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저속형 전기자동차 주행시 시스템 영향분석 - VISSIM 시뮬레이션을 이용하여 -

The Effect Analysis of NEV(Neighborhood Electric Vehicle) Driving - with VISSIM Simulation -

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요 약

저속형 전기자동차가 일반 자동차와 함께 도로에 주행을 하기 위해서는 교통 전략이 필요하다. 저속형 전기자동차는 가솔린, 디젤, LPG 등을 연료로 사용하는 일반 자동차에 비해 급격한 가속이 불가능하기 때문에 교통상황에 방해가 될 수 있으며 정체의 원인이 될 수 있다. 녹색신호가 켜지고 저속형 전기자동차를 포함한 모든 자동차는 도로를 주행하게 될 것이나 저속형 전기자동차의 최고속은 50km/h에 불과하다. 이것은 후행차량에게 방해가 될 수 있으며 교차로 정체의 원인이 될 수 있다. 이러한 이유로 본 연구에서는 선행신호를 가진 큐점프 등의 교통체계를 고려해 볼 필요가 있다. 저속형 전기자동차의 도로 운영을 분석하기 위해 본 연구는 3가지 시나리오를 설정하여 분석하였다. 첫째로 저속형 전기차와 일반차량이 도로에 혼합되어 운행하는 경우, 두 번째는 저속형 전기차만을 위한 전용차로, 세 번째는 큐점프 차선을 만들고 선행신호를 부여하는 것이다. 각각의 시나리오는 혼잡상황과 비혼잡상황에서 전기자동차의 전체 비율에 따라 분석되었다. 그 결과 우리는 전기차가 20% 이상 통행하는 경우, 통행속도를 증가시키려면 전용차선으로 운영하는 것이 효과적이라고 볼 수 있었으며 시나리오 3은 정체나 평균속도 그 어떠한 것에도 긍정적인 영향을 끼치지는 못했다고 나타났다.

Abstract

To share the lanes with conventional vehicles, traffic operation strategy is needed for NEV (Neighborhood Electric Vehicle). Because NEV cannot accelerate sharply as fast as common car include gasoline, diesel and LPG cars, they may interrupt traffic conditions and make traffic delay. After green lights turn on, all vehicles run through the street including NEV, but NEV have a maximum speed which is 50km/h. It can be an obstacle for following vehicles and will make traffic delay of the intersection. In this reason, we need to organize traffic systems like queue jump with priority traffic signal. To analyze the necessity for NEV road operations, we simulate three scenarios in congested and non-congested conditions. First is that we examine the condition which is mixed NEV and cars on the road, the second one is that we set up lane only NEV can accepted in simulation and last one is making queue jump lane and providing priority signal for NEV. In conclusion, we can conclude that making lane only for NEV is effective to improve travel speed when rate of NEVs is over 20%. Also queue jump lane and priority signal cannot make good effect to intersection delay and average speed.

Key words : Neighborhood electric vehicle, Vissim simulation, Queue jump lane, Priority signal, Traffic delay

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Ⅰ. Introduction

NEV stands for neighborhood electric vehicle, which would have driving range of 40km in normal driving condition and is equipped with six-12v deep-cycle lead acid batteries[1]. The government will allow the driving on the street from April, 2010. In this trend, a lot of people have interest with NEV, but it is a controversial issue whether it can drive on the street safely, it has no interruption to any other vehicles and it is appropriate to current signal systems or not. In this paper, we want to analyze about these. With simulation program, we can figure out the traffic delay in the intersection and total travel time with two conditions such as NEV and cars mixed all lanes and NEV have to drive only first lane which is the closest to sidewalk.

〈Fig. 1〉 Image of NEV
Source : CT&T company http://www.ctnt.co.kr

For this research, we did an experiment with NEV in Ilsan, Gyeonggi and simulation by using VISSIM program. We make some conditions and assumptions for this study, which is related to lane uses and attribute about the cars and NEVs.

This study wants to simulate the day when NEVs will drive with cars on the road and make sure which methodology is appropriate to NEV operation. The government mentioned that NEV should not drive in the road which has over 60km/h speed and have other regulations.

Ⅱ. Background

Regulations for operating an NEV vary by state in the US. The federal government allows state and local governments to make additional safety requirements. For example, the State of New York requires additional safety equipments to include windshield wipers, window defroster, speedometer, odometer and a back-up light. In general, they must be titled and registered, and the driver must be licensed. Because airbags are not required the NEV cannot normally run on highways or freeways. NEVs in many states are restricted to roads with a speed limit of 35 mph which is 56 km/h or less. It is the similar meaning of Zone 30[2].

In United States, the National Highway Traffic Safety Administration has published safety guidelines in the United States which apply to vehicles operating in the 20~25mph speed range. As of January 2007, twenty-five of the fifty states of the United States had passed legislation legalizing the use of low-speed vehicles on highways in the state. By 2009, nearly all 50 states allow NEVs, to drive on their roads. As of end of 2008, 9 states had made it legal to drive them 35 mph speed, most on 45 mph streets. In 2009, Texas has passed a new law (SB129) allowing them to drive 35 mph on 45 mph roads. California and New Mexico have proposed laws in their respective legislatures.

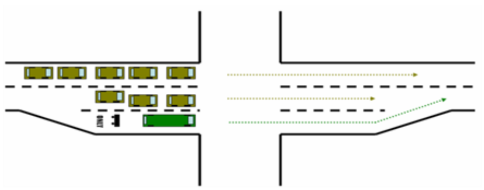
Low-Speed Vehicle (LSV) is another type of electric vehicles. It refer to a legal class of four-wheel vehicles which have a speed range approximately 32km/h to 40km/h that allow them to travel on public roads not accessible to all golf carts or NEV. In Canada, LSV is defined as a vehicle under Motor Vehicle Safety Regulations. It is powered by an electric motor, produces no emissions. E-Jeepney in Philippines also can be an example. LSV is also called Quadricycle in some countries in Europe.

Ⅲ. Approach

We simulated several conditions which are related to operation of NEV by using VISSIM program. VISSIM program is a microscopic simulation program for multi-modal traffic flow modeling and it developed by PTV AG in Germany[3].

In this study, we simulated three scenarios in congested and non-congested conditions, one is that NEVs and cars are mixed in all lanes, the second one is NEVs have to be operated in only first lane and last one is making a queue jump lane and giving priority signal for NEV. Queue jump is a type of roadway geometry typically found in BRT (Bus Rapid Transit) systems. It consists of an additional travel lane on the approach to a signalized intersection. This lane is often restricted to transit vehicles only, though some variations may permit bicyclists, mopeds, and/or motorcycles.

The intent of the lane is to allow the higher-capacity vehicles to cut to the front of the queue, reducing the delay caused by the signal and improving the operational efficiency of the transit system. A queue jump lane is generally accompanied by a signal which provides a phase specifically for vehicles within the queue jump. Such a signal reduces the need for a designated receiving lane, as vehicles in the queue jump lane get a “head-start” over other queued vehicles and can therefore merge into the regular travel lanes immediately beyond the signal.

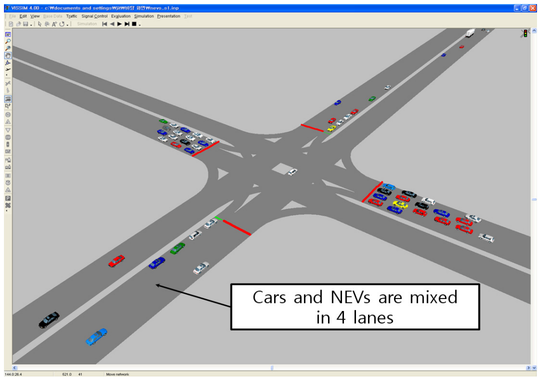


〈Fig. 2〉 Queue Jump

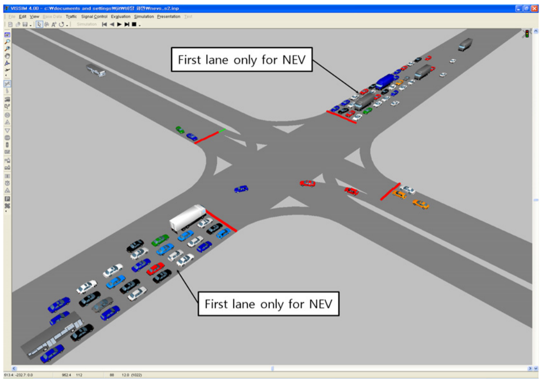
This study sets up maximum speed for NEVs in simulation program to reflect characteristic which cannot make as fast as common vehicles. And signal time is set up straight direction 40sec and left-turn 20sec, so total cycle is 120 sec.

〈Table 1〉 Scenario of Simulation

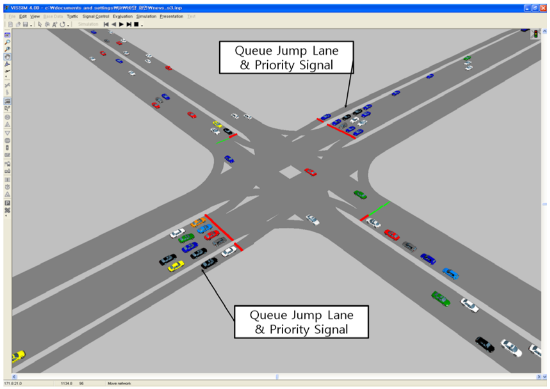
	Scenario #1	Scenario #2	Scenario #3
Simulation Time	During 7200 seconds		
Flow	1) non-congested condition(v/c=0.5) - Inbound volumes 700vph 2) congested condition(v/c=0.9~1.0) - Inbound volumes 2,000vph All directions, left 15%, straight 75%, right 10%		
Vehicle Rate (%) (Cars : NEVs)	1) 95 : 5 2) 90 : 10 3) 80 : 20		
Lane Condition	Cars and NEVs are mixed in 4 lanes	First lane only for NEV	Queue Jump Lane & Priority Signal



〈Fig. 3〉 VISSIM Simulation of Scenario #1



〈Fig. 4〉 VISSIM Simulation of Scenario #2



〈Fig. 5〉 VISSIM Simulation of Scenario #3

Ⅳ. Results and Analysis

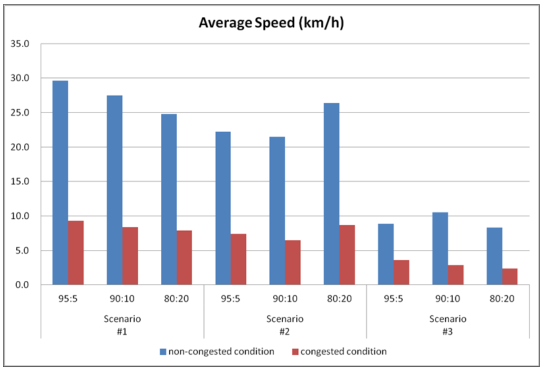
To analyze the relationships about rate of NEV on the road, we assume that there are three conditions, 5%, 10% and 20% NEV operations rates of total traffic. Table 2 shows average speed and total delay according to each scenario. As increase the rate of NEV, average speed decreases in scenario #1 in both conditions, it means that NEVs make a bad effect to intersection delay including other types of vehicles regardless of V/C. Also total delays become larger and larger as the NEVs increase. Also we need to compare with scenario 2 which has the regulation that all NEVs have to be operated only in first lane.

In scenario 1, travel speeds drop as the rates of NEV increase in congested and non-congested conditions. In scenario 2, travel speeds drop from 5% to 10% of NEVs, but when the rate of NEVs becomes 20%, travel speed is improved. In scenario 3 is not same as others. That shows different patterns in congested and non-congested conditions. When non-congested condition, it indicates that queue jump land and priority signal will be helpful when rate of NEVs is 10%. Also this strategy will not work when the V/C is over 0.9.

Table 3 shows that delay also increases in all scenarios and conditions when the rate of NEVs increases.

〈Table 2〉 Average Speed(km/h) according to Scenarios

	Vehicle Rate (%) (Cars : NEVs)	Average Speed(km/h)	
		non-congested condition	congested condition
Scenario #1	95:5	29.6	9.3
	90:10	27.5	8.4
	80:20	24.8	7.9
Scenario #2	95:5	22.2	7.4
	90:10	21.5	6.5
	80:20	26.4	8.7
Scenario #3	95:5	8.9	3.6
	90:10	10.5	2.9
	80:20	8.3	2.4

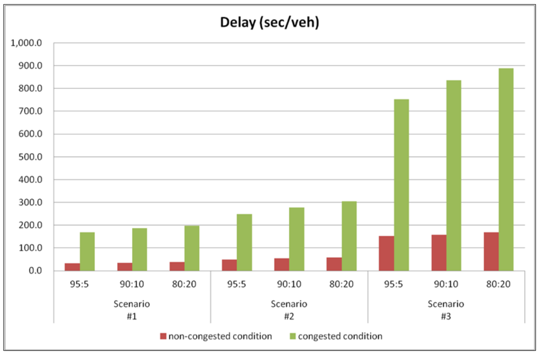


〈Fig. 6〉 Average Speed(km/h) according to Scenarios and Rate of NEVs

〈Table 3〉 Delay(sec/veh) according to Scenarios

	Vehicle Rate (%) (Cars : NEVs)	Delay(sec/veh)	
		non-congested condition	congested condition
Scenario #1	95:5	33.5	168.5
	90:10	35.2	187.4
	80:20	37.7	196.9
Scenario #2	95:5	49.8	248.4
	90:10	54.4	278.1
	80:20	57.2	304.3
Scenario #3	95:5	152.0	752.5
	90:10	156.9	836.2
	80:20	168.4	889.3

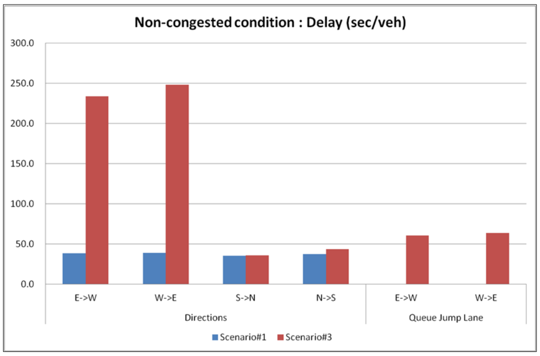
In Scenario #3, priority signal and queue jump lane cannot give any good effect for all intersection and vehicles because the signal has to cut green time for other vehicles. Table 2 and 3 show that queue jump lane cannot give a good effect to other lanes and itself. Queue jump lanes do not have a lower delay than other scenarios, either.



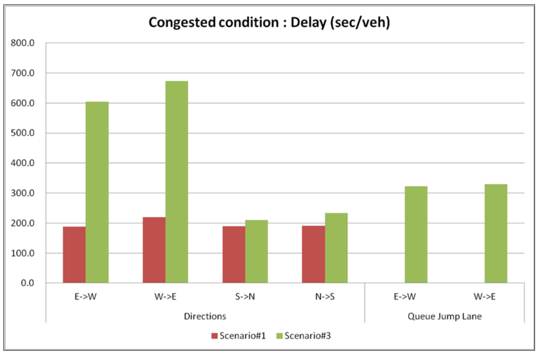
〈Fig. 7〉 Delay(sec/veh) according to Scenarios and Rate of NEVs

〈Table 4〉 Comparison Delay(sec/veh) between Scenario #1 and #3(80:20)

		non-congested condition		congested condition	
		Scenario #1	Scenario #3	Scenario #1	Scenario #3
Directions	E->W	38.5	234.1	187.5	604.5
	W->E	39.2	248.1	219.6	673.7
	S->N	35.6	36.0	189.3	210.2
	N->S	37.4	43.9	191.2	233.1
Queue Jump Lane	E->W	N/A	60.8	N/A	323.5
	W->E		63.6		329.2



〈Fig. 8〉 Comparison Delay(sec/veh) between Scenario #1 and #3(non-congested condition, 80:20)



〈Fig. 9〉 Comparison Delay(sec/veh) between Scenario #1 and #3(congested condition, 80:20)

This paper analyzes the delay in each direction. When the rate of NEVs is 20% of total traffics in non-congested condition, it shows similar patterns when the NEVs share the road with other vehicles. On the other hand, delay of east bound is higher than that of west bound in scenario 3. Congested condition has similar pattern as non-congested condition.

Ⅴ. Conclusion and Limitation

It is certain that the average speed drop and total delay rise will be occurred when NEVs operate on the road because NEVs' speed is not as high as conventional vehicles and do not have acceleration ability like conventional ones. Government mentioned that NEV will be permitted road driving in law soon. In this trend, we need to analyze which methodology is more appropriate to both NEVs and conventional vehicles. First of all, NEVs do not have to disturb the traffic flow, so it is necessary to study and research carefully. In this research, we can make conclusions like below statements.

1) it is clear that NEV makes the speed dropping of other vehicles and more delay if they are allowed to drive.
2) In the condition of 20% NEVs' rate on the road, it is the best way to share the road with NEVs

and conventional vehicles to reduce delays. In here, it is a controversial issue to make clear about safety for NEVs.

3) When rate of NEVs is over 20%, we need to consider making only lane for NEVs to improve travel speed.
4) Queue jump lane and priority signal for NEV cannot make any better effect for both NEVs and conventional vehicles, especially the same direction traffics.
5) The regulation and enactment of relative law are necessary for the effective NEV operation.

There is a limitation in this research that the simulation VISSIM cannot reflect all specification about NEV perfectly because the program does not provide function for future transportation yet.

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