Terengganu routes representation for development of Malaysia Driving Cycle: Route selection methodology

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Abstract. A program to develop a harmonized light duty test cycle that will represent typical conditions for Malaysia is going to be developed, named Malaysia Driving Cycle (MDC). The development of MDC will adapt the methodology from the worldwide harmonized light duty driving test cycle (WLTC). Terengganu has been chosen as one of the regions for in-use driving data collection. In developing MDC, the route selection phase must be carried out first before proceeding to the route data collection. This paper describes briefly on the methodology used for the route selection, the selected routes and the driving conditions for route data collection in Terengganu region. Road Traffic Volume Malaysia (RTVM) version 2015 and Google Maps are used to study the route selection in Terengganu region. By adapting the methodology of WLTC, 11 routes in the Terengganu region have been selected to contribute the speed-time data for development of Malaysia Driving Cycle (MDC). The selected routes consist of urban, rural, and motorway road. For the route data collection, the driving conditions (peak, off-peak, weekend) are considered to collect the samples for each route and direction.

Keywords. Route selection, driving cycle, Terengganu region, Malaysia driving cycle, driving condition, light duty driving test cycle.

1. Introduction
Transport carbon emissions are the major contributory of air pollution [1]. Emission standards play a major role in controlling the vehicular emissions for a cleaner air. Many countries use driving cycles to determine regional vehicular emissions due to traffic patterns [2]. By using measured emission inventories as baseline emission, standards are set up or emission zones are established to control emissions. Through the working party on pollution and energy transport program (GRPE), a worldwide harmonized light duty driving test cycle (WLTC) was introduced to represent typical driving characteristics around the world [3]. A driving cycle is a series of data points that represents speed versus time [4], speed and gear selection as a function of time [2], speed versus distance [5], or time versus gradient [6] in a specific region or part of a road segment. Driving cycles have been used throughout the world for traffic engineering [7], emission purposes [8] and to estimate the fuel
consumption [9]. A test vehicle will run on a chassis dynamometer according to developed driving cycles to estimate the fuel consumption and to develop the emission inventories by collecting the total emission. Then, the collected emissions are analysed by using a gas analyser [10]. Malaysia Automotive Institute (MAI), an agency under the Ministry of International Trade and Industry (MITI), initiated a program to develop a harmonized light duty test cycle for Malaysia, known as Malaysia Driving Cycle (MDC), which will represent typical conditions for Malaysia. Terengganu, which is located in the east coast of Peninsular Malaysia, has been chosen as one of the regions for in-use driving data collection. In the process of developing MDC, the route selection phase must be carried out first before proceeding to the route data collection, the cycle construction and the cycle assessment. This paper describes briefly on the methodology used for the route selection, the selected routes and the driving conditions for route data collection in Terengganu region.

2. Methodology of Terengganu route selection

Figure 1 presents the flowchart of Terengganu route selection methodology. All routes in Terengganu region were studied by referring to Road Traffic Volume Malaysia (RTVM) version 2015 published by the Ministry of Works, Malaysia [11]. The traffic flow and quality of traffic service for each route is categorized based on level of service (LOS). Raw data of traffic volume is extracted first from RTVM 2015 then ranked up based on the LOS and peak hour traffic flow as shown in Figure 2. All routes are selected based on consideration of LOS and traffic volume. If the selected route is in the same networks or chains, the route is discarded as described in [12]. The route selection was also verified with Google Maps to confirm the traffic conditions of selected routes. On the other hand, Google Maps will not only be utilized to assess the road geography of selected routes, but also to determine the start/end point. Self-assessment and route validation are obligatory to ensure the selected routes are free from major road construction and any road diversion before route data collection is started.

![Figure 1. Flowchart of Terengganu route selection methodology.](image-url)
Table 1 summarizes the selected urban roads that represent LOS F at Terengganu, which there are 3 routes with census stations and 2 routes without census stations. Route 1 (R1), covers the location from Gong Badak to Kuala Terengganu, route 2 (R2), covers the location from Kuala Terengganu to Chendering through Surau Panjang, and route 3 (R3), covers the location from Kuala Terengganu to Jerteh. Another 2 routes are selected to cover the urban roads in the inner city of Kuala Terengganu (KT). Meanwhile, route 4 (R4), covers the north inner city and route 5 (R5) covers the south inner city as shown in Figure 4.
Table 1. Selected urban roads.

| Route | Census station no. | LOS | Start point | End point | Peak hour | Distance covered (km) |
|-------|-------------------|-----|-------------|-----------|-----------|-----------------------|
| R1D1  | TR405             | F   | Petron Gong Badak | Shell Bukit Tunggal | 0700 - 0800 | 6.8                   |
| R1D2  | TR405             | F   | Shell Bukit Tunggal | Petron Gong Badak | 1700 - 1800 | 8.2                   |
| R2D1  | TR406             | F   | SMK Seri Payong | Masjid Kg. Kubang Ikan | 1700 - 1800 | 7.4                   |
| R2D2  | TR406             | F   | Masjid Kg. Kubang Ikan | SMK Seri Payong | 1700 - 1800 | 7.4                   |
| R3D1  | TR103             | F   | Masjid Al-Falah | Shell Kg. Padang Luas | 1200 - 1300 | 6.3                   |
| R3D2  | TR103             | F   | Shell Kg. Padang Luas | Masjid Al-Falah | 1200 - 1300 | 7.5                   |
| R4D1  | KT North Inner City | F | Shell Cabang Tiga | Food Court Batu Burok | 1700 - 1830 | 5.5                   |
| R4D2  | KT North Inner City | F | Food Court Batu Burok | Shell Cabang Tiga | 1700 - 1830 | 7.2                   |
| R5D1  | KT South Inner City | F | Plaza Perabot Perdana | Shell Burok | 1700 - 1830 | 5.6                   |
| R5D2  | KT South Inner City | F | Shell Burok | Plaza Perabot Perdana | 1700 - 1830 | 6.4                   |

Table 2 summarizes the selected rural roads at Terengganu identifying 2 routes that represent LOS C and 2 routes that represent LOS A. For LOS C, route 6 (R6), covers the location from Kuala Terengganu to Jerteh through Tepoh, while route 7 (R7), covers the location from Kuala Terengganu to Jerteh through Mengabang Panjang and Batu Rakit. Meanwhile, for LOS A, route 8 (R8), covers the location from Kuala Terengganu to Kuala Berang and route 9 (R9), covers the location from Kuala Berang to Tanggol.

Table 2. Selected rural roads.

| Route | Census station no. | LOS | Start point | End point | Peak hour | Distance covered (km) |
|-------|-------------------|-----|-------------|-----------|-----------|-----------------------|
| R6D1  | TR401             | C   | Caltex Bukit Jong | Shell Kuala Nerus | 0700 - 0800 | 9.3                   |
| R6D2  | TR401             | C   | Shell Kuala Nerus | Caltex Bukit Jong | 0700 - 0800 | 7.7                   |
| R7D1  | TR404             | C   | Masjid Al-Ehsan | Petronas Mukim Merang | 1700 - 1800 | 8.5                   |
| R7D2  | TR404             | C   | Petronas Mukim Merang | Masjid Al-Ehsan | 1700 - 1800 | 8.5                   |
| R8D1  | TR407             | A   | Caltex Bukit Payong | Shell Wakaf Tapai 2 | 0700 - 0800 | 13.0                  |
| R8D2  | TR407             | A   | Shell Wakaf Tapai 2 | Caltex Bukit Payong | 1700 - 1800 | 14.0                  |
| R9D1  | TR501             | A   | Masjid Kg. Pengkalan | SK Tanggol | 0700 - 0800 | 12.5                  |
| R9D2  | TR501             | A   | SK Tanggol | Masjid Kg. Pengkalan | 1700 - 1800 | 12.5                  |

Table 3 summarizes the selected motorway roads at Terengganu that cover the East Coast Expressway (ECE), which consists of ECE1 (LPT1) and ECE2 (LPT2). Highway 1 (H1), covers the location from Karak to Jabor (LPT1), while highway 2 (H2), covers the location from Jabor to Kuala Nerus (LPT2).

Table 3. Selected motorway roads.

| Route | Census station no. | LOS | Start point | End point | Distance covered (km) |
|-------|-------------------|-----|-------------|-----------|-----------------------|
| H1D1  | -                 | -   | Plaza Tol Jabor Outbound | Plaza Tol Gambang Outbound | 36.1                   |
| H1D2  | -                 | -   | Plaza Tol Gambang Outbound | Plaza Tol Jabor Outbound | 36.7                   |
| H2D1  | -                 | -   | Plaza Tol Kuala Terengganu | Plaza Tol Ajil | 31.7                   |
| H2D2  | -                 | -   | Plaza Tol Ajil | Plaza Tol Kuala Terengganu | 32.7                   |
Figure 3. Locations of route selection at Terengganu.

Figure 4. Location of north (Route 4) and south (Route 5) inner city in Kuala Terengganu.

4. Self-assessment of the road geography and traffic conditions

Figure 5 demonstrates a Google Maps assessment and verification of traffic conditions for the selected routes in Terengganu region. Google Maps is not only capable to view the live traffic conditions, but also the typical traffic conditions in an area for a specific day and time. Verification of traffic conditions by Google Maps is necessary rather than relying solely on RTVM data since the traffic conditions can be displayed more effectively.
5. Driving conditions for route data collection

Apart from selecting routes based on the road types (urban, rural and motorway), the driving conditions (peak, off-peak and weekend) were also taken into account in the development of WLTC [3]. The peak hours for each route have been stated in Table 1, Table 2 and Table 3. There is no peak hour for motorway roads. Therefore, for Terengganu region, the data samples for peak and off-peak conditions are collected on Monday, Tuesday and Wednesday (weekday). In the meantime, the weekend data samples are collected on Saturday. Table 4 summarizes the number of samples to be collected for each route and direction based on the driving conditions.

Figure 5. Examples of traffic condition assessment by Google Maps.
Table 4. Driving conditions for route data collection

| Driving conditions | Samples for each route and direction |
|--------------------|--------------------------------------|
| Peak               | 3                                    |
| Off-peak           | 2                                    |
| Weekend            | 2                                    |
| Highway            | 2                                    |

6. Conclusion
This paper mainly focuses on the route selection at Terengganu as one of the regions in Malaysia contributing to speed-time data collection for overall MDC data collection campaign. The route selection are based on RTVM data version 2015 by referring to the level of service (LOS) and peak hour traffic flow for each route in Terengganu region. 11 routes have been selected to represent the Terengganu region, which consists of urban, rural, and motorway road based on WLTC. It is recommended to verify the traffic conditions by Google Maps and to perform self-assessment to ensure the selected routes are free from major road construction and any route diversion. The speed-time data collection can be executed once all the selected routes are validated to be suitable for route data collection.

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