1_1 + 8.39 ACTSTOP_1_1 - 4.4652 RCI_1_1
            + 2.233 BOARDING_1_1 + 0.714 ALIGHTING_1_1 + 0.0421 Bd Sq_1_1
+ 60.09 SIGNAL_1_1
            + 0.0 Heavy Rain_1_1_0 + 7.84 Heavy Rain_1_1_1
```

TT vs Busway:

Regression Analysis: ACTTT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	11	69770174	6342743	18818.88	0.000
LENGTH_1_1	1	14516392	14516392	43070.05	0.000
ADHERENCE_seg1_1_1	1	12444	12444	36.92	0.000
ACTSTOP_1_1	1	3330274	3330274	9880.90	0.000
RCI_1_1	1	6804272	6804272	20188.23	0.000
SIGNAL_1_1	1	1791681	1791681	5315.91	0.000
BOARDING_1_1	1	274358	274358	814.02	0.000
ALIGHTING_1_1	1	6490	6490	19.26	0.000
Bd Sq_1_1	1	5935	5935	17.61	0.000
Alig Sq_1_1	1	7951	7951	23.59	0.000
Light Rain_1_1	1	4732	4732	14.04	0.000
Heavy Rain_1_1	1	3794	3794	11.26	0.001
Error	88682	29889512	337		
Lack-of-Fit	81701	28621863	350	1.93	0.000
Pure Error	6981	1267649	182		
Total	88693	99659686			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
18.3587	70.01%	70.00%	70.00%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	140.177	0.663	211.30	0.000	
LENGTH_1_1	47.227	0.228	207.53	0.000	5.58
ADHERENCE_seg1_1_1	-0.001541	0.000254	-6.08	0.000	1.02
ACTSTOP_1_1	16.881	0.170	99.40	0.000	1.77
RCI_1_1	-1.5733	0.0111	-142.09	0.000	4.23
SIGNAL_1_1	-22.624	0.310	-72.91	0.000	3.10
BOARDING_1_1	1.5586	0.0546	28.53	0.000	4.71
ALIGHTING_1_1	-0.3003	0.0684	-4.39	0.000	4.75
Bd Sq_1_1	0.01477	0.00352	4.20	0.000	3.57
Alig Sq_1_1	0.02864	0.00590	4.86	0.000	4.00
Light Rain_1_1					
1	0.674	0.180	3.75	0.000	1.03
Heavy Rain_1_1					
1	0.603	0.180	3.36	0.001	1.03

Regression Equation

```
ACTTT_1_1 = 140.177 + 47.227 LENGTH_1_1 - 0.001541 ADHERENCE_seg1_1_1
+ 16.881 ACTSTOP_1_1
            - 1.5733 RCI_1_1 - 22.624 SIGNAL_1_1 + 1.5586 BOARDING_1_1 -
 0.3003 ALIGHTING_1_1
            + 0.01477 Bd Sq_1_1 + 0.02864 Alig Sq_1_1 + 0.0 Light Rain_1_1_0
            + 0.674 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 0.603 Heavy Rain_1_1_1
```

TT vs Arterial:

Regression Analysis: ACTTT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	11	9633019	875729	878.04	0.000
LENGTH_1_1	1	2263848	2263848	2269.82	0.000
ADHERENCE_seg1_1_1	1	13695	13695	13.73	0.000
ACTSTOP_1_1	1	697528	697528	699.37	0.000
RCI_1_1	1	2113677	2113677	2119.25	0.000
SIGNAL_1_1	1	620415	620415	622.05	0.000
BOARDING_1_1	1	60341	60341	60.50	0.000
ALIGHTING_1_1	1	156666	156666	157.08	0.000
Bd Sq_1_1	1	8813	8813	8.84	0.003
Alig Sq_1_1	1	42920	42920	43.03	0.000
Light Rain_1_1	1	4935	4935	4.95	0.026

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Heavy Rain_1_1	1	11065	11065	11.09	0.001
Error	17390	17344240	997		
Lack-of-Fit	17100	17108766	1001	1.23	0.009
Pure Error	290	235474	812		
Total	17401	26977259			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
31.5811	35.71%	35.67%	35.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	106.27	2.36	45.06	0.000	
LENGTH_1_1	209.68	4.40	47.64	0.000	3.98
ADHERENCE_seg1_1_1	-0.00679	0.00183	-3.71	0.000	1.07
ACTSTOP_1_1	22.031	0.833	26.45	0.000	1.40
RCI_1_1	-2.1469	0.0466	-46.04	0.000	1.67
SIGNAL_1_1	-10.762	0.431	-24.94	0.000	4.79
BOARDING_1_1	1.400	0.180	7.78	0.000	5.88
ALIGHTING_1_1	1.741	0.139	12.53	0.000	6.30
Bd Sq_1_1	-0.0313	0.0105	-2.97	0.003	4.97
Alig Sq_1_1	-0.03112	0.00474	-6.56	0.000	4.78
Light Rain_1_1					
1	1.269	0.570	2.22	0.026	1.06
Heavy Rain_1_1					
1	2.360	0.709	3.33	0.001	1.06

Regression Equation

```
ACTTT_1_1 = 106.27 + 209.68 LENGTH_1_1 - 0.00679 ADHERENCE_seg1_1_1
+ 22.031 ACTSTOP_1_1
            - 2.1469 RCI_1_1 - 10.762 SIGNAL_1_1 + 1.400 BOARDING_1_1
+ 1.741 ALIGHTING_1_1
            - 0.0313 Bd Sq_1_1 - 0.03112 Alig Sq_1_1 + 0.0 Light Rain_1_1_0
            + 1.269 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 2.360 Heavy Rain_1_1_1
```

TT vs other type of roads:

Regression Analysis: ACTTT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	11	9633019	875729	878.04	0.000
LENGTH_1_1	1	2263848	2263848	2269.82	0.000
ADHERENCE_seg1_1_1	1	13695	13695	13.73	0.000
ACTSTOP_1_1	1	697528	697528	699.37	0.000
RCI_1_1	1	2113677	2113677	2119.25	0.000

SIGNAL_1_1	1	620415	620415	622.05	0.000
BOARDING_1_1	1	60341	60341	60.50	0.000
ALIGHTING_1_1	1	156666	156666	157.08	0.000
Bd Sq_1_1	1	8813	8813	8.84	0.003
Alig Sq_1_1	1	42920	42920	43.03	0.000
Light Rain_1_1	1	4935	4935	4.95	0.026
Heavy Rain_1_1	1	11065	11065	11.09	0.001
Error	17390	17344240	997		
Lack-of-Fit	17100	17108766	1001	1.23	0.009
Pure Error	290	235474	812		
Total	17401	26977259			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
31.5811	35.71%	35.67%	35.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	106.27	2.36	45.06	0.000	
LENGTH_1_1	209.68	4.40	47.64	0.000	3.98
ADHERENCE_seg1_1_1	-0.00679	0.00183	-3.71	0.000	1.07
ACTSTOP_1_1	22.031	0.833	26.45	0.000	1.40
RCI_1_1	-2.1469	0.0466	-46.04	0.000	1.67
SIGNAL_1_1	-10.762	0.431	-24.94	0.000	4.79
BOARDING_1_1	1.400	0.180	7.78	0.000	5.88
ALIGHTING_1_1	1.741	0.139	12.53	0.000	6.30
Bd Sq_1_1	-0.0313	0.0105	-2.97	0.003	4.97
Alig Sq_1_1	-0.03112	0.00474	-6.56	0.000	4.78
Light Rain_1_1					
1	1.269	0.570	2.22	0.026	1.06
Heavy Rain_1_1					
1	2.360	0.709	3.33	0.001	1.06

Regression Equation

```
ACTTT_1_1 = 106.27 + 209.68 LENGTH_1_1 - 0.00679 ADHERENCE_seg1_1_1
+ 22.031 ACTSTOP_1_1
            - 2.1469 RCI_1_1 - 10.762 SIGNAL_1_1 + 1.400 BOARDING_1_1
+ 1.741 ALIGHTING_1_1
            - 0.0313 Bd Sq_1_1 - 0.03112 Alig Sq_1_1 + 0.0 Light Rain_1_1_0
            + 1.269 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 2.360 Heavy Rain_1_1_1
```

RT vs CBD:

Regression Analysis: ACTRT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	120508471	17215496	11243.09	0.000
LENGTH_1_1	1	43395760	43395760	28340.88	0.000
ADHERENCE_seg1_1_1	1	293208	293208	191.49	0.000
ACTSTOP_1_1	1	355198	355198	231.97	0.000
RCI_1_1	1	7714427	7714427	5038.13	0.000
SIGNAL_1_1	1	2133059	2133059	1393.06	0.000
Light Rain_1_1	1	22042	22042	14.40	0.000
Heavy Rain_1_1	1	14166	14166	9.25	0.002
Error	28188	43161663	1531		
Lack-of-Fit	23177	39039553	1684	2.05	0.000
Pure Error	5011	4122111	823		
Total	28195	163670134			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
39.1306	73.63%	73.62%	73.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	101.69	1.57	64.75	0.000	
LENGTH_1_1	261.21	1.55	168.35	0.000	4.47
ADHERENCE_seg1_1_1	-0.02053	0.00148	-13.84	0.000	1.21
ACTSTOP_1_1	8.840	0.580	15.23	0.000	1.31
RCI_1_1	-1.8869	0.0266	-70.98	0.000	1.85
SIGNAL_1_1	-9.899	0.265	-37.32	0.000	3.38
Light Rain_1_1					
1	2.193	0.578	3.79	0.000	1.06
Heavy Rain_1_1					
1	2.076	0.683	3.04	0.002	1.05

Regression Equation

```
ACTRT_1_1 = 101.69 + 261.21 LENGTH_1_1 - 0.02053 ADHERENCE_seg1_1_1
+ 8.840 ACTSTOP_1_1
            - 1.8869 RCI_1_1 - 9.899 SIGNAL_1_1 + 0.0 Light Rain_1_1_0
            + 2.193 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 2.076 Heavy Rain_1_1_1
```

RT vs Motorway:

Regression Analysis: ACTRT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	241695215	40282536	16845.42	0.000
LENGTH_1_1	1	77729757	77729757	32505.16	0.000
ADHERENCE_seg1_1_1	1	934463	934463	390.78	0.000
ACTSTOP_1_1	1	36420	36420	15.23	0.000
RCI_1_1	1	3069508	3069508	1283.61	0.000
SIGNAL_1_1	1	5905301	5905301	2469.49	0.000
Heavy Rain_1_1	1	66977	66977	28.01	0.000
Error	18047	43155886	2391		
Lack-of-Fit	14581	37045500	2541	1.44	0.000
Pure Error	3466	6110387	1763		
Total	18053	284851102			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
48.9010	84.85%	84.84%	84.84%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	160.23	5.64	28.43	0.000	
LENGTH_1_1	60.546	0.336	180.29	0.000	2.00
ADHERENCE_seg1_1_1	0.02863	0.00145	19.77	0.000	1.06
ACTSTOP_1_1	-3.862	0.990	-3.90	0.000	1.29
RCI_1_1	-2.7695	0.0773	-35.83	0.000	1.58
SIGNAL_1_1	57.65	1.16	49.69	0.000	2.37
Heavy Rain_1_1					
1	5.51	1.04	5.29	0.000	1.00

Regression Equation

```
ACTRT_1_1 = 160.23 + 60.546 LENGTH_1_1 + 0.02863 ADHERENCE_seg1_1_1 -
 3.862 ACTSTOP_1_1
            - 2.7695 RCI_1_1 + 57.65 SIGNAL_1_1 + 0.0 Heavy Rain_1_1_0
            + 5.51 Heavy Rain_1_1_1
```

ETSEIB

RT vs Motorway:

Regression Analysis: ACTRT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	6	45264892	7544149	31127.82	0.000
LENGTH_1_1	1	8274999	8274999	34143.37	0.000
ADHERENCE_seg1_1_1	1	2115	2115	8.73	0.003
ACTSTOP_1_1	1	4039	4039	16.66	0.000
RCI_1_1	1	2057213	2057213	8488.24	0.000
SIGNAL_1_1	1	2774264	2774264	11446.86	0.000
Heavy Rain_1_1	1	4786	4786	19.75	0.000
Error	88687	21494213	242		
Lack-of-Fit	72251	20030055	277	3.11	0.000
Pure Error	16436	1464158	89		
Total	88693	66759106			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
15.5679	67.80%	67.80%	67.80%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	104.850	0.540	194.00	0.000	
LENGTH_1_1	32.561	0.176	184.78	0.000	4.66
ADHERENCE_seg1_1_1	0.000632	0.000214	2.95	0.003	1.01
ACTSTOP_1_1	-0.467	0.114	-4.08	0.000	1.11
RCI_1_1	-0.77967	0.00846	-92.13	0.000	3.43
SIGNAL_1_1	-27.899	0.261	-106.99	0.000	3.04
Heavy Rain_1_1					
1	0.667	0.150	4.44	0.000	1.00

Regression Equation

```
ACTRT_1_1 = 104.850 + 32.561 LENGTH_1_1 + 0.000632 ADHERENCE_seg1_1_1 -
 0.467 ACTSTOP_1_1
            - 0.77967 RCI_1_1 - 27.899 SIGNAL_1_1 + 0.0 Heavy Rain_1_1_0
            + 0.667 Heavy Rain_1_1_1
```

RT vs Arterial:

Regression Analysis: ACTRT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	7	5679188	811313	960.86	0.000
LENGTH_1_1	1	3476209	3476209	4116.97	0.000
ADHERENCE_seg1_1_1	1	11520	11520	13.64	0.000
ACTSTOP_1_1	1	52057	52057	61.65	0.000
RCI_1_1	1	1664894	1664894	1971.78	0.000
SIGNAL_1_1	1	759601	759601	899.62	0.000
Light Rain_1_1	1	3140	3140	3.72	0.054
Heavy Rain_1_1	1	6240	6240	7.39	0.007
Error	17394	14686834	844		
Lack-of-Fit	15261	13198244	865	1.24	0.000
Pure Error	2133	1488590	698		
Total	17401	20366022			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
29.0579	27.89%	27.86%	27.82%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	77.89	2.07	37.70	0.000	
LENGTH_1_1	211.43	3.30	64.16	0.000	2.63
ADHERENCE_seg1_1_1	-0.00608	0.00165	-3.69	0.000	1.02
ACTSTOP_1_1	5.331	0.679	7.85	0.000	1.10
RCI_1_1	-1.8143	0.0409	-44.40	0.000	1.51
SIGNAL_1_1	-9.447	0.315	-29.99	0.000	3.01
Light Rain_1_1					
1	1.012	0.525	1.93	0.054	1.06
Heavy Rain_1_1					
1	1.771	0.652	2.72	0.007	1.06

Regression Equation

```
ACTRT_1_1 = 77.89 + 211.43 LENGTH_1_1 - 0.00608 ADHERENCE_seg1_1_1
+ 5.331 ACTSTOP_1_1
            - 1.8143 RCI_1_1 - 9.447 SIGNAL_1_1 + 0.0 Light Rain_1_1_0
            + 1.012 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 1.771 Heavy Rain_1_1_1
```

RT vs other type of roads:

Regression Analysis: ACTRT_1_1 versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	5	19704589	3940918	284.25	0.000
LENGTH_1_1	1	714683	714683	51.55	0.000
ADHERENCE_seg1_1_1	1	105627	105627	7.62	0.006
ACTSTOP_1_1	1	599734	599734	43.26	0.000
RCI_1_1	1	7181104	7181104	517.96	0.000
Light Rain_1_1	1	39312	39312	2.84	0.092
Error	13023	180552253	13864		
Lack-of-Fit	9709	169876728	17497	5.43	0.000
Pure Error	3314	10675525	3221		
Total	13028	200256842			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
117.746	9.84%	9.81%	9.74%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	199.7	18.1	11.04	0.000	
LENGTH_1_1	145.2	20.2	7.18	0.000	1.75
ADHERENCE_seg1_1_1	-0.01915	0.00694	-2.76	0.006	1.23
ACTSTOP_1_1	-19.33	2.94	-6.58	0.000	1.99
RCI_1_1	-2.924	0.128	-22.76	0.000	2.54
Light Rain_1_1					
1	-4.02	2.39	-1.68	0.092	1.00

Regression Equation

```
ACTRT_1_1 = 199.7 + 145.2 LENGTH_1_1 - 0.01915 ADHERENCE_seg1_1_1 -
 19.33 ACTSTOP_1_1
            - 2.924 RCI_1_1 + 0.0 Light Rain_1_1_0 - 4.02 Light Rain_1_1_1
```

SD vs CBD:

Regression Analysis: STOPDELAY_1_ versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	10	15028299	1502830	3166.98	0.000
LENGTH_1_1	1	90587	90587	190.90	0.000
ADHERENCE_seg1_1_1	1	1114345	1114345	2348.31	0.000
ACTSTOP_1_1	1	1497999	1497999	3156.80	0.000
RCI_1_1	1	257876	257876	543.43	0.000
BOARDING_1_1	1	708970	708970	1494.04	0.000
ALIGHTING_1_1	1	70533	70533	148.64	0.000
Bd Sq_1_1	1	76735	76735	161.71	0.000
Alig Sq_1_1	1	2544	2544	5.36	0.021
Light Rain_1_1	1	6815	6815	14.36	0.000
Heavy Rain_1_1	1	10216	10216	21.53	0.000
Error	28185	13374668	475		
Lack-of-Fit	25605	13349636	521	53.74	0.000
Pure Error	2580	25032	10		
Total	28195	28402967			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
21.7837	52.91%	52.89%	52.86%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	19.431	0.618	31.43	0.000	
LENGTH_1_1	6.954	0.503	13.82	0.000	1.52
ADHERENCE_seg1_1_1	-0.039188	0.000809	-48.46	0.000	1.16
ACTSTOP_1_1	24.633	0.438	56.19	0.000	2.41
RCI_1_1	-0.2960	0.0127	-23.31	0.000	1.36
BOARDING_1_1	3.1354	0.0811	38.65	0.000	5.82
ALIGHTING_1_1	1.0163	0.0834	12.19	0.000	6.54
Bd Sq_1_1	-0.05081	0.00400	-12.72	0.000	4.64
Alig Sq_1_1	-0.00949	0.00410	-2.32	0.021	5.14
Light Rain_1_1					
1	1.219	0.322	3.79	0.000	1.06
Heavy Rain_1_1					
1	1.764	0.380	4.64	0.000	1.05

Regression Equation

STOPDELAY_1_1 = 19.431 + 6.954 LENGTH_1_1 - 0.039188 ADHERENCE_seg1_1_1
+ 24.633 ACTSTOP_1_1
- 0.2960 RCI_1_1 + 3.1354 BOARDING_1_1 + 1.0163 ALIGHTING_1_1
- 0.05081 Bd Sq_1_1 - 0.00949 Alig Sq_1_1 + 0.0 Light Rain_1_1_0

```
              + 1.219 Light Rain_1_1_1 + 0.0 Heavy Rain_1_1_0
+ 1.764 Heavy Rain_1_1_1
```

SD vs Motorway:

Regression Analysis: STOPDELAY_1_ versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	9	13086436	1454048	1460.04	0.000
LENGTH_1_1	1	2165767	2165767	2174.70	0.000
ADHERENCE_seg1_1_1	1	581603	581603	584.00	0.000
ACTSTOP_1_1	1	485029	485029	487.03	0.000
RCI_1_1	1	1046156	1046156	1050.47	0.000
BOARDING_1_1	1	304670	304670	305.93	0.000
ALIGHTING_1_1	1	59337	59337	59.58	0.000
Bd Sq_1_1	1	4719	4719	4.74	0.030
Alig Sq_1_1	1	46616	46616	46.81	0.000
Heavy Rain_1_1	1	9737	9737	9.78	0.002
Error	18044	17969909	996		
Lack-of-Fit	17308	17754592	1026	3.51	0.000
Pure Error	736	215317	293		
Total	18053	31056345			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
31.5578	42.14%	42.11%	42.07%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	90.54	4.29	21.10	0.000	
LENGTH_1_1	9.627	0.206	46.63	0.000	1.82
ADHERENCE_seg1_1_1	-0.023221	0.000961	-24.17	0.000	1.12
ACTSTOP_1_1	16.412	0.744	22.07	0.000	1.75
RCI_1_1	-1.6921	0.0522	-32.41	0.000	1.73
BOARDING_1_1	2.725	0.156	17.49	0.000	7.53
ALIGHTING_1_1	-1.047	0.136	-7.72	0.000	8.52
Bd Sq_1_1	-0.01764	0.00810	-2.18	0.030	5.89
Alig Sq_1_1	0.03293	0.00481	6.84	0.000	6.03
Heavy Rain_1_1					
1	2.101	0.672	3.13	0.002	1.00

Regression Equation

```
STOPDELAY_1_1 = 90.54 + 9.627 LENGTH_1_1 - 0.023221 ADHERENCE_seg1_1_1
+ 16.412 ACTSTOP_1_1
              - 1.6921 RCI_1_1 + 2.725 BOARDING_1_1 - 1.047 ALIGHTING_1_1
```

```
- 0.01764 Bd Sq_1_1 + 0.03293 Alig Sq_1_1 + 0.0 Heavy Rain_1_1_0
+ 2.101 Heavy Rain_1_1_1
```

SD vs Busway:

Regression Analysis: STOPDELAY_1_ versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

```
Method

Categorical predictor coding  (1, 0)


Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15


Analysis of Variance

Source                    DF    Adj SS   Adj MS   F-Value  P-Value
Regression                 9  18355052  2039450  15205.25    0.000
  LENGTH_1_1               1    804291   804291   5996.44    0.000
  ADHERENCE_seg1_1_1       1     42237    42237    314.90    0.000
  ACTSTOP_1_1              1   2032203  2032203  15151.22    0.000
  RCI_1_1                  1   1105993  1105993   8245.80    0.000
  BOARDING_1_1             1   1010150  1010150   7531.23    0.000
  ALIGHTING_1_1            1    204294   204294   1523.12    0.000
  Bd Sq_1_1                1     57882    57882    431.54    0.000
  Alig Sq_1_1              1     13826    13826    103.08    0.000
  Light Rain_1_1           1      2693     2693     20.08    0.000
Error                  88684  11895014      134
  Lack-of-Fit          81703  11175753      137      1.33    0.000
  Pure Error            6981    719261      103
Total                  88693  30250066


Model Summary

      S    R-sq  R-sq(adj)  R-sq(pred)
11.5814  60.68%     60.67%      60.67%


Coefficients

Term                      Coef   SE Coef  T-Value  P-Value   VIF
Constant                34.654     0.343   101.01    0.000
LENGTH_1_1               9.376     0.121    77.44    0.000  3.97
ADHERENCE_seg1_1_1   -0.002832  0.000160   -17.75    0.000  1.01
ACTSTOP_1_1             13.179     0.107   123.09    0.000  1.76
RCI_1_1               -0.63077   0.00695   -90.81    0.000  4.18
BOARDING_1_1            2.9904    0.0345    86.78    0.000  4.71
ALIGHTING_1_1           1.6774    0.0430    39.03    0.000  4.71
Bd Sq_1_1             -0.04611   0.00222   -20.77    0.000  3.57
Alig Sq_1_1           -0.03776   0.00372   -10.15    0.000  4.00
Light Rain_1_1
  1                      0.501     0.112     4.48    0.000  1.01


Regression Equation

STOPDELAY_1_1 = 34.654 + 9.376 LENGTH_1_1 - 0.002832 ADHERENCE_seg1_1_1
+ 13.179 ACTSTOP_1_1
```

```
- 0.63077 RCI_1_1 + 2.9904 BOARDING_1_1 + 1.6774 ALIGHTING_1_1
- 0.04611 Bd Sq_1_1 - 0.03776 Alig Sq_1_1 + 0.0 Light Rain_1_1_0
+ 0.501 Light Rain_1_1_1
```

SD vs Arterial:

Regression Analysis: STOPDELAY_1_ versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	9	2000949	222328	1187.40	0.000
LENGTH_1_1	1	27629	27629	147.56	0.000
ADHERENCE_seg1_1_1	1	5234	5234	27.95	0.000
ACTSTOP_1_1	1	371820	371820	1985.80	0.000
RCI_1_1	1	12300	12300	65.69	0.000
BOARDING_1_1	1	134857	134857	720.24	0.000
ALIGHTING_1_1	1	192286	192286	1026.95	0.000
Bd Sq_1_1	1	11416	11416	60.97	0.000
Alig Sq_1_1	1	20422	20422	109.07	0.000
Heavy Rain_1_1	1	448	448	2.39	0.122
Error	17392	3256468	187		
Lack-of-Fit	17102	3182712	186	0.73	1.000
Pure Error	290	73756	254		
Total	17401	5257417			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
13.6835	38.06%	38.03%	37.98%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	21.35	1.01	21.09	0.000	
LENGTH_1_1	-11.776	0.969	-12.15	0.000	1.03
ADHERENCE_seg1_1_1	-0.004150	0.000785	-5.29	0.000	1.04
ACTSTOP_1_1	15.967	0.358	44.56	0.000	1.38
RCI_1_1	-0.1408	0.0174	-8.11	0.000	1.23
BOARDING_1_1	2.0590	0.0767	26.84	0.000	5.70
ALIGHTING_1_1	1.6555	0.0517	32.05	0.000	4.64
Bd Sq_1_1	-0.03506	0.00449	-7.81	0.000	4.81
Alig Sq_1_1	-0.02003	0.00192	-10.44	0.000	4.16
Heavy Rain_1_1					
1	0.462	0.299	1.55	0.122	1.01

Regression Equation

```
STOPDELAY_1_1 = 21.35 - 11.776 LENGTH_1_1 - 0.004150 ADHERENCE_seg1_1_1
+ 15.967 ACTSTOP_1_1
          - 0.1408 RCI_1_1 + 2.0590 BOARDING_1_1 + 1.6555 ALIGHTING_1_1
```

```
- 0.03506 Bd Sq_1_1 - 0.02003 Alig Sq_1_1 + 0.0 Heavy Rain_1_1_0
+ 0.462 Heavy Rain_1_1_1
```

SD vs other type of roads:

Regression Analysis: STOPDELAY_1_ versus LENGTH_1_1, ADHERENCE_se, ACTSTOP_1_1, RCI_1_1, ...

Method

Categorical predictor coding (1, 0)

Stepwise Selection of Terms

α to enter = 0.15, α to remove = 0.15

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	8	2126842	265855	4880.94	0.000
LENGTH_1_1	1	10114	10114	185.68	0.000
ADHERENCE_seg1_1_1	1	869	869	15.96	0.000
ACTSTOP_1_1	1	259437	259437	4763.10	0.000
RCI_1_1	1	3985	3985	73.16	0.000
BOARDING_1_1	1	13642	13642	250.46	0.000
ALIGHTING_1_1	1	26193	26193	480.88	0.000
Bd Sq_1_1	1	1788	1788	32.82	0.000
Alig Sq_1_1	1	1420	1420	26.07	0.000
Error	13020	709174	54		
Lack-of-Fit	10200	696907	68	15.71	0.000
Pure Error	2820	12267	4		
Total	13028	2836016			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
7.38025	74.99%	74.98%	74.93%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-4.35	1.18	-3.70	0.000	
LENGTH_1_1	17.73	1.30	13.63	0.000	1.84
ADHERENCE_seg1_1_1	0.001757	0.000440	3.99	0.000	1.26
ACTSTOP_1_1	16.868	0.244	69.02	0.000	3.50
RCI_1_1	-0.07169	0.00838	-8.55	0.000	2.75
BOARDING_1_1	4.642	0.293	15.83	0.000	1.99
ALIGHTING_1_1	1.8759	0.0855	21.93	0.000	10.34
Bd Sq_1_1	-0.2392	0.0418	-5.73	0.000	1.84
Alig Sq_1_1	-0.03138	0.00615	-5.11	0.000	6.43

Regression Equation

```
STOPDELAY_1_1 = -4.35 + 17.73 LENGTH_1_1 + 0.001757 ADHERENCE_seg1_1_1
+ 16.868 ACTSTOP_1_1                - 0.07169 RCI_1_1 + 4.642 BOARDING_1_1
+ 1.8759 ALIGHTING_1_1               - 0.2392 Bd Sq_1_1 - 0.03138 Alig Sq_1_1
```