Paper ID #

A Study on the Effects of Green Wave System on CO2 Emissions

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Abstract

This paper describes the result of a simulation study about the effects of green wave system on CO2 emissions. Green wave system typically controls (or give the information of) the vehicle's speed to smooth traffic flow and to improve road traffic environment. The various green wave system has been demonstrated through the field operation tests in various regions responding to the expectation of the synergistic effect by the collaboration with automated driving and V2I communications. Therefore, we focused on the situation when the automated vehicles would became widely used to the road traffic in real world, and discussed the environmental impact of green wave system using our evaluation tool that combined traffic simulation and CO2 emission model.

Keywords: Green Wave System, CO2 Emissions, Traffic Simulation

Introduction

The purpose of this study is to describe the environmental impact of green wave system to road traffic. In recent years, green wave system is highly expected to smooth road traffic and improve the environment. Various types of the system have been demonstrated, for example, the field operation tests in three regions (Kanagawa, Gunma and Aichi) were practiced in Japan from 2014 to 2015. In addition, green wave system is begging to be studied as one of key technologies to support automated driving. In general, green wave system controls (or give the information of) the vehicle's speed not to stop at the signal intersection. The target speed is estimated using the signal timing information and the distance to the signal intersection in real time. On the other hand, automated driving system is similarly needed to control the acceleration and the speed. Therefore, it is said that these two systems have the complementary strength of the cooperation to improve the environmental of road traffic. In this study, we discuss the effects of green wave system using the combination of traffic simulation model and CO2 emission model, based on the assumption that automated driving is widely used in the future.

Evaluation Framework

To discuss the impact of green wave system on CO2 emissions, we applied an evaluation tool[1] of the combination of traffic simulation model (TS) and CO2 emission model (EM) developed in Energy ITS

Project (from 2008 to 2012). Figure 1 shows the framework of the evaluation tool. The model type of TS is mesoscopic scale model to be able applied various types of TS. Therefore, the interface between TS and EM is considered the data passing based on the simplified vehicle behaviour data consists on the short trip or the short stop with the average speed profiles. This data is named Stepwise Speed Function (SSF). On the other hand, EM is also modelled by the statistical approach based on the actual vehicle's behaviours and engine characteristics to calculate CO2 emissions using SSF from TS. This framework is verified and validated using our benchmark data set according to "Guidelines for Assessing the Effects of ITS on CO2 Emissions - International Joint Report -" (IJR).

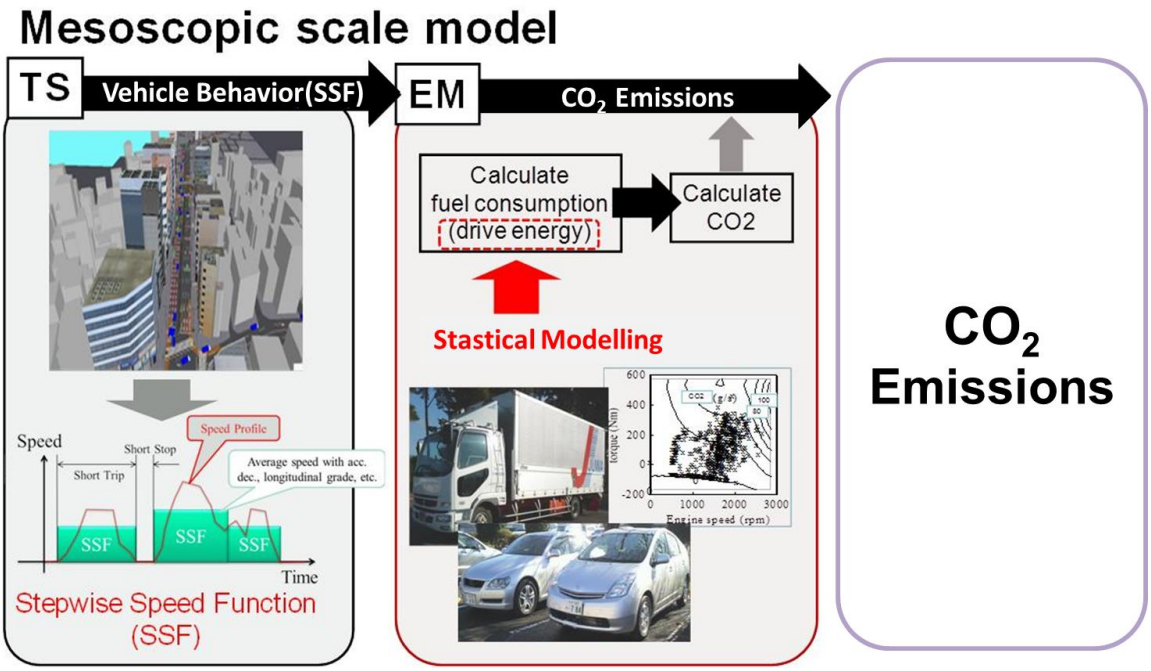

Figure1 – Evaluation Framework of CO2 Emissions

Modelling of Green Wave System

Reference Model of CO2 Impact

We propose some steps for the impact study of ITS system on CO2 emissions in JIR. Making the "Reference model" is the first step of implementation of the evaluation target system. The reference model aims to describe and to be understood the impact mechanism from the evaluation target system to CO2 emissions for everyone involved. Figure 2 shows the reference model of green wave system with automated vehicle. We assumed that green wave system consists on automated vehicle (AV) and signal controller and V2I beacon and traffic sensor for two type of green wave system by signal control optimization or maintaining of vehicle's speed. In this study, we focused the service of maintaining of vehicle's speed, and implemented the green wave system in TS. The model type of TS we applied is the micro scale model named MicroAVENUE[2].

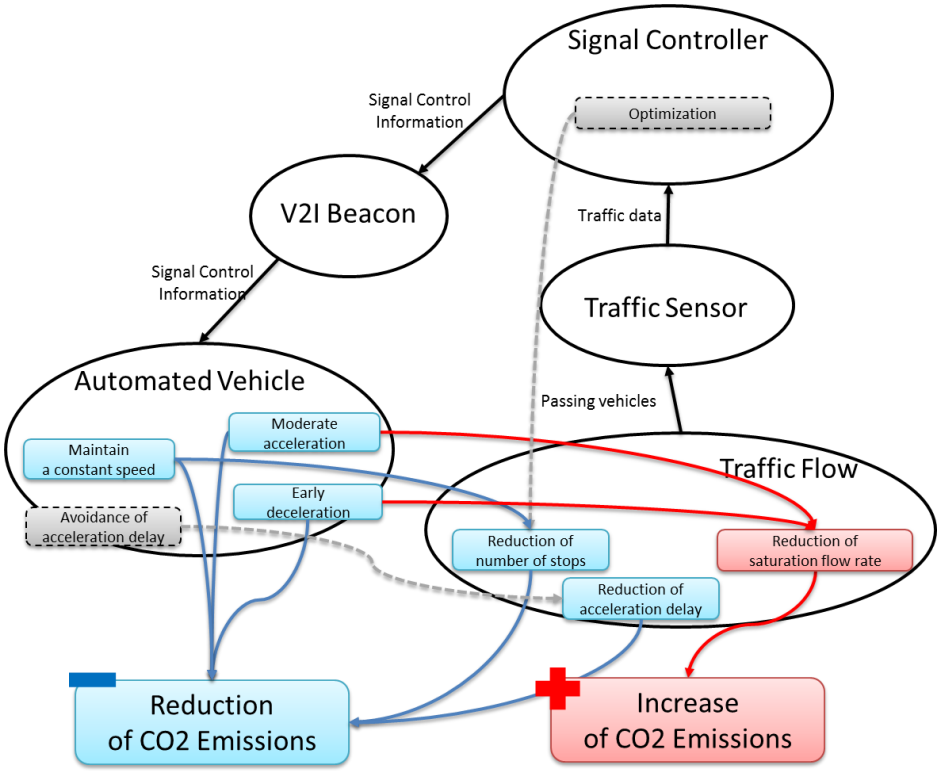

Figure 2 – Reference Model of Green Wave System with Automated Vehicle

Implementation of Green Wave System

We implemented the green wave system (GW) to MicroAVENUE according to the reference model in Figure 2. Figure 3 shows the image of the implemented model of green wave system. The green wave system gets the signal timing plan from each signal controller and send the signal timing information to target vehicles through V2I beacon. The target vehicle with GW find the possible speed to pass though not to stop at signal intersection. Then the vehicle maintains the target speed based or decelerate on the two assistance options below.

-Passing Assistance:

If the vehicle can pass though without stop at the intersection, the device requests the vehicle to keep the target speed.

-Stopping Assistance:

If the vehicle cannot pass through, the device requests the vehicle to decelerate earlier (no acceleration). Figure 5 shows the demonstration.

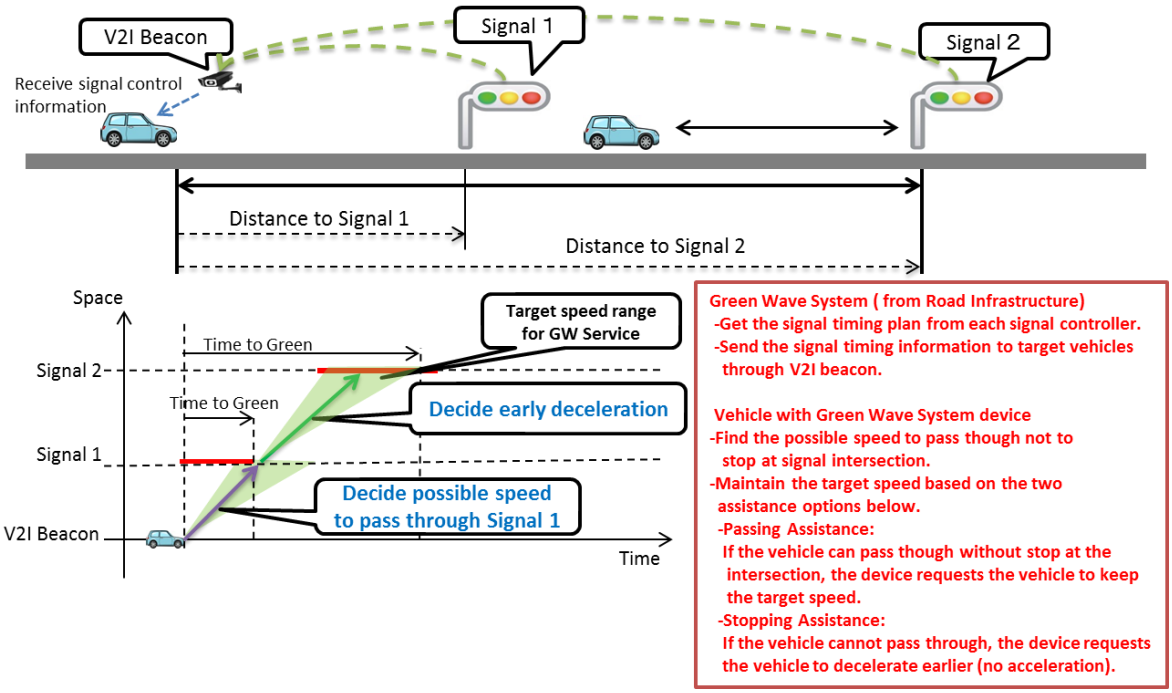

Figure 3 –Implemented model of green wave system

The behaviours of the vehicle with GW is verified in the test case of three intersection as shown in Figure 4. We confirmed that the vehicle trajectories with GW are smooth comparing to the vehicle trajectories without GW.

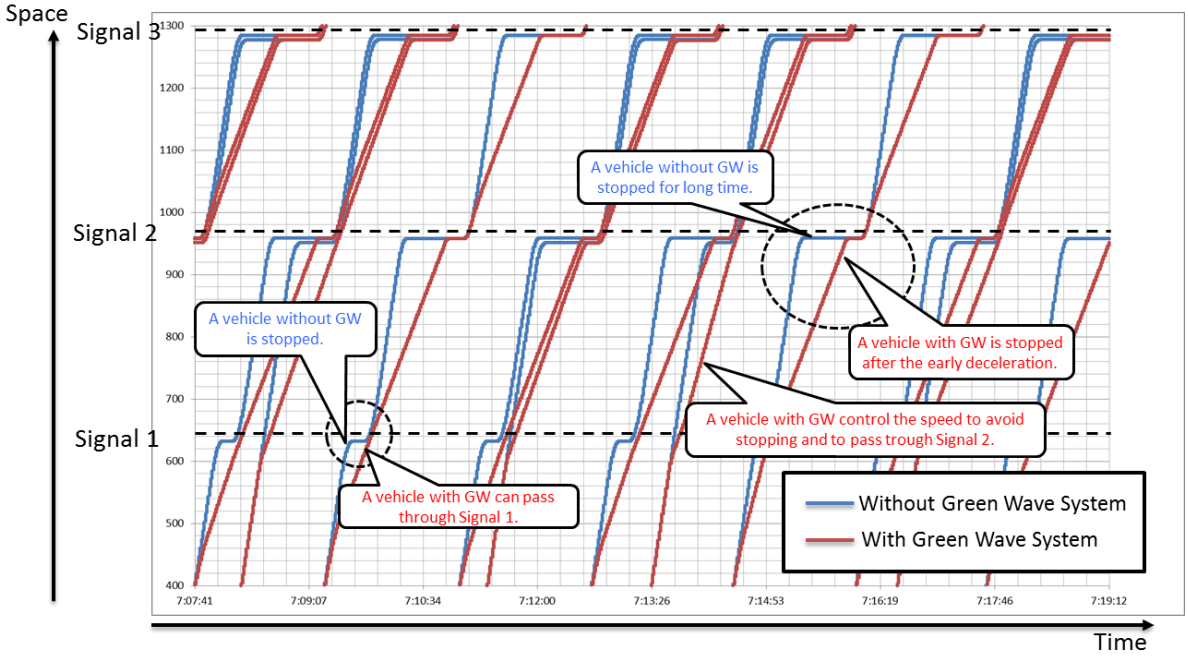

Figure 4 – Demonstration of Green Wave System for Verification

Evaluation of Green Wave System

Figure 5 shows the target area for the evaluation. We chose Route 16 in Kashiwa city for about 16 km. In this study, the traffic census data of Ministry of Land, Infrastructure, Transport and Tourism was used to make the input file and the validation data. Figure 6 and Figure 7 shows an example of vehicle trajectories of base case (without GW). We calibrated the simulation parameters to fit the real traffic situation and validated the reproducibility comparing to the census data such as traffic volume and average speed.

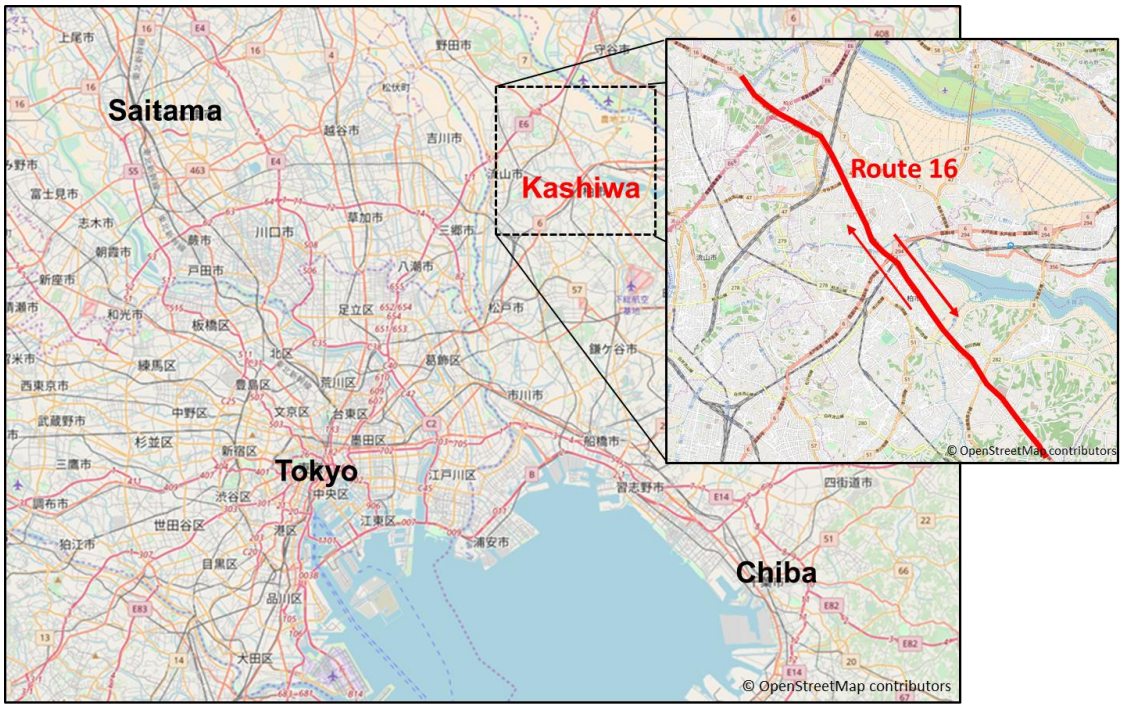

Figure 5 – Target Area(Route 16, Kashiwa)

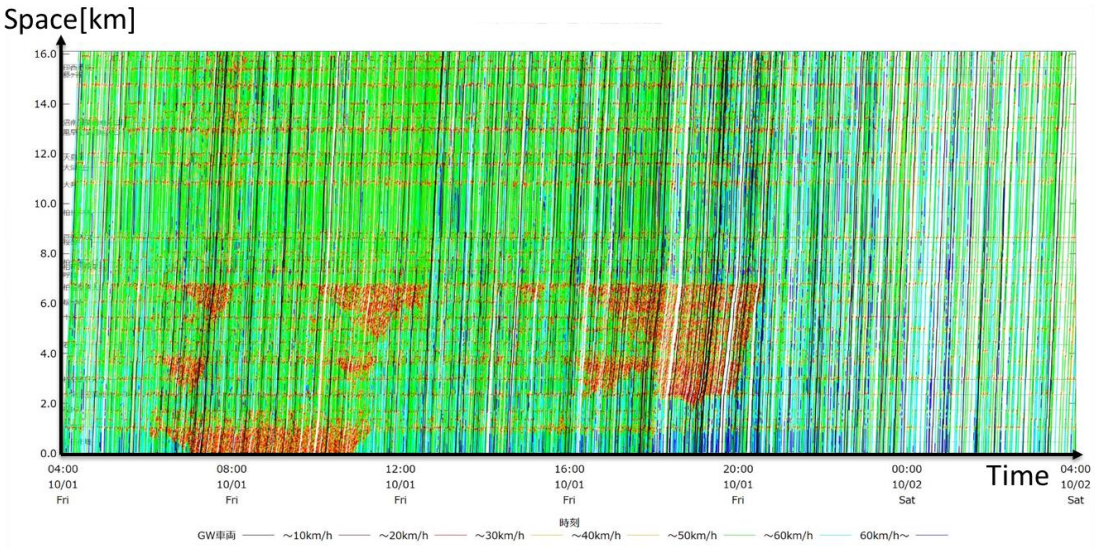

Figure 6 – An Example of Vehicle Trajectories of Base Case (without GW), from North to South

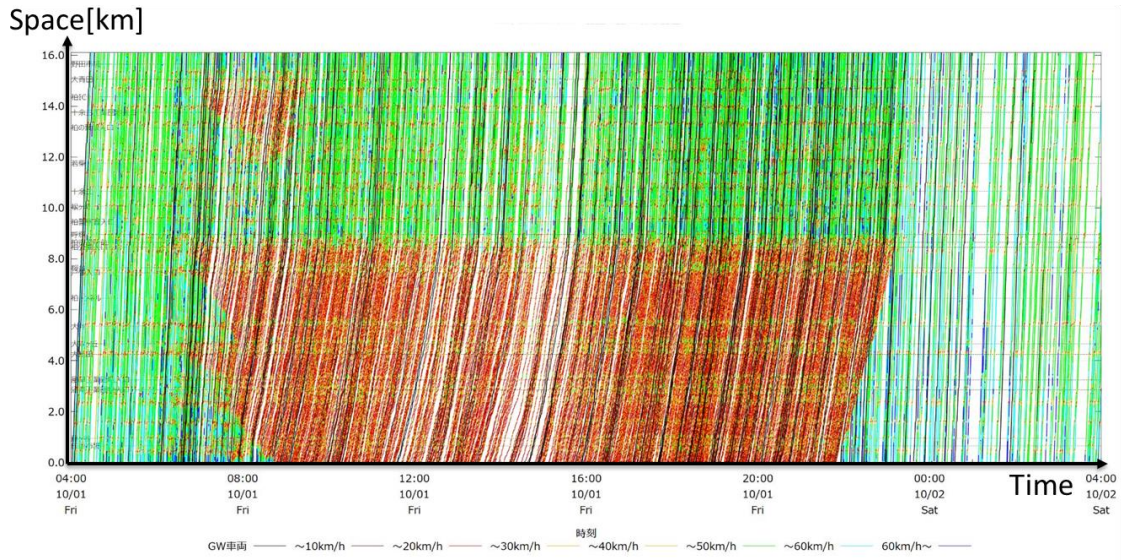

Figure 7 – An Example of Vehicle Trajectories of Base Case (without GW), from South to North

Future Works

We developed the evaluation model of green wave system and built the base case of Route 16 in Kashiwa city. As the future works, we have a plan to simulate the future cases changing some parameters (such as the penetration of GW vehicles) on the assumption that the green wave system is introduced. And we will analyse the condition that green wave system have a major impact on traffic flow and road environment. On the other hand, we will also discuss the ineffective situation, and conclude and describe our result in the World Congress.

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