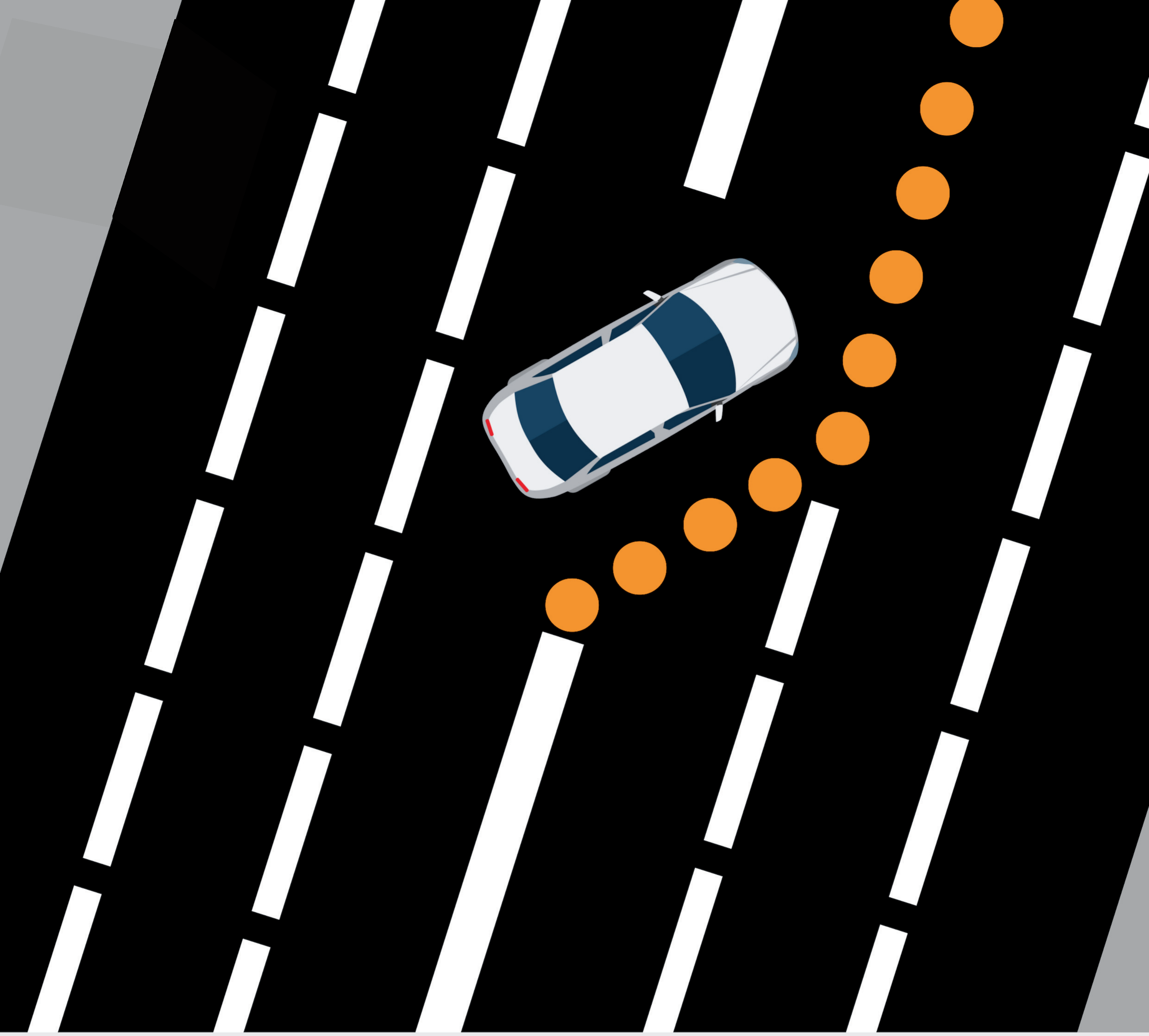

IMPLEMENTING TIDAL FLOW LANE SYSTEM

2023
GUIDELINE

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

KEMENTERIAN PENGANGKUTAN MALAYSIA

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FOREWORD

In bustling urban environments, traffic congestion has become an unfortunate reality that affects the lives of millions of people every day. Traffic congestion not only leads to frustrating delays but also has adverse effects on productivity, air quality, and the quality of life for individuals and communities. It hampers economic growth, strains transportation systems, and poses challenges for emergency response services. As cities in Malaysia continue to grow and thrive, the challenge of managing traffic congestion has become increasingly critical. It is imperative that we explore innovative and effective solutions to address this issue and ensure the smooth flow of traffic for the benefit of all road users.
Recognizing the urgency of the situation, both short- and long-term solutions are required to provide relief to congested road networks. Tidal flow lanes (TFLs), among other strategies, emerge as a viable and practical option for easing traffic bottlenecks and enhancing overall traffic flow efficiency.

This guideline serves as a valuable resource for policymakers, transportation planners, and engineers seeking effective ways to address traffic congestion in Malaysia. By examining the principles and considerations behind implementing TFL, this document offers practical insights and best practices to guide the planning and implementation of these traffic management measures. The guideline regards traffic density factors, especially areas that reach Level of Service (LOS) E and is considered as a short-term solution.

While TLF may not be a panacea for all traffic congestion problems, they offer a tangible and immediate solution that can be implemented relatively quickly. By utilizing existing road infrastructure more efficiently and optimizing traffic flow in congested areas, TLF can significantly alleviate congestion-related challenges.

In short, this guideline aims to ensure the uniformity and effectiveness of implementing tidal route and to provide the best satisfaction and service to road users. In relation, it is hoped that this guideline will be able to assist the government in drafting, improving, modifying, and setting national infrastructure development policies from time to time.

1 INTRODUCTION

The post-pandemic period has witnessed a significant exacerbation of traffic congestion in Malaysia. A report from The World Bank titled "Malaysia Economic Monitor, June 2015 - Transforming Urban Transport" highlighted the alarming fact that working-class Malaysians endure approximately one million wasted hours per day due to traffic congestion, a figure that is expected to have doubled since the report's publication. The cumulative toll of one million hours lost to traffic congestion annually equates to a staggering RM 10–20 billion.

Recognizing the gravity of the situation, the Malaysian government has expressed deep concern over the escalating traffic congestion in Kuala Lumpur and has set goals for a comprehensive solution by 2030. In pursuit of this objective, the Cabinet Committee on Traffic Congestion (JKMJR) under the Deputy Prime Minister's leadership has been tasked with developing strategies to alleviate the traffic issues. These efforts involve close collaboration between various stakeholders.

In response to the urgent need for effective measures to mitigate traffic congestion, the Minister of Transport has entrusted the Malaysian Institute of Road Safety Research (MIROS) with the responsibility of creating a comprehensive guideline for implementing the Tidal Flow Lane (TFL) System. This guideline will serve as a standardized framework to be adopted by all Malaysian road authorities as one of the key countermeasures to alleviate traffic congestion.

This process and procedure outlined within this document will serve as a valuable resource for planners, engineers, and policymakers involved in the transportation sector. By embracing innovative solutions and collaborative efforts, we can forge a path towards a more seamless and efficient transportation network that meets the needs of our growing population.

1.1 The TFL System

The TFL is an established traffic management strategy that has proven effective in mitigating traffic congestion. This approach involves reversing the direction of travel on designated lanes thereby increasing the directional capacity (Ampountolas et al., 2018). TFL implementation is predominantly targeted on existing roads that experience capacity issues during peak hours due to increased traffic (Kutz, 2004). Additionally, TFL can be employed during special events such as large sporting gatherings, concerts, or evacuation scenarios, as well as when the number of regular driving lanes is reduced due to roadworks (Kutz, 2004; Elvik et al., 2009; AASHTO, 2011). Figure 1 depicts the general layout of the TFL, aimed at improving traffic capacity and reliability of the overall road transport system. The class of vehicles allowed through this TFL is Class 1 (passenger cars/vans/multi-purpose vehicles) and Class 4 (taxi/limo) only.

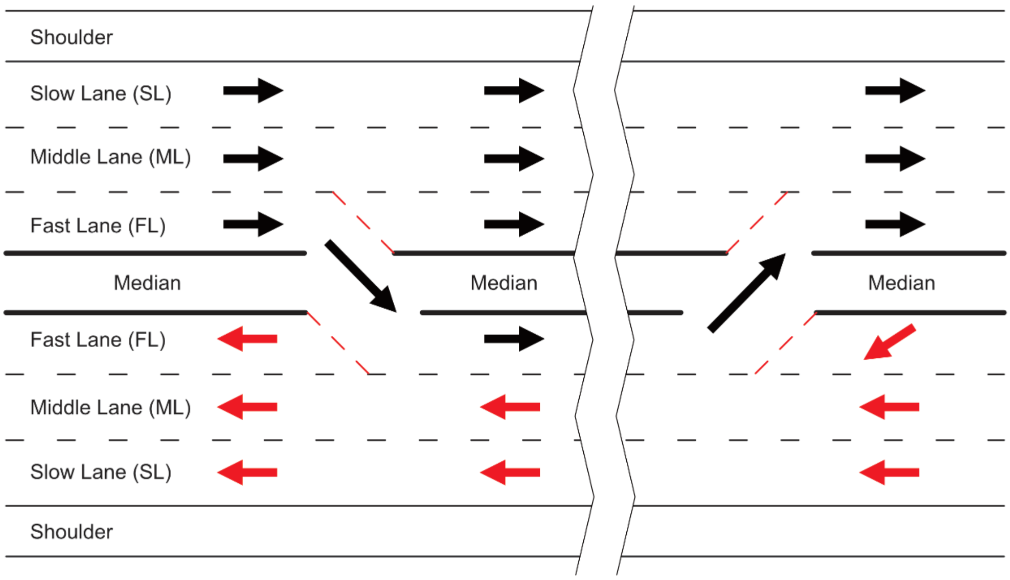


Figure 1: Tidal Flow Lane

1.2 Purpose and Aim

This guideline aims to establish standardisation and facilitate the regulatory process in implementing the TFL in Malaysia. It is applicable for use on selected road alignments involving planned traffic dispersal. It is the responsibility of all road authorities to ensure the smooth flow of traffic on the existing route, provide acceptable level of travel comfort for road users, and avoid the possibility of crash while the tidal route is in operation.

This guideline serves as a guide for all road authorities planning on implementing the TFL system. Road authorities are encouraged to adhere to this guideline ensuring uniform standards are achieved. Indirectly, this guideline will increase the safety awareness among TFL operators without sacrificing the safety of road users and the traffic flow.

The purpose of this guideline is:

i. To ensure that the TFL system is able to disperse the traffic in order to improve the level of service for the road users.
ii. To ensure that the measures taken by road operators implementing the tidal flow system are more systematic, efficient, orderly, uniform, and safe.

1.3 Scope of the Guideline

This guideline is applicable for the implementation of a TFL system on Malaysian roads which includes guiding principles, determining the TFL feasibility, as well as its flow of operation and management. The guideline is intended for the implementation of planned TFL on selected road which has fulfilled the criteria presented in section 2. The implementation of the TFL is a short-term countermeasure by road authorities to overcome the traffic congestion at peak times (morning and evening) and road authorities are to ensure a certain Level of Service (LOS) on their roads.

2 TFL GUIDING PRINCIPLES

The implementation of TFL requires the establishment of guiding principles to ensure a safe and efficient traffic management system. These principles provide a framework for road authorities to plan, design, and operate TFL in a manner that maximizes the benefits of the operations while minimizing potential risks and hazards.

2.1 The Guiding Principles

Road authorities are responsible for adhering to guiding principles, devising appropriate policies, and allocating adequate resources to ensure the safe and effective operation of TFL. In the execution of these duties, they are also expected to implement contingency plans in the event of unforeseen circumstances that pose risks to the safety of road users. Adhering to these principles yields significant benefits, the most significant being the reduction of the risk in road crashes.

2.1.1 Principle 1: Acknowledging the Negative Effects

There are many studies outlining both the positive and negative implication of TFL implementation related to traffic flow conditions, travel-time, crash risk and others (Elvik *et al.* 2009). It is crucial that road authorities and relevant stakeholders possess a comprehensive understanding of the detrimental outcomes that can arise from the implementation of a poorly conceived TFL plan. To facilitate this understanding, Figure 2 outlines the significant positive and negative effects that are closely linked to TFL operations.

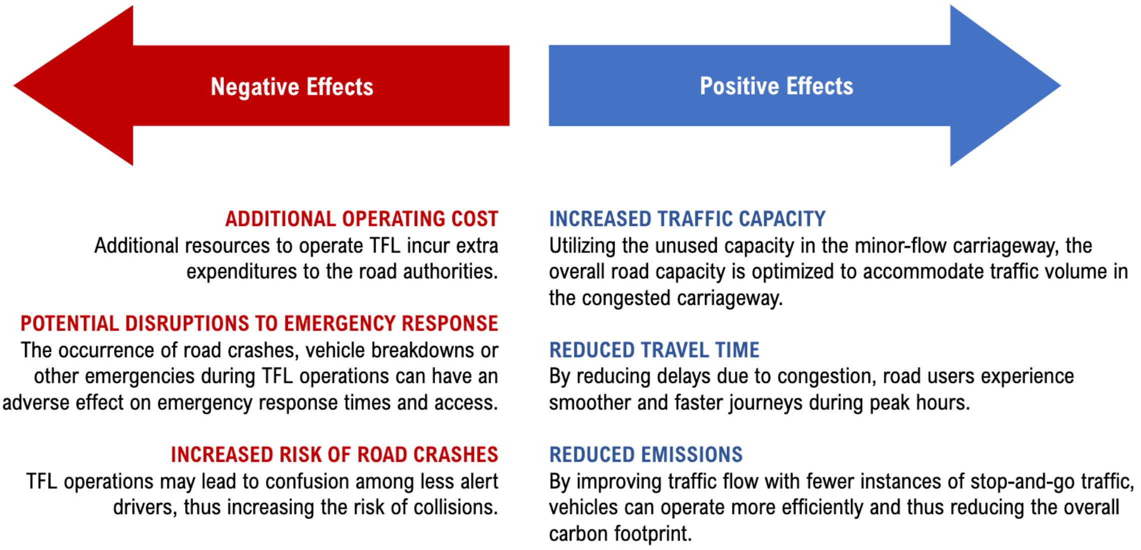


Figure 2: List of major positive and negative effects of TFL

By acknowledging the presence of negative effects with TFL implementation, road authorities should incorporate strategies within their implementation plan to assess the magnitude of each countermeasure.

2.1.2 Principle 2: Minimizing Risk to Collisions

Proper management is essential to address the safety risks associated with TFL operations. Previous studies indicate increases in the numbers of crashes, especially in rush hours; the effects of TFL on crashes have been estimated as shown in Table 1 (Elvik *et al.* 2009). However, the analyses indicate that the increases are non-significant, suggesting there may be unaccounted factors affecting the study.

Table 1: Effects of TFL on crashes

Crash severity	**Percentage change in the number of crashes**		
	Types of crash affected	Best estimates	95% confidence interval
Injury crash	All crash	+18	(-16; +66)
Unspecified	Crash in rush hour	+15	(-3; +37)
	All crash	+4	(-5; +13)

One of the primary risks is the increased potential for head-on collisions. The risk of head-on collisions along TFL is similar to a single carriageway unless a portable safety barrier system is used to segregate the opposing flows. Additionally, at the entry point of the TFL, there is an elevated risk of rear-end collisions due to significant difference in vehicle speeds. The risk of collisions due to the implementation of TFL may be contributed by the following:

i. Confusion about the right of way.
ii. Reduced lane width.
iii. Inadequate separation measures
iv. Limited sight distance
v. Lane misuse (by direction or vehicle type)

To mitigate these risks, good risk management strategies should be adopted. It is recommended that road authorities align their risk management strategies according to the hierarchy as shown in Figure 3. In risk management strategy, the most effective approach is to eliminate the risk altogether. Further reduction or mitigation in risk is in ensuring that the TFL operates by selecting locations with low risk of crashes for the starting and ending points and shortening the operation time. The least effective approach within the hierarchy is by using protective gear to minimize injuries. However, it is denoted that at all levels of risk mitigation, the use of protective gear is essential and should be implemented for all on-site personnel.

Figure 3: The hierarchy of risk management and examples of associated actions

2.1.3 Principle 3: Ensuring a Positive Return-On-Investment

Implementation of TFL incurs additional costs to the road operators as more resources (e.g., personnels, equipment, materials, and time) are required to carry out the operation. These are on top of costs affecting others such as road crashes, travel-time losses (which could be the case when TFL is poorly designed) and environmental pollution that are often neglected but highly significant as far as the socio-economic and the health of people is concerned. Evaluating the ROI sometime into the implementation of TFL is important because it not only informs decision makers on the extent of the positive effects of the strategy but also the scale of any negative impacts upon the road users, the road authorities, and the environment in the longer term. Decision makers should particularly set a high priority to address the latter to ensure that these impacts are kept lower than they were before TFL is implemented.

A commonly used analysis in the evaluation of ROI is the benefit-cost ratio (BCR). The benefit components need to be determined and assessed over a period long enough for sufficient information to be collected. The metrics associated with the benefit components need to be monetized and compared with the cost component to determine if the ROI is positive (where the nett benefit is more than the cost) or negative (nett benefit less than the cost). To produce reliable estimates of ROI, it is recommended that road operators engage with the relevant consultants to collect information and perform analyses to derive the following metrics (not limited to):

i. Travel time before and during TFL implementation
ii. Risk of road crashes before and during TFL implementation

In circumstances when the TFL operations' ROI is negative, it warrants the road operator to call for a pause and evaluate what could be improved to yield a positive ROI. If left unchecked, negative ROI yields long-term negative impacts such as increasing deaths and injuries that caused permanent disabilities, increasing operating costs, and sustained environmental degradation. Hence, economic appraisal of TFL implementation is a critical component for good decision making and accountability. Figure 4 shows the processes that should be undertaken periodically by the road operators to ensure they strive towards achieving higher ROI throughout the TFL implementation.

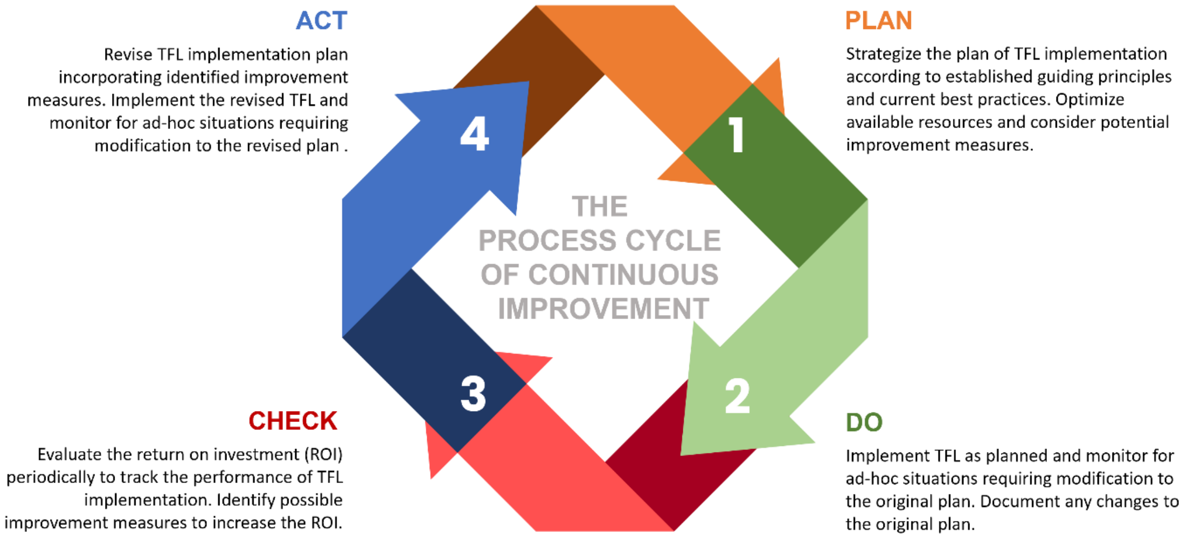


Figure 4: The PDCA Cycle of continuous improvement

2.2 Translating adoption of guiding principles into actions

As many industry players are now embracing the best practices of ESG (environmental, social and governance) in their business operations, it is important for every road operator to ensure their TFL operations follow the above guiding principles while maximising the ROI. Implementation of TFL that adopts ESG best practices not only help in the preservation of the environment (through reduction in carbon emissions by alleviating congestion) but could also ensure the safety of on-site personnel and minimize unnecessary expenditures through good labour practices and good corporate governance.
For road operators that have been publishing their annual public sustainability reports, incorporating disclosures of the metrics on their TFL operations can indeed help in adding value to their ESG performance.

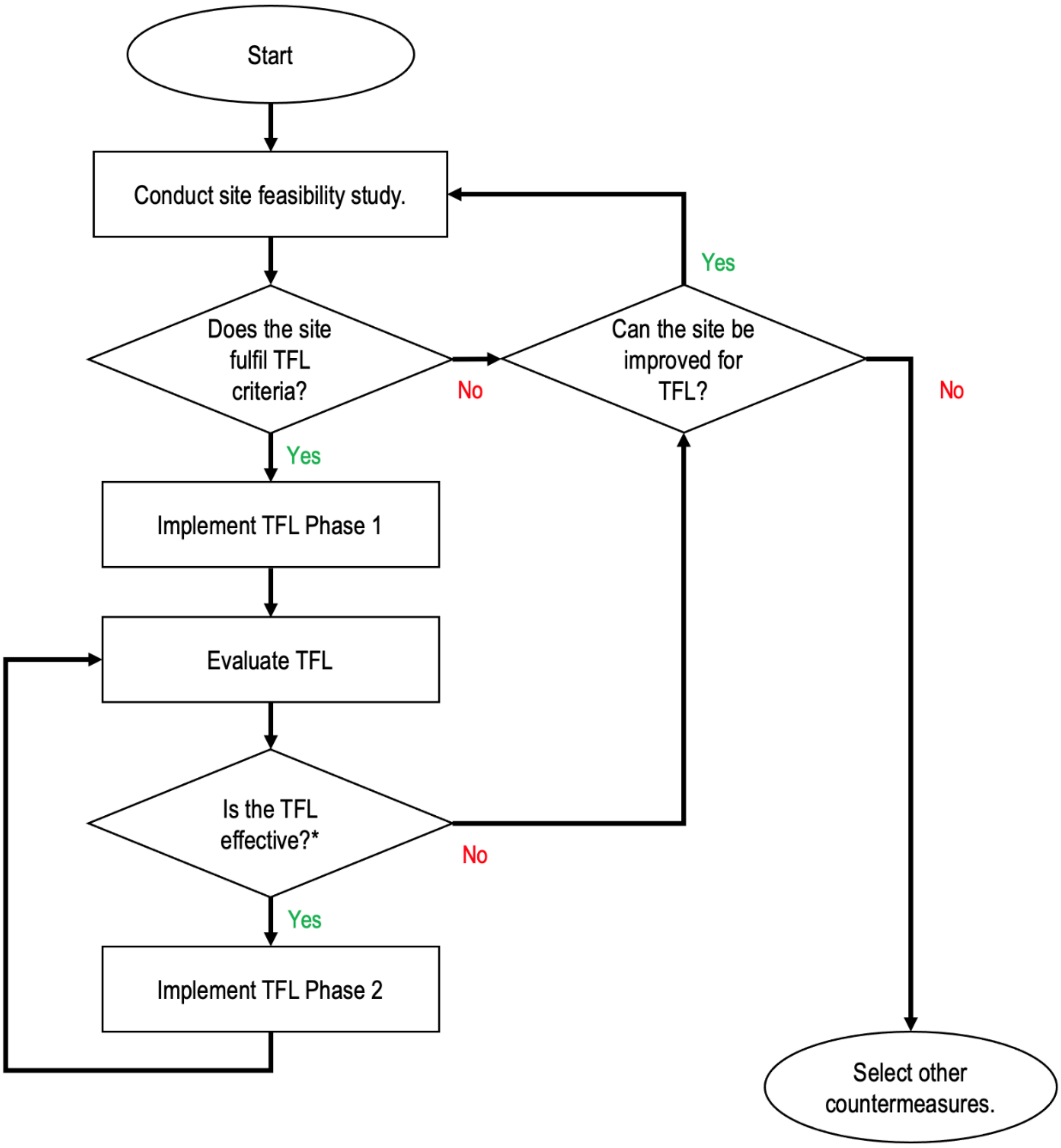
All in all, regardless of the scale of the TFL operations and the nature of constraints, road operators are highly recommended to regard the following practices as their priorities:

i. **Design** the system to be 'forgiving' to human errors: We must respect the limitations of human as a road user such that the TFL must be a self-explaining lane. Although considered as a temporary traffic management strategy, due consideration must be given to its design to minimize human errors.
ii. **Adopt** a variable operation time: There should not be a fixed daily operation time but instead shorten the operation time as much as possible within the gazetted hours. On-site personnel should monitor the traffic situation and call for early closure if necessary (when traffic eases or when there is a breakdown).
iii. **Invest** in cost-effective solutions in operating the system: Some technologies require high up-front costs but yield long-term returns. They are both cost-effective and safer compared to conventional way of handling on-site operations such as mobilizing and demobilizing of channelizing devices and guiding the traffic.

3 TFL EXECUTION FLOW

The establishment of guiding principles for implementing TFL is essential in striking a balance between mobility and safety. Road authorities have the responsibility of ensuring the adoption of these principles and taking the necessary actions to establish a safe and effective TFL system.

Below is process flow in the planning and implementation for TFL (Figure 5). The flow to implement the TFL begins with obtaining prerequisite documents and information, followed by the feasibility study, then confirming the criteria for TFL. When the criteria are met and the decision has been made to set up a TFL system, a two-phase operation process shall be applied.



* As TFL is considered a short-term (3-5 years) solution, plans for a sustainable and long-term solution should be considered.

Figure 5: Process flow of TFL installation

3.1 Feasibility Study

The feasibility study consists of a series of decision making based on information obtained from existing documents as well as on-site verification.

3.1.1 Prerequisite Documents and Information

To gain a comprehensive understanding of the proposed road segment for TFL, authorities planning to implement the TFL must obtain the information specified in Table 2.

Table 2: Prerequisite documents and information for TFL

	Documents and information	Compulsory	Optional
1	Proposed location plan or as-built drawings of the road	X	
2	Daily traffic data (e.g., 16-hour or 24-hour count daily traffic count)	X	
3	Level of Service (LOS) at the proposed location both direction	X	
4	Proposed design of the TFL (distance, start and end location)	X	
5	History Crash data		X
6	Road safety audit stage 5 or road safety inspection		X

3.1.2 Site Verification

Research has indicated that TFL are applicable on certain types of roads that fulfil prerequisite criteria (Striewski et al. 2022; Elvik et al. 2009). Therefore, site visit should be conducted during peak and off-peak hour to verify site condition. Strip map consisting of all access points (ramp, interchange, signalised junction) should be generated to assist in observing the traffic flow patterns.

3.1.3 TFL Criteria

The TFL implementation requires careful consideration and must confirm to three key criteria i.e., traffic composition, road geometry, and road safety as outlined in Table 3. The traffic composition criteria aid authorities in understanding the current traffic patterns during peak hours. This analysis enables them to identify the prevailing traffic directions and evaluate the volume of vehicles using the road segment. This information helps determine the necessity of the TFL and guides decisions on its optimal lane location and direction, leading to significant congestion reduction.

The physical layout and geometry of the road segment play a critical role in the successful implementation of the TFL. Factors such as the number of lanes, lane width, entry and exit points, merging zones, and any potential bottlenecks or obstacles along the segment must be carefully evaluated. By ensuring proper road geometry, the TFL can seamlessly integrate with the existing road infrastructure, preventing unnecessary disruptions and enhancing the overall traffic flow efficiency.

An additional criterion of utmost importance during the implementation of the TFL is safety. Comprehensive safety assessments must be conducted to identify and mitigate potential risks associated with the lane configuration. Factors such as visibility, signage and lane markings should be optimized to minimize the chances of crashes or conflicts between vehicles using the TFL and those in adjacent lanes. Furthermore, consideration should be given to pedestrian safety and the impact of the TFL on pedestrian crossings and access points.

Table 3: Criteria for TFL

Criteria		Congested carriageway	Minor-flow Carriageway (Proposed TFL)
1) **Traffic Composition**	Percentage split traffic volume*	65%	35%
	Heavy vehicle flow rate*	< 20 HV / hour	-
2) **Road Geometry**	Number of carriageways	Dual	
	Minimum length of the proposed TFL	1 kilometre	
	Minimum number of lanes	3 lanes	3 lanes
	Start and end point of TFL	- At straight road section - Median width is less than 3 metre - Gradient at less than ±3% - Clear and adequate visibility - **NOT** at split-level median/carriageway - Careful considerations should be made regarding type of access configuration such as signalised intersections, consecutive off- and on- ramp, and close-spacing access that may cause further disruption to the traffic flow.	
3) **Road Safety**	Maximum 85^{th} percentile speed*	-	90km/h
	Visibility	Must have adequate street lighting along the proposed TFL.	
	Other	It is **NOT** recommended to have a TFL if there are: - at-grade pedestrian crossing - sharp curve - location with limited or obstructed horizontal sight distance. - tunnel	

Notes:
*Data during peak hour, and heavy vehicle in this case is classified as lorry trailer/ articulated lorries, rigid lorries with 2 or more axles and the permissible gross weight exceeding 2.5 tons.

3.2 Implementation Phase

Once the criteria are fulfilled, TFL can be implemented. The implementation of TFL is divided into two phases; Phase 1 and Phase 2. Additionally, promotion and awareness of the TFL is required prior to the implementation of TFL (as detailed in section 4.6).

i. Phase 1:
   a. Phase 1 is a trial period of **3 months,** in which the road authority is required to evaluate the operation in terms of traffic flow operation and traffic safety.
   b. Engineering judgement is essential in determining TFL implementation. Authorities have the option to employ various methods, including road safety inspection (RSI), traffic impact assessment (TIA), and pre- and post-evaluation of the TFL. Input from the public can serve as valuable feedback to determine the need for further analysis on the suitability of TFL.
   c. The evaluation findings will result in either of the following decisions:

- Positive trial assessment, i.e., traffic condition improves with TFL. This allows TFL implementation to proceed to Phase 2;
- TFL activation worsens traffic conditions, authorities should reassess the site to identify opportunities for facility enhancement to adopt TFL or consider alternative solutions. The findings will dictate the progression of the TFL to Phase 2.

ii. Phase 2:

  a. Phase 2 is a one-year operational period, which can only be executed if Phase 1 outcome is positive.
  b. The performance of TFL in Phase 2 is closely monitored and evaluated at the end of the one-year period. Following similar evaluation procedure in Phase 1, and using sound engineering judgement, authorities can decide whether to resume TFL for the following year and repeat the monitoring and evaluation process as shown in Figure 5.
  c. As TFL is considered a short-term solution (3-5 years), plans for a sustainable and long-term solution should be in place.

4 TFL OPERATIONS

To ensure a smooth and safe operation during the 3-month trial period (Phase 1) implementation, it is crucial to establish an appropriate setup for the TFL. The subsequent section outlines the operational setup requirements for TFL, which include the traffic management plan, equipment utilization, personnel and vehicle preparation, response and monitoring facilities, as well as promotion and awareness activities.

4.1 Traffic Management Plan (TMP)

The Traffic Management Plan of TFL consists of a basic guide for determining the optimal start and end points of TFL and the standard traffic management drawing suggested to be imposed on site.

4.1.1 The start and end point of TFL

The start and end points of the TFL are crucial for safety and traffic efficiency. They serve as transition zones where drivers must be aware of changing traffic patterns. These zones required to be equipped with clear signage to give drivers enough information about the switch in lane direction and ample time to make appropriate decision.

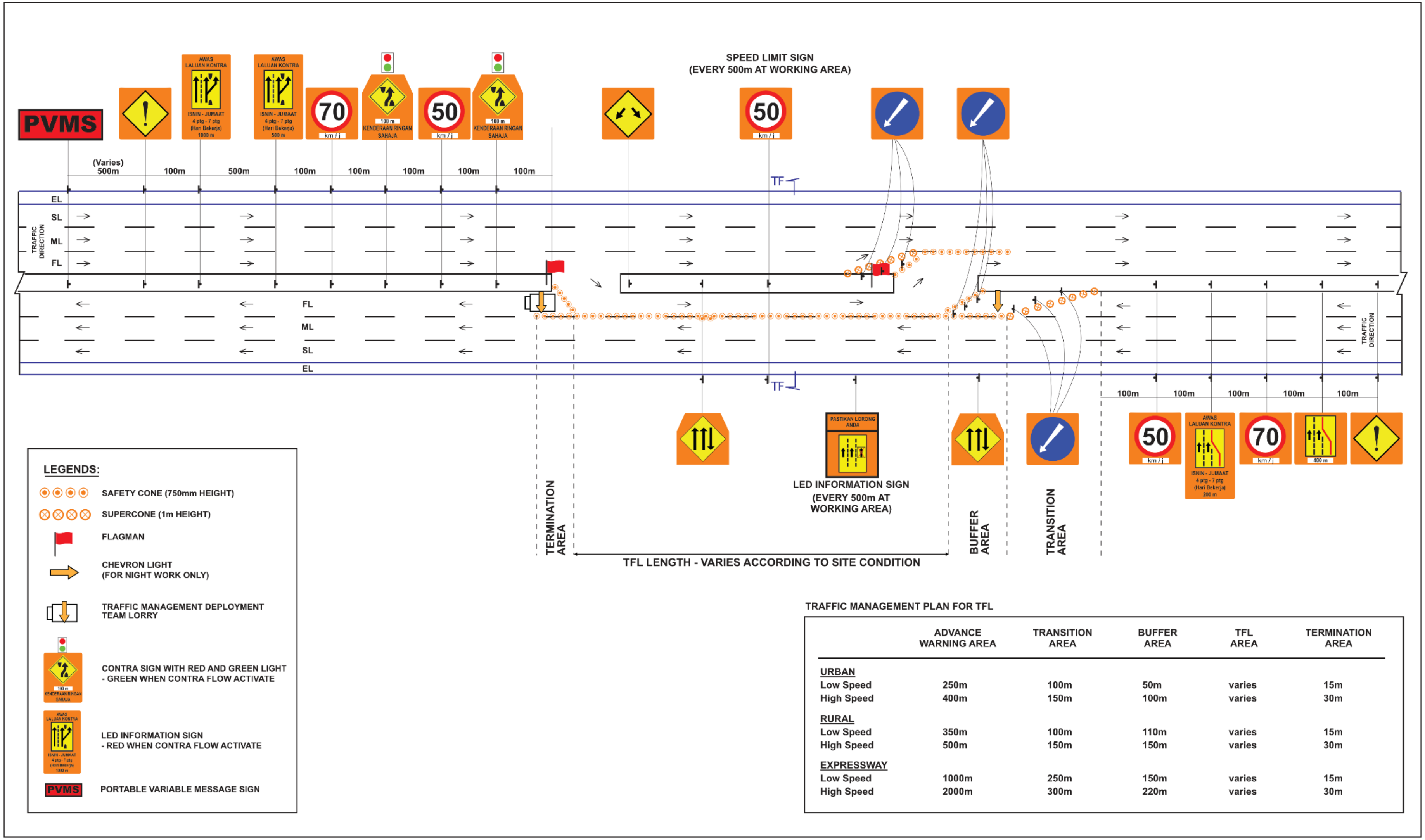
Selecting optimal start and end points is vital as the TFL aims to maximize road capacity during peak hours while minimizing inconvenience to drivers during lane direction changes. Properly chosen the start and end points prevent confusion and potential crashes. Table 4 provides a summary of advisable TFL start and end points.

Table 4: Advisable TFL start and end points

Recommended	Not Recommended
Straight road section Gradient at less than ±3% Clear and adequate visibility Ensure no blind spots	Curve road section or dangerous bends Gradient at more than ±3% Median with split level of carriageway Weaving area more than 500m Location with two or more consecutive exits are to be at least 500m apart In tunnels Where open drainage is present on median

4.1.2 Standard drawing and layout

Figure 6 illustrates the standard drawing for the TMP, outlining crucial information about traffic signs, cones position, and barriers, as well as designated traffic flow directions. This drawing provides a consistent reference for authorities and contractors, ensuring the effective and uniform implementation of the TFL. Adherence to this standard enhances safety, optimizes traffic flow, and minimizes disruptions during TFL activation, creating a safer and more efficient road environment for all road users.



	ADVANCE WARNING AREA	TRANSITION AREA	BUFFER AREA	TFL AREA	TERMINATION AREA
URBAN					
Low Speed	250m	100m	50m	varies	15m
High Speed	400m	150m	100m	varies	30m
RURAL					
Low Speed	350m	100m	110m	varies	15m
High Speed	500m	150m	150m	varies	30m
EXPRESSWAY					
Low Speed	1000m	250m	150m	varies	15m
High Speed	2000m	300m	220m	varies	30m

Figure 6: Proposed TMP for TFL

4.2 Equipment

It is essential to inform road users about TFL and provide them with sufficient time to safely and orderly enter or exit the TFL. The TFL systems typically employ multiple lane control methods such as the use of traffic cones and warning signs to notify vehicles in both directions, aiming to minimize confusion and prevent head-on collisions. However, the control methods for these lanes are not limited to a specific approach, and road authorities are encouraged to incorporate the latest technology for on-site implementation.

4.2.1 Cone and Safety Barriers

Traffic guidance cones are an essential safety tool that increases visibility, is lightweight and portable, and has great stability via its wide base. Several aspects must be considered when employing a traffic guidance cone, pre-, during, and post- TFL activation:

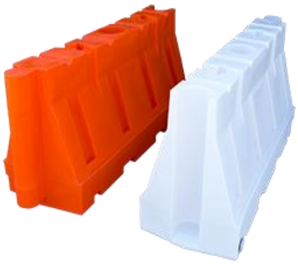
i. Pre-activation of TFL: Arrange the traffic guidance cone starting from the opening point in accordance with the predetermined placement (see Figure 6). To ensure stability, the traffic guidance cone shall be weighted down with a rubber base, preventing displacement caused by strong winds or surface runoff.
ii. During TFL activation: On-site personnel continuously monitor the lane to ensure that the placement of the cones (spacing between cones is 10 meters - 12 meters) is orderly and organized.
iii. Post-TFL activation: Before deactivating the TFL, traffic operators must ensure that all vehicles have exited the lane. The collection of cones placed along the TFL should follow a "first in, last out" approach. To gather the cones, operators should travel in the opposite direction of the traffic flow, ensuring that all vehicle headlights and beacon lights are switched on to draw attention to the vehicle ahead.

The equipment required for lane control are outlined in Table 5 below.

Table 5: Type of traffic guidance cone used in TFL operation

No.	Equipment details	Picture	Placement	Remarks
1	**Super Cone 1000mm** used to close or separate the TFL from road users for a period of less than 24 hours. Minimum Weight: 6kg		Each configuration requires a 5-metre distance.	Transition area/Taper Zone

Table 5: Type of traffic guidance cone used in TFL operation (Cont.)

No.	Equipment details	Picture	Placement	Remarks
2	**750mm Safety Cone** used to close or separate the TFL from road users for a period of less than 24 hours. Minimum Weight: 4.4kg		Straight road: 10 meters - 12 meters	Working Zone
3	**New Jersey Barrier (NJB) – Plastic Type** Weight: Dry weight of 10kg Dimension: 1000mm (L) x 800mm (H) x 500 (W)		Entry and exit points for the TFL	Shall be organised alternating colours of red and white and must be interlocked.

Source: Garis Panduan Pelaksanaan Pengurusan Trafik: LLM/GP/T6-08

4.2.2 Signages

Various factors need to be taken into account regarding road signage in TFL operations:

i. Pre-activation of TFL: install warning signs before placing cones.
ii. Post-activation of TFL: remove all warning signs and turned away from traffic in both directions.

The specific details of the road signage required for the TFL are provided in the Table 6 and may differ according to road authority and TFL operation.

Table 6: Type of signage used in TFL operation

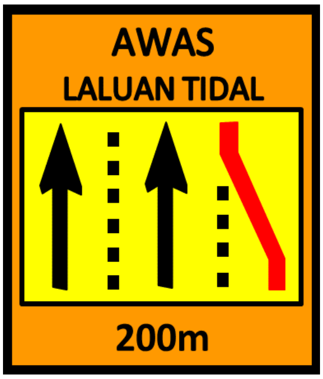
No.	Equipment details	Picture	Placement	Remarks
1	**Temporary Informative Sign** Shape: Rectangular Size varies according to legend (word message / symbol) on sign. Colour: Black on Orange background		200 meters.	Placed at 200 meters before the TFL entrance.
2	**Temporary Informative Sign** Shape: Rectangular Size varies according to legend (word message / symbol) on sign. Colour: Black on Orange background		200 meters	Placed in the opposite lane, the right lane is closed to traffic.
3	**Temporary Directional Arrow Sign (T28)** Provide early information to users about the transition lane ahead.		At transition area/tapper zone and buffer area.	Traffic is diverted from the TFL.

Table 6: Type of signage used in TFL operation (Cont.)

No.	Equipment details	Picture	Placement	Remarks
4	**TFL Diversions Start Sign** *(Papan Tanda Permulaan Lencongan Laluan Tidal)*		50 meters.	Placed at 50 meters before the start of the temporary road diversion.
5	**Temporary Special Signs "CLASS 1 & 4 (LIGHT VEHICLES ONLY)"**		100 meters.	Placed at the entrance of the TFL.

Source: LLM, Pasport Keselamatan Operasi Lebuh Raya (EOSP) and JKR Standard Specification for Road Works – Section 19: Traffic Management at Work Zones

4.2.3 Additional equipment

Alongside the deployment of traffic cones and warning signs, it is recommended to utilize supplementary equipment, such as digital signage or Intelligent Transportation Systems (ITS) equipment (see Table 7), during the TFL operation. This will enable users to receive real-time safety information, ensuring they stay well-informed throughout the duration of the TFL operation.

Table 7: Various digital displays used to assist TFL system

No.	Equipment details	Picture	Placement	Remarks
1	Variable Message Sign (VMS) or Electronic Board	 	Before entering the TFL or at the end or the termination area of the TFL	* Green arrows (existing path and tidal path) * Red arrow (remaining lane after 1 lane for tidal passage)

Table 7: Various digital displays used to assist TFL system (Cont.)

No.	Equipment details	Picture	Placement	Remarks
2	Digital signage indicating activation or deactiation of TFL	 	In the TFL	The green arrow indicates that the tidal pathway is being activated

Source: LLM, Pasport Keselamatan Operasi Lebuh Raya (EOSP) and JKR Standard Specification for Road Works – Section 19: Traffic Management at Work Zones

4.3 Personnel Safety

Road worker safety training and the proper use of personal protective equipment (PPE) are crucial aspects of ensuring the well-being of those engaged in road works and maintenance.

4.3.1 Training

All personnel must undergo task-specific training, with a strong focus on safety. Comprehensive training programs should be provided to all road workers, emphasizing safety protocols, hazard identification, and emergency procedures. In certain situations, it may be beneficial to conduct a rehearsal on an abandoned segment of roadway to further enhance preparedness and coordination.

Additionally, to ensure efficient and smooth operations, a supervisor should thoroughly review installation assignments with the crew before heading into the field. This step becomes particularly crucial when introducing new procedures or when there are new team members. Regular safety refreshers and updates on new equipment are essential to reinforce safe practices and minimize risks.

4.3.2 Personal Protective Equipment (PPE)

PPE plays a vital role in improving the safety and well-being of workers engaged in road works. PPE for road works typically includes high-visibility clothing, hard hats and safety boots. Employers should conduct thorough risk assessments to identify potential hazards and provide appropriate PPE to ensure the safety and well-being of road workers. The following are the recommended for workers:

i. High-visibility safety jacket: This includes fluorescent-coloured vests or jackets with reflective strips, making workers easily visible to motorists and other workers, especially in low-light conditions.
ii. Safety helmet: These protect the head from falling objects and potential impacts on construction sites or in areas with overhead hazards.
iii. Safety boots: Sturdy, steel-toed boots offer foot protection against heavy objects, sharp debris, slippery surfaces, and other potential hazards.

iv. Safety gloves: Gloves provide hand protection from cuts, abrasions, and exposure to harmful substances.

Employers should ensure that the PPE used are in good functioning condition. For example, the reflective material on high-visibility clothing should not be dulled out by dirt. The combination of these essential PPE items ensures that road workers are well-protected and can carry out their tasks with increased safety and confidence.

By prioritizing safety training and proper PPE usage, road workers can confidently execute their tasks, reducing the likelihood of accidents and creating a safer work environment for everyone involved.

4.4 Vehicle Operation

Special traffic control vehicles should be available for placement, maintenance and removal of traffic control devices and signs. The vehicle may be in the form of lorries used for the traffic management deployment and emergency response.

4.4.1 Traffic management deployment team lorry

The following is the proposed specification for the traffic management deployment team (TMDT) lorry:

i. The lorry shall be a minimum 1 tonne lorry with cargo hood and grill and shall be white in colour.
ii. The lorry shall be equipped with the following accessories:
   a. Arrow light mounted on lorry rooftop with collapsible holder.
   b. Reflective yellow and red stripes with 150mm width on both sides and rear of the lorry.
   c. Project sticker with package location, hotline number and contractor logo.
   d. Digital video camera (DVR) to be fixed in the lorry.
   e. 1 unit of strobe light (amber-coloured) fixed on the lorry rooftop.

The application requirements for TMDT lorry are as follows:

i. TMDT lorry shall be used to ferry workers and/or traffic management devices.
ii. The lorry and accessories shall be maintained by the contractor at all times to ensure that the lorry and accessories are in good condition.

4.4.2 Roof mounted LED arrow light for TMDT lorry

Roof mounted LED arrow light should be mounted on the TMDT lorry with proposed recommendations:

i. The support frame shall be a minimum of 400mm x 400mm x 3mm thick angle iron.
ii. The light shall be able to work even when vehicle's engine is turned off.
iii. The light shall have a flashing frequency of 40 - 55 times per minute.
iv. It shall be visible from a minimum distance of not less than 1000m to warn the road users.
v. The dimensions of the board shall be 1280mm (L) x 750mm (H).
vi. The LED shall be able to show the Arrow Left, Arrow Right and Double Arrow

The application requirements for roof mounted LED arrow light are as follows:

i. During operations, the LED arrow light shall be mounted on TMDT lorry rooftop with collapsible holder to secure the arrow light board.
ii. LED arrow light shall be used when the TMDT lorry carries out its duty at work area.
iii. Displaced, malfunctioning or damaged arrow light boards shall be rectified immediately.

4.4.3 Emergency response team (ERT) vehicle

Specification for ERT vehicle:

i. The vehicle shall be a minimum 1 tonne lorry with cargo hood and shall be white in colour.
ii. Each ERT lorry shall be equipped with the following accessories:
    a. 1 unit of amber coloured light bar fixed on the rooftop.
    b. Reflective yellow and red stripes with 150mm width on both sides and rear of the lorry.
    c. Project sticker with package location, hotline number and Contractor logo.
    d. Digital video recorder (DVR) to be fixed in the lorry.
    e. Built-in rack at the back of the lorry for storage of ERT equipment.

Requirements for ERT:

i. ERT lorry shall be provided by the Contractor to the Traffic ERT for patrolling and attending to emergency needs and situations for day and night operations.
ii. The response time to reach affected area and initiate necessary action shall not be more than 30 minutes.
iii. Each ERT lorry shall be equipped with a complete set of ERT equipment.
iv. Equipment inside the ERT lorry shall be stored properly at all times to ease the handling and installation process when attending to emergency needs and situations.
v. The ERT lorry and accessories shall be properly maintained at all times to ensure that they are in good working condition.
vi. ERT lorry vehicle is strictly for the use of ERT personnel only and its use to ferry workers is strictly prohibited.
vii. Sufficient equipment should be available, and this includes (not limited to):
    a. Battery powered torch lights
    b. Blinkers
    c. Brooms
    d. Car battery jumper
    e. Fire extinguisher
    f. First-aid kit
    g. Flat head scoops
    h. Oil absorbent
    i. Toolbox
    j. Towing cable set
    k. Traffic super cones
    l. Water pump with accessories
    m. Walkie-talkies

4.5 Response and monitoring

In the event of any emergency or incident, it is of utmost importance to prioritise saving lives and minimising losses. Consequently, the concessionaires or operators must always be on standby and fully prepared to respond swiftly to any unexpected situation within the TFL area or at the entry and exit points of the TFL. The response teams should be composed of:

i. Towing and recovery vehicle - the vehicle should be prepared on site to ensure the fast and efficient recovery of any breakdown vehicle.
ii. Motorcycle patrol - is preferred over larger response vehicle due to its ease manuevre characteristic and able to reach the site quickly. The motorcycle patrol officer should be trained to be able to administer first aid, secure the scene, and actively manage traffic during incident.
iii. Scene management team - to be provided to clear any debris or wreckage resulting from any incident.
iv. Decision maker at control room - The personnel on site must be always in contact with the decision makers at the control center to ensure that appropriate decisions can be made based on the condition at scene. The decision maker should also contact the relevant agencies such as POLICE, BOMBA, hospital or JPAM immediately. In addition, the control centre should also make announcement about the incidents on the nearest VMS, and other social media to alert the road users.

After the incident occurrence, the team should carry out incident investigation to find out the root cause of the incident. The investigation report should include:

i. The details of the incident (including the location, vehicles, and persons involved);
ii. Photographic evidence;
iii. All the equipment used at the incident scene.

Figure 7: Rescue team or Ronda (Source: Grand Saga FB)

4.6 Promotion and public awareness

Promoting the use of TFL on highways can be an effective way to improve traffic flow and reduce congestion. The use of TFL systems requires a multi-faceted approach, including education, awareness, and stakeholder involvement. By implementing these multifaceted strategies, the public can be effectively engaged in the adoption of TFL on highways. The following strategies can be implemented to increase awareness amongst road users on tidal flow operations along their route commute:

i. Engage stakeholder involvement:
   a. Collaborate with transportation authorities, city officials, and community organizations to jointly promote TFL systems through various initiatives.
   b. Conduct pilot projects and field trials of TFL systems on selected highway sections to gather data and demonstrate their positive impact.
   c. Continuously monitor and evaluate the effectiveness of TFL systems and communicate the ongoing benefits to the public through updated data and statistics.
ii. Develop and implement education and awareness campaigns
   a. Develop an educational campaign to inform the public about the benefits and functioning of TFL on highways.
   b. Use visual representations, such as graphics or animations, to help people understand how TFL systems work and their advantages.
iii. Conduct public engagement
   a. Encourage public engagement by soliciting feedback, conducting surveys, and organizing public meetings to address concerns and gather suggestions.
   b. Gather testimonials and case studies from those who have experienced the benefits of TFL and share them through different media channels.
iv. Utilise media and service announcement medium:
   a. Work with local media outlets to generate positive coverage and raise awareness about TFL systems.
   b. Available Variable Message Sign (VMS) facility can also be programmed to display up-to-date information on TFL operation, specifically at entry and exit points as early warning to roadway users approaching the locations.

4.7 Prohibition of Motorcycles and Heavy Vehicles

The implementation of the TFL System necessitates strict adherence to vehicle type regulations to ensure optimal traffic flow and safety. Motorcycles and heavy vehicles are prohibited from utilizing the TFL. This prohibition is crucial to maintain the efficiency and effectiveness of the TFL, as motorcycles may not adhere to the same traffic patterns as larger vehicles, potentially causing disruptions, while heavy vehicles may impede the flow of traffic due to their size and slower acceleration. To enforce this prohibition, clear and conspicuous signage will be strategically placed along the TFL, indicating the restrictions on motorcycles and heavy vehicles. Additionally, dedicated enforcement personnel will be stationed to monitor and enforce compliance, supported by appropriate legal measures and penalties for violations. It is imperative that these regulations be communicated comprehensively to the public to ensure a smooth and successful operation of the TFL System.

5 CONCLUSIONS

The TFLs is an established short term traffic management strategy that has proven effective in mitigating traffic congestion. The purpose of a TFL is to increase road capacity in the direction with the heavier traffic flow during peak hours. By using one or more lanes of minor-flow carriageway for traffic in the congested direction and adjusting the flow as needed, the system aims to alleviate congestion and improve overall traffic flow efficiency.

The purpose of establishing this Guideline for Implementing the TFL System is to provide a valuable resource for road authorities, policymakers, transportation planners, and engineers in Malaysia who are seeking effective solutions to tackle traffic congestion. The implementation of the TFL system should adhere to three main principles: recognizing the potential drawbacks of TFL, minimizing collision risks, and ensuring a positive return-on-investment. By adhering to these principles, the safe and effective operation of the TFL can be ensured.

The TFL implementation also requires careful consideration and must conform to three key criteria i.e., traffic composition, road geometry, and road safety. The understanding on the traffic composition helps to understand peak hour traffic patterns, identifying prevailing directions and vehicle volume so that optimal TFL location and direction decisions will effectively reduce congestion. Road segment geometry evaluation ensures seamless TFL integration and safety assessments prioritize visibility, signage, and lane markings to minimize crashes and pedestrian risks during TFL implementation.

While TLF may not be a panacea for all traffic congestion problems, they offer a tangible and immediate solution that can be implemented relatively quickly.

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