GROSTLOG 2018
Global Research on Sustainable Transport & Logistics

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/atlr

Strategies To Overcome Traffic Congestion In Jakarta Through Color Clustering Car (C3) Approach

Suharto Abdul Majid[1*], Tjuk Sukardiman[2], Aang Gunawan[3], Andri Primadi[4], Hendro Kuntohadi[5], R. Didiet Hidayat[6], Irwan Chairuddin[7], Nuryadi[8], Syaiful Anwar[9]
[1,2,3,4,5,6,7,8,9]Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia
*Corresponding Author: samtrisakti1531@gmail.com

Abstract

The level of congestion in Jakarta is getting higher by diverse-complex factors; one of which is caused by the unbalanced growth of vehicles volume with the length of road. This research aimsto find ways to overcome traffic through the private vehicles restriction approach based on the vehicle colors, known as color clustering or color grouping. The purpose of this paper is to (1) Determine the profile and vehicle color trends that exist in DKI Jakarta, (2) Determine the contribution of color clustering method in reducing traffic congestion in Jakarta.Data are collected through observation and interview surveys. The data collection is done by using systematic sampling. Data analysis applies quantitative statistical data analysis and daily traffic average (LHR) formula. Results showthere is trend in private car colors that is dominated by black (39.4%), silver (28.5%), white (21.2%), red (5.3%), blue (3.4 %), green (1.18%), gold (0.6%), yellow (0.2%), and pink (0.05%). Implementing color clustering in reducing the traffic level varies in different scenarios with minimal contribution limit at the average of 20%. Contributions can be improved by adding the time off for each color group in a scheduling period.

Keywords: Traffic Congestion, Vehicle Color, Transportation Demand Management, Car Pooling

Introduction

Land transportation in urban areas, especially in Jakarta facing complex and difficult problems: congestion and road density in almost any location. The planning and realization of infrastructure development has often been done, but the congestion persists.

Many attempts have been carried out by transportation experts in Indonesia, and the results have not appeared optimistic about the smooth, orderly, neat and pleasant traffic. Construction of new infrastructure has been widely implemented,

but it enhances highway user demand, particularly the use of private cars and motorcycles.

Directorate of Traffic Police of the Metropolitan Jakarta Raya cited the growth of vehicles reached 5,500 up to 6,000 units per day. The number is dominated by motorcycle that reaches 4,000 to 4,500 units per day. As for the growth of four-wheeled vehicles reaches 1,600 units per day;every yearit increases 12 percent.

According to the Public Relations of Jakarta Police, the number ofvehicles in Jakarta until December 2014 is as follows: 3,226,009 units of private cars, 362,066 busses, 673,661 units of freight cars, 13,084,372 motorcycles, and 137,859 units of special vehicles. The total number of vehicles in Jakarta is as many as 17,523,967 units.

Meanwhile, the length of roads in the city reached 7208 Km, meet only 60 percent of the total actual needs. Based on the calculation of the Ministry of Public Works (PU), with a population of nearly 12 million people, Jakarta needs a road along 12,000 Km.

With the addition of area or length of the road averaged of 1%, while the growth in the number of vehicles in Jakarta averaged over 10 percent per year, big possibility that the city will be paralyzed in 2016 when no serious, systematic, and comprehensive strategies and efforts to prevent it.

Color Clustering or Color Grouping is a strategy to restrict the use of private vehicles operating on the streets, since the volume of private vehicles operating on the roads is not comparable with the breadth and length of roads available.

Literature Review

According to the Center for Strategic Studies of Public Works (2009), the congestion in the capital area has become a chronic disease since early 1990s, with the trend towards an increasingly alarming. Various solutions are offered, but none runs effectively to overcome the problem; because the solutions offered (eg: line 3-in-1, special bus lane, road improvements and the construction of toll roads) tend to be disaggregated (partial), not systematic, and not continuous.

One of the crucial and complex issues occuring in the city of Jakarta and other major cities in the world is the traffic jam that is now increasingly alarming. Congestion is theoretically characterized by the unstable flow, slow travel speed, and long queues of vehicles, which typically occurs at a concentration of socio-economic activities or on the crossing traffic in urban centers.

Severe congestion, as happened in Jakarta can be viewed from two sides: the supply side and demand side.

Pustra PU stated that the increase in roads (including toll roads) in Jakarta, Bogor, Depok, Tangerang, Bekasi (Jabodetabek) is 1% per year, which is not comparable to the rate of vehicle reaching 11% per year. This causes severe congestion at peak hours.

Data from the Automotive Industry Association in Indonesia (2014) showed that the production and sale of vehicles in Indonesia rose sharply every year, where vehicle production is not able to offset the high market demand. As an illustration, in 2013, the number of vehicles produced by Gaikindo amounted to 1,206,543 units while the number of demands as much as 1,229,811 units. There is a difference of 23,268 units of market demand has not been met by the national automotive industry. This trend continued since 2008 to 2013.

Academics discuss principles to overcome the congestion, one of which is the principle of transit-oriented development (TOD) and transportation demand management (TDM). TOD can be categorized as one of the urban planning concepts, such as intelligent urbanism or smart growth which stresses the importance to develop an efficient city in land use.

In Jakarta, the average speed at peak hours has reached 10 km per hour and the volume capacity ratio (VCR) in some metropolitan areas have already reached 100 percent (Tamin, 2016).

Another study linking congestion with increased expenses due to traffic cost was conducted by Gito Sugianto, Siti Malkamah, Munawar Ahmad, and Heru Sutomo (2011) – taking the case in the urban center of Yogyakarta, Indonesia.Sugianto et al stated that traffic jams happen when travel demand exceeds

the road capacity. Their research results show an increase of congestion cost for private car users Rp 2,914.99 per trip. This amount shows the difference of the result of congestion in general for Rp 5,513.77 per trip when compared to the free flow speed condition (no loss) amounted to Rp 2,598.78 per trip.

Ofyar Z. Tamin (2003) stated that many countries begin to accept the fact that the increase in transport demand will never be accommodated in the transport infrastructure system. That's because efforts to increase the quality and quantity of transportation service system in a given area will improve the accessibility in those areas which would stimulate the re-occurrence of an increase in transport demand.

Therefore, the "predict and provide" approach used by decision makers in various policies on urban transport systems development in Indonesia, should be replaced with "predict and prevent" approach – one of the efforts is by managing the need for transportation, known as transportation demand management (TDM).

Orski (1998) in Tamin (2008) defined TDM as a way to influence the behavior of movement perpetrators in order to reduce the magnitude of the need for movement or spreading these needs in space and time.

Mean while, Andrea Broaddus, Todd Litman and Gopinath Menon from GTZ Germany (2010), explained the transportation demand management (TDM) as a strategy to maximize the efficiency of urban transport system by limiting the use of private vehicles and promoting the more effective-healthy and environmentally-friendly transportations, such as public transport and non-motorized transport.

Color clustering method is a strategy to restrict the use of private vehicles that need to be tested and developed to overcome the level of congestion in major cities, as in Jakarta. The main principle of the color clustering is to limit the use of private vehicles on the road on a rotation based on the schedule set by policy makers. Other strategies on vehicles restrictions include a three in one, electronic road pricing (ERP) or satelite road pricing (SRP), the implementation of even-odd license plate number and vehicle age restrictions.

Dadang S, Ludfi D, Harnen S, and Achmad W (2012) declared that the concept of movement in urban areas is generally dominated by the movement of

commuters. The increase in population causes the more dense traffic and higher trip seizures and pull in the city. Jakarta Macro Transportation Pattern policy (PTM) that combines three strategies simultaneously is considered correct. As Tamin (2008) stated that none of the policies (single solution) can directly solve completely the problem of urban transport. The Policies taken should be a combination of some strategies to solve existing transportation problems.

Some keywords that underlie the color clustering approach are TOD, TDM, push and pull, and the promotion of mass transport usage done at once. The core concept is restricting the use of private vehicles through scheduling scheme of specific vehicle colors that may not operate on certain days. This strategy is part of sharing-space campaign on the same limited street. Implementing this strategy requires strong leadership and the political will of all stakeholders and at the same time a widespread awareness of the road users to accept the color clustering policy.

Research Method

The population in this study is all private cars in Jakarta based on data in 2015 as much as 8,358,327. Primary data of private cars based on three observation locations are as many as 367,215. The sampling method is carried out systematically and obtained minimum samples of 349.

The Daily Traffic Average (LHR) formula is applied to process the primary data, and is calculated as follow:

$$\text{LHR}=\frac{Q_x}{X}$$

Where:

Q_x = traffic volumes observed for more than 1 day and less than 365 days

X = number of observation days

If developed from a collection of field data with a particular Traffic Center (TC) duration, then the formula specified as follows:

$$LHR = \frac{\sum_{i=1}^{x} Q_x}{X \times \frac{t_1 - t_0}{24}}$$

Where:

Q_x = traffic volumes observed for more than 1 day and less than 365 days

X = number of observation days

t_0 = TC started time

t_1 = TC ended time

Sample collection on vehicle colors in Jakarta used both primary data and secondary data. Primary data was collected through sampling techniques. While secondary data were obtained from government institution, in this case from Regiden Ditlantas Polda Metro Jaya.

The survey was conducted in May and June 2015, each performed for one week observation in several observation points has been determined. The survey was conducted in the morning and afternoon.

The three observation locations chosen, referred as Traffic Center (TC), are TC1 Kebon Jeruk (direction Tangerang), TC2 Tamini (direction Bogor), and TC3 Galaxy (direction Bekasi). Those are in accordance with the traffic density level mapped in the Macro Transportation Pattern (PTM) documents, DKI Jakarta.

According to the PTM document (Elly Sinaga, 2011), the number of Jabodetabek trips in 2010 is as follows:

Total travel as much as 30,300,000 consists of traveling within the city of Jakarta 22,450,000, the journey from Tangerang and its surroundings as much as 3,250,000, trips from Bogor and its surroundings as much as 2,500,000, and trips from Bekasi and surrounding as much as 2,100,000.

Preceding the survey, interviews and discussions with experts in the field of transport (especially urban transport) were conducted, to get their view on overcoming traffic congestion in Jakarta by Color Clustering method. The transportation experts interviewed are coming from ITB, UGM, UI, Untar, and

Transport Studies Forum between universities and the Indonesian Transportation Society.

The views of the experts vary; some agree and some others disagree about color clustering research. But, in general they agree that this research has not been done, at least in the colleges where the experts work, and they support the research to be carried out – on the condition, later in practice, should be coupled with law enforcement, which means there must be a clear legal umbrella.

Result And Discussion

In the early part, the primary and secondary data and their interpretation are presented. At the second part, the calculation result and simulation of vehicle color data grouped by day and distributed Monday through Saturday are presented. Simulation on Sunday is ignored, considering that on Sunday relatively no traffic jam.

In the second part, scenarios on car colors that are not allowed to operate on certain roads are shown. Basically, private car owners are requested their willingness to not use their cars within one particular day in the Jakarta area – both for internal affairs in the city, out of town, or from the outside to the city. Instead, people are encouraged to use public transport on the day they cannot use private vehicles.

In the simulation, there are lots of options and scenarios based on the corridor, operation time allocation, day allocation, color combinations groupings, dark-light color grouping, and the number of days off for each color group. However, paying attention to the effectiveness and users' willingness on vehicle day off, the maximum day off is limited to two days in one week. Then not all the options are presented in this paper.

Here are the primary data of a survey result that was conducted in May 2015:

Primary data on private car colors are recorded under observation points considered congested traffic that is on TC1 Kebon Jeruk (direction Tangerang), TC2 Tamini (Bogor), and TC 3 Galaxy (direction Bekasi).

On TC1, revealed the dominant car colors are black, silver, white, red, blue, gold, green, yellow, and pink. On TC2, cars are dominated in black, silver, white, red, blue, gold, green, yellow, and pink. While on TC3, the dominant colors are black, silver, white, red, blue, green, yellow, pink, and gold. From the total of the three TCsare then obtained the dominant colors in the following order: (1) black, (2) silver, (3) white, (4) red, (5) blue, (6) green, (7) gold, (8) yellow), and (9) pink.

More on private car color data recorded by surveyors either on TC1, TC2 and TC3 on observation dates of 7th, 8th, 9th, 11th, 12th, and May 13th, 2015 respectively are presented in Table 1 below.

Tabel 1 Total Vehicle Colors under Total Observation Points (TC1, TC2, TC3)

Colors of Car	**TC 1**	**TC 2**	**TC 3**	**TOTAL**
Black	54295	44684	45859	144838 (40%)
White	23089	25782	29033	77904 (21%)
Silver	33085	34990	36735	104810 (29%)
Red	6843	6661	6073	19577 (5%)
Blue	3091	5275	4158	12524 (3%)
Yellow	267	332	79	678 (1%)
Green	1011	1333	1977	4321 (1%)
Pink	51	75	57	183 (0,1%)
Gold	2136	239	5	2380 (0,1%)
Total	123.868	119.371	123.976	367.215

Source: Processed from Survey Result, 2015

Secondary Data

Based on data of private cars in Jakarta taken from the Directorate of Traffic Polda Metro Jaya, during the period of last six years (2010-2015) there is a change of car colors trend where in 2010, the dominant car colors are respectively: (1) black (2,637,817), (2) blue (866,065), (3) red (837,633), (4) silver (385,551), and (5) white (260,843), followed by (6) green (250,230) and (7) yellow (87,600). Subsequently in 2015, the color sequence is dominated by: (1) black (3443329), (2) Red (1296697), (3) white (1021892), (4) blue (977 990), and (5) silver (472 499), followed by (6) green (322 363) and (7) yellow (138 701). In 2015 there is a

significant change of color trend in the following order: black, white, red, blue, silver, green, yellow, and brown. The black color still dominates and is followed by white.

Tabel 2 Data of Private Cars in DKI Jakarta Based on Colors, Year 2010-2015

Year	Colors of Car								
	Black	**White**	**Silver**	**Red**	**Blue**	**Green**	**Yellow**	**Brown**	**Others**
2010	2.637.817	260.843	385.551	837.633	866.065	250.230	113.344	87.600	401.270
2011	2.814.362	368.488	413.680	955.461	892.171	276.038	117.566	82.643	446.777
2012	3.009.601	636.150	425.645	1.078.288	904.901	297.472	120.189	84.347	499.713
2013	3.157.569	709.842	455.221	1.147.175	952.915	315.724	128.191	81.373	540.010
2014	3.314.252	889.060	465.100	1.241.569	974.886	324.138	133.522	84.365	579.357
2015	3.443.329	1.021.892	472.499	1.296.697	977.990	322.363	138.701	83.212	601.644

Source: The Indonesian National Police, 2015.

Note:

Data of 2010 – 2014, condition per December 31 Desember.

Data of 2015, condition per October 24th 2015.

Interview Results with Private Vehicle Users

During the interviews, six questions are proposed, consisting three enclosed questions and three open-ended questions.

The six questions are as follow:

(1) Do you use a private car to the office? (2) Do you use a private car every day? (3) Do you have more than one car? (4) Why do you use a private car? (5) Why don't you use public transportation? (6) What is your expectation that Jakarta jam-free?

The number of respondents who are willing to answer the questions is 60 private vehicle users are drawn at random to represent all three TC observation points.

For question number one, all 60 respondents(100%) use private vehicles. On question number two, 57 respondents (95%) answered "Yes" and 3 respondents (5%) answered "No".Fifteen respondents or 25% answered "Yes" to question number three, and 45 respondents or 75% answered "No". In responding question number four, the average answered more comfortable, safe, convenient,

economical, and flexible.To the question number five, the average answered the access is too far, crowded and inefficient in time. In responding question number six, the average answered reduce vehicles selling, improve facilities and public transport, add and simplify road access.

It is also revealed in the interview that the color of vehicles owned by respondents who answered "Yes" to question number one and two are as follows: Black (19), White (14), Silver (15), Red (6), Blue (1) Yellow (1), Green (2) Pink (1), Gold (0), and Others (1).

Meanwhile, from 15 respondents who answered "Yes" to question number three is obtained having more than one vehicles by colors is as follows: Black (8), White (2) Silver (2), Red (2), and Blue (1).

The respondents' answers illustrate the vehicle color trend – from the most to the least is dominated by the following colors: Black, Silver, White, Red, Blue, and Green. This is not much different from field observation and secondary data from Polda Metro Jaya.

The survey results are divided into two options: (1) Based on a combination of all corridors (TC1, TC2 and TC3), and (2) Based on corridors restriction, in this case TC1, TC2 and TC3 are calculated separately, as the characteristics are different. But in the second part, TC3 is not taken into account because the data is less valid, so that in the second part, only TC1 and TC2 are processed and analyzed.

The calculation and scheduling results more in the first part of option 1 and option 2 in Table 3 and Table 4 as follows:

Tabel 3 Scheduling Option 1: Cars with colors that can and cannot be operated

Colors	Percentage	Mon	Tue	Wed	Thus	Fri	Sat	Sun
Black	39%	v	v	v	Off day	v	v	v
White	21%	v	v	Off day	v	v	v	v
Silver	29%	v	Off day	v	v	v	v	v
Red, Blue, Yellow, Green, Pink, Gold	11%	Off day	v	v	v	Off day	v	v
Total Cars Operated	100%	89%	71%	79%	61%	89%	100%	100%

In option 1, with the scheduling of Monday through Friday, the color groups get one day off in a week is black, white, and silver, while the other color groups get 2 days off in a week. On average 22.2% reduction in congestion.

Tabel 4 Scheduling Option 2: Cars with colors that can and cannot be operated

Colors	Percentage	Monday	Tuesday	Wed	Thursday	Friday	Saturday	Sunday
Black	39.44%	v	v	v	Off day	v	v	v
White	21.21%	v	v	Off day	v	v	v	v
Silver	28.54%	v	Off day	v	v	v	v	v
Red	5.33%	Off day	v	v	v	v	v	v
Blue, Yellow, Green, Pink	5.47%	v	v	v	v	Off day	v	v
Total Cars operated	100.00%	94.67%	71.46%	78.79%	60.56%	94.53%	100%	100%

In option 2, the color grouping of the cars is increased to five color groups: black, white, silver, red, and other colors (in this case blue, yellow, green, and pink are grouped into one group). Each color group gets a day off in a week with Monday-Friday scheduling scenarios. The average reduction on vehicle operating in one week is by 20%.

More on the calculation and scheduling results at the second part are as follow: Based on sampling in TC1 and TC2 at 6:00 to 22:00, a recapitulation of daily traffic is obtained as follows:

Tabel 5 Recapitulation of the Total Number of Vehicles per Day in TC1 and TC2 (Survey Result at 06.00-22.00)

Colors of Cars	Thurs	Friday	Sat	Mon	Tues	Wed	Total / Day	Total
Black	16,383	16,619	15,894	16,586	16,909	16,588	16,497	98,979
White	7,794	8,234	7,901	8,303	8,467	8,172	8,145	48,871
Silver	10,982	11,475	10,826	11,752	11,724	11,316	11,346	68,075
Red	2,248	2,086	2,264	2,220	2,505	2,181	2,251	13,504
Blue	1,269	1,306	1,633	1,470	1,414	1,274	1,394	8,366
Green	405	340	438	387	410	364	391	2,344
Yellow	149	110	129	59	75	77	100	599
Pink	19	32	27	16	17	15	21	126
Gold	402	444	446	324	385	374	396	2,375
Total	39,651	40,646	39,558	41,117	41,906	40,361	40,540	243,239

Source: Processed from Survey Result, 2015.

If the survey duration is shortened by the cut-off at 18.00, then a recapitulation of daily traffic obtained is as follows:

Tabel 6 Recapitulation of Total Number of Vehicles per Day in TC1 and TC2 (Survey Result at 06.00-18.00)

Colors Of Cars	Thurs	Friday	Sat	Mon	Tues	Wed	Total /Day	Total
Black	13,425	13,169	12,232	13,265	13,964	13,507	13,260	79,562
White	5,992	6,428	6,071	6,481	6,721	6,584	6,380	38,277
Silver	8,726	9,201	8,485	9,185	9,260	9,324	9,030	54,181
Red	1,736	1,551	1,730	1,681	1,864	1,711	1,712	10,273
Blue	997	990	1,264	1,179	1,177	1,061	1,111	6,668
Green	357	293	323	327	346	309	326	1,955
Yellow	125	65	112	43	65	66	79	476
Pink	18	28	25	16	17	15	20	119
Gold	353	351	342	281	331	335	332	1,993
Total	31,729	32,076	30,584	32,458	33,745	32,912	32,251	193,504

Source: Processed from Survey Result, 2015.

Based on the LHR formula, the calculation obtained is as follow:

Qx	Q1	Q2	Q3	Q4	Q5	Q6
	21,496	20,437	21,184	20,512	19,891	20,348
x	6					
t_0	6					
t_1	22					
LHR	30,967					

Figure 2. LHR in TC1

Qx	Q1	Q2	Q3	Q4	Q5	Q6
	18,155	20,209	18,374	20,605	22,015	20,013
x	6					
t_0	6					
t_1	22					
LHR	29,843					

Figure 3. LHR in TC2

The setting on TC1 and TC2 based Monday-Friday scheduling at 6:00 to 22:00 (16 hours) and at 6:00 to 18:00 (12 hours) with a grouping of five colors and one day off for each color group, then the results are obtained as follow:

A. Scenario of Color Combinations in TC1 Monday-Friday (06.00 – 22.00)

Tabel 7 Scenario C3 in TC 1 (16 hours)

Colors	Days				
	MON	**TUES**	**WED**	**THURS**	**FRI**
Black	9,049				
White		3,848			
Silver			5,514		
Red				1,141	
Blue				515	
Green					169
Yellow					45
Pink					9
Gold					356
Others					
Total	9,049	3,848	5,514	1,656	578

Tabel 8 Scenario C3 in TC1 (16 hours)

Colors	Days					TOTAL	%
	MON	TUES	WED	THURS	FRI		
Total Average / day (Normal)	20,645	20,645	20,645	20,645	20,645	103,223	100%
Total Average / day (CC16)	11,596	16,797	15,131	18,989	20,067	82,579	80%
Vehicle Reduction / day (CC16)	9,049	3,848	5,514	1,656	578	20,645	20%

B. Scenario of Colors Combination in TC1 Monday – Friday (06.00 – 18.00)

Tabel 9 Scenario C3 in TC1 (12 hours)

Colors	Days				
	MON	TUES	WED	THURS	FRI
Black	7,499				
White		3,050			
Silver			4,493		
Red				842	
Blue				422	
Green					144
Yellow					31
Pink					7
Gold					292
Others					
Total	7,499	3,050	4,493	1,264	475

Tabel 10 Scenario C3 in TC1 (12 hours)

	Days					TOTAL	%
	MON	TUES	WED	THURS	FRI		
Total Average / day (Normal)	16,780	16,780	16,780	16,780	16,780	83,899	100%
Total Average / day (CC12)	9,281	13,730	12,287	15,516	16,305	67,119	80%
Vehicle Reduction / day (CC12)	7,499	3,050	4,493	1,264	475	16,780	20%

C. Scenario of Colors Combination in TC2 Monday – Friday (06.00-22.00)

Tabel 11 Scenario C3 in TC2 (16 hours)

Colors	Days				
	MON	**TUES**	**WED**	**THURS**	**FRI**
Black	6,940				
White		3,866			
Silver			5,083		
Red				1,110	
Blue				800	
Green					212
Yellow					90
Pink					10
Gold					44
Others					
Total	6,940	3,866	5,083	1,910	356

Tabel 12 Scenario C3 in TC2 (16 hours)

Colors	Days					**TOTAL**	**%**
	MON	**TUES**	**WED**	**THURS**	**FRI**		
Total Average / day (Normal)	19,895	19,895	19,895	19,895	19,895	99,476	100%
Total Average / day (CC16)	12,955	16,029	14,812	17,985	19,539	81,321	82%
Vehicle Reduction / day (CC16)	6,940	3,866	5,083	1,910	356	18,155	18%

D. Scenario of Colors Combination in TC2 Monday – Friday (06.00-18.00)

Tabel 13 Scenario C3 in TC2 (12 hours)

Colors	Days				
	MON	**TUES**	**WED**	**THURS**	**FRI**
Black	5,752				
White		3,329			
Silver			4,537		
Red				870	
Blue				690	
Green					182
Yellow					48
Pink					13
Gold					40
Others					
Total	5,762	3,329	4,537	1,560	283

Tabel 14 Scenario C3 in TC2 (12 hours)

	Days					TOTAL	%
	MON	**TUES**	**WED**	**THURS**	**FRI**		
Total Average / day (Normal)	15,471	15,471	15,471	15,471	15,471	77,354	100%
Total Average / day (CC12)	9,709	12,142	10,934	13,911	15,188	61,883	80%
Vehicle Reduction / day (CC12)	5,762	3,329	4,537	1,560	283	15,471	20%

Based on the A, B, C, and D scenarios by dismissing color group vehicles for one day on Monday-Friday scheduling, the averaga vehicle reduction on both TCs is made by 20%. Unless on the TC2 scenario with a duration of 16 hours, average vehicle reduction in one week is obtained by 18%.

CONCLUSION

Color grouping is done by several options. In the first model, colors are grouped into two options: (A) by four color groups: (1) black, (2) silver, (3) white, (4) red, blue, green, gold, yellow, and pink. (B) by five color groups: (1) black, (2), silver (3) white, (4) red, (5) blue, green, gold, yellow, and pink.

In the second model, the color grouping for operating-off vehicle scheduling, the options are made based on color combinations.

Based on the daily traffic average (LHR) formula, a scheduling scenario is made and divided into two models based on the combined corridor (without region or corridor limitation) and based on the corridor (region restriction). In the first part (joint corridors), with two options, vehicle reduction results in average are as much as:

In option 1, the average vehicle reduction reaches 22.2%.

In option 2, the average vehicle reduction in a week is by 20%.

In the second part, by applying the four scheduling scenarios, the congestion reduction results in average is as much as:

Contributions in applying color clustering method in reducing the number of vehicles operating on the roads can be improved by adding the time off for each

color group of vehicles in one week both on Monday-Friday and Monday-Saturday schedulings. One-day-off pattern for color groups in the Monday-Friday scheduling contribute in reducing the congestion on average by 20%.

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