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Date:	3/18/2010
To:	Marie Treazise, WisDOT Bureau of Highway Operations
From:	Amanda Ryadi, Wisconsin TOPS Lab
Subject:	Ramp Metering Evaluation – Technical Memo #8 Paramics Micro-simulation

This memorandum summarizes the ramp metering micro-simulation modeled with Paramics. The purposes of the evaluation with the micro-simulation model are for future alternatives analysis use and for analyzing how the ramp meters interact with each other along the I-94 corridor.

The Models

The Paramics models include the entire I-94 East-West corridor from CTH SS to Carferry Drive on I-794 which is approximately 24 miles long. It also includes a portion of I-43 from the Marquette Interchange up to the Hillside Interchange. The volume entered in the model is taken from WisDOT's 2008 Peak Hour Weekday Volume data. The peak period for AM is set to be 6:15 – 8:15 AM and for PM is set to be 6:00 – 8:00 PM. The models created are named as follows:

- RM_AM (with detector)
- RM_PM (with detector)
- RM_AM_SimpleRamp (pre-timed)
- RM_PM_SimpleRamp (pre-timed)

The models have included the recommended action previously provided in technical memos # 5 and 7. Therefore, ramp meters are not installed in the following locations:

- RM-67-123 I-94 WB @ CTH SS
- RM-67-120 I-94 WB @ CTH G
- RM-67-113 I-94 WB @ CTH T
- RM-67-069 I-94 EB @ CTH T
- RM-67-062 I-94 WB @ Moorland Rd

After excluding the five ramp meters mentioned above, there are 22 ramp metering locations in total installed in the model.

RM_AM and RM_PM

The ramp meters are programmed in Paramics to closely emulate how ramp meters work in the real world. In Paramics, detectors are placed on both the mainline and the ramp. The detectors placed on the mainline are used to measure the gap between vehicles and the detectors placed on the ramp are used to detect the presence of a vehicle on the lane. When the mainline detector detects a gap between vehicles less than 1 second, which is a gap value that is assumed to be the threshold of congestion in the

model, the programmed ramp meter is automatically turned on with 2 seconds green time and 12 seconds red time for each lane, as shown in Figure 1. When the ramp meter is not active and the gap between vehicles is more than 1 second, the signal will have 1 second green time and 6 seconds red time for each lane to discharge the vehicles faster, as shown in Figure 2. The ramp detectors will affect whether the signal is to turn green or to turn red. If there is no vehicle detected on a lane, that lane will have continuous red signal until a vehicle is detected then the signal will turn green to discharge the vehicle as shown in Figure 3.

Figure 1. Ramp Meter is Active with 2 Seconds Green Time and 12 Seconds Red Time

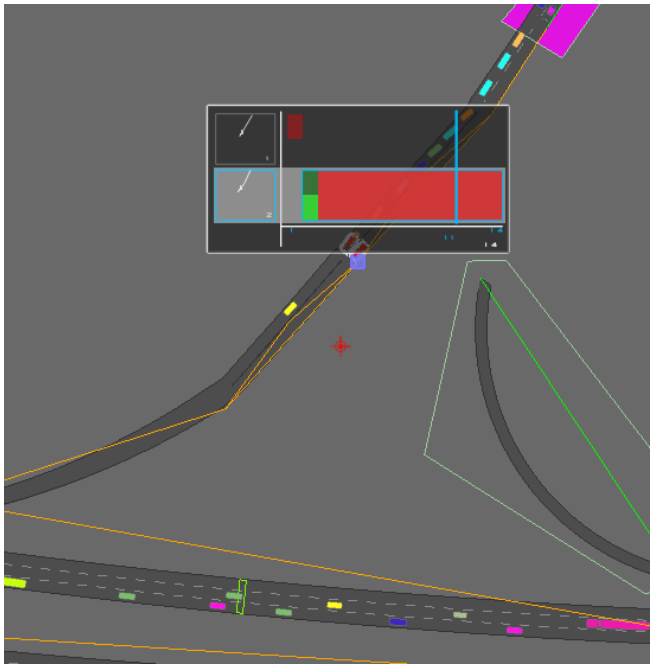


Figure 2. Ramp Meter is Inactive with 1 Second Green Time and 6 Seconds Red Time

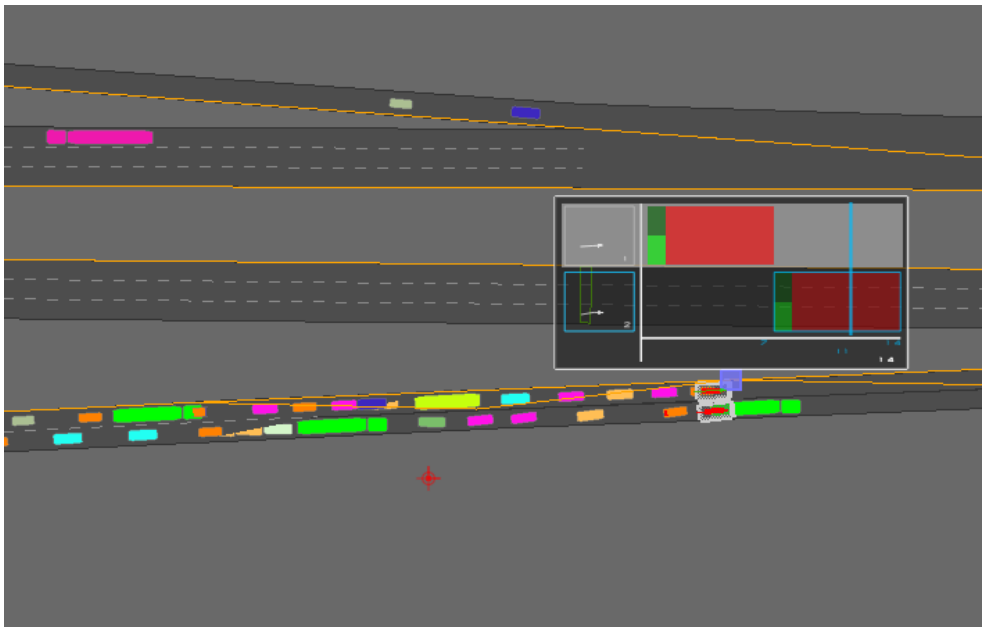
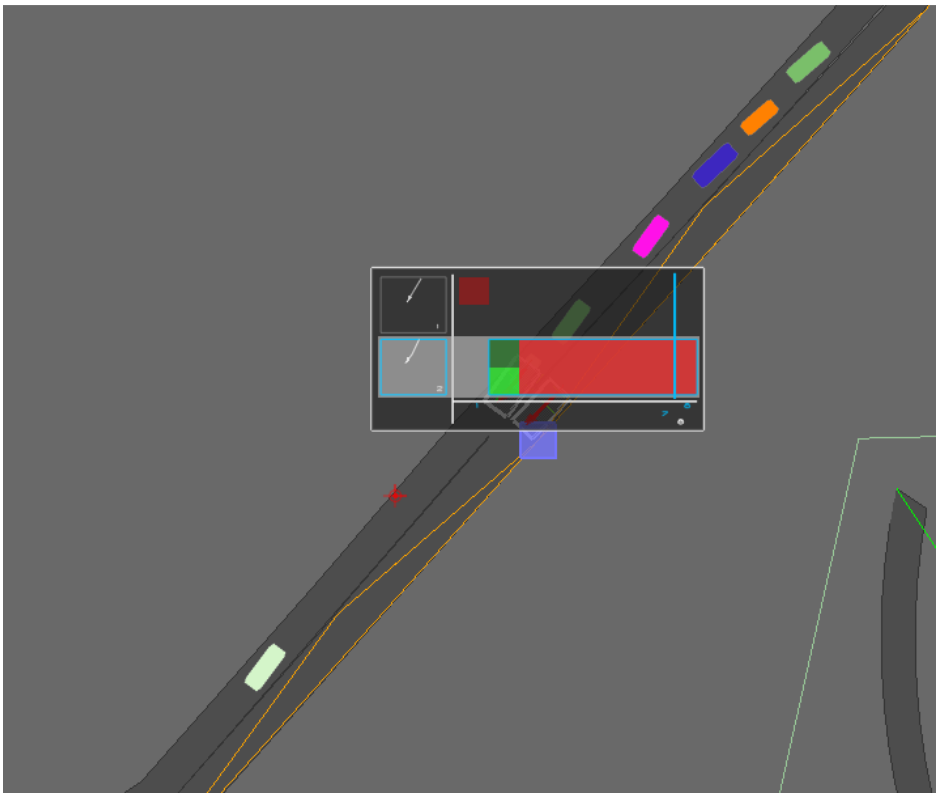


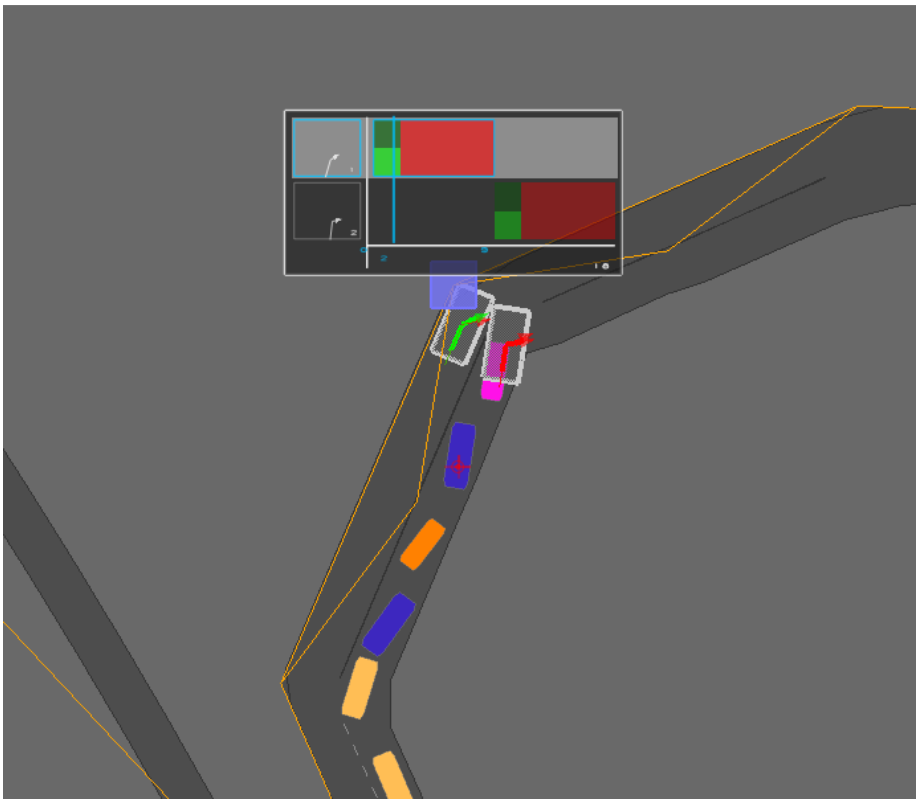
Figure 3. Ramp Meter is Only Active on the Lane with Vehicles



RM_AM_SimpleRamp and RM_PM_SimpleRamp

Paramics unfortunately has many software limitations, therefore at times causes the programming to not function the way it is supposed to. To minimize any programming errors in Paramics, alternative models are created with simple ramp metering configuration. These models do not have any detectors placed. The signal timing is set to have 2 seconds green time and 7 seconds red time for each lane. The ramp will discharge vehicles from the lanes in an alternating manner the way ramp meter works in the real world. However, the signal will turn green with or without having a vehicle on the lane as shown in Figure 4.

Figure 4. The Signal Turns Green with or without a Vehicle Present

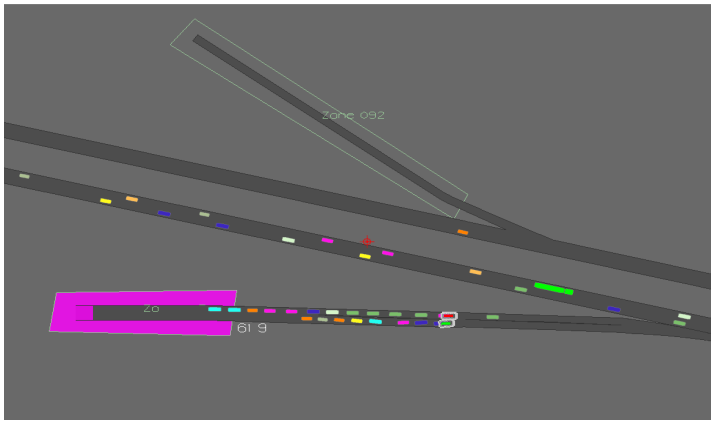


Simulation Results

MORNING PEAK, RM_AM

After running the simulation, the model would show the number of cars that cannot be discharged from the zone due to the congestion. This shows that having the ramp meter at the location causes a long queue. As shown in Figure 6, RM-67-121 at CTH G has 619 vehicles that cannot go into the system due to the long queue. Therefore, RM-67-121 should be further evaluated to improve its operation.

Figure 6. Long Queue on RM-67-121 I-94 EB @ CTH G



Other locations that have high volume blocked from coming into the system:

- RM-67-068 I-94 EB @ CTH J (341 vehicles blocked)
- RM-67-067 I-94 EB @ CTH F (711 vehicles blocked)
- RM-67-063 I-94 EB @ Barker Rd (1540 vehicles blocked)
- RM-67-042 and RM-67-043 I-94 EB @ Moorland Rd (1151 combined vehicles blocked)
- RM-40-061 I-94 WB @ Hwy 100 (955 vehicles blocked)
- RM-40-010 I-94 WB @ 84th St (287 vehicles blocked)
- RM-40-004 I-94 EB @ 84th St (116 vehicles blocked)
- RM-40-009 I-94 WB @ 70th St (118 vehicles blocked)
- RM-40-007 I-94 EB @ 68th St (279 vehicles blocked)
- RM-40-003 I-94 WB @ Hawley Rd (115 vehicles blocked)

AFTERNOON PEAK, RM_PM

After running the simulation, the following locations are found to have very long queue and high number of vehicles blocked from getting into the system due to the vehicle discharge rate of the ramp meters:

- RM-67-068 I-94 EB @ CTH J (123 vehicles blocked)
- RM-67-067 I-94 EB @ CTH F (851 vehicles blocked)
- RM-67-063 I-94 EB @ Barker Rd (1084 vehicles blocked)
- RM-67-042 and RM-67-043 I-94 EB @ Moorland Rd (809 combined vehicles blocked)
- RM-40-061 I-94 WB @ Hwy 100 (162 vehicles blocked)
- RM-40-021 I-94 EB @ Hwy 100 (161 vehicles blocked)
- RM-40-010 I-94 WB @ 84th St (190 vehicles blocked)
- RM-40-004 I-94 EB @ 84th St (148 vehicles blocked)
- RM-40-009 I-94 WB @ 70th St (285 vehicles blocked)
- RM-40-007 I-94 EB @ 68th St (362 vehicles blocked)
- RM-40-003 I-94 WB @ Hawley Rd (786 vehicles blocked)
- RM I-94 EB @ Hawley Rd (270 vehicles blocked)
- RM-40-002 I-94 WB @ 28th St (119 vehicles blocked)
- RM-40-075 I-94 EB @ 25th St (240 vehicles blocked)

MORNING PEAK, RM_AM_SimpleRamp

After running the simulation, the following locations are found to have very high number of vehicles being blocked from entering the system:

- RM-67-121 I-94 EB @ CTH G (680 vehicles blocked)
- RM-67-068 I-94 EB @ CTH J (294 vehicles blocked)
- RM-67-067 I-94 EB @ CTH F (684 vehicles blocked)
- RM-67-063 I-94 EB @ Barker Rd (1314 vehicles blocked)
- RM-67-042 and RM-67-043 I-94 EB @ Moorland Rd (1070 combined vehicles blocked)
- RM-40-061 I-94 WB @ Hwy 100 (467 vehicles blocked)
- RM-40-021 I-94 EB @ Hwy 100 (91 vehicles blocked)
- RM-40-010 I-94 WB @ 84th St (311 vehicles blocked)

AFTERNOON PEAK, RM_PM_SimpleRamp

After running the simulation, the following locations are found to have very long queue and high number of vehicles blocked from entering the system:

- RM-67-068 I-94 EB @ CTH J (491 vehicles blocked)
- RM-67-067 I-94 EB @ CTH F (1116 vehicles blocked)
- RM-67-065/066 I-94 WB @ Bluemound Rd (688 vehicles blocked)
- RM-67-063 I-94 EB @ Barker Rd (1727 vehicles blocked)
- RM-67-042 and RM-67-043 I-94 EB @ Moorland Rd (1140 combined vehicles blocked)
- RM-40-061 I-94 WB @ Hwy 100 (489 vehicles blocked)
- RM-40-021 I-94 EB @ Hwy 100 (289 vehicles blocked)
- RM-40-010 I-94 WB @ 84th St (292 vehicles blocked)
- RM-40-004 I-94 EB @ 84th St (312 vehicles blocked)
- RM-40-002 I-94 WB @ 28th St (420 vehicles blocked)
- RM-40-075 I-94 EB @ 25th St (290 vehicles blocked)

Concluding Remarks

Micro-simulation of the I-94 East-West corridor yields valuable information. However, the accuracy of the results warrants scrutiny. The micro-simulation model can be customized further using the exact timing that is currently used for each of the current ramp meters to improve the accuracy of the results. So, each ramp meter would have its own signal timing and vehicle discharge rate. The coding can also be customized further to simulate a scenario that is closer to how it is in the real world. For example, the ramp meter can be further programmed to be green at all time when there is no congestion detected on the mainline.

For all the ramp meters that are listed to have very long queue due to the slow vehicle discharge rate of the ramp meters, it is recommended that these ramp meters to be further evaluated for improved operation. Improving and customizing the timing to discharge the vehicle faster in the model would improve the result. Nevertheless, using the exact timing used currently in the real world would be more recommendable to give a more valuable result.