Appendix I:
Simulation Testing Results

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1 Introduction

This appendix summarizes the progress and findings of Task 12, the follow-on effort to VSC Task 6A. In this task, the focus is on evaluating simulated DSRC performance in an urban intersection environment densely populated with DSRC-equipped vehicles. This environment includes a nearby highway for compounding nearby message traffic effects.

In order to accomplish this goal, several modifications were made to the DSRC simulator, originally developed under task 4 and enhanced under task 6A. The most significant change was the addition of an intersection traffic and roadway environment to the simulator. This involved the addition of buildings to the simulation environment, which necessitated the creation of new radio frequency (RF) models to accommodate multi-path, dominant effects due to radio signal reflections off the buildings. The team conducted road tests at a representative city intersection with buildings at all four corners to develop these empirical RF models for the simulator. For comparison, DSRC performance was also evaluated without buildings present in the intersection setting. This was done using empirically derived highway RF models for open road conditions.

Once the RF models and intersection models were constructed, a number of simulation cases were defined in order to closely examine communication channel performance under varying conditions in the urban setting. Each simulation case required at least one complete simulation test run. These results were then analyzed using additional mathematical tools, often several analyses were run per simulation case, in order to produce presentable results contained in this appendix.

1.1 Simulation Test Scenarios and Setup

The simulation scenarios described in this appendix were focused upon high-volume, signalized intersections. For potential future field testing of cooperative intersection crash countermeasures built upon DSRC technology, it is important to determine if DSRC is likely to support this class of applications in such dense traffic situations.

Accordingly, simulation test scenarios were designed to focus on a high-volume intersection environment. The following sections discuss the overall simulation test scenarios and setup.

1.1.1 Intersection Simulation Environment

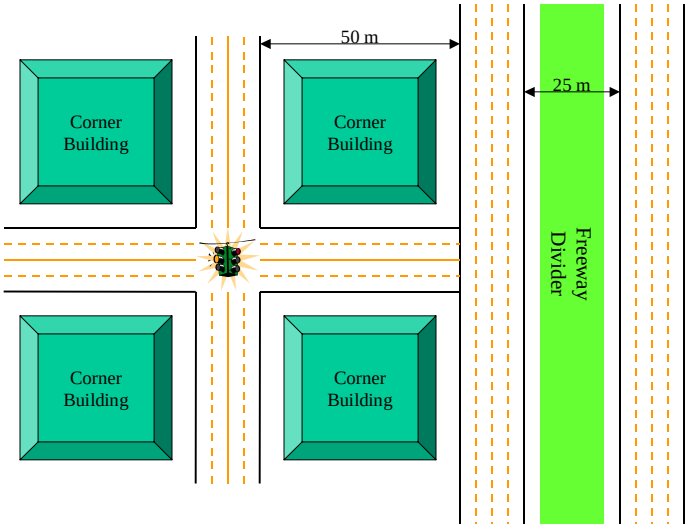


Figure 1-1: Intersection Simulation Environment

As shown in Figure 1-1: Intersection Simulation Environment, an intersection with four lanes of traffic in each leg is defined. Each lane is four meters wide. There are buildings at each corner spaced 8m from the edges of the roads so that there is a shadowing effect for communications around the corner. One freeway with four lanes in each direction is placed near the intersection. There is a 25-meter open gap between the two directions of travel with no barrier in between. The freeway runs parallel to one of the roads forming the intersection. The distance between the freeway edge and this road is 50m. The close presence of the freeway in this setup is meant to feed in a large amount of external interference. This combination of roadways creates an environment with potentially very high vehicle count in an intersection environment in a believable manner.

One RSU node is placed at a 5-meter height in the middle of the intersection. Four commercial RSUs are to be placed along the four legs of the intersection. These commercial RSUs will inject additional non-safety messages into the channel.

Vehicle flows for both the intersection roads and the freeway are configured in dense but believable manners. The vehicle density is 80 cars per lane mile on the freeway. One road of the intersection has 134 cars per lane mile, assuming the traffic is flowing, while the other road has a stopped-traffic density of 230 cars per lane mile.

1.1.2 Simulation Communication Settings

Four types of messages are configured to compete for channel access in the simulation test scenarios.

- **Routine Safety Messages**. Some applications specified in task 3 call for routine safety messages transmitted at 10Hz. This is the base setting for all vehicles in the simulation. Some other communication load parameter values are also evaluated through the course of this project. In some scenarios, these messages are also retransmitted by the intersection RSU to help them reach around the corner.
- **Emergency Messages**. In each simulation test scenario, some vehicles or the intersection RSU are configured to transmit high priority emergency messages.
- **Commercial RSU Messages**. These four commercial RSUs are configured to periodically transmit beacon messages into the control channel advertising their services to all nearby vehicles.
- **Cascading Emergency Messages**. This is a pattern of emergency messages among some selected vehicles. This pattern is meant to emulate communication behaviors of intersection safety applications in a general manner. Please see the following section for more details.

All transmissions are sent at a power intended for a range of 200m, unless specifically reconfigured in some simulation test scenarios. All routine safety messages are 200 Bytes long. Emergency messages for both the RSU and vehicles on the intersection roads are 500 bytes long.

1.2 Cascading Emergency Message Protocol Design

As described in the above section, most of the communications in each simulation test scenarios are messages on their own, whether they are routine safety messages or emergency ones. They would also be evaluated on their own, which means each message is examined to see how well it individually is received by nearby receivers. Although these results would provide understanding regarding how effective DSRC broadcast communications would be in certain settings, they do not show how well a particular safety application would fare.

A cascading emergency message pattern is designed to emulate the behaviors of some safety applications in a more direct manner in order to gain better insight of the safety applications' performance from the communication angle.

There are many ways for an emergency to happen at an intersection. A car could run the red light or some aggressive lane change maneuvers could cause a close call. Assuming such a situation is detected, either by a vehicle or the infrastructure, and made aware to a car approaching the intersection in some manner, it could trigger cascading events and associated communications through the traffic. For example, the lead vehicle may have to brake hard, causing the next car in the lane to brake as well, and so on and so forth.

Cascading messages of this type have a dependency among them. The following rule defines one such class of cascading events and communications.

For all vehicles in an affected lane and for each cascading flow, each car immediately starts its turn of transmitting high priority emergency messages if and only if it receives one such message from the car immediately ahead.

The team designed and implemented two cascading protocols to model these emergency message patterns in simulation test scenarios. They are described in detail in the following subsections.

1.2.1 Repetition based Cascading Protocol

The simplest method is the tried-and-true repetition technique. Each vehicle, at its turn of transmission, repeats its message N times. The N parameter needs to be set sufficiently high to ensure successful propagation of the event and emergency messages through the traffic, yet low enough to prevent vicious competition among these vehicles for the channel access. The figures below show the pseudo-code and SDL diagram of this protocol.

```
Repetition based Cascading Protocol:
VSCAgent:
when a packet is received
if packet is emergency message {

              if the sender is from the car in front
              {
                     if it is a new emergency message
                     {
record the message ID
(stop the old retransmission if it is still active)
                                start retransmitting, for N times
                     }
              }
if the sender is from the car behind it
{
       do nothing
}

}
```

Figure 1-2: Pseudo Code of Repetition-Based Cascading Protocol

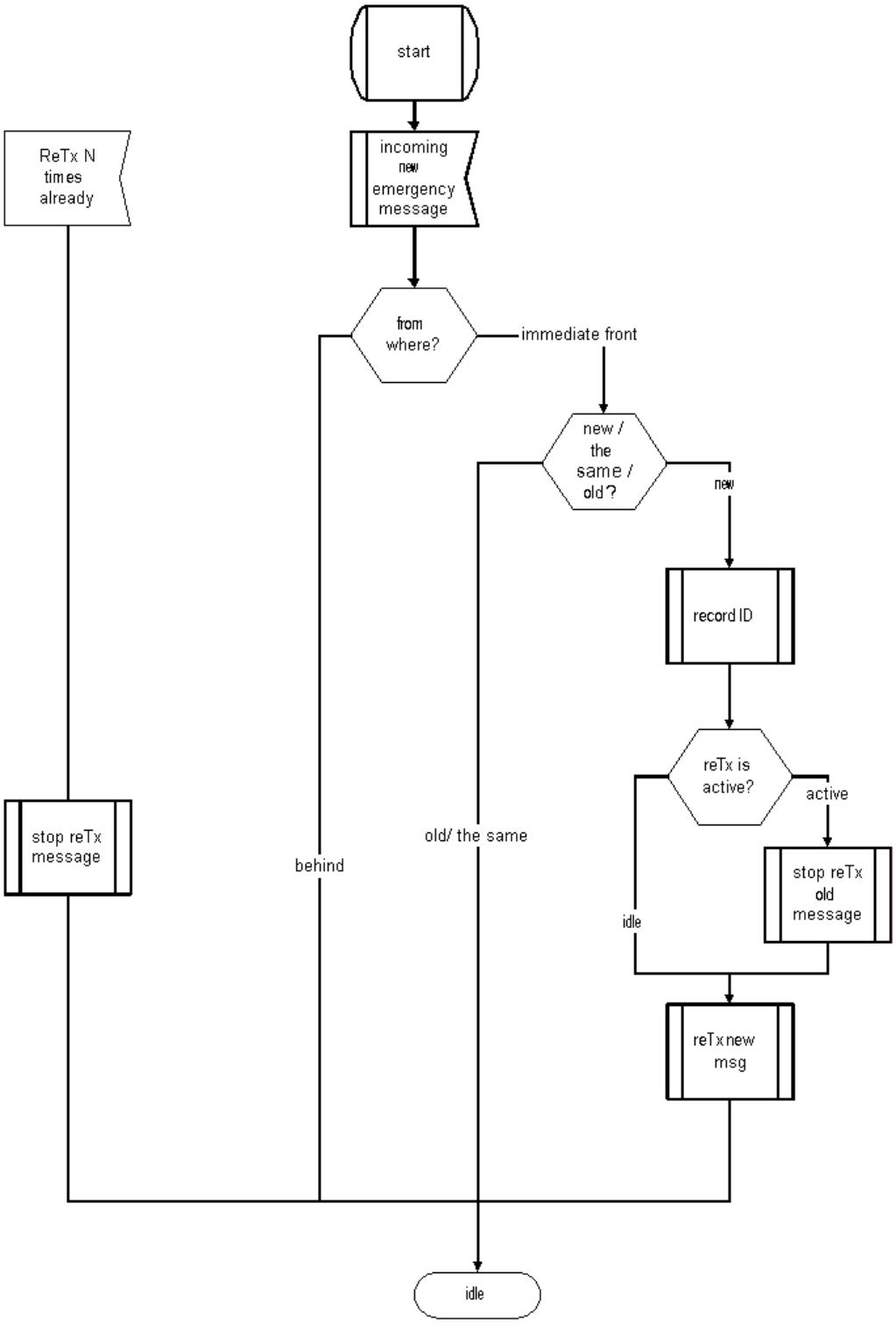


Figure 1-3: SDL Diagram of Repetition-Based Cascading Protocol

1.2.2 Feedback-Based Cascading Protocol

The repetition-based cascading protocol, although simple, is neither efficient nor reliable in ensuring message propagation. Therefore another feedback-based protocol is designed by adding one more rule.

> *Each vehicle, while at its turn of transmission, repeats until it receives one such message from any vehicle behind*[1]*. At this point it stops transmission.*

This protocol is designed so a vehicle would transmit enough times to ensure message propagation, but no more. The figures below show the pseudo-code and SDL diagram of this protocol.

```
Feedback based Cascading Protocol:
VSCAgent:
when a packet is received
if packet is emergency message {

              if the sender is from the car in front of it
              {
                     if it is a new emergency message
                     {
record the message ID
(stop the old retransmission if it is still active)
                            start retransmitting
                     }
              }
if the sender is from the cars behind it
{

       if the message ID is the same as current ID,
              stop retransmitting

}

}
```

Figure 1-4: Pseudo Code of Feedback-Based Cascading Protocol

[1] Assuming all vehicles involved would transmit emergency messages containing the same cascading event id, then a car could, upon reception of an emergency message containing the same id from behind, infer that its own transmission has been properly cascaded through.

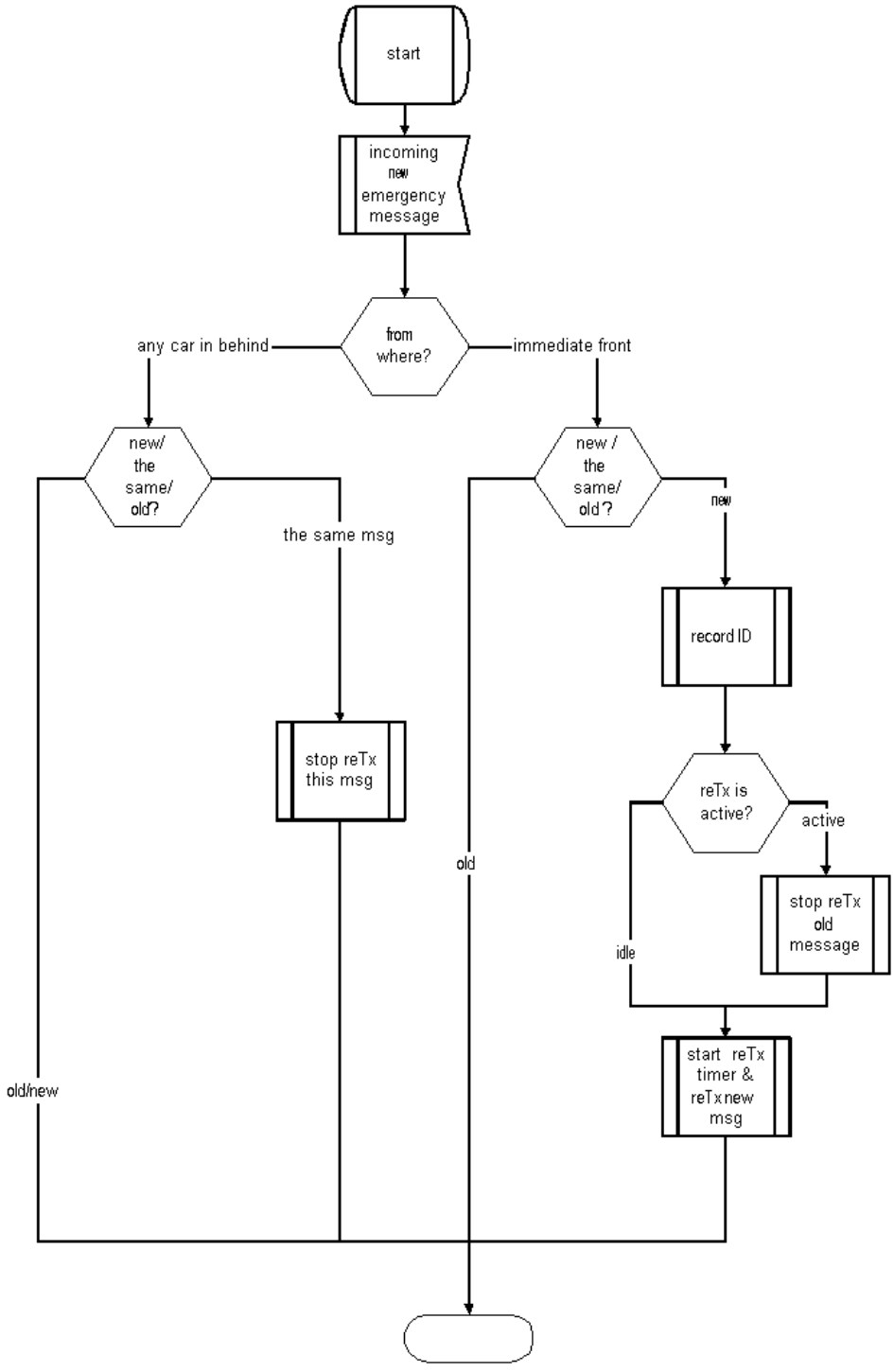


Figure 1-5: SDL Diagram of Feedback-Based Cascading Protocol

2 Simulator Update

The DSRC simulator underwent significant changes in order to configure and run intersection-based simulation test cases. These areas of change are indicated in the simulator architecture figure below. Major updates are described further in the following sections.

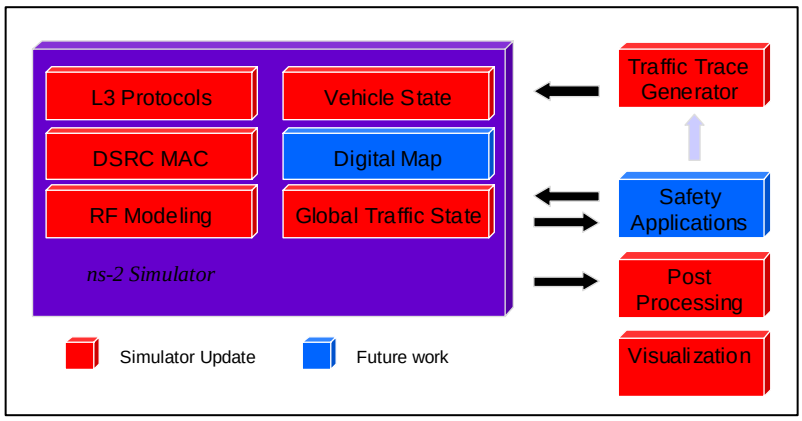


Figure 2-1: DSRC Simulator Architecture

2.1 Traffic Trace Generator

Mobile (cars, OBU) and fixed (roadside units, RSU) nodes were distributed in an intersection environment (Figure 2) that also included a nearby highway. This scenario was generated in response to a Department of Transportation request for simulation testing in a highly congested intersection environment. A new traffic generator was developed to create a specific traffic input file for this scenario.

Since the scenario involved road segments with different traffic patterns, the traffic generator had to incorporate a method of defining and controlling traffic flow based on road segment and travel direction. It also had to contain road shapes, lengths, widths, relative positions, allowable speed ranges, and the presence or absence of buildings.

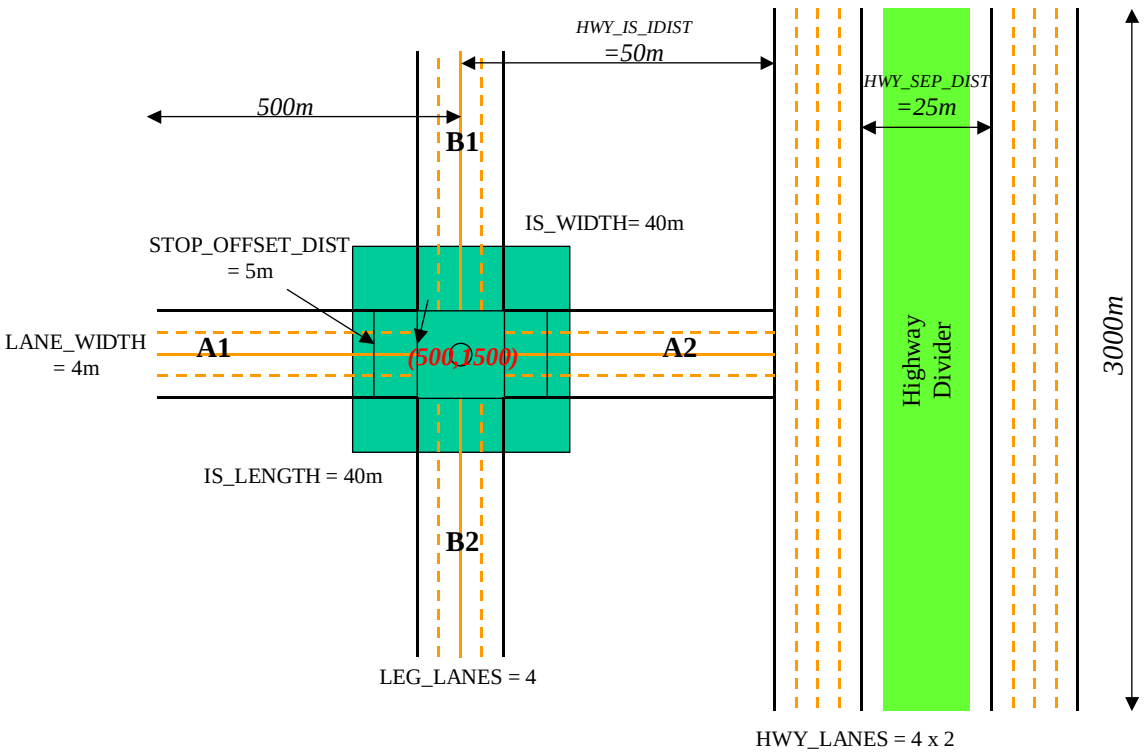


Figure 2-2: General Intersection Scenario

The traffic generator divides the scenario into several components (Figure 3):

1. Divided highway
2. Intersecting roads A and B and their sub-segments (A1, A2, B1, and B2)
3. Intersection (shown in teal in Figure 2)
4. Commercial RSU locations (shown in royal blue in Figure 3)

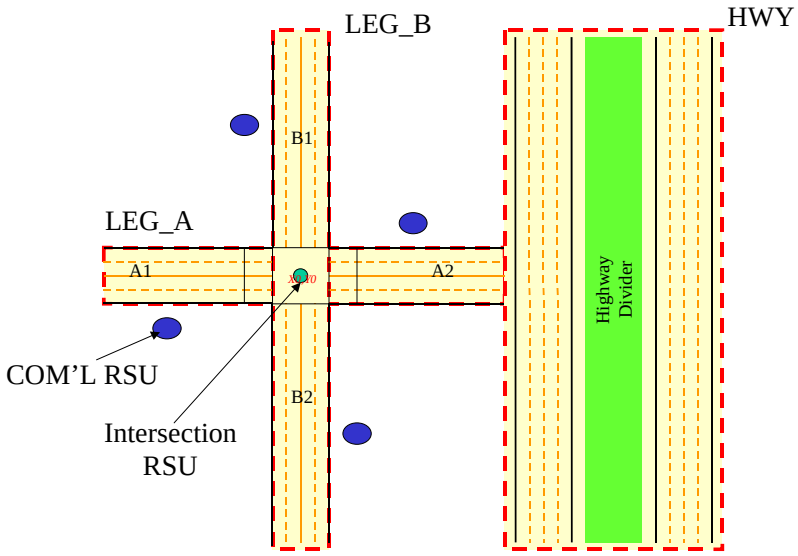


Figure 2-3: Components of Intersection Scenario

The traffic generator can create a traffic input file for each of the components or a combination of selected components. While unrealistic, in order to create the best chance for a high density of communications, all roadways including road segment A2 and the highway are at the same elevation. As such, communications on the intersecting roads A and B may be received on the highway and vice versa, but vehicles from the highway do not intersect nor commingle with vehicles on A or B.

The highway is composed of four lanes in each direction. The vehicles (or nodes) on each lane have fixed speeds that vary (between 60 and 120 km/h) by lane assignment and the vehicle density is fixed at 80 cars per lane mile. A representative node distribution is shown in Figure 4. The number of nodes and the length of each lane are calculated so that a consistent number of nodes remain within the borders of the simulation area.

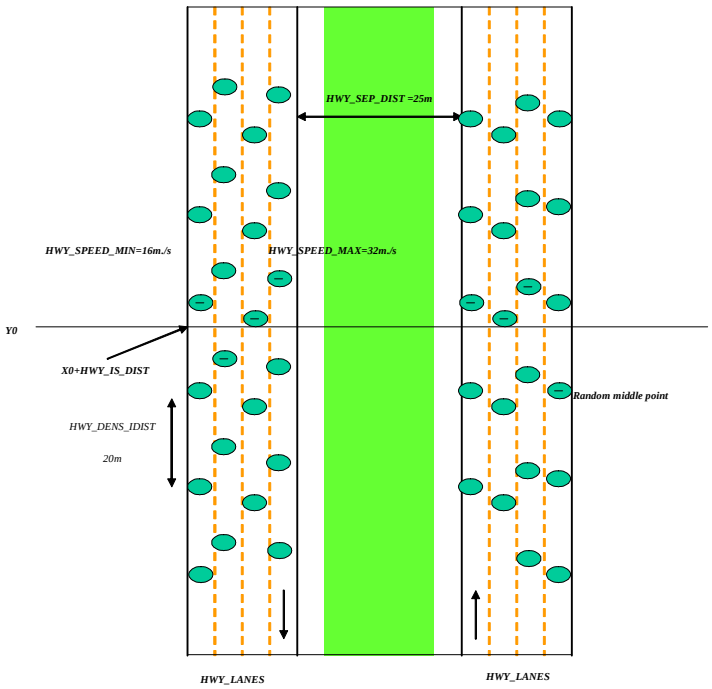


Figure 2-4: Node Distribution and Movement on Highway

Nodes are distributed on the intersecting roads as shown in Figure 5. As depicted, road B traffic has a green light at the intersection and road A has a red light.

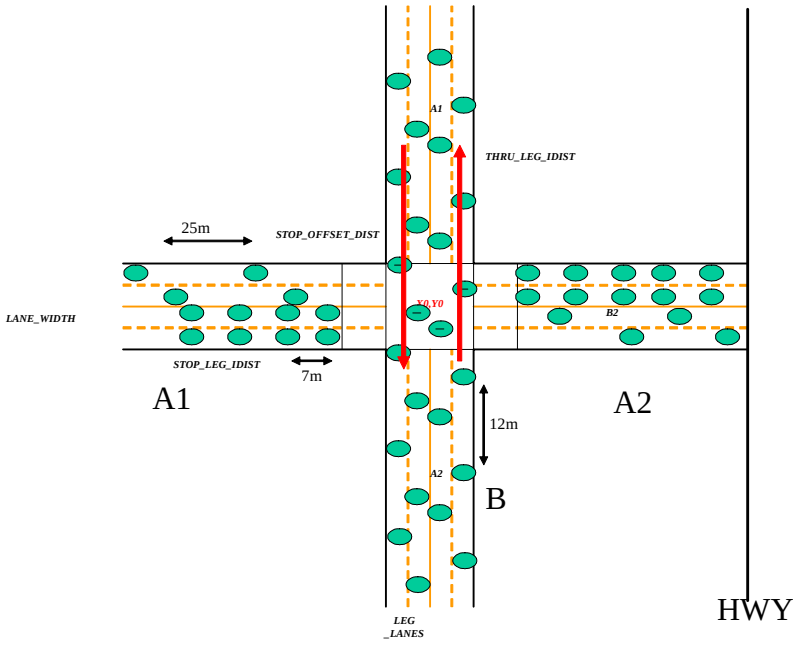


Figure 2-5: Node Distribution on Intersection Legs

Road A nodes approaching the intersection are stopped at the red light and are tightly spaced at 230 cars per lane mile (7m between nodes), which is significantly higher than the road B node density of 134 cars per lane mile (12m between nodes). Road A nodes traveling away from the intersection are spaced at 64 cars per lane mile (25m between nodes). The nodes on road B move similarly to nodes on the highway, but at lower speeds. The minimal speed is ~29 km/h and maximum is ~58 km/h.

Adding all vehicle on-board unit (OBU) nodes and the few RSU nodes in the simulation environment yields roughly 1900 separate communication nodes.

2.2 Vehicle State and L3 Protocols

2.2.1 Vehicle Node IDs

Each node is assigned an ID. These are used to differentiate between nodes in different road segments. The first digit of the ID indicates the node's road segment.

Scenario component	ID range	Prefix	Node type
Highway	1-999	0	1
Road A	1001-1999	1	2
Road B	2001-2999	2	2
Intersection RSU	0		3
Commercial RSU	3001-3999	3	4

Table 2.1. Node ID prefixes

2.2.2 Node Behavior Customization

Previous versions of the simulator had only limited support for customizing a node's behavior. Every node was identical in the protocol stack and protocol parameters. The only difference is their location and priority level. However, task 12 requires much more control on each node. Based on location, there are four types of nodes: Highway, Intersecting Road, Intersection RSU, and Commercial RSU. Each type of node is expected to have unique VSC application settings. Furthermore, each node has unique event-driven communications. Therefore, the nodes need to be customized, as delineated below.

2.2.2.1 Methods of Node Customization

With the nodes' IDs, it is possible to customize the node in two ways:

A. Define several vehicle types. Each type has certain protocol settings and routine communication patterns. Each node is assigned a vehicle type in the scenario input file. The node is configured while the scenario input file as being parsed.

B. Use a plug-in script in which all transmit events of each node are defined. Solution A groups the nodes' behavior. It has the advantage that when the scenario requires changing the behavior of one vehicle type, it only needs to be changed in the definition for that vehicle type. All nodes belonging to that vehicle type will be configured accordingly when the scenario file is parsed.

Solution B makes each node unique. It allows each node's behavior to be totally different than the others. So unique event-driven messages are possible with this solution.

2.2.2.2 Implementation of Node Configuration

A combination of the above two solutions was implemented. Vehicle type is defined in an initial script. Each node is configured according to its vehicle type and routine transmissions are defined. After the configuration, a communication file for event-driven transmissions of each node is loaded.

	Type	Routine transmit	Set-interval	Set-priority	Size
Nodes on HWY	0	ON_ASYN	0.1	1	500
Nodes in intersection	1	ON_ASYN	0.1	1	200
Intersection RSU	2	ON_ASYN/OFF	0.1	1	500
Commercial RSU	3	ON_ASYN/OFF	1.0	0	500

Table 2.2. Example Initial Script Node Configuration

Event driven communication

A TCL script (communication file) is used to describe all event-driven communications. The simulator loads this script.

Command syntax:

$ns at *time* "*agent_name* send"

Example Scripts:

```
$ns at 1.6 "$agent_1 send"
$ns at 1.64 "$agent_29 send"
```

2.3 RF Modeling

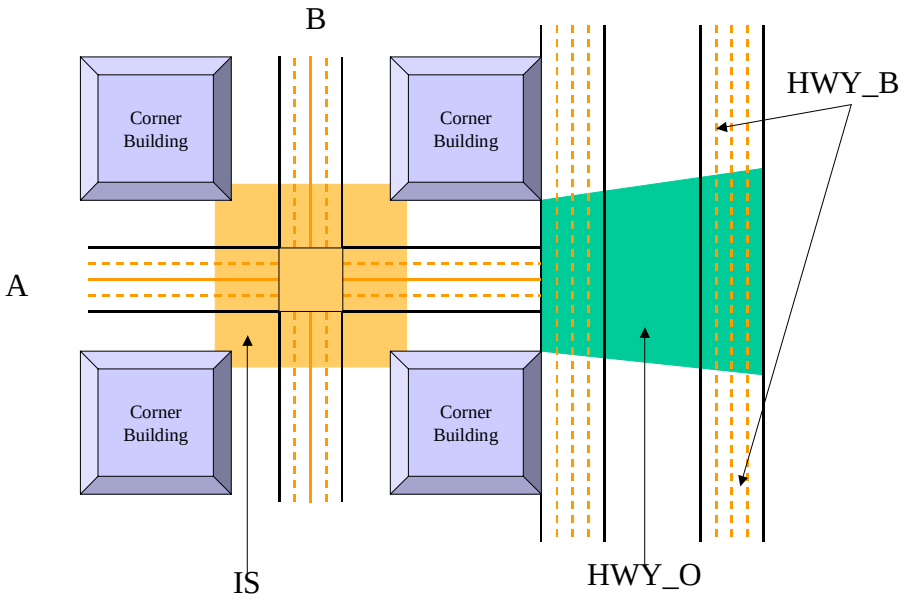


Figure 2-6: RF Model Regions

2.3.1 Motivation

Because of the complexity of the urban environment with buildings, the computation of reception power not only depends on the mutual distance between the sender and receiver, but also on the radio frequency (RF) characteristics in the space between them (e.g., multipath effects, obstructions). For simulation tests in the mixed urban/highway environment, multiple RF models are required. A decision function was implemented in the simulated DSRC physical (PHY) layer to choose the proper model for computation. In the scenarios without buildings, a single RF model was used for all communications in all regions for the intersection and highway environments.

2.3.2 RF Model Selection

There are two methods of deciding which model to choose when buildings are present in the simulation environment.

A. Query a Map. If there is a common map available for all nodes, the PHY layer can query the map, which checks the sender and receiver's location and uses the appropriate model.

B. Use the location information in the node ID. By checking the sender's ID, the simulator knows whether a receiver and sender are in the same region. This information is used to make the decision on which RF model to use.

The common map solution is a complete solution. A map can tell precisely what is in-between the sender and receiver and determine the real radio path. However, such a solution is very complex and requires a great deal of computation. In addition, this is general purpose research, so it is not meaningful to use a very specific map. The second solution is only a partial solution; with only this information, it is hard to choose the correct model precisely.

So the final implementation is a hybrid solution: the ID determines whether the sender and receiver are on the same road. Two special regions are also defined: IS (intersection) and HWY_O (highway open). The IS region represents the real intersection area, in which there are no buildings. HWY_O represents the region on the highway where the nodes can influence communications at the intersection.

Further regions are denoted as intersecting roads A and B, and HWY_B (highway blocked), which does not have a clear line of sight (LOS) to the intersection when buildings are present. Note that commercial RSUs are contained within roads A or B and, as such, do not constitute a region.

2.3.3 RF Model Development

Since a highway RF model had already been developed for task 6A, most efforts were focused on creating an RF model for the newly defined urban environment. This was done by finding a real-world intersection similar to the one defined in the simulator and collecting extensive empirical RF measurements. The intersection used for data collection is pictured below and is indicated by the blue dot. Many tests were conducted at and around this intersection in order to collect statistically significant amounts of data at appropriate ranges. The primary range of interest is 200m and below. This was selected since it generally included most intersection safety applications envisioned in the VSC Task 3 report.

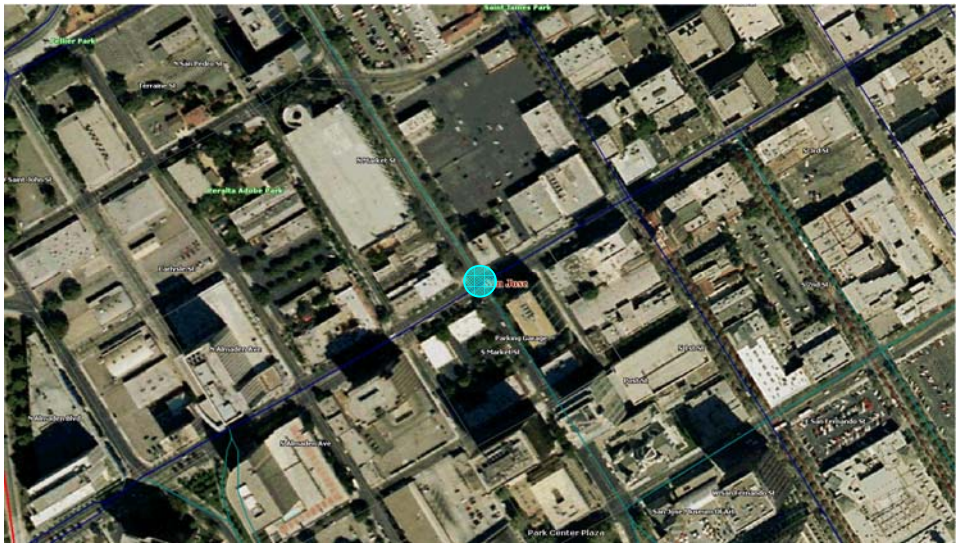


Figure 2-7: City Intersection RF Model Data Collection Site

Data was collected using multiple test vehicles, a single intersection RSU test stand, DSRC communications test kits (CTK) as developed in Tasks 4 and 6A, and DSRC-tuned antennas developed in Task 6C. New WAVE radio modules (WRM) from Task 6D were not yet available at the time of data collection.

Based on the data collected at this intersection and previously on the highway, three different types of RF models were derived[2]:

Highway: Model for highway and for all roads when no buildings are present
City: Model for nodes within LOS on city roads with buildings present
Blocked: Model for nodes with buildings blocking the LOS path

[2] It is important to note that RF modeling for intersections is an enormously complex task. There are many factors that impact the RF behaviors, including intersection landscape, street geometry, corner building shape, position, material, etc. Due to the resource and timing restrictions, the models implemented in this task are derived from measurements obtained at one particular urban intersection. These are not meant to generalize all intersections. On the other hand, this intersection was selected carefully to match the one agreed within VSCC and with DOT for the simulation scenarios. Accordingly, the RF models are meaningful for this simulation study.

These three models were implemented in the simulator and applied to reception power calculations based on the following decision table.

Node location	A	B	IS	HWY_O	HWY_B
A	City	Blocked	City	City	Blocked
B	-	City	City	Blocked	Blocked[3]
IS	-	-	City	City	Blocked
HWY-O	-	-	-	Highway	Highway
HWY-B	-	-	-	-	Highway

Figure 2-8: RF Model Selection Decision Table

2.3.4 RF Model Implementation

By analyzing the data collected from road tests, empirical Nakagami parameters were derived for each RF model. Each model has a different set of Nakagami parameters, which give the models their characteristic traits and accurately portrays performance based on statistical analysis of applicable RF data collection.

Additionally, two variants of each model were used in the simulations. For each distance measured between test vehicles, many transmitted packets were collected, but received signal strength that always varied significantly. For simplicity, 80 percent of the most likely reception signal strengths at each distance were used to develop a distributed RF model. The blue upper and lower boundary lines in the following charts represent this distributed range of most likely signal strengths. The deterministic model further simplifies this distribution by representing the average value (in red) over the distributed range of signal strengths. Details of each model are listed below together with simulation results showing the reception probability with no interference.

It is interesting to observe that signal attenuation within one urban canyon is less severe than on highways. The reason is that buildings on both side of the street are able to contain and channel the signal through multi-path effects, which is less available on the open highways. The implication is that, for the same transmission power and assuming same interference level, the reception of a packet is likely better than that on a highway. Of course, reception around a corner in an urban setting is much less than within the same street, as expected.

[3] Please note that transmission between B and HWY_B is a special case. The sender and the receiver are placed on opposite sides of a building block. Assuming no RF signal penetration through the building, the signal attenuation is calculated according to two, around-corner propagations using the blocked model. There is a further 15 dB signal loss to account for additional reflections.

2.3.4.1 Highway RF Model

Nakagami Parameters	Highway Model Values
gamma0	1.9
gamma1	3.8
d0_gamma	200
d1_gamma	600
m0	1.5
m1	0.75
m2	0.75
d0_m	80

Figure 2-9: Highway RF Model Nakagami Parameters

The above table shows the Nakagami parameters for the highway RF model, while the figure below shows the signal attenuation over distance for this model.

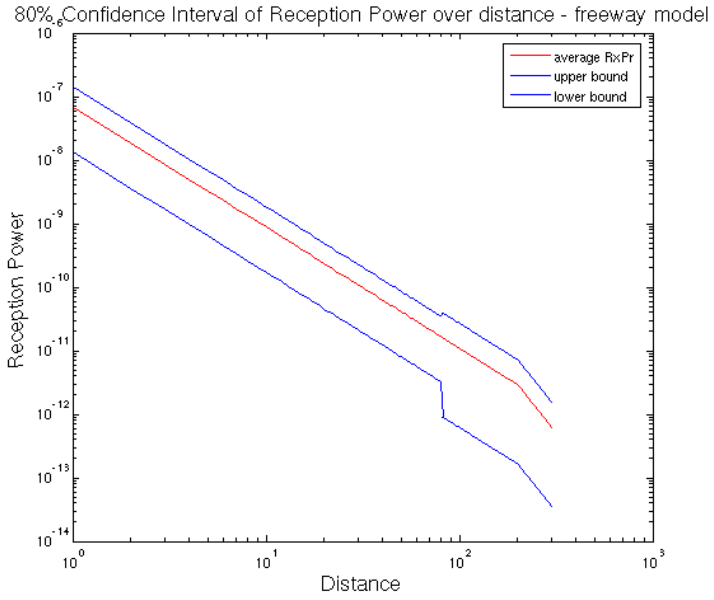


Figure 2-10: Signal Attenuation Over Distance, Highway RF Model

2.3.4.1.1 Ideal Performance With Highway RF Model

The following simulation result shows the impact by the highway RF model on message reception in an ideal (interference free) environment.

Sender location	Middle of the freeway
Receiver location	All nodes on freeway
Communication Activities	Single sender sends message periodically with no interference
Transmission Range	200m

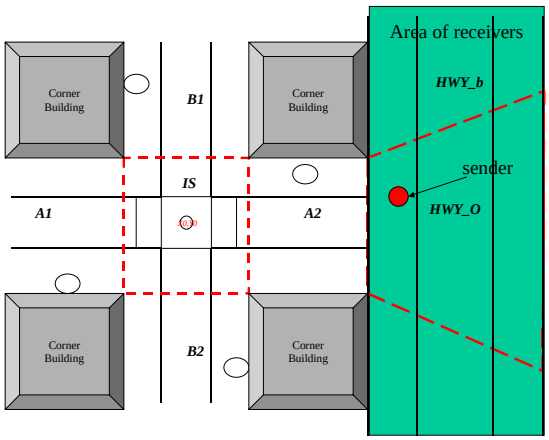


Figure 2-11: Simulation Setting, Single Sender on Freeway, Highway RF Model

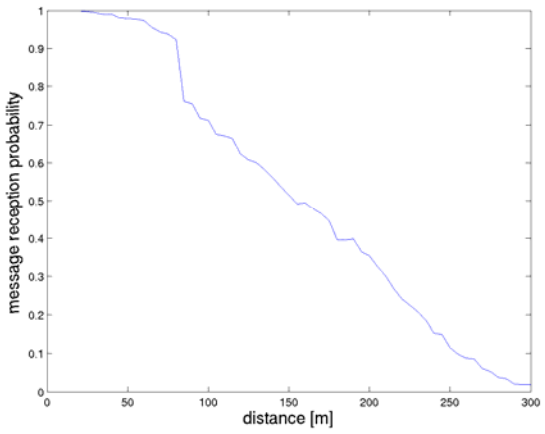


Figure 2-12: Reception Probability on Freeway, Single Sender on Freeway, Highway RF model

2.3.4.2 City RF Model

Nakagami Parameters	City Model Values
gamma0	1.5
gamma1	4
d0_gamma	125
m0	0.75
m1	0.5
d0_m	125

Figure 2-13: City RF Model Nakagami Parameters

The above table shows the Nakagami parameters for the city RF model, while the figure below shows the signal attenuation over distance for this model.

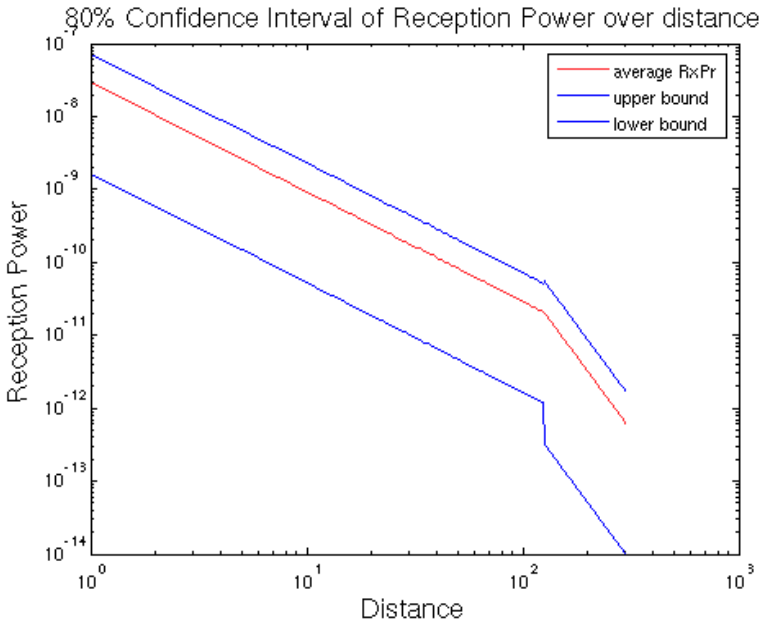


Figure 2-14: Signal Attenuation over Distance, City RF Model

2.3.4.2.1 Ideal Performance with City RF model

The following simulation result shows the impact by the city RF model on message reception in an ideal (interference free) environment.

Sender location	Middle of the intersection
Receiver location	Road B (the through road)
Communication Activities	Single sender sends message periodically with no interference
Transmission Range	200m

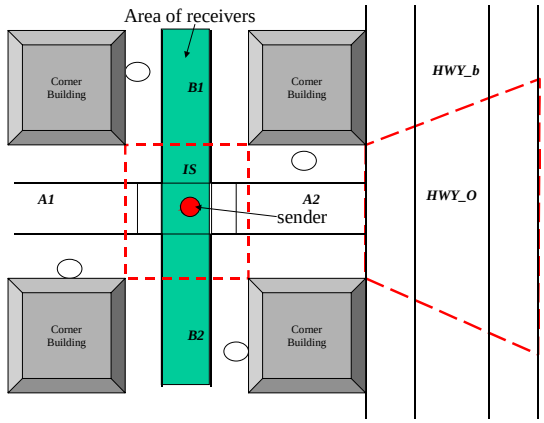


Figure 2-15: Simulation Setting, Single Sender in Intersection, City RF Model

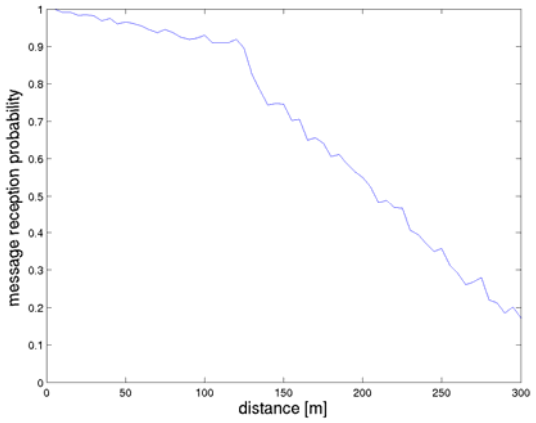


Figure 2-16: Reception Probability within Urban Canyon, Single Sender in Intersection, City RF Model

2.3.4.3 Blocked RF Model

Nakagami Parameters	Blocked Model Values
Gamma0	2
Gamma1	10
d0_gamma	125
m0	0.5
m1	0. 5
d0_m	125

Figure 2-17: Blocked RF Model Nakagami Parameters

The above table shows the Nakagami parameters for the blocked RF model, while the figure below shows the signal attenuation over distance for this model.

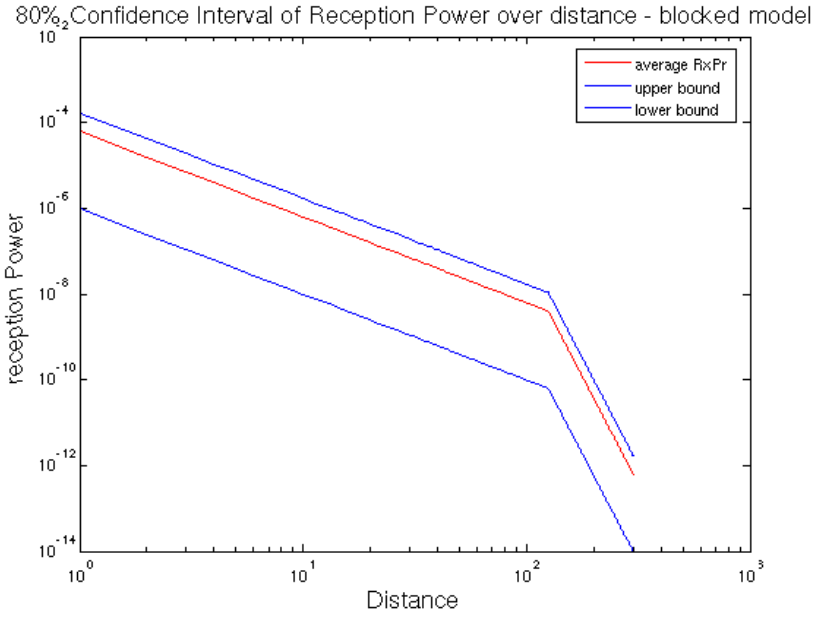


Figure 2-18: Signal Attenuation over Distance, Blocked RF Model

2.3.4.3.1 Ideal Performance with Blocked RF model

The following simulation results show the impact by the blocked RF model on message reception in an ideal (interference free) environment.

Sender location	A node on Road A close to the intersection
Receiver location	Road B (outside of the IS area)
Communication Activities	Single sender sends message periodically with no interference
Transmission Range	200m

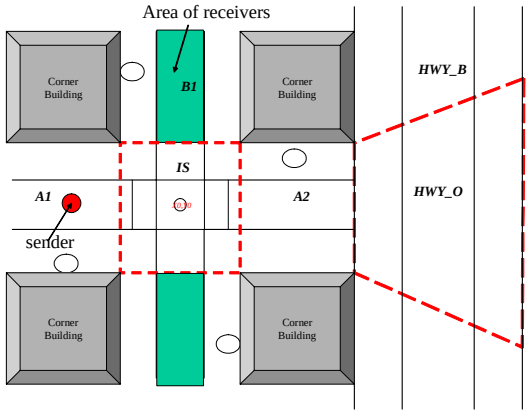


Figure 2-19: Simulation Setting, Single Sender Around Corner, Blocked RF Model

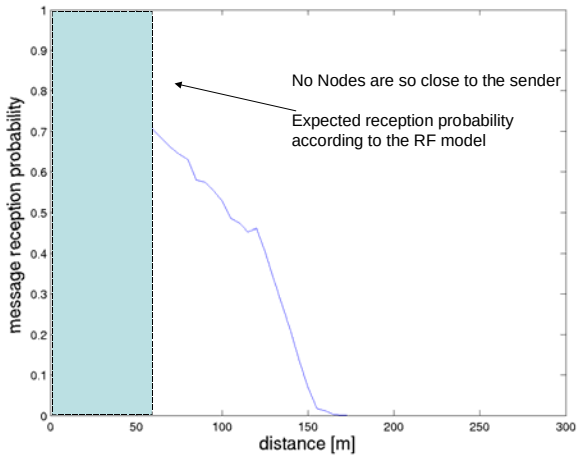


Figure 2-20: Reception Probability Around Corner, Single Sender, Blocked RF model

3 Simulation Test Matrix

The following sections describe the parameter settings for all simulation tests conducted for this task. Please refer to the later chapters for the full results of all the simulation tests.

3.1 Batch 1, Routine and Emergency Safety Messaging in Saturated Channel

As shown in the table below, this batch of simulation tests places the emphasis on stressing the channel. All OBUs are arranged to transmit routine safety messages at 10Hz with an intended range of 200m. Four commercial RSUs placed at roadside all inject messages into the channel as well in some of the scenarios.

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Deterministic or Distributed	Buildings in corners or not	RSU or OBU	200m or 300m	ON or OFF	1/2/5/10 Hz	200m or 100m	Repetition or feedback
1	Deterministic	Open	RSU	200m	ON	10Hz	200m	
2	Deterministic	Open	RSU	200m	OFF	10Hz	200m	
3	Deterministic	Building	RSU	200m	ON	10Hz	200m	
4	Deterministic	Building	RSU	200m	OFF	10Hz	200m	
5	Deterministic	Open	OBU	200m	ON	10Hz	200m	
6	Deterministic	Open	OBU	200m	OFF	10Hz	200m	
7	Deterministic	Building	OBU	200m	ON	10Hz	200m	
8	Deterministic	Building	OBU	200m	OFF	10Hz	200m	
9	Distributed	Open	RSU	200m	ON	10Hz	200m	
10	Distributed	Open	RSU	200m	OFF	10Hz	200m	
11	Distributed	Building	RSU	200m	ON	10Hz	200m	
12	Distributed	Building	RSU	200m	OFF	10Hz	200m	
13	Distributed	Open	OBU	200m	ON	10Hz	200m	
14	Distributed	Open	OBU	200m	OFF	10Hz	200m	
15	Distributed	Building	OBU	200m	ON	10Hz	200m	
16	Distributed	Building	OBU	200m	OFF	10Hz	200m	

3.2 Batch 2, Routine and Emergency Safety Messaging in Less Stressful Channel

This second batch of simulation tests is configured in reaction to the results from the first batch. Given the large number of vehicles present around intersections and on the freeway, it is clear that transmitting routine safety messages from all of them at 10Hz creates a saturated channel. Routine safety messages have collapsed performances across the board. Therefore, it is necessary to adjust the channel load and re-evaluate the routine safety message performance. Instead of reducing the vehicle density, which is set at a

level quite plausible in reality, the team decided to reduce the routine message transmission frequency since it is a communication design option.

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Deterministic or Distributed	Buildings in corners or not	RSU or OBU	200m or 300m	ON or OFF	1/2/5/10 Hz	200m or 100m	Repetition or feedback
17	Distributed	Open	RSU	200m	ON	2Hz	200m	
18	Distributed	Open	OBU	200m	ON	2Hz	200m	
19	Distributed	Building	RSU	200m	ON	2Hz	200m	
20	Distributed	Building	OBU	200m	ON	2Hz	200m	
21	Distributed	Open	RSU	300m	ON	2Hz	200m	
22	Distributed	Open	OBU	300m	ON	2Hz	200m	
23	Distributed	Building	RSU	300m	ON	2Hz	200m	
24	Distributed	Building	OBU	300m	ON	2Hz	200m	
25	Distributed	Open	RSU	200m	ON	1Hz	200m	
26	Distributed	Open	OBU	200m	ON	1Hz	200m	
27	Distributed	Building	RSU	200m	ON	1Hz	200m	
28	Distributed	Building	OBU	200m	ON	1Hz	200m	
29	Distributed	Open	RSU	300m	ON	1Hz	200m	
30	Distributed	Open	OBU	300m	ON	1Hz	200m	
31	Distributed	Building	RSU	300m	ON	1Hz	200m	
32	Distributed	Building	OBU	300m	ON	1Hz	200m	
33	Distributed	Open	RSU	200m	ON	5Hz	200m	
34	Distributed	Open	OBU	200m	ON	5Hz	200m	
35	Distributed	Building	RSU	200m	ON	5Hz	200m	
36	Distributed	Building	OBU	200m	ON	5Hz	200m	
37	Distributed	Open	RSU	300m	ON	5Hz	200m	
38	Distributed	Open	OBU	300m	ON	5Hz	200m	
39	Distributed	Building	RSU	300m	ON	5Hz	200m	
40	Distributed	Building	OBU	300m	ON	5Hz	200m	

After analyzing the results of the aforementioned tests, the presence of commercial RSU messages on the channel has evidently no effect whatsoever. This is expected since their communication load pales in comparison with the number of other vehicles and their transmissions. Accordingly, this parameter is no longer varied in this batch.

3.3 Batch 3, Intersection RSU Retransmission of Routine Safety Messages

Given the challenge caused by the RF model for messaging performance around the corner, there is interest from the vehicle safety community to use intersection RSU retransmission techniques to improve the situation. This batch of simulation tests is designed to evaluate this concept.

Two levels of channel load are evaluated. One is saturated, with all vehicles transmitting routine safety messages at 10Hz. Another is more moderate at 2Hz since the earlier results showed comparatively better overall communication performance at this stress level.

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Deterministic or Distributed	Buildings in corners or not	RSU or OBU	200m or 300m	ON or OFF	1/2/5/10 Hz	200m or 100m	Repetition or feedback
41	Distributed	Building	NA	200m	ON	2Hz	200m	
42	Distributed	Building	NA	200m	ON	10Hz	200m	

3.4 Batch 4, Cascading Emergency Messages from Intersection

This batch of simulation tests evaluates the performance of emergency message cascading within one lane from the intersection. The cascading emergency message pattern is used to emulate intersection safety application communication behaviours as a dangerous situation is discovered at the intersection.

Two emergency message cascading protocols are evaluated. One uses the tried-and-true repetition method. The other uses a more intelligent feedback based method, which means a car will stop repeating emergency messages if it detects subsequent transmissions by its intended audience behind.

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Deterministic or Distributed	Buildings in corners or not	RSU or OBU	200m or 300m	ON or OFF	1/2/5/10 Hz	200m or 100m	Repetition or feedback
43	Distributed	Building	OBU Cascading in one lane	200m	ON	5Hz	200m	Repetition
44	Distributed	Building		200m	ON	5Hz	200m	Smart protocol2
45	Distributed	Building		200m	ON	10Hz	200m	Repetition
46	Distributed	Building		200m	ON	10Hz	200m	Smart protocol2

3.5 Batch 5, Additional Simulation Tests

This batch of simulation tests contains additional configurations as requested by other VSCC members.

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Deterministic or Distributed	Buildings in corners or not	RSU or OBU	200m or 300m	ON or OFF	1/2/5/10 Hz	200m or 100m	Repetition or feedback
47	Distributed	Open	RSU	200m	ON	NA	NA	
48	Distributed	Building	RSU	200m	ON	NA	NA	
49	Deterministic	Open	RSU	200m	ON	10Hz	100m	
50	Deterministic	Building	RSU	200m	ON	10Hz	100m	

4 Analysis

In this section, the team analyzes the simulation results and makes observations of the implications for both the underlining communication design as well as its usage by safety applications.

4.1 Routine Safety Messages at Intersection

This task was initiated with the desire to find out how well DSRC would work in a high volume intersection with plenty of external interference sources. It is not unexpected that impact from a highly loaded channel on the routine safety messages among vehicles is severe.

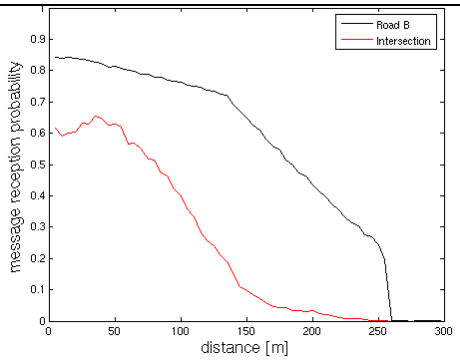


Figure 4-1: Reception Probability of Routine Messages, Sender on Road B, scenario 3

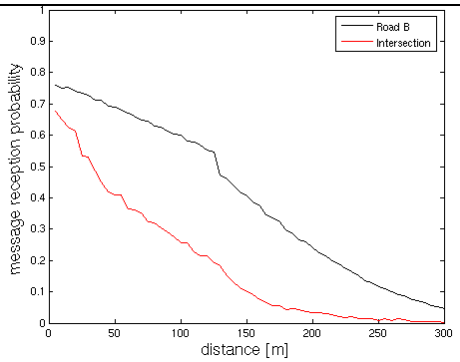


Figure 4-2: Reception Probability of Routine Messages, Sender on Road B, Scenario 11

The first batch of simulation tests is designed to stress the channel to the limit. All vehicle OBUs, which numbers about 2000, are configured to transmit a 200 Byte message at 10 Hz to the intended range of 200 Meter. The results demonstrate a collapsed channel weighted down by these routine safety messages for receivers at the intersection as shown by the red lines in the figures above for scenario 3 and 11.

The only difference between these two scenarios is the usage of the RF model. Scenario 3 uses the RF model deterministically while scenario 11 uses it in a distributed manner. Using the RF model in a distributed manner causes further degradation of the messaging performance[4]. However, the dominating outcome is the saturated channel and the collapsed messaging performance for all routine safety messages at the intersection. This

[4] Using the RF model deterministically is equivalent to drawing circles around a sender. A receiver is either able to receive (or be interfered by) the message or not simply by its position in or outside of the circles. This view is simplistic and clean, but not realistic. Using the RF model in a distributed manner means there is an average for the received signal strength at a particular distance, but the actual value for each instance of transmission is the result of a distribution function. This is **Messages** more realistic but also implies less communication performance in comparable settings for two reasons. First, even within the so-called reception range, some messages still would not be receivable by some nodes due to the possible lower than receivable signal strength value. Second, more nodes are possible interferers.

is true for all other simulation tests in the first batch. Please check the figures presented in the later chapters for scenario 1-4 and 9-12 for further details.

The results in the first batch of simulation tests clearly indicate a general saturation of the channel. Accordingly, the second batch is configured to reduce the overall channel loading. The results show improvements in message reception probability. However, it is important to note that it takes more than just a reception probability over distance figure for one to understand the implication of such communication performance for safety applications. For example, it could be better for a safety application to transmit five messages each at 50 percent reception probability than to deliver one message reliably in the same time frame. The following figures show both the routine message reception rate at the intersection as well as the time period necessary for a sender to be confident to 90 percent, 95 percent and 99 percent that at least one message would be received for scenarios 27, 19, 35 and 11. These four scenarios are otherwise configured in the same way, but with communication load defined by routine safety message rate of 1Hz, 2Hz, 5Hz, and 10Hz respectively. Please see the later chapters for similar figures of some other scenarios.

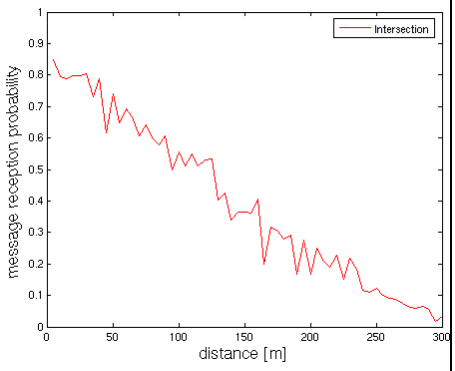
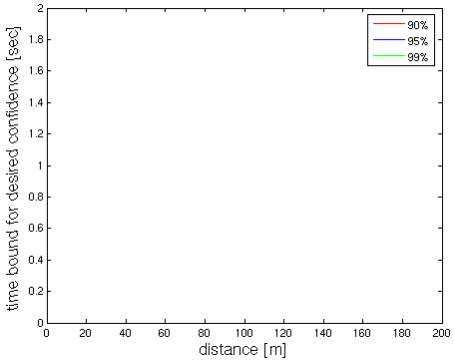
	Reception probability	Time Bound
1 Hz		

Figure 4-3: Reception Probability of Routine at Intersection, scenario 27

Figure 4-4: Time Bound for desired Confidence for Routine Messages Reception at Intersection, Scenario 27

2 Hz

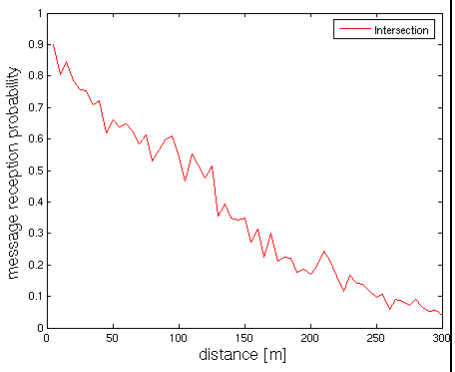


Figure 4-5: Reception Probability of Routine Messages at Intersection, Scenario 19

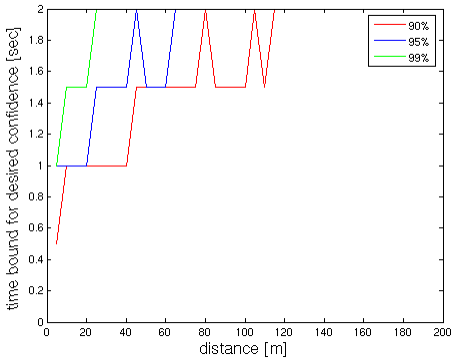


Figure 4-6: Time Bound for Desired Confidence for Routine Messages Reception at Intersection, Scenario 19

5 Hz

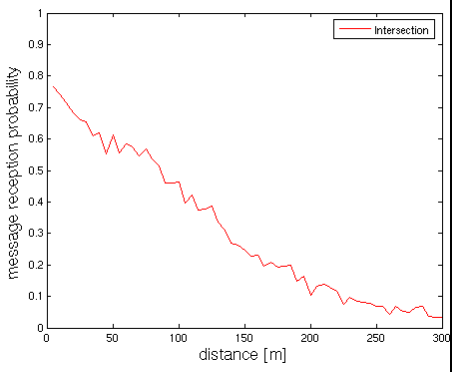


Figure 4-7: Reception Probability of Routine Messages at Intersection, Scenario 35

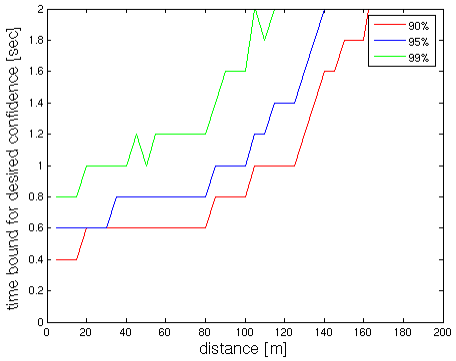


Figure 4-8: Time Bound for Desired Confidence for Routine Messages Reception at Intersection, Scenario 35

10 Hz

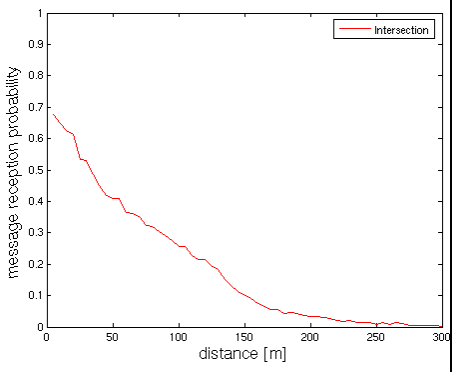


Figure 4-9: Reception Probability of Routine Messages at Intersection, Scenario 11

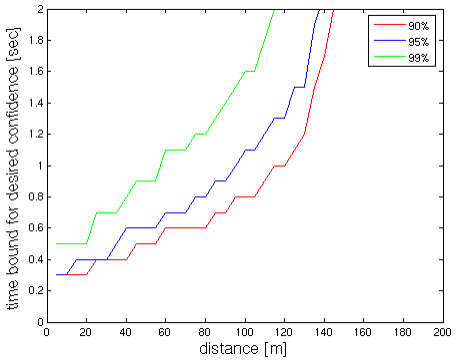
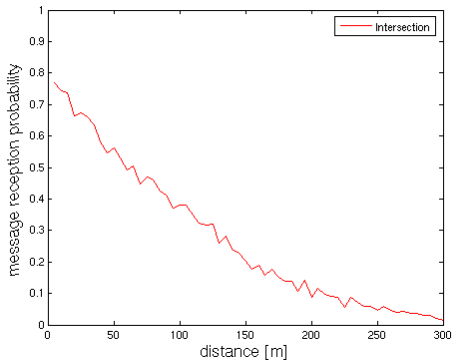
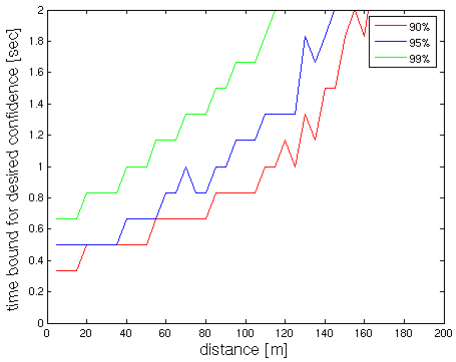
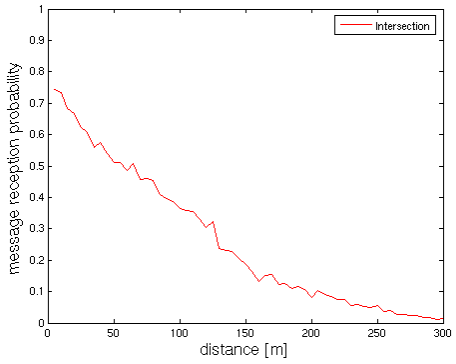
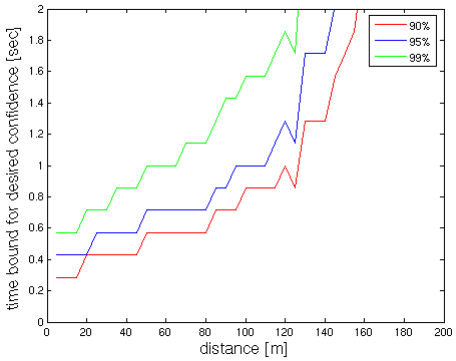


Figure 4-10: Time Bound for Desired Confidence for Routine Messages Reception at Intersection, Scenario 11

It is interesting to see that message reception latency at certain confidence level figures for scenario 11 and 35 are similar even though the later has only half of the routine

message transmission rate of the former. This is due to the improved message reception rate in the less stressful case. Additional simulation test runs are configured to further examine the implication of reduced routine message transmission rate. Please see Chapter 8 for further details.

	Reception probability	Time Bound
6 Hz		
	Figure 4-11: Reception Probability of Routine Messages at Intersection, Based on Scenario 11, Routine Message Adjusted to 6 Hz	**Figure 4-12: Time Bound for Desired Confidence for Routine Message Reception at Intersection, Based on Scenario 11, Routine Message Adjusted to 6 Hz**
7 Hz		
	Figure 4-13: Reception Probability of Routine Messages at Intersection, Based on Scenario 11, Routine Message Adjusted to 7 Hz	**Figure 4-14: Time Bound for Desired Confidence for Routine Message Reception at Intersection, Based on Scenario 11, Routine Message Adjusted to 7 Hz**

8 Hz

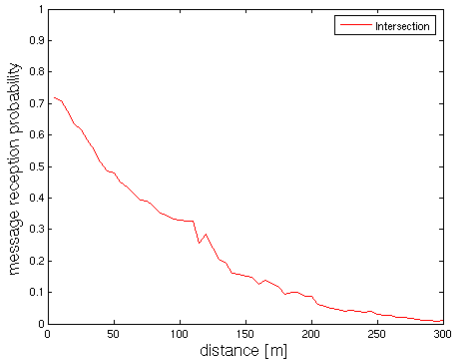


Figure 4-15: Reception Probability of Routine Messages at Intersection, Based on Scenario 11, Routine Message Adjusted to 8 Hz

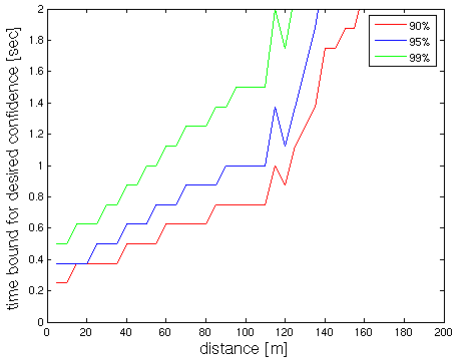


Figure 4-16: Time Bound for Desired Confidence for Routine Message Reception at Intersection, Based on scenario 11, Routine Message Adjusted to 8 Hz

9 Hz

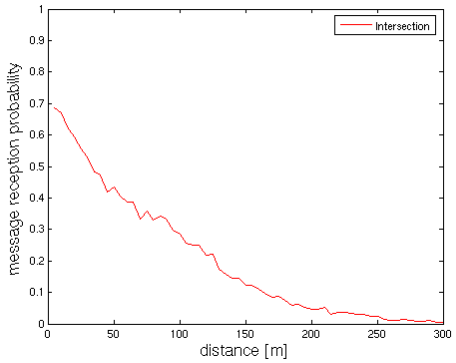


Figure 4-17: Reception Probability of Routine Messages at Intersection, Based on Scenario 11, Routine Message Adjusted to 9 Hz

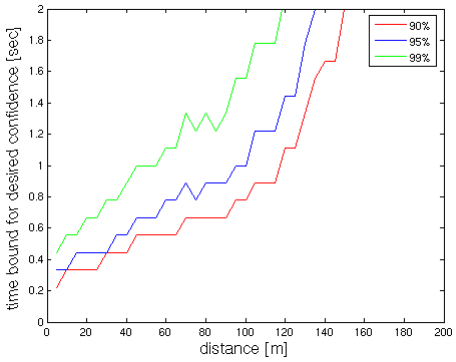


Figure 4-18: Time Bound for Desired Confidence for Routine Message Reception at Intersection, Based on Scenario 11, Routine Message Adjusted to 9 Hz

The figures above show the results of additional simulation test runs based on scenario 11 but with routine message transmission rate set at 6Hz, 7Hz, 8Hz, and 9Hz. Although there is a shift in message reception rate according to the channel loading, message reception latency at certain confidence level figures do not seem to differ much.

Taken together, routine safety messaging reception is sensitive to the channel loading, but more careful evaluation is necessary before the implication for safety applications are understood. The routine safety message reception latency at certain confidence level analysis shows similar results for a range of channel load (i.e. from 6Hz to 10Hz). Accordingly, it may not be necessary for all cars to transmit routine messages at 10Hz to 200 meter in congested environments as called for in the preliminary communications requirements in the Task 3 document. In the context of simulation test scenarios discussed above, transmitting less may be just as effective as sending more frequently.

It is also important to point out that none of the above cases would be able to satisfy the preliminary communication requirements listed in Task 3. Task 3 asks for 100 ms communication latency without specifying distance. This is equivalent to drawing a

horizontal line at 100 ms line in all the figures above. The simulation environment is configured to represent a high-volume intersection environment with high external interference levels in a believable manner. Within this context, the simulation results show that it is not feasible to have everyone transmitting messages at 10 Hz to 200 meters as described in Task 3 and achieving perfect performance. The implication is that the DSRC community may have to reevaluate how safety applications use DSRC communications in highly congested environments as a follow up to Task 3 and provide updated guidance in judging the results obtained here.

4.2 Emergency Safety Message at Intersection

4.2.1 Emergency Message from Intersection RSU

In comparison with the routine safety messages, emergency messages consistently have better reception at any distance. The figures below show the reception rates of emergency messages from the intersection RSU for scenario 11, 35, 19, and 27. These four scenarios are the same as the last four analyzed in the previous section on routine safety message performance.

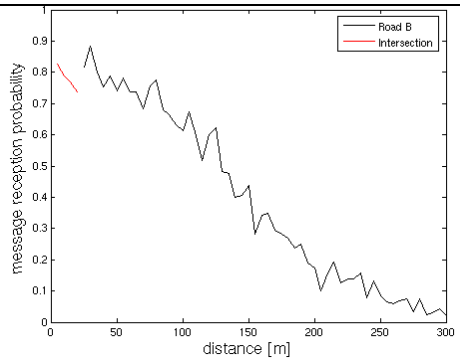


Figure 4-19: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

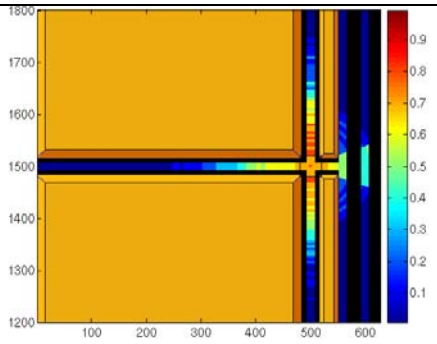


Figure 4-20: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

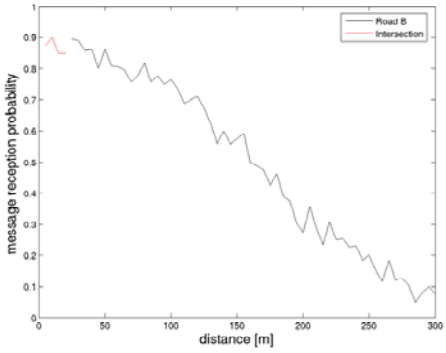


Figure 4-21: Reception Probability of Emergency Messages-Scenario 35, Road B, Sender RSU

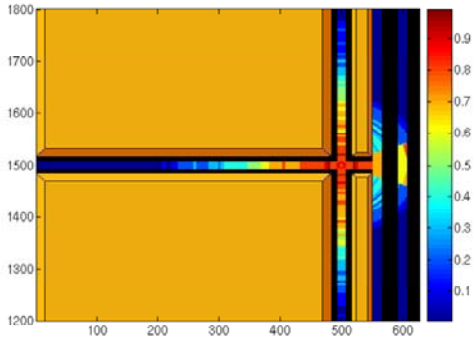


Figure 4-22: Reception Probability of Emergency Messages-Scenario 35, Sender RSU

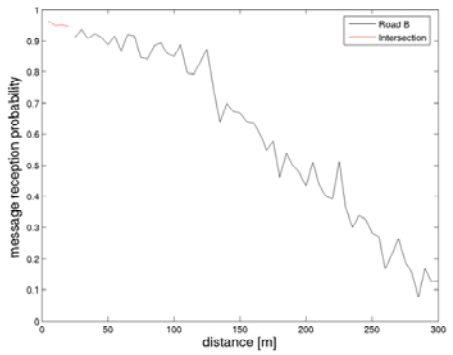


Figure 4-23: Reception Probability of Emergency Messages-Scenario19, Road B, Sender RSU

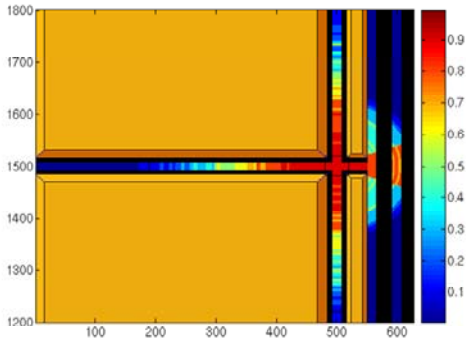


Figure 4-24: Reception Probability of Emergency Messages-Scenario19, Sender RSU

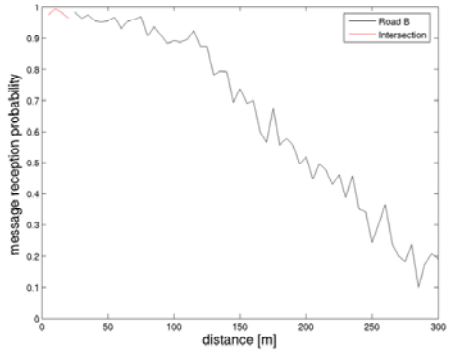


Figure 4-25: Reception Probability of Emergency Messages-Scenario 27, Road B, Sender RSU

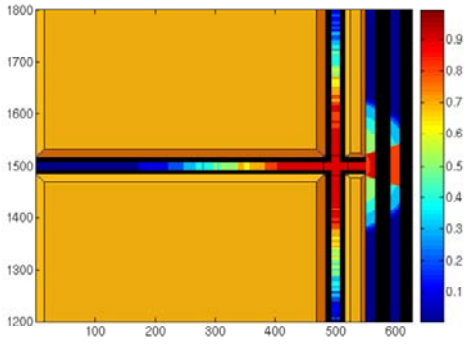


Figure 4-26: Reception Probability of Emergency Messages-Scenario 27, Sender RSU

With a less stressful channel, emergency messages from the intersection RSU perform even better. This is demonstrated in the figures above, which are the results for scenario 35, 19, and 27. As the routine safety message rate is reduced to 5Hz, 2Hz and 1Hz, the emergency message reception is quickly improved to almost matching the ideal performance permitted by the RF models. As a quick note, scenario 47 and 48 are configured with no routine safety messages. As expected, the emergency message reception in these two scenarios matches the upper bound set by the RF models.

4.2.2 Emergency Message from Vehicle OBUs

The performance of emergency messages from vehicle OBUs also follows the same pattern as the ones for RSU messages. Figure 4-27 and Figure 4-28 below show the results for scenario 15, which is comparable with scenario 11 and with the only difference being the source of emergency messages.

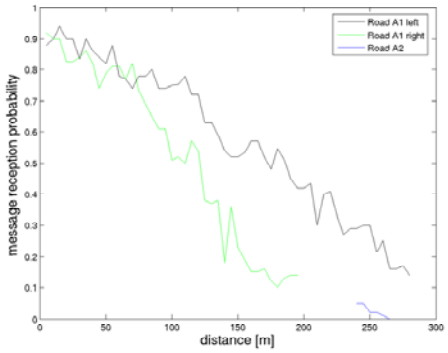


Figure 4-27: Reception Prob. of Emergency Messages - Scenario15, Rd. A, Sender on Rd. A1

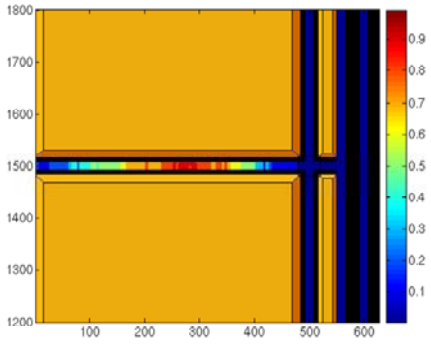


Figure 4-28: Reception Prob. of Emergency Messages-Scenario 15, Sender on Rd. A1

In batch 2, the team also evaluated the impact of increased transmission power for emergency messages. The figures below show the results for scenarios 36 and 40. The channel loading for both scenarios is defined by a routine safety message rate of 5Hz. Emergency messages in scenario 36 are transmitted at the same power as routine safety messages and the intended range is 200 meters. In scenario 40, this power is raised to a level intended for 300-meter range.

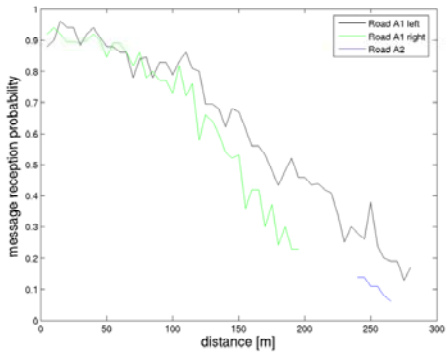


Figure 4-29: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on Rd. A1

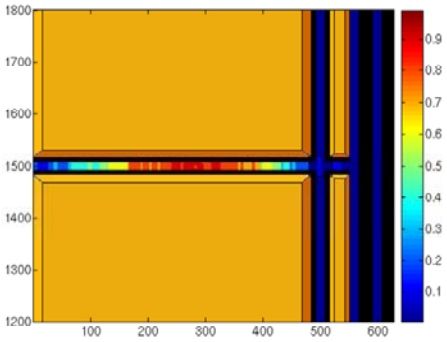


Figure 4-30: Reception Prob. of Emergency Messages-Scenario 36, Sender on Rd. A1

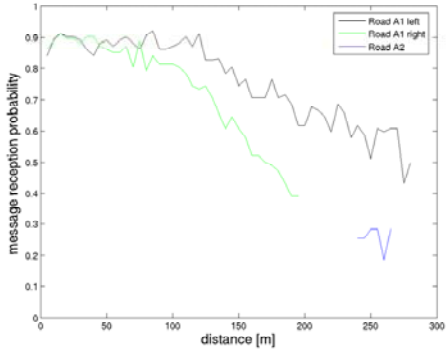


Figure 4-31: Reception prob. of Emergency Messages – Scenario 40, Rd. A, Sender on Rd. A1

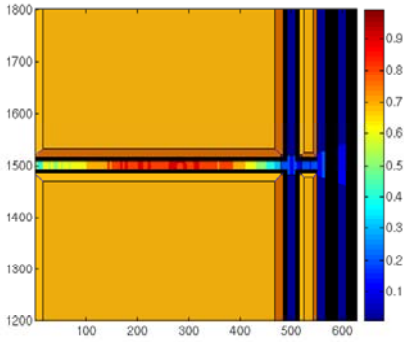


Figure 4-32: Reception Prob. of Emergency Messages-Scenario 40, Sender on Rd. A1

The results show substantial improvement for emergency messages with increased transmission power.

4.3 Intersection RSU Rebroadcast of Vehicle OBU Messages

There was a general acknowledgement within the vehicle safety community that broadcast around the corner is unlikely to have a satisfactory performance in intersection settings. This is certainly true for the measurement as well as for the simulation test results. Consequently, there is a desire to find ways to compensate for this problem. One of the ideas is to have the intersection RSU rebroadcast vehicle OBU messages.

Obviously, RSU retransmission of OBU messages will increase the load on the channel and may be counter-productive when there is already a stressful channel. On the other hand, this idea certainly appears to show promise when the channel loading is moderately low. One subtle advantage of this vehicle-to-infrastructure-to-vehicle approach is the benefit of an RSU's antenna placement. Because the intersection RSU's antenna is expected to be placed in line of sight with most vehicles around the intersection, the

reception probability should be relatively higher for both the vehicle to RSU link as well as the RSU to vehicle link. Taken together, it is thought that RSU retransmission of OBU messages could dramatically improve the message reception around the corner, if the channel is not overly stressed as a consequence.

The figures below show the broadcast performance from road section A1 around the corner to road B. Scenario 41 has a channel load defined by a routine safety message rate of 2Hz while scenario 42 has the rate set at 10Hz.

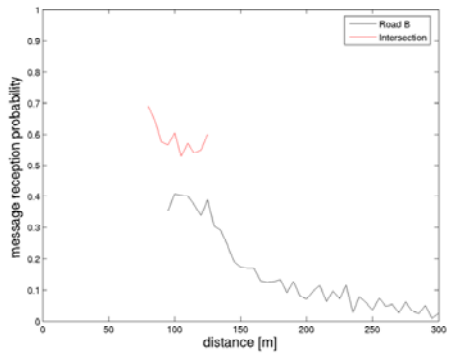


Figure 4-33: Reception Prob. of Routine Message Scenario 41, Rd. B, Sender on Rd. A1

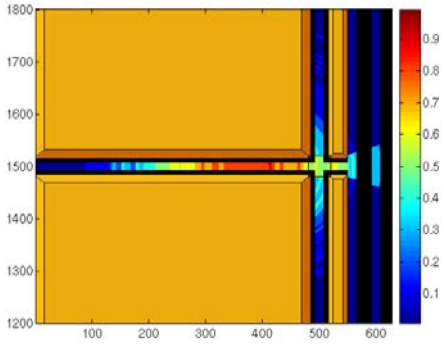


Figure 4-34: Reception Probability of Emergency Messages-Scenario 41, Sender on Rd. A1

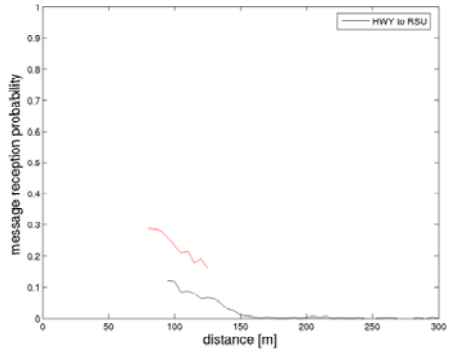


Figure 4-35: Reception prob. of Routine Message Scenario 42, Rd. B, Sender on Rd. A1

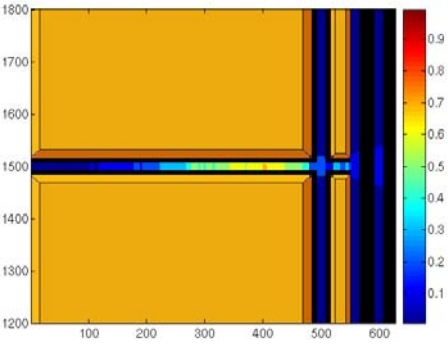
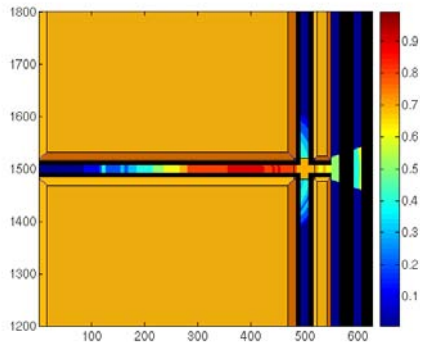
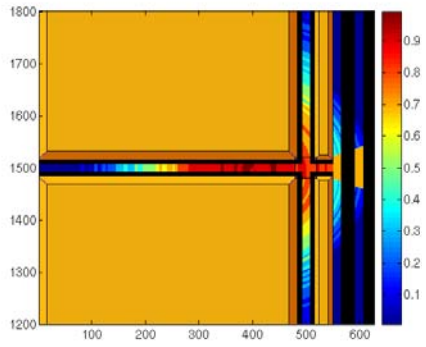
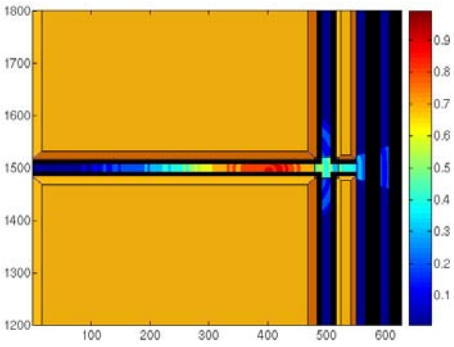
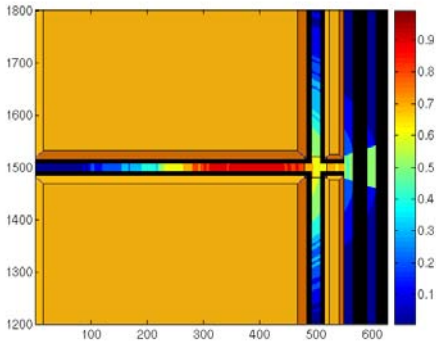
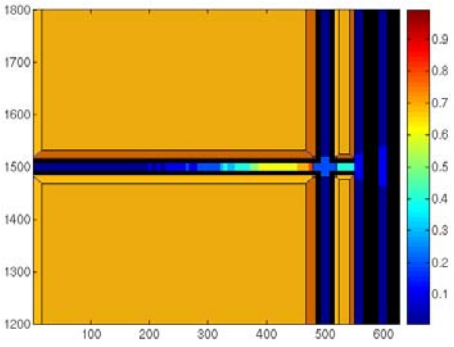
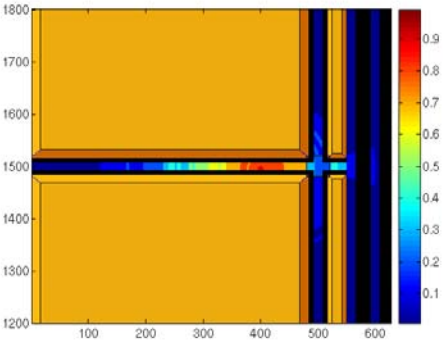


Figure 4-36: Reception Probability of Emergency Messages-Scenario 42, Sender on Rd. A1

Around the corner message reception in a saturated channel, as shown in Figure 4-35 and Figure 4-36, is very low as expected. The results in a much less stressful channel as shown in Figure 4-33 and Figure 4-34, however, do not match expectation. The starting assumption is that even if RSU retransmission doubles the amount of messages in the channel, the overall load is still lower than the scenarios with a routine safety message rate set at 5Hz. But the results look as if coming from a saturated channel.

The problem turns out to be how an RSU competes with other OBUs for channel access. The IEEE 802.11 MAC is meant to be fair. The RSU is competing with a very large number of nearby OBUs for transmission opportunities. If it has roughly the same number of messages to be sent as all other OBUs, then everyone would have roughly the same messaging performance. This is no longer true when the RSU is configured to

retransmit other OBUs' routine safety messages. For each message successfully transmitted into the channel by the RSU, several other OBUs would be competing at the same time and would have injected their share of the messages into the channel as well. Many of these messages would be received by the RSU and added into its queue for rebroadcast. Now another round of competition begins anew between the RSU and a number of other OBUs. In this manner, the number of messages waiting in the RSU's queue quickly increases until a point at which the RSU has to drop messages before transmitting them. Indeed, the RSU's queue drop rate in scenario 41 is found to be 67 percent!

	Without RSU Rebroadcast	With RSU Rebroadcast
Routine message transmission at 2Hz		
	Figure 4-37: Visualization of Emergency Messages Reception WITHOUT RSU Rebroadcast, Routine Message at 2Hz	**Figure 4-38: Visualization of Emergency Messages Reception WITH RSU Rebroadcast, Routine Message at 2Hz**
Routine message transmission at 5Hz		
	Figure 4-39: Visualization of Emergency Messages Reception WITHOUT RSU Rebroadcast, Routine Message at 5Hz	**Figure 4-40: Visualization of Emergency Messages Reception WITH RSU Rebroadcast, Routine Message at 5Hz**
Routine message transmission at 10Hz		
	Figure 4-41: Visualization of Emergency Messages Reception WITHOUT RSU Rebroadcast, Routine Message at 10Hz	**Figure 4-42: Visualization of Emergency Messages Reception WITH RSU Rebroadcast, Routine Message at 10Hz**

In short, RSU rebroadcast of routine OBU messages would not be productive unless there is a very low channel load to begin with. On the other hand, RSU rebroadcast of OBU

emergency messages shows improvement in both low and moderately stressed channels, as shown in the figures above[5]. This is because OBU emergency messages are not sent from all cars at all times. Consequently, the RSU is able to keep up with these messages so long as the channel is not saturated.

4.4 Cascading Emergency Messages

The scenarios in the batch 4 of the simulations are designed to emulate the communication patterns of intersection vehicle safety applications in emergency time. The following figures show the results for scenarios 43 to 46. The top two are for scenarios with a channel load defined by a routine safety message rate of 5Hz while the lower two are with the rate of 10Hz. The left column shows results of cascading emergency message through the simple repetition method, while the right column uses a more controlled feedback oriented method. Please see the earlier section on simulation scenarios and setup for details.

Each figure shows the time it takes for the cascading message to reach each car within a single lane from the intersection. The Y-axis shows time in seconds while the X-axis shows the number of cars from the starting point. The X-axis goes up to 70 cars, which is about 500 meters from the starting point.

The blue line shows the time at which each vehicle starts its turn of transmissions; while the red line shows the time at which each car first hears one of such emergency messages from ahead. Because of the arbitrarily strict rule that allows each vehicle to start its emergency transmission only if it hears from the car immediately ahead, the blue line is progressing significantly slower than the red line initially. In this way, the red line could be read as the lower bound for emergency messages to cascade through a lane of traffic.

[5] Please see Appendix C for further details.

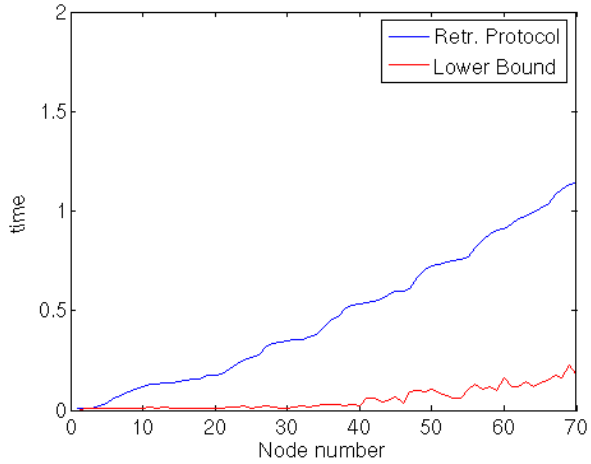


Figure 4-43: Message Cascading Over Nodes, Scenario 43, Repetition

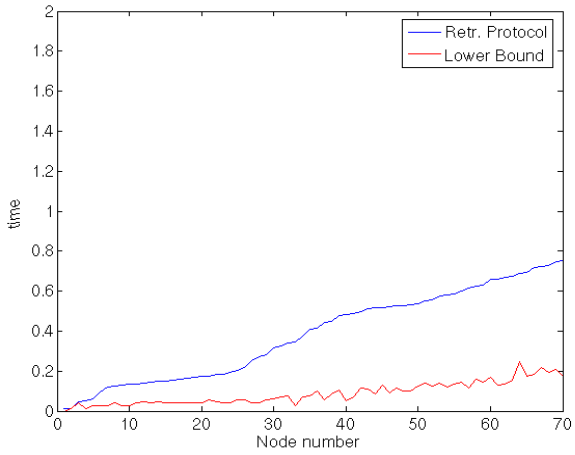


Figure 4-44: Message Cascading Over Nodes, Scenario 44, Feedback

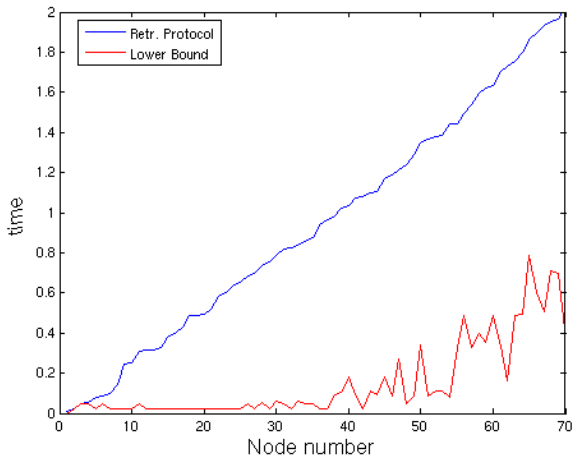


Figure 4-45: Message Cascading Over Nodes, Scenario 45, Repetition

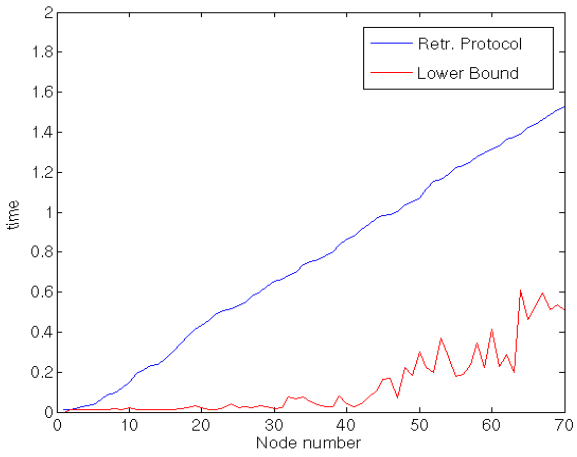


Figure 4-46: Message Cascading Over Nodes, Scenario 46, Feedback

Overall, emergency messages seem to cascade consistently even in a very saturated channel. Please note that all scenarios are configured so that a node would wait 20 ms before its next transmission (if necessary). The result in Figure 4-46 shows it takes slightly more than 20 ms on average for the emergency message to cascade from car to car. This means each hop is taking about 1 retransmission each. Therefore, there is certainly potential for this performance to be improved upon via tuning the parameters

5 Detailed Simulation Test Results

In this appendix section, detailed results are provided for the entire simulation test scenarios described in the five batches of simulation matrixes.

5.1 Batch 1, Routine and Emergency Safety Messaging in Saturated Channel

5.1.1 Scenario 1

Simulation Scenario Settings:

RF Model	Deterministic
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	No buildings
Commercial RSU	On, 500 bytes/ 2Hz/ 200m
Routine Messages	200 bytes /10Hz /200m

5.1.1.1 Reception Probability of Emergency Messages

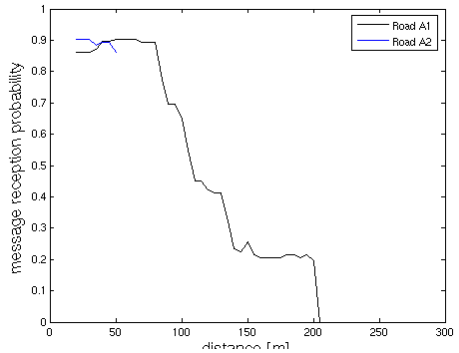


Figure 5-1: Reception Probability of Emergency Messages-Scenario1, Road A, Sender RSU

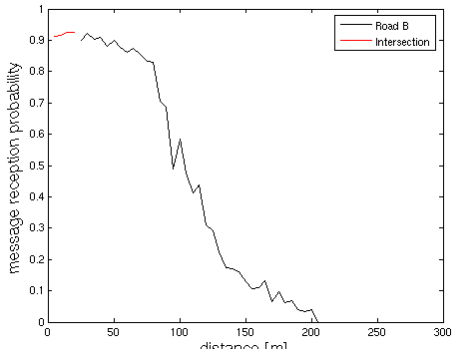


Figure 5-2: Reception Probability of Emergency Messages-Scenario 1, Road B, Sender RSU

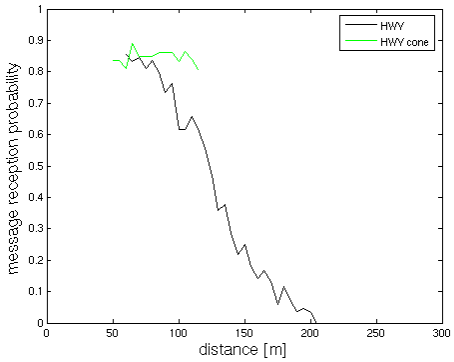


Figure 5-3: Reception Probability of Emergency Messages-Scenario 1, HWY, Sender RSU

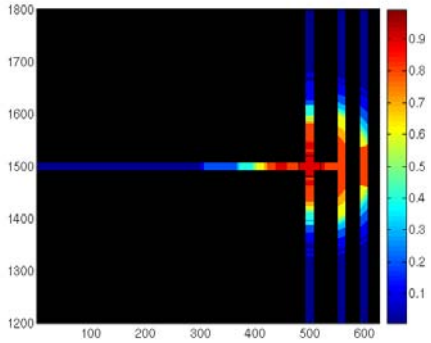


Figure 5-4: Reception Probability of Emergency Messages-Scenario 1, Sender RSU

5.1.1.2 Reception Probability of Routine Messages

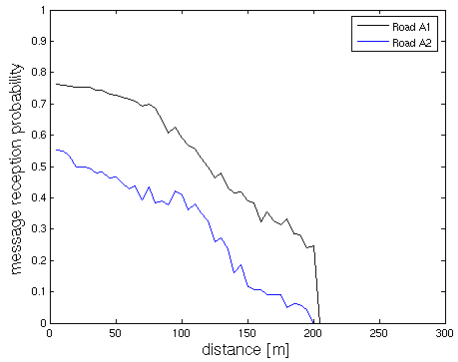


Figure 5-5: Reception Probability of Routine Messages on Road A, Scenario 1

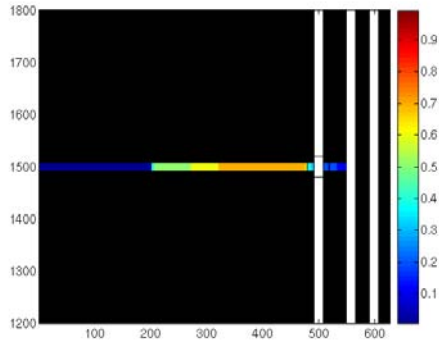


Figure 5-6: Reception Probability of Routine Messages on Road A, Scenario 1

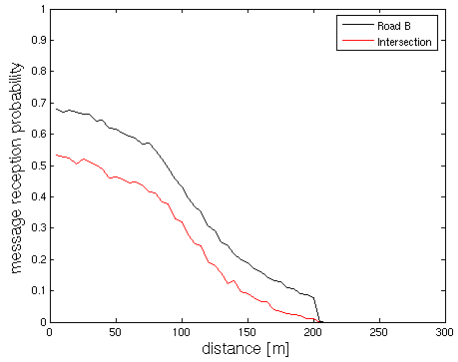


Figure 5-7: Reception Probability of Routine Messages on Road B, Scenario 1

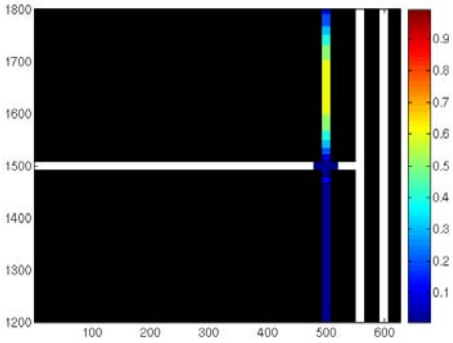


Figure 5-8: Reception Probability of Routine Messages on Road B, Scenario 1

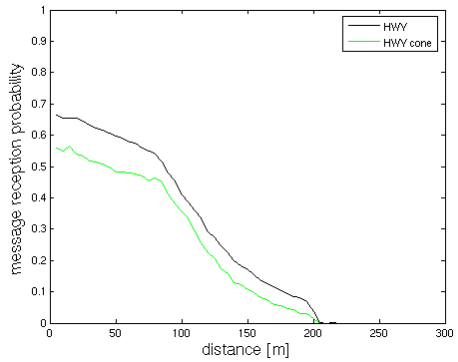


Figure 5-9: Reception Probability of Routine Messages on HWY, Scenario 1

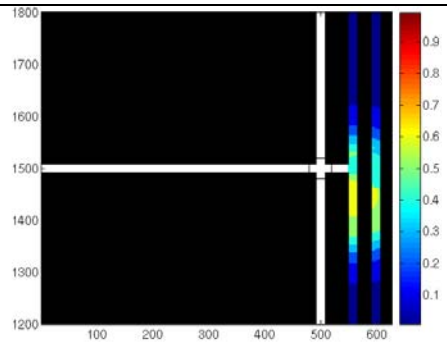


Figure 5-10: Reception Probability of Routine Messages on HWY, Scenario 1

5.1.2 Scenario 2

Simulation Scenario Settings:

RF Model	Deterministic
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	No buildings
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.2.1 Reception Probability of Emergency Messages

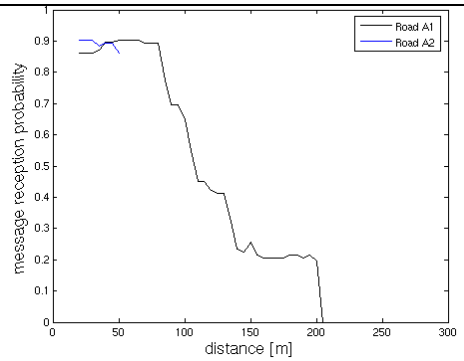


Figure 5-11: Reception Probability of Emergency Messages-Scenario 2, Road A, Sender RSU

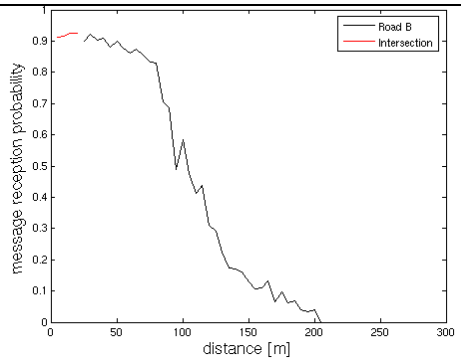


Figure 5-12: Reception Probability of Emergency Messages-Scenario 2, Road B, Sender RSU

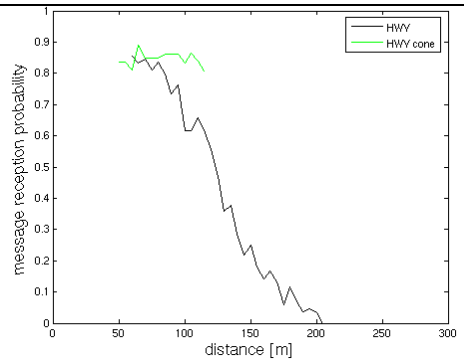


Figure 5-13: Reception Probability of Emergency Messages-Scenario 2, HWY, Sender RSU

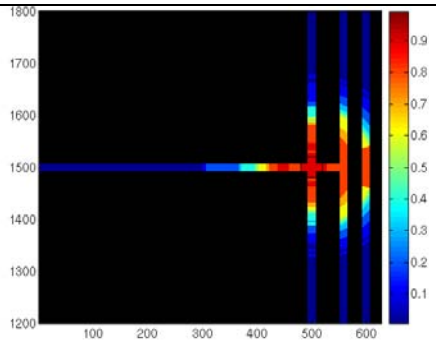


Figure 5-14: Reception Probability of Emergency Messages-Scenario 2, Sender RSU

5.1.2.2 Reception Probability of Routine Messages

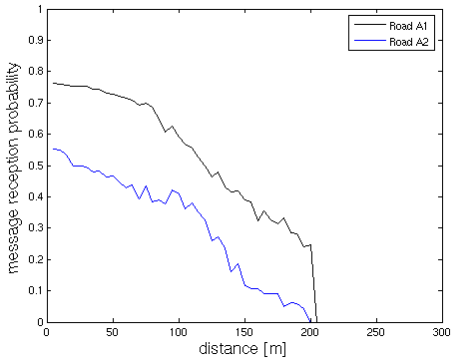


Figure 5-15: Reception Probability of Routine Messages on Road A, Scenario 2

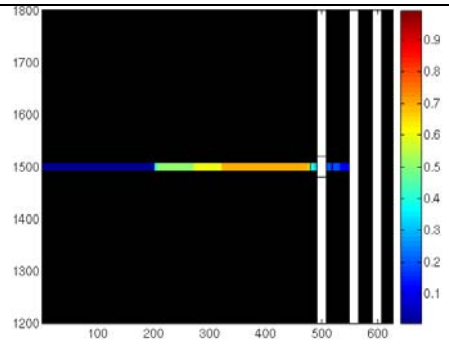


Figure 5-16: Reception Probability of Routine Messages on Road A, Scenario 2

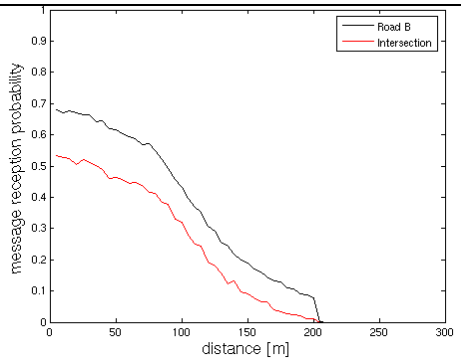


Figure 5-17: Reception Probability of Routine Messages on Road B, Scenario 2

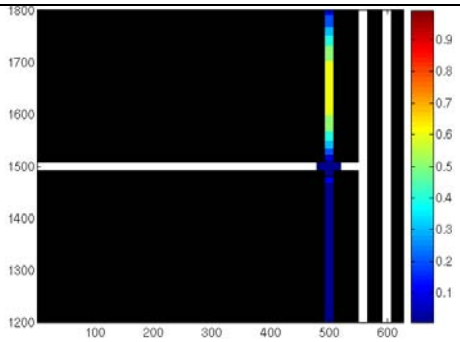


Figure 5-18: Reception Probability of Routine Messages on Road B, Scenario 2

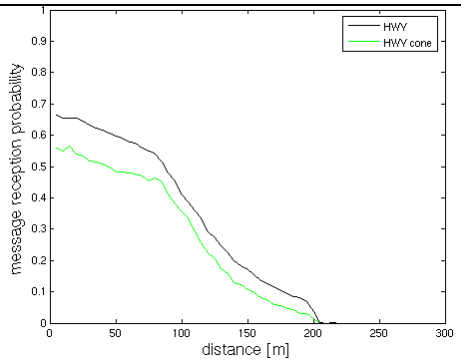


Figure 5-19: Reception Probability of Routine Messages on HWY, Scenario 2

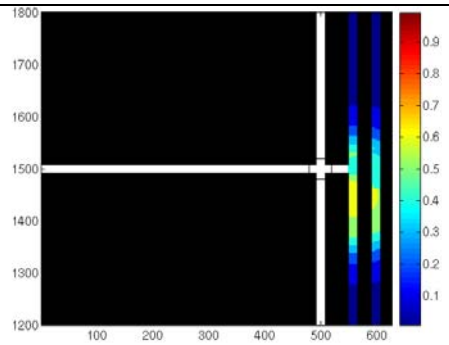


Figure 5-20: Reception Probability of Routine Messages on HWY, Scenario 2

5.1.3 Scenario 3

Simulation Scenario Settings:

RF Model	Deterministic
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /10Hz /200m

5.1.3.1 Reception Probability of Emergency Messages

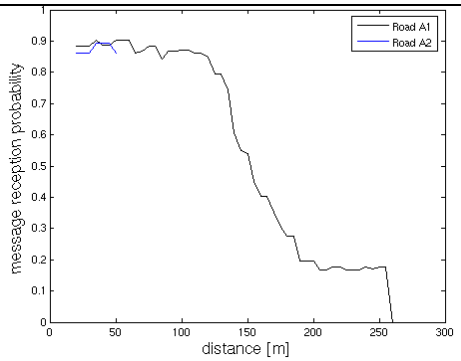


Figure 5-21: Reception Probability of Emergency Messages-Scenario 3, Road A, Sender RSU

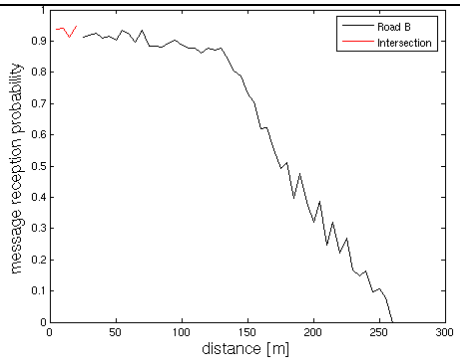


Figure 5-22: Reception Probability of Emergency Messages-Scenario 3, Road B, Sender RSU

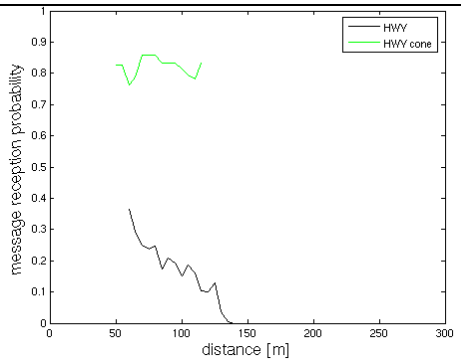


Figure 5-23: Reception Probability of Emergency Messages-Scenario 3, HWY, Sender RSU

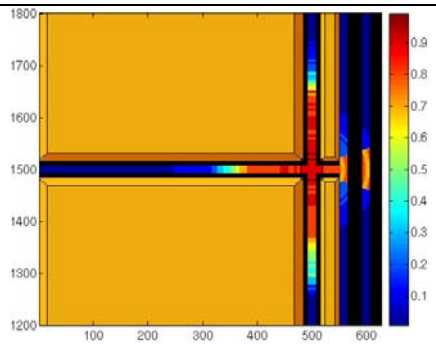


Figure 5-24: Reception Probability of Emergency Messages-Scenario 3, Sender RSU

5.1.3.2 Reception Probability of Routine Messages

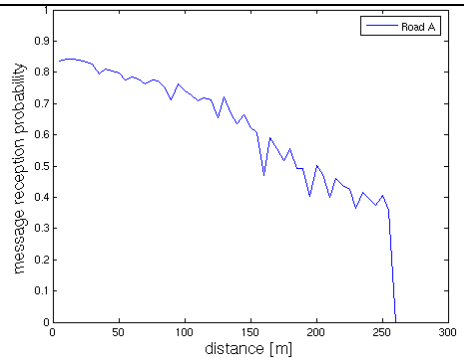


Figure 5-25: Reception Probability of Routine Messages on Road A, Scenario 3

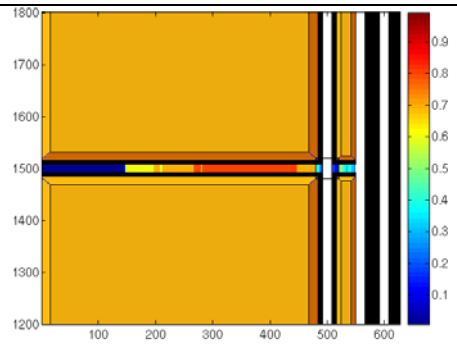


Figure 5-26: Reception Probability of Routine Messages on Road A, Scenario 3

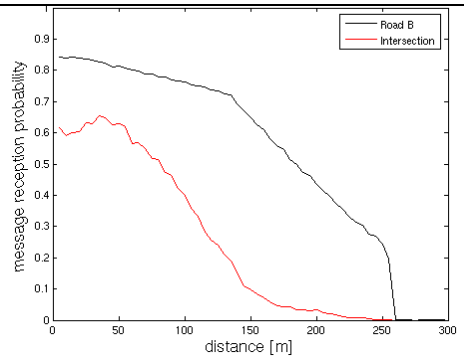


Figure 5-27: Reception Probability of Routine Messages on Road B, Scenario 3

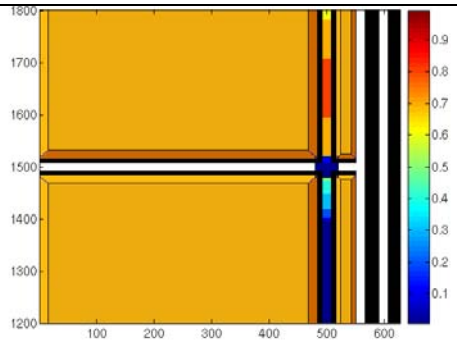


Figure 5-28: Reception Probability of Routine Messages on Road B, Scenario 3

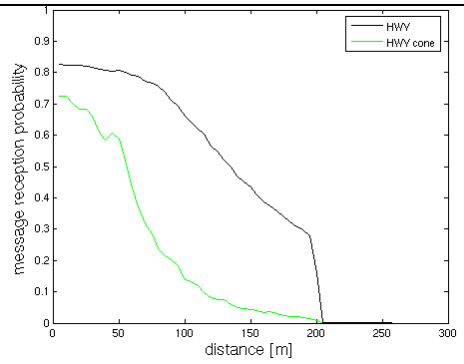


Figure 5-29: Reception Probability of Routine Messages on HWY, Scenario 3

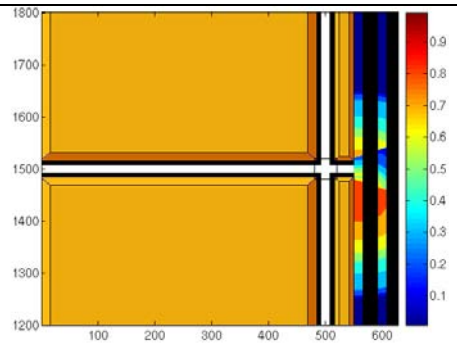


Figure 5-30: Reception Probability of Routine Messages on HWY, Scenario 3

5.1.4 Scenario 4

Simulation Scenario Settings:

RF Model	Deterministic
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.4.1 Reception Probability of Emergency Messages

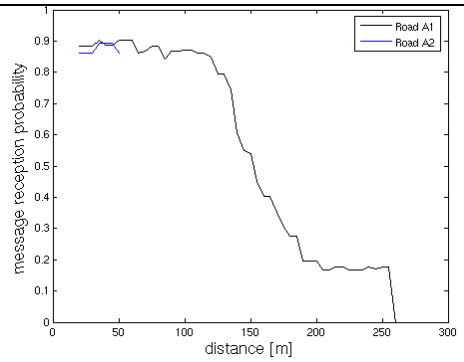


Figure 5-31: Reception Probability of Emergency Messages-Scenario 4, Road A, Sender RSU

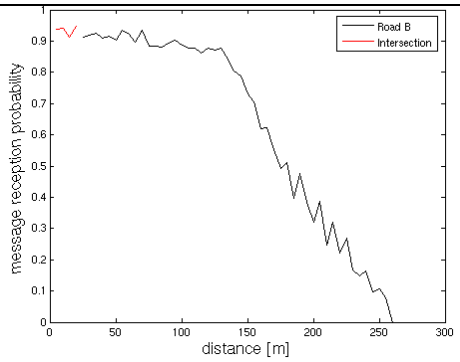


Figure 5-32: Reception Probability of Emergency Messages-Scenario 4, Road B, Sender RSU

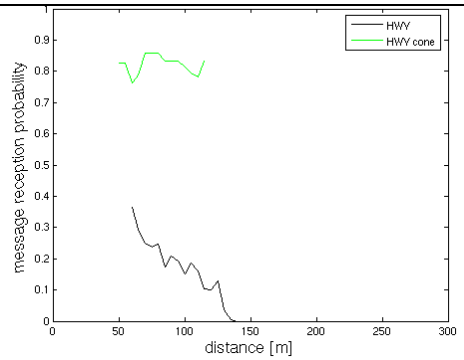


Figure 5-33: Reception Probability of Emergency Messages-Scenario 4, HWY, Sender RSU

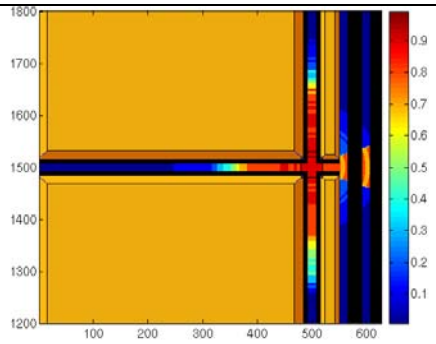


Figure 5-34: Reception Probability of Emergency Messages-Scenario 4, Sender RSU

5.1.4.2 Reception Probability of Routine Messages

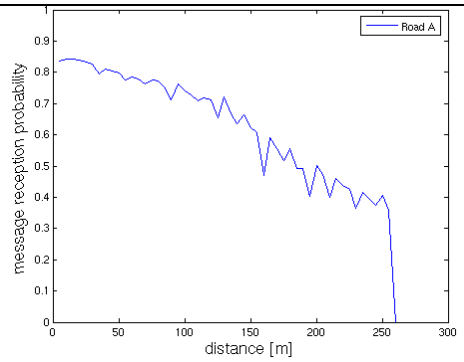


Figure 5-35: Reception Probability of Routine Messages on Road A, Scenario 4

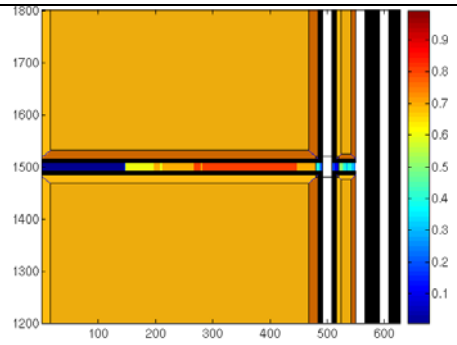


Figure 5-36: Reception Probability of Routine Messages on Road A, Scenario 4

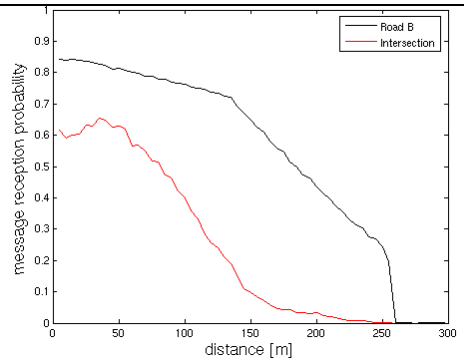


Figure 5-37: Reception Probability of Routine Messages on Road B, Scenario 4

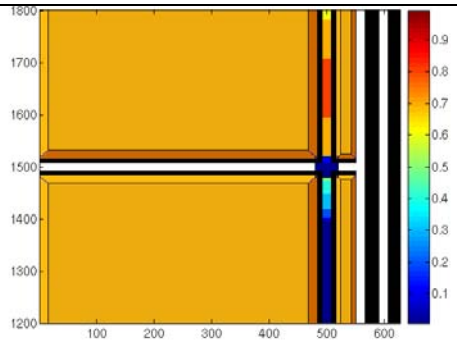


Figure 5-38: Reception Probability of Routine Messages on Road B, Scenario 4

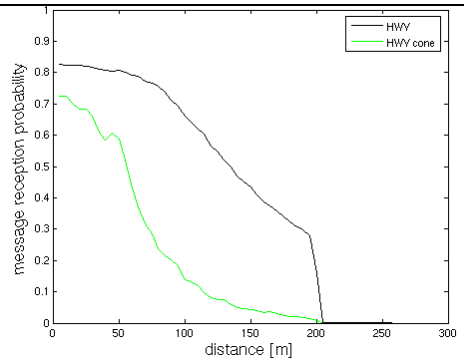


Figure 5-39: Reception Probability of Routine Messages on HWY, Scenario 4

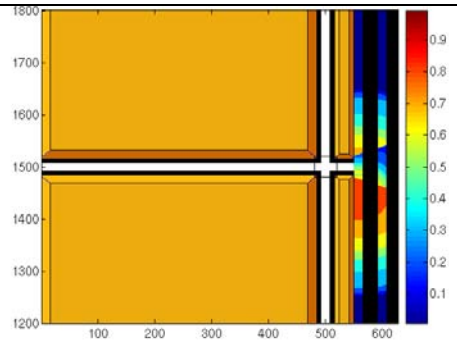


Figure 5-40: Reception Probability of Routine Messages on HWY, Scenario 4

5.1.5 Scenario 5

Simulation Scenario Setting:

RF Model	Deterministic
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	No building
Commercial RSU	On, 500bytes/ 2Hz/ 200m
Routine Messages	200byte /10Hz /200m

5.1.5.1 Reception Probability of Emergency Messages from OBU on A1

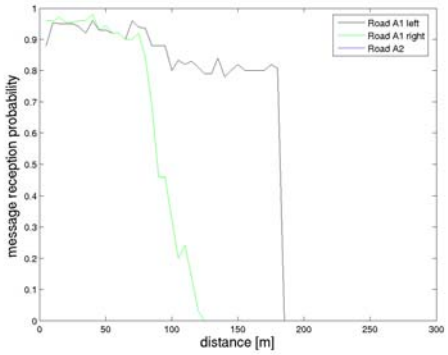


Figure 5-41: Reception Prob. of Emergency Messages - Scenario5, Rd. A, Sender on Rd. A1

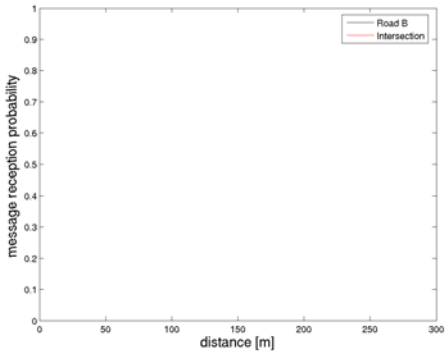


Figure 5-42: Reception Prob. of Emergency Messages - Scenario5, Rd. B, Sender on Rd. A1

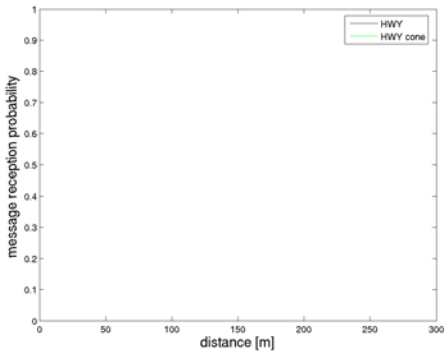


Figure 5-43: Reception Prob. of Emergency Messages - Scenario5, HWY, Sender on Rd. A1

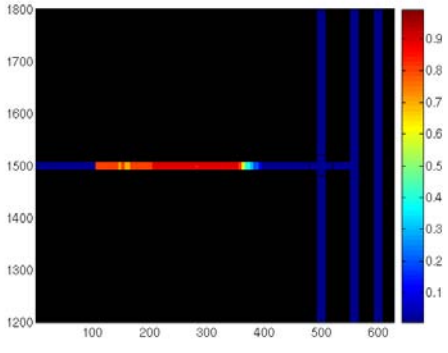


Figure 5-44: Reception Prob. of Emergency Messages-Scenario 5, Sender on Rd. A1

5.1.5.2 Reception Probability of Emergency Messages from OBU on A2

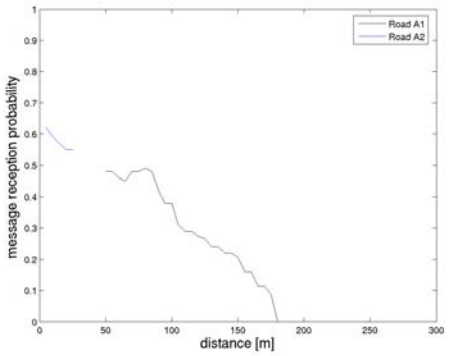


Figure 5-45: Reception Prob. of Emergency Messages – Scenario 5, Rd. A, Sender on Rd. A2

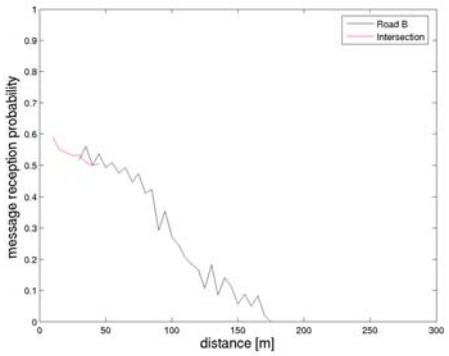


Figure 5-46: Reception Prob. of Emergency Messages – Scenario 5, Rd. B, Sender on Rd. A2

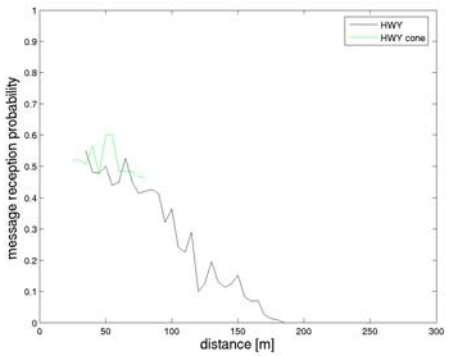


Figure 5-47: Reception Prob. of Emergency Messages – Scenario 5, HWY, Sender on Rd. A2

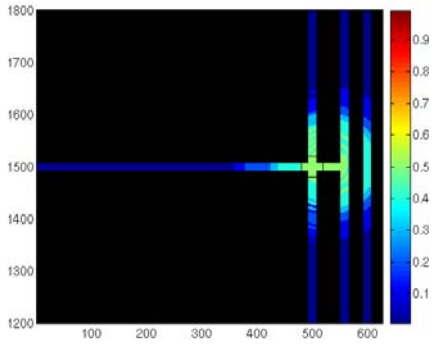


Figure 5-48: Reception Prob. of Emergency Messages-Scenario 5, Sender on Rd. A2

5.1.5.3 Reception Probability of Emergency Messages from OBU on B

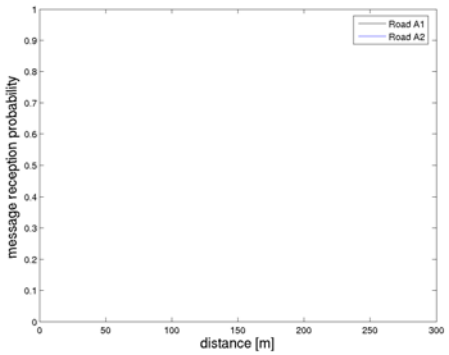


Figure 5-49: Reception Prob. of Emergency Messages – Scenario 5, Rd. A, Sender on Rd. B

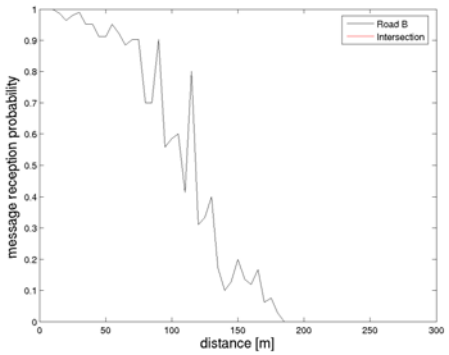


Figure 5-50: Reception Prob. of Emergency Messages – Scenario 5, Rd. B, Sender on Rd. B

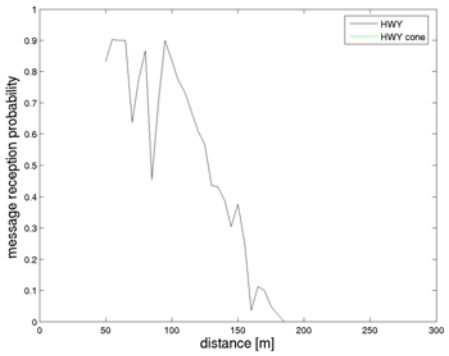


Figure 5-51: Reception Prob. of Emergency Messages – Scenario 5, HWY, Sender on Rd. B

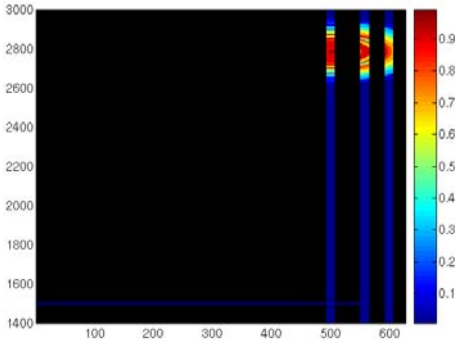


Figure 5-52: Reception Prob. of Emergency Messages-Scenario 5, Sender on Rd. B

5.1.5.4 Reception Probability of Emergency Messages from OBU on HWY

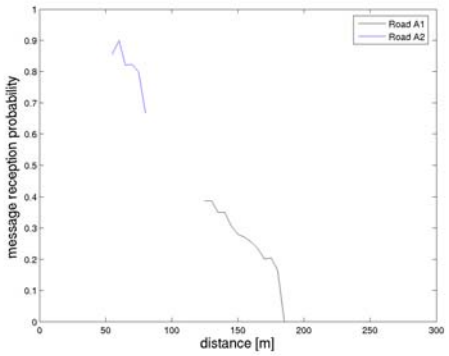


Figure 5-53: Reception Prob. of Emergency Messages – Scenario 5, Rd. A, Sender on HWY

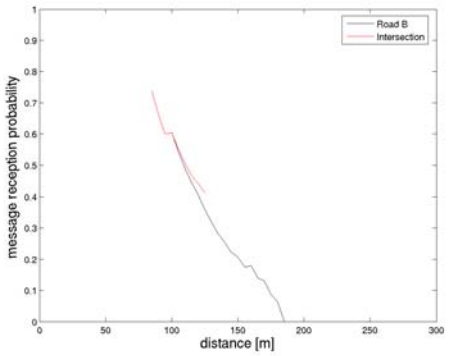


Figure 5-54: Reception Prob. of Emergency Messages – Scenario 5, Rd. B, Sender on HWY

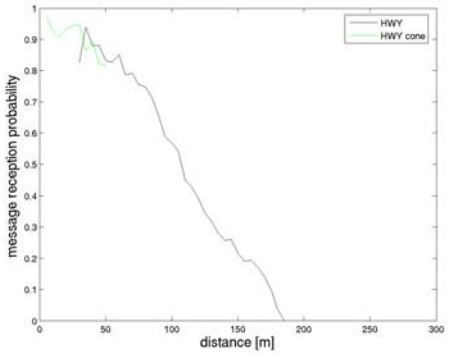


Figure 5-55: Reception Prob. of Emergency Messages – Scenario 5, HWY, Sender on HWY

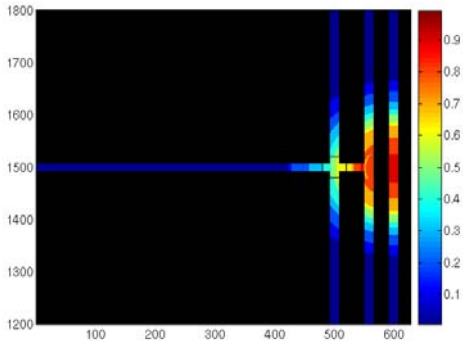


Figure 5-56: Reception Prob. of Emergency Messages-Scenario 5, Sender on HWY

5.1.6 Scenario 6

Simulation Scenario Setting:

RF Model	Deterministic
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	No building
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.6.1 Reception Probability of Emergency Messages from OBU on A1

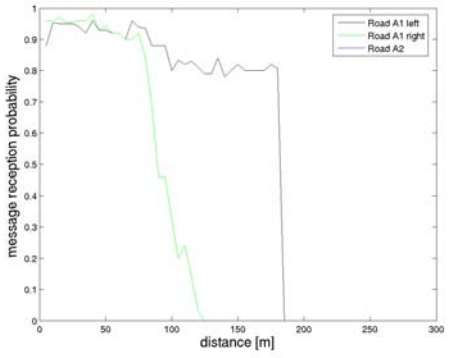


Figure 5-57: Reception Prob. of Emergency Messages – Scenario 6, Rd. A, Sender on Rd. A1

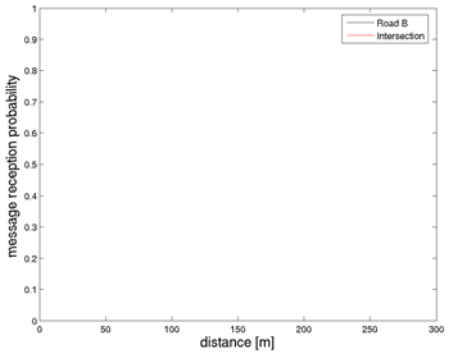


Figure 5-58: Reception Prob. of Emergency Messages – Scenario 6, Rd. B, Sender on Rd. A1

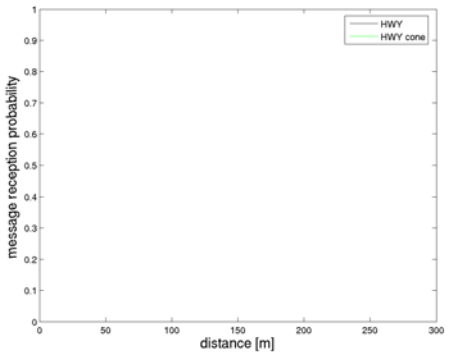


Figure 5-59: Reception Prob. of Emergency Messages – Scenario 6, HWY, Sender on Rd. A1

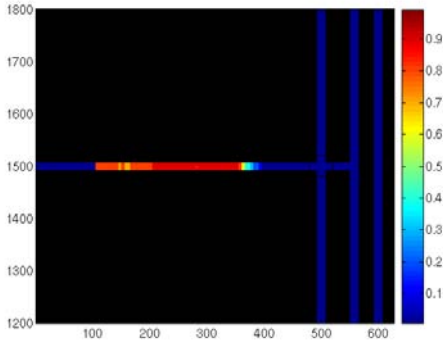


Figure 5-60: Reception Prob. of Emergency Messages-Scenario 6, Sender on Rd. A1

5.1.6.2 Reception Probability of Emergency Messages from OBU on A2

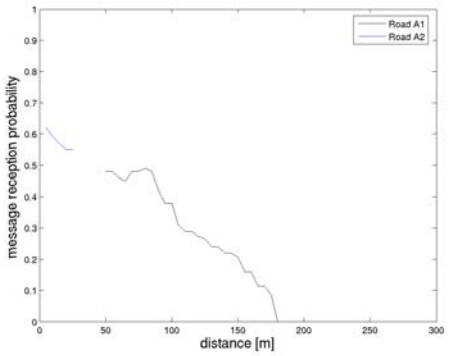


Figure 5-61: Reception Prob. of Emergency Messages – Scenario 6, Rd. A, Sender on Rd. A2

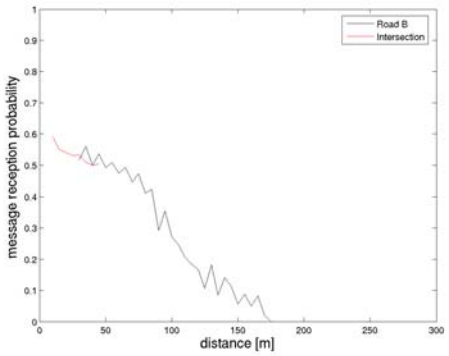


Figure 5-62: Reception Prob. of Emergency Messages – Scenario 6, Rd. B, Sender on Rd. A2

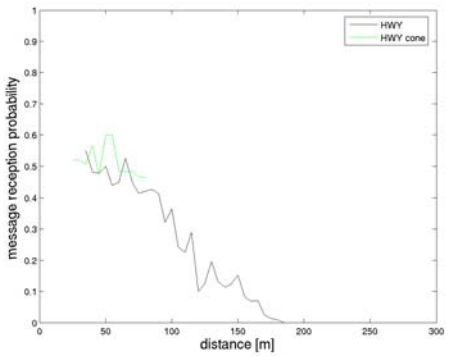


Figure 5-63: Reception Prob. of Emergency Messages – Scenario 6, HWY, Sender on Rd. A2

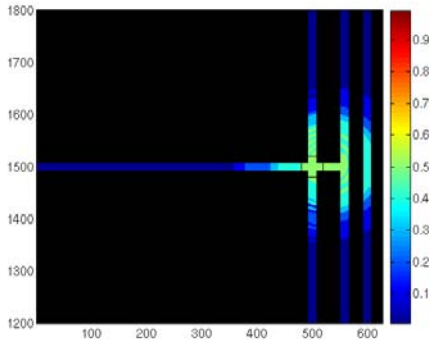


Figure 5-64: Reception Prob. of Emergency Messages-Scenario 6, Sender on Rd. A2

5.1.6.3 Reception Probability of Emergency Messages from OBU on B

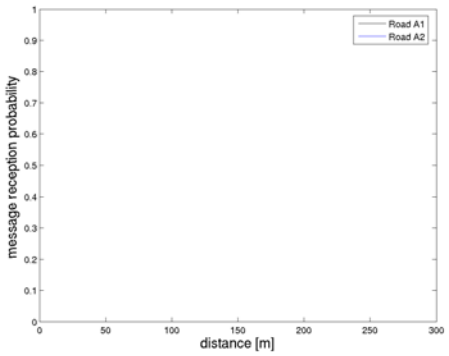


Figure 5-65: Reception Prob. of Emergency Messages – Scenario 6, Rd. A, Sender on Rd. B

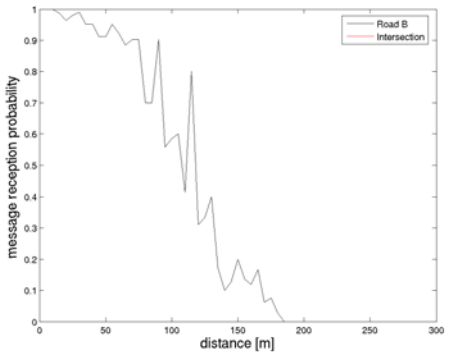


Figure 5-66: Reception Prob. of Emergency Messages – Scenario 6, Rd. B, Sender on Rd. B

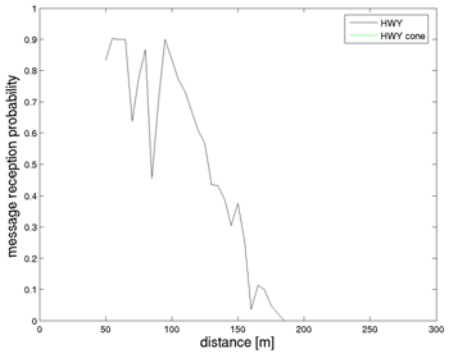


Figure 5-67: Reception Prob. of Emergency Messages – Scenario 6, HWY, Sender on Rd. B

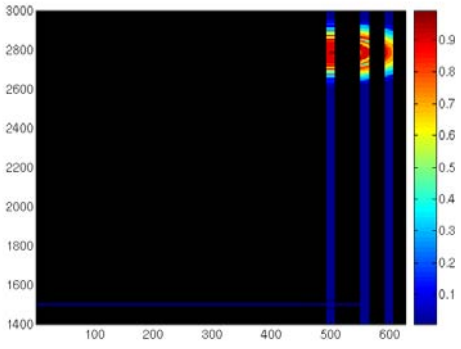


Figure 5-68: Reception Prob. of Emergency Messages-Scenario 6, Sender on Rd. B

5.1.6.4 Reception Probability of Emergency Messages from OBU on HWY

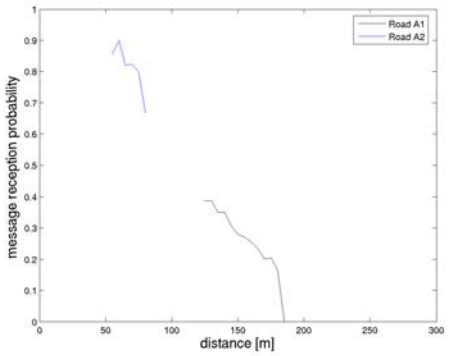


Figure 5-69: Reception Prob. of Emergency Messages – Scenario 6, Rd. A, Sender on HWY

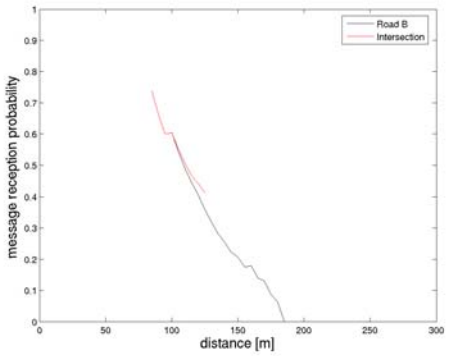


Figure 5-70: Reception Prob. of Emergency Messages – Scenario 6, Rd. B, Sender on HWY

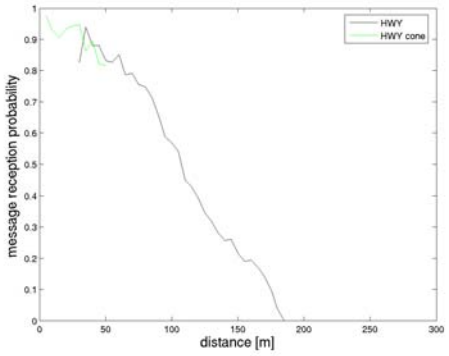


Figure 5-71: Reception Prob. of Emergency Messages – Scenario 6, HWY, Sender on HWY

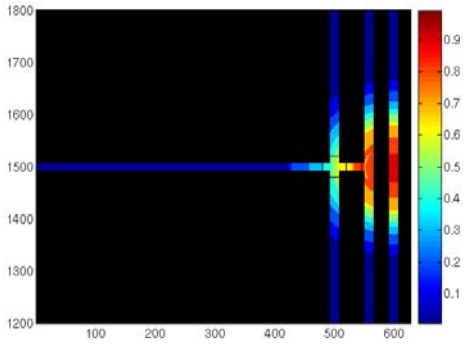


Figure 5-72: Reception Prob. of Emergency Messages-Scenario 6, Sender on HWY

5.1.7 Scenario 7

Simulation Scenario Setting:

RF Model	Deterministic
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	Tall building
Commercial RSU	On, 500bytes/ 2Hz/ 200m
Routine Messages	200byte /10Hz /200m

5.1.7.1 Reception Probability of Emergency Messages from OBU on A1

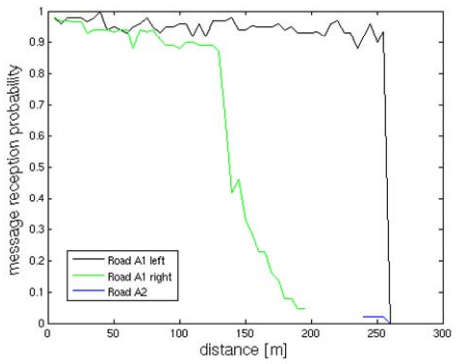


Figure 5-73: Reception Prob. of Emergency Messages – Scenario 7, Rd. A, Sender on Rd. A1

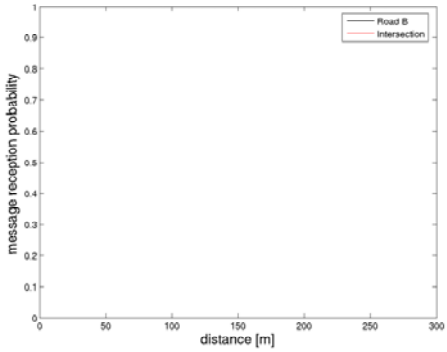


Figure 5-74: Reception Prob. of Emergency Messages – Scenario 7, Rd. B, Sender on Rd. A1

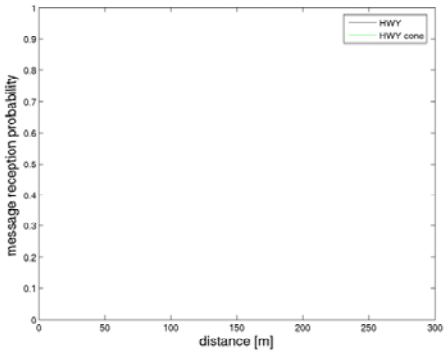


Figure 5-75: Reception Prob. of Emergency Messages – Scenario 7, HWY, Sender on Rd. A1

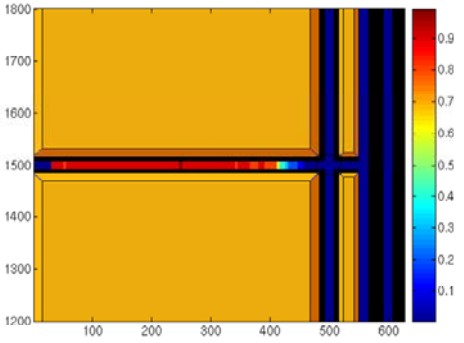


Figure 5-76: Reception Prob. of Emergency Messages-Scenario 7, Sender on Rd. A1

5.1.7.2 Reception Probability of Emergency Messages from OBU on A2

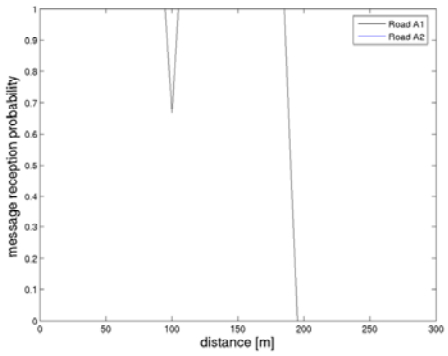


Figure 5-77: Reception Prob. of Emergency Messages – Scenario 7, Rd. A, Sender on Rd. A2

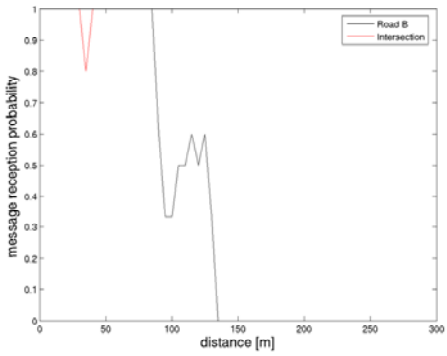


Figure 5-78: Reception Prob. of Emergency Messages – Scenario 7, Rd. B, Sender on Rd. A2

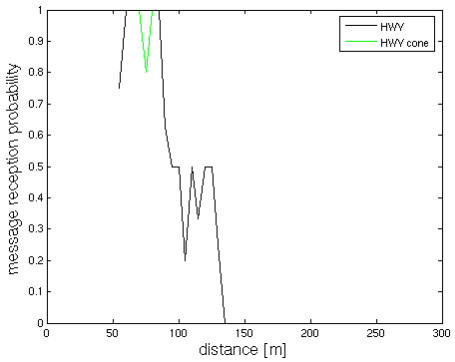


Figure 5-79: Reception Prob. of Emergency Messages – Scenario 7, HWY, Sender on Rd. A2

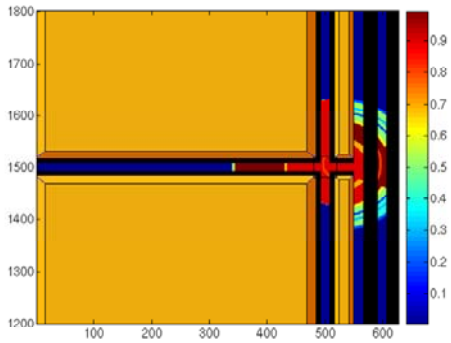


Figure 5-80: Reception Prob. of Emergency Messages-Scenario 7, Sender on Rd. A2

5.1.7.3 Reception Probability of Emergency Messages from OBU on B

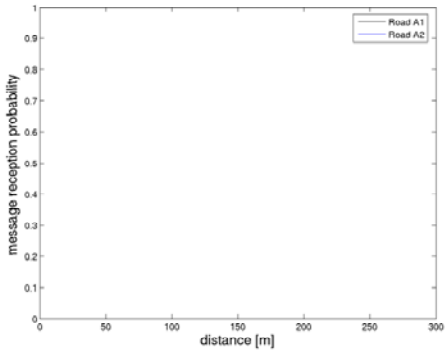


Figure 5-81: Reception Prob. of Emergency Messages – Scenario 7, Rd. A, Sender on Rd. B

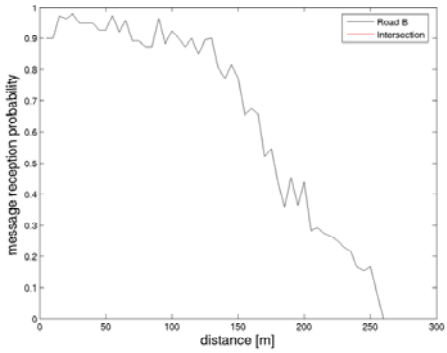


Figure 5-82: Reception Prob. of Emergency Messages – Scenario 7, Rd. B, Sender on Rd. B

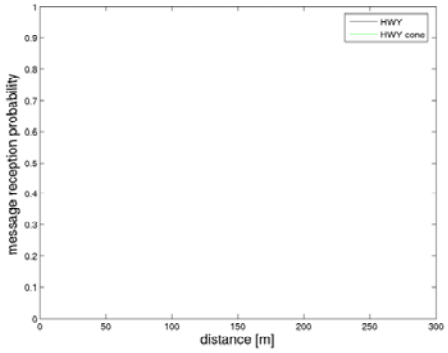


Figure 5-83: Reception Prob. of Emergency Messages – Scenario 7, HWY, Sender on Rd. B

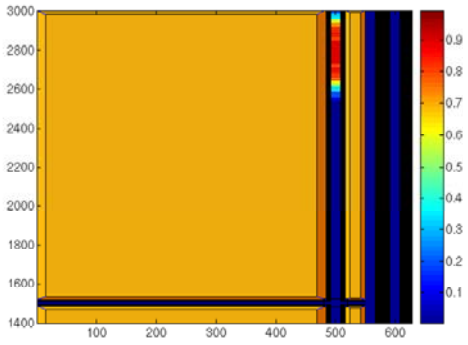


Figure 5-84: Reception Prob. of Emergency Messages-Scenario 7, Sender on Rd. B

5.1.7.4 Reception Probability of Emergency Messages from OBU on B

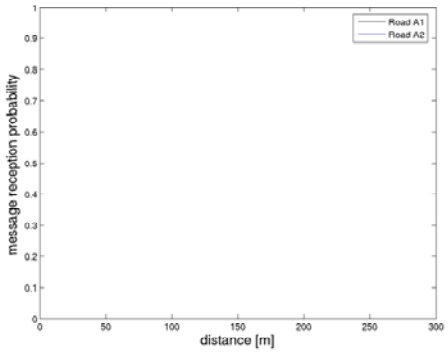


Figure 5-85: Reception Prob. of Emergency Messages – Scenario 7, Rd. A, Sender on Rd. B

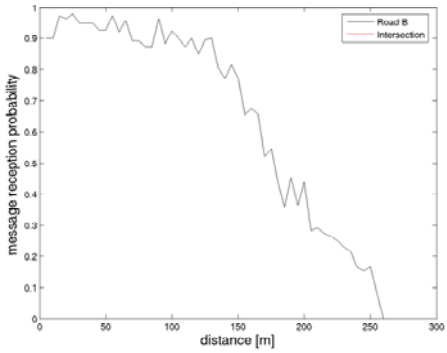


Figure 5-86: Reception Prob. of Emergency Messages – Scenario 7, Rd. B, Sender on Rd. B

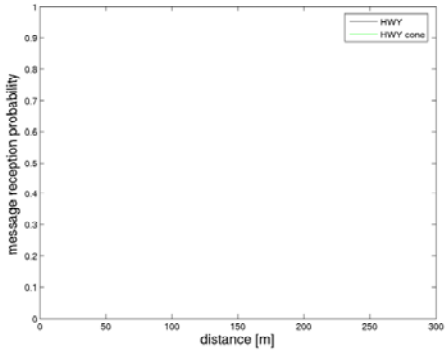


Figure 5-87: Reception Prob. of Emergency Messages – Scenario 7, HWY, Sender on Rd. B

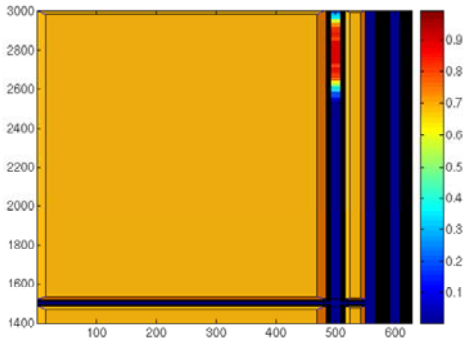


Figure 5-88: Reception Prob. of Emergency Messages-Scenario 7, Sender on Rd. B

5.1.7.5 Reception Probability of Emergency Messages from OBU on HWY

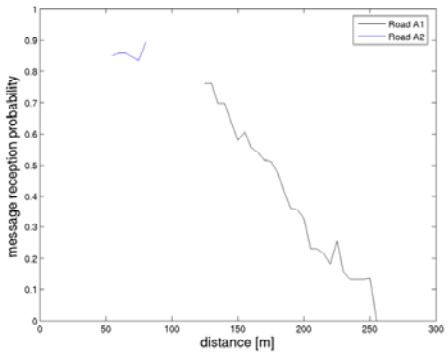


Figure 5-89: Reception Prob. of Emergency Messages – Scenario 7, Rd. A, Sender on HWY

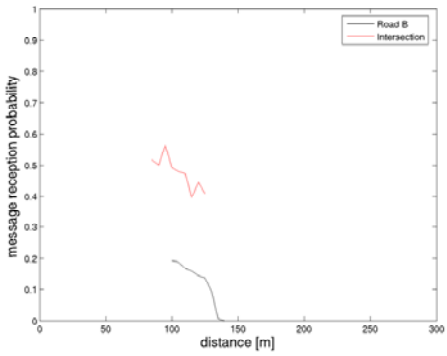


Figure 5-90: Reception Prob. of Emergency Messages – Scenario 7, Rd. B, Sender on HWY

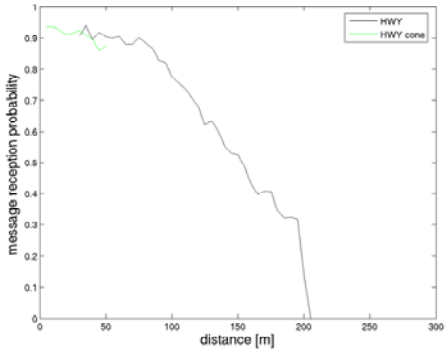


Figure 5-91: Reception Prob. of Emergency Messages – Scenario 7, HWY, Sender on HWY

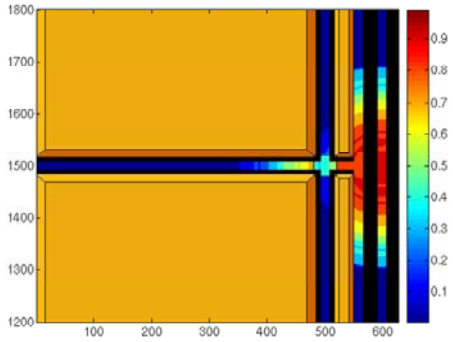


Figure 5-92: Reception Prob. of Emergency Messages-Scenario 7, Sender on HWY

5.1.8 Scenario 8

Simulation Scenario Setting:

RF Model	Deterministic
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	Tall building
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.8.1 Reception Probability of Emergency Messages from OBU on A1

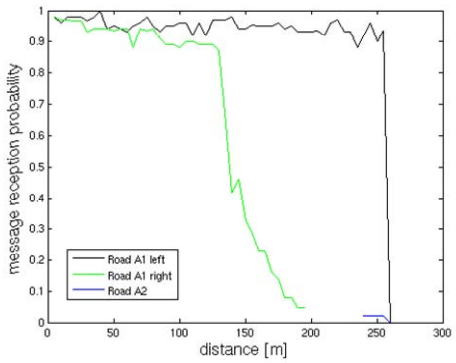


Figure 5-93: Reception Prob. of Emergency Messages – Scenario 8, Rd. A, Sender on Rd. A1

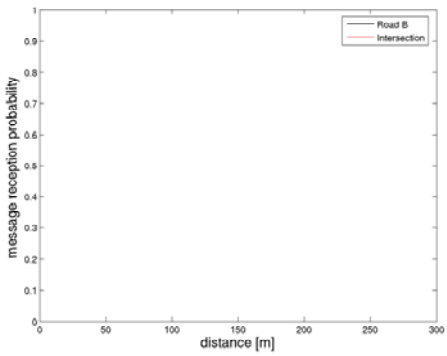


Figure 5-94: Reception Prob. of Emergency Messages – Scenario 8, Rd. B, Sender on Rd. A1

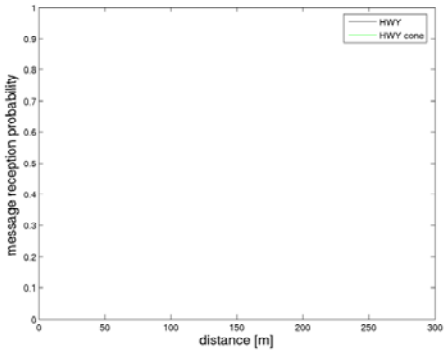


Figure 5-95: Reception Prob. of Emergency Messages – Scenario 8, HWY, Sender on Rd. A1

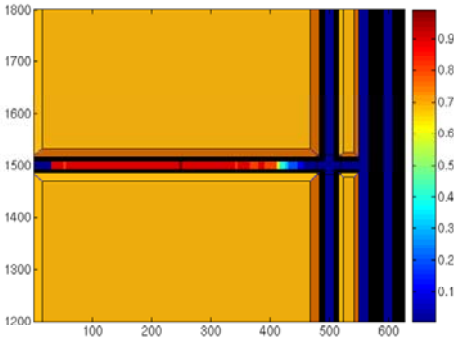


Figure 5-96: Reception Prob. of Emergency Messages-Scenario 8, Sender on Rd. A1

5.1.8.2 Reception Probability of Emergency Messages from OBU on A2

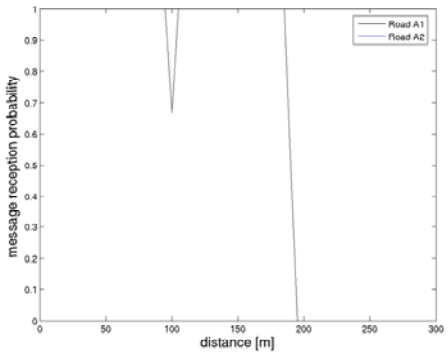


Figure 5-97: Reception Prob. of Emergency Messages – Scenario 8, Rd. A, Sender on Rd. A2

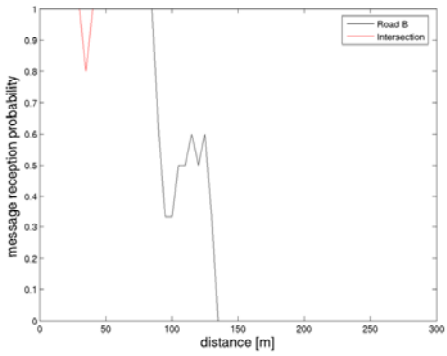


Figure 5-98: Reception Prob. of Emergency Messages – Scenario 8, Rd. B, Sender on Rd. A2

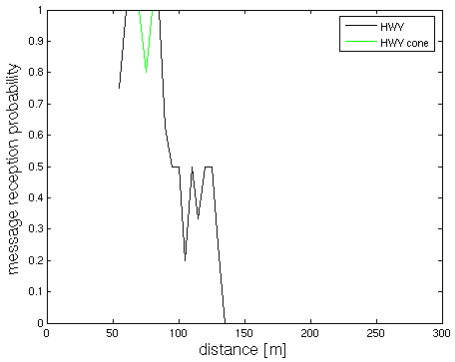


Figure 5-99: Reception Prob. of Emergency Messages – Scenario 8, HWY, Sender on Rd. A2

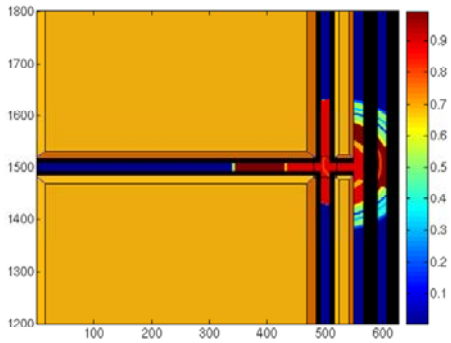


Figure 5-100: Reception Prob. of Emergency Messages-Scenario 8, Sender on Rd. A2

5.1.8.3 Reception Probability of Emergency Messages from OBU on B

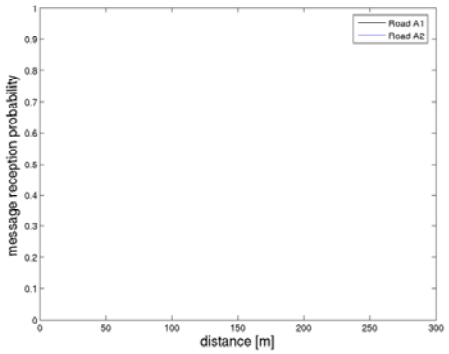


Figure 5-101: Reception Prob. of Emergency Messages – Scenario 8, Rd. A, Sender on Rd. B

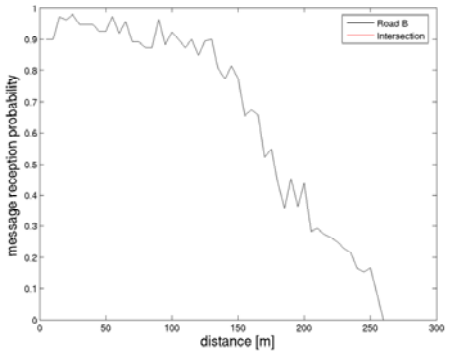


Figure 5-102: Reception Prob. of Emergency Messages – Scenario 8, Rd. B, Sender on Rd. B

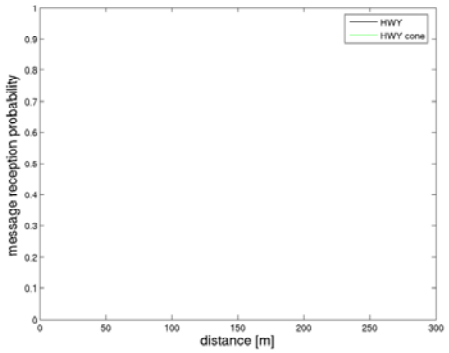


Figure 5-103: Reception Prob. of Emergency Messages – Scenario 8, HWY, Sender on Rd. B

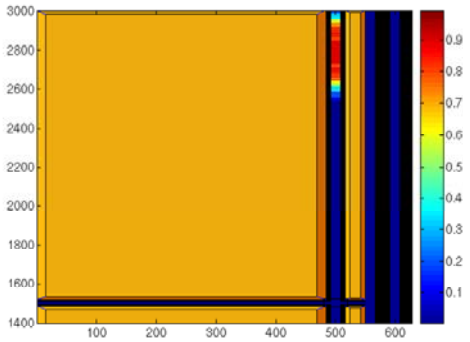


Figure 5-104: Reception Prob. of Emergency Messages-Scenario 8, Sender on Rd. B

5.1.8.4 Reception Probability of Emergency Messages from OBU on HWY

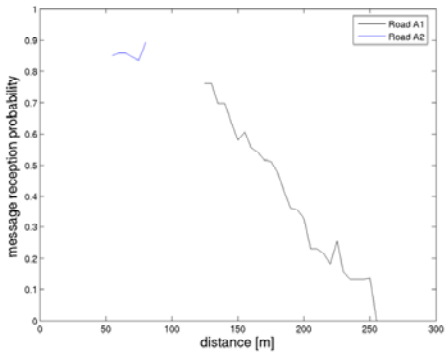


Figure 5-105: Reception Prob. of Emergency Messages – Scenario 8, Rd. A, Sender on HWY

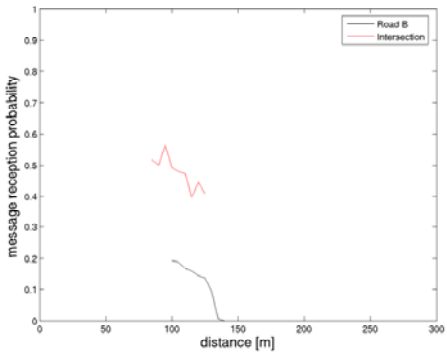


Figure 5-106: Reception Prob. of Emergency Messages – Scenario 8, Rd. B, Sender on HWY

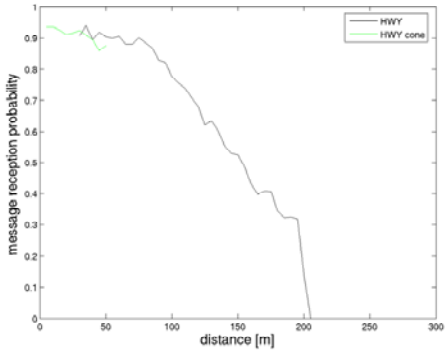


Figure 5-107: Reception Prob. of Emergency Messages – Scenario 8, HWY, Sender on HWY

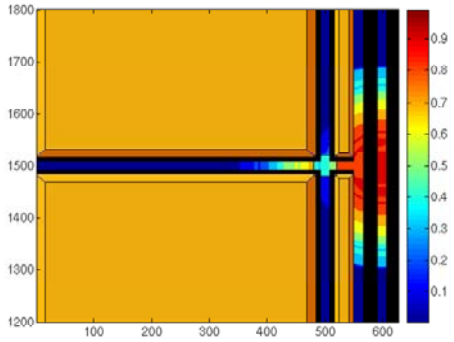


Figure 5-108: Reception Prob. of Emergency Messages-Scenario 8, Sender on HWY

5.1.9 Scenario 9

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	No buildings
Commercial RSU	On, 500 bytes/ 2Hz/ 200m
Routine Messages	200 bytes /10Hz /200m

5.1.9.1 Reception Probability of Emergency Messages

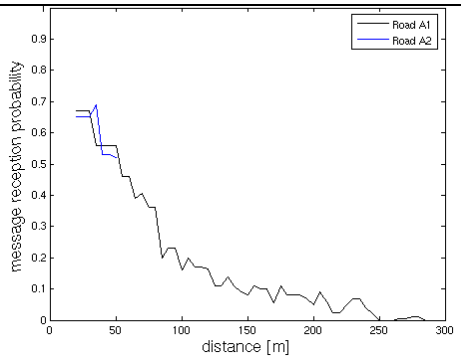


Figure 5-109: Reception Probability of Emergency Messages-Scenario 9, Road A, Sender RSU

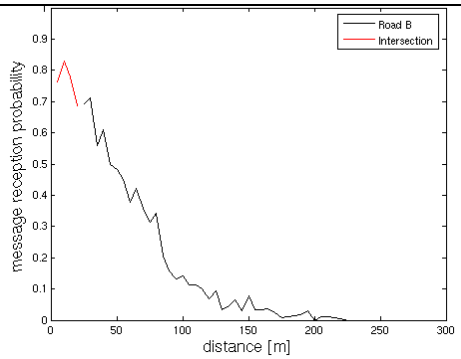


Figure 5-110: Reception Probability of Emergency Messages-Scenario 9, Road B, Sender RSU

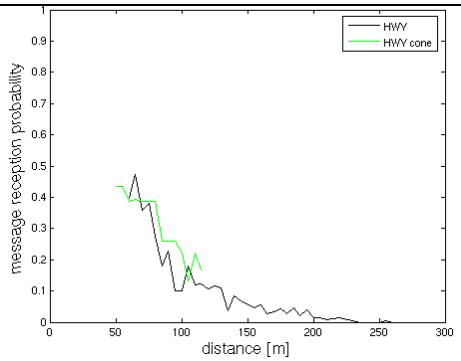


Figure 5-111: Reception Probability of Emergency Messages-Scenario 9, HWY, Sender RSU

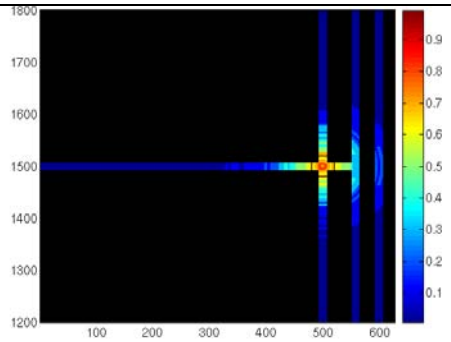


Figure 5-112: Reception Probability of Emergency Messages-Scenario 9, Sender RSU

5.1.9.2 Reception Probability of Routine Messages

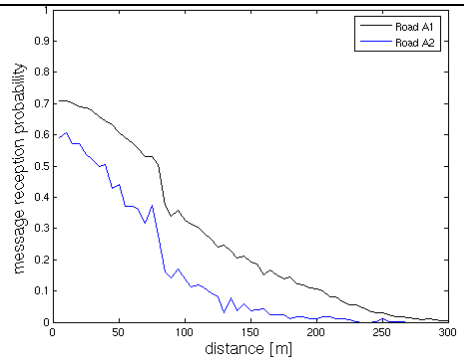


Figure 5-113: Reception Probability of Routine Messages on Road A, Scenario 9

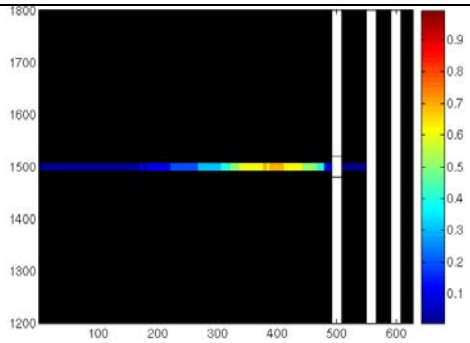


Figure 5-114: Reception Probability of Routine Messages on Road A, Scenario 9

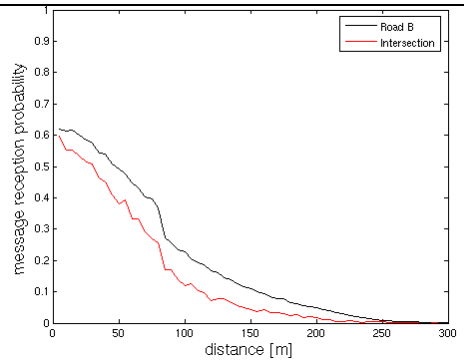


Figure 5-115: Reception Probability of Routine Messages on Road B, Scenario 9

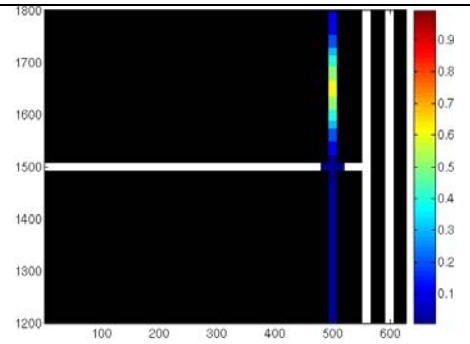


Figure 5-116: Reception Probability of Routine Messages on Road B, Scenario 9

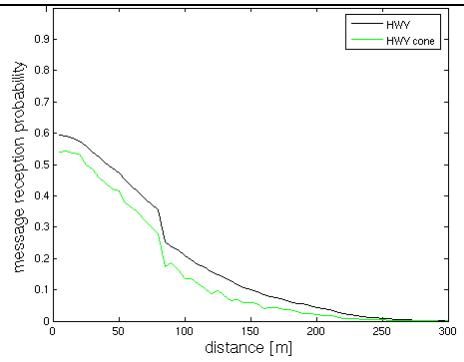


Figure 5-117: Reception Probability of Routine Messages on HWY, Scenario 9

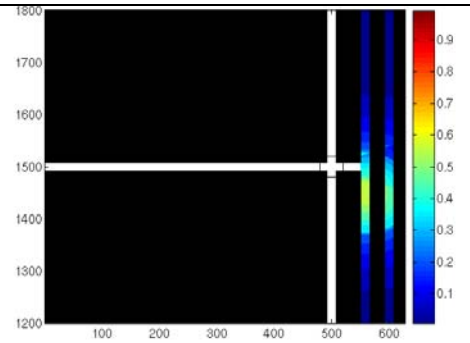


Figure 5-118: Reception Probability of Routine Messages on HWY, Scenario 9

5.1.10 Scenario 10

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	No buildings
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.10.1 Reception Probability of Emergency Messages

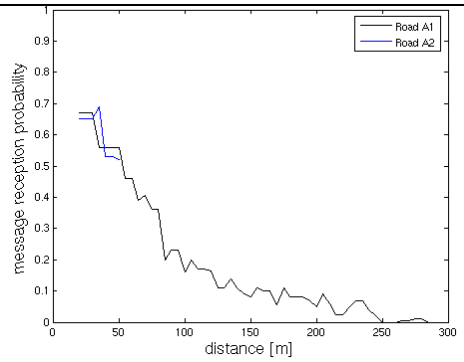


Figure 5-119: Reception Probability of Emergency Messages-Scenario 10, Road A, Sender RSU

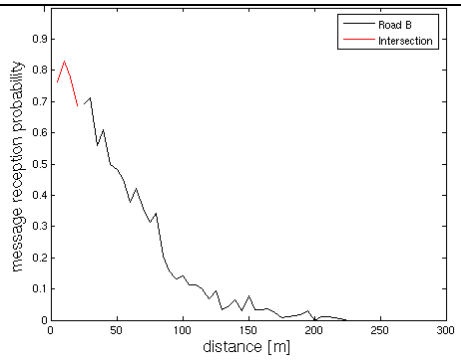


Figure 5-120: Reception Probability of Emergency Messages-Scenario 10, Road B, Sender RSU

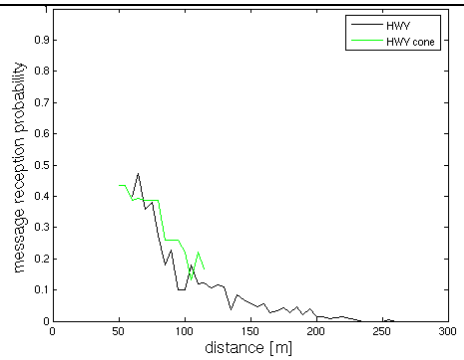


Figure 5-121: Reception Probability of Emergency Messages-Scenario 10, HWY, Sender RSU

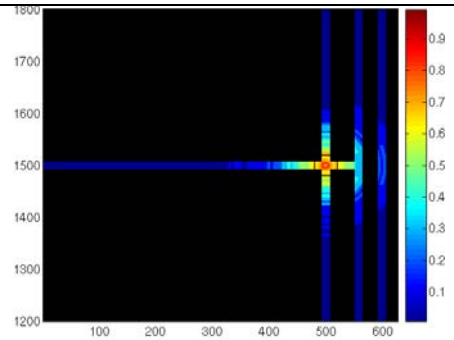


Figure 5-122: Reception Probability of Emergency Messages-Scenario 10, Sender RSU

5.1.10.2 Reception Probability of Routine Messages

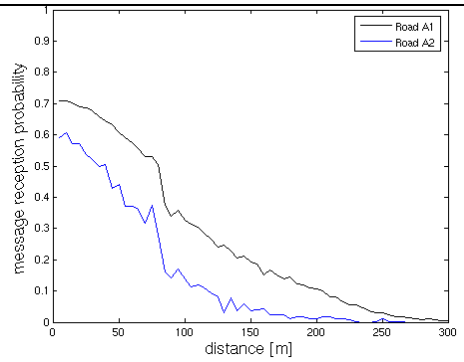


Figure 5-123: Reception Probability of Routine Messages on Road A, Scenario 10

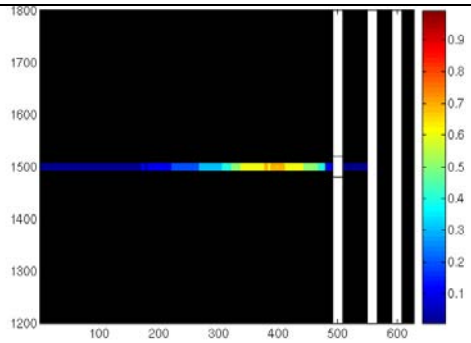


Figure 5-124: Reception Probability of Routine Messages on Road A, Scenario 10

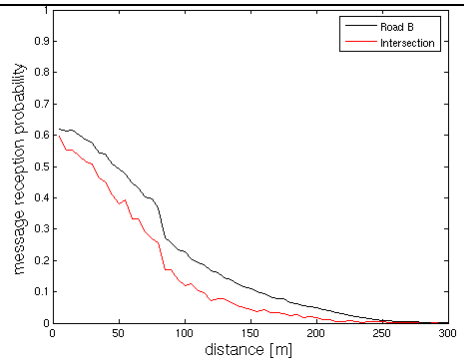


Figure 5-125: Reception Probability of Routine Messages on Road B, scenario 10

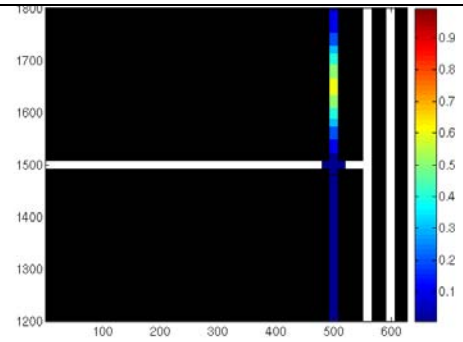


Figure 5-126: Reception Probability of Routine Messages on Road B, scenario 10

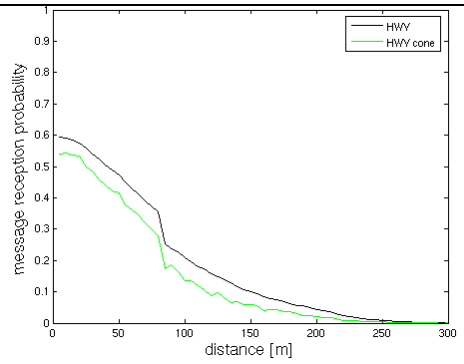


Figure 5-127: Reception Probability of Routine Messages on HWY, scenario 10

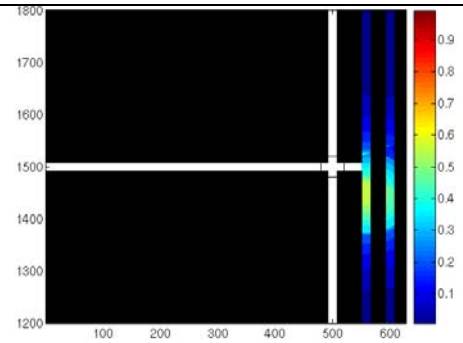


Figure 5-128: Reception Probability of Routine Messages on HWY, scenario 10

5.1.11 Scenario 11

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /10Hz /200m

5.1.11.1 Reception Probability of Emergency Messages

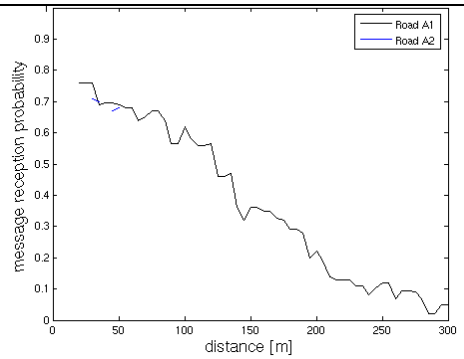


Figure 5-129: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

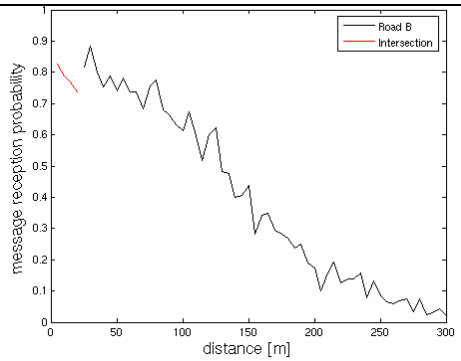


Figure 5-130: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

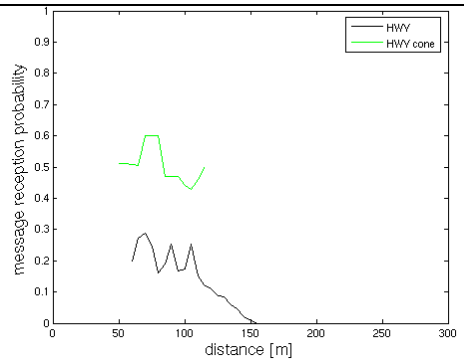


Figure 5-131: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

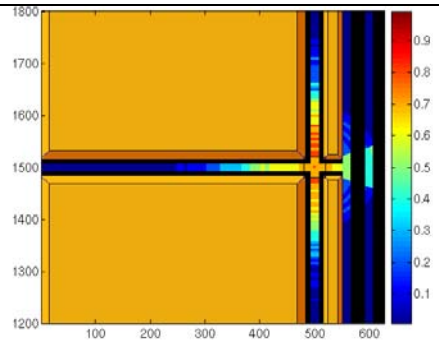


Figure 5-132: Reception Probability of Emergency Messages-Scenario11, Sender RSU

5.1.11.2 Reception Probability of Routine Messages

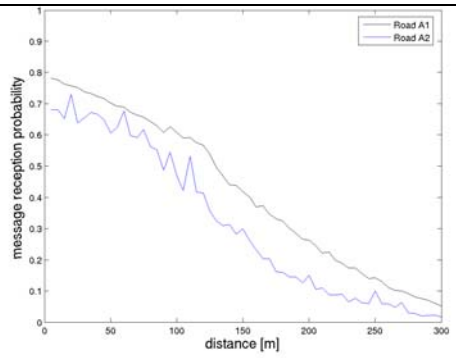


Figure 5-133: Reception Probability of Routine Messages on Road A, Scenario 11

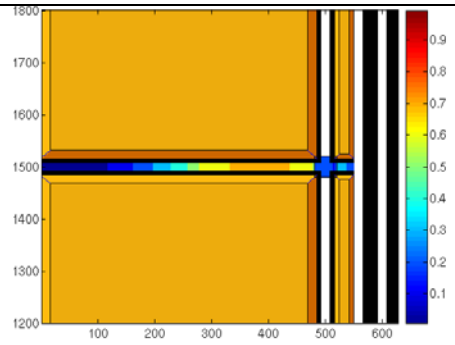


Figure 5-134: Reception Probability of Routine Messages on Road A, Scenario 11

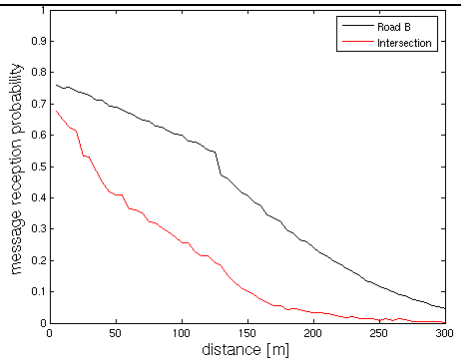


Figure 5-135: Reception Probability of Routine Messages on Road B, Scenario 11

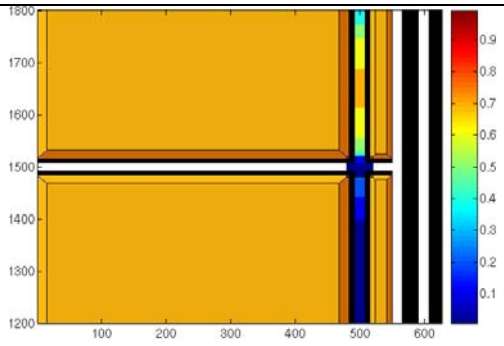


Figure 5-136: Reception Probability of Routine Messages on Road B, Scenario 11

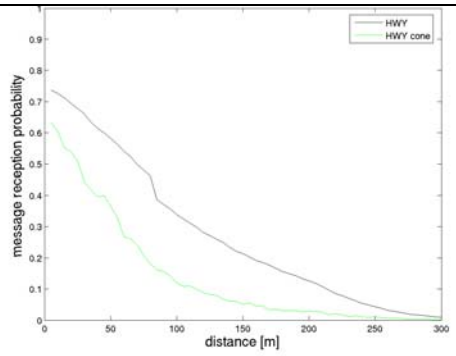


Figure 5-137: Reception Probability of Routine Messages on HWY, Scenario 11

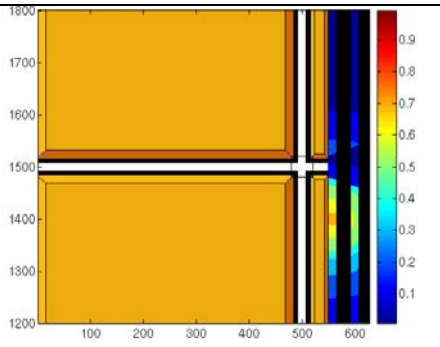


Figure 5-138: Reception Probability of Routine Messages on HWY, Scenario 11

5.1.12 Scenario 12

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.12.1 Reception Probability of Emergency Messages

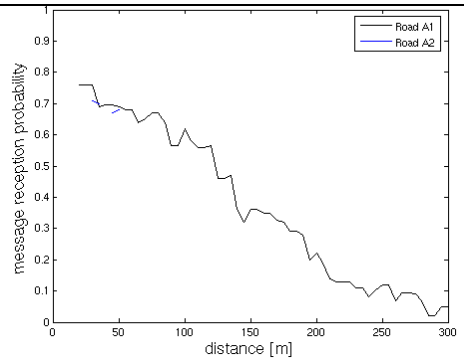


Figure 5-139: Reception Probability of Emergency Messages-Scenario12, Road A, Sender RSU

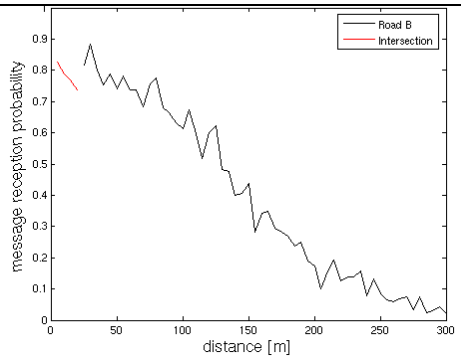


Figure 5-140: Reception Probability of Emergency Messages-Scenario12, Road B, Sender RSU

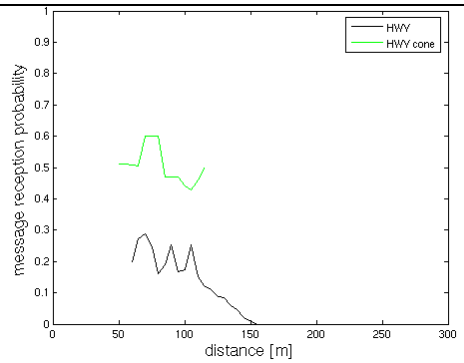


Figure 5-141: Reception Probability of Emergency Messages-Scenario12, HWY, Sender RSU

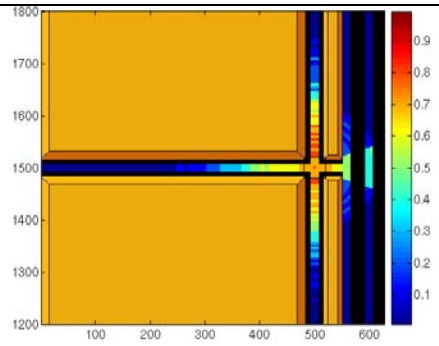


Figure 5-142: Reception Probability of Emergency Messages-Scenario12, Sender RSU

5.1.12.2 Reception Probability of Routine Messages

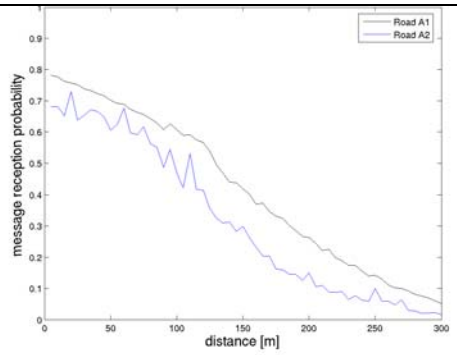


Figure 5-143: Reception Probability of Routine Messages on Road A, Scenario 12

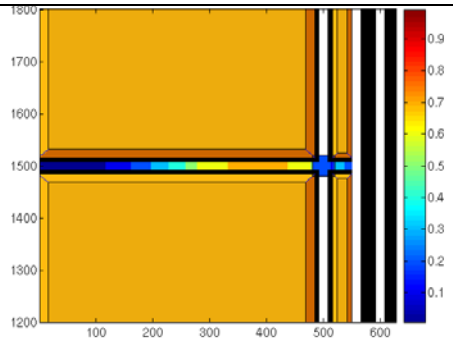


Figure 5-144: Reception Probability of Routine Messages on Road A, Scenario 12

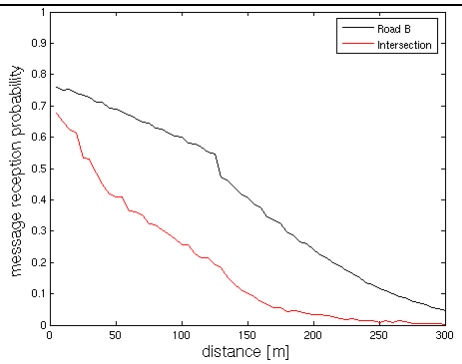


Figure 5-145: Reception Probability of Routine Messages on Road B, Scenario 12

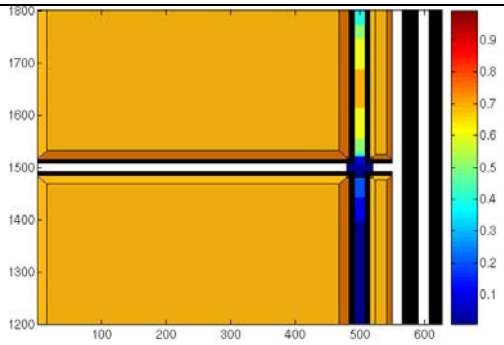


Figure 5-146: Reception Probability of Routine Messages on Road B, Scenario 12

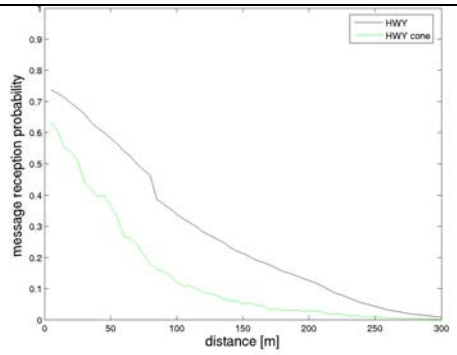


Figure 5-147: Reception Probability of Routine Messages on HWY, Scenario 12

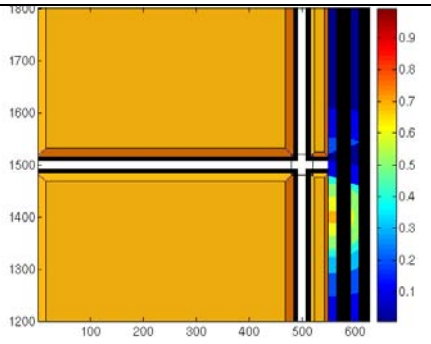


Figure 5-148: Reception Probability of Routine Messages on HWY, Scenario 12

5.1.13 Scenario 13

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	No building
Commercial RSU	On, 500bytes/ 2Hz/ 200m
Routine Messages	200byte /10Hz /200m

5.1.13.1 Reception Probability of Emergency Messages From OBU on A1

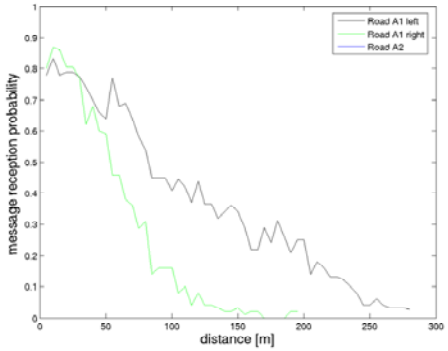


Figure 5-149: Reception Prob. of Emergency Messages – Scenario 13, Rd. A, Sender on Rd. A1

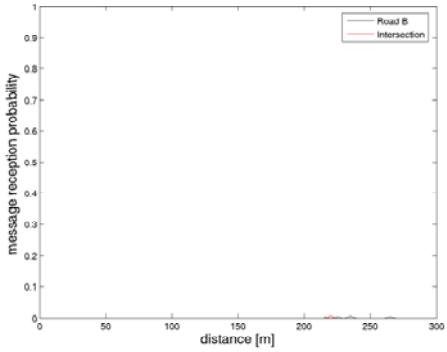


Figure 5-150: Reception Prob. of Emergency Messages – Scenario 13, Rd. B, Sender on Rd. A1

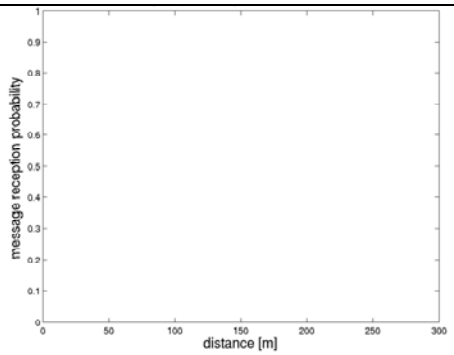


Figure 5-151: Reception Prob. of Emergency Messages – Scenario 13, HWY, Sender on Rd. A1

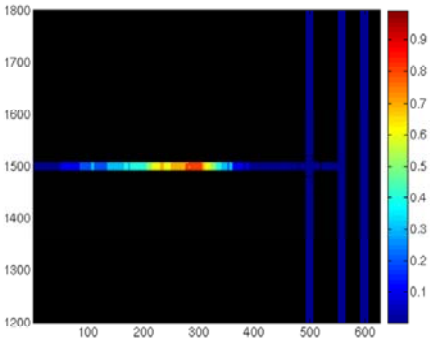


Figure 5-152: Reception Prob. of Emergency Messages-Scenario 13, Sender on Rd. A1

5.1.13.2 Reception Probability of Emergency Messages From OBU on A2

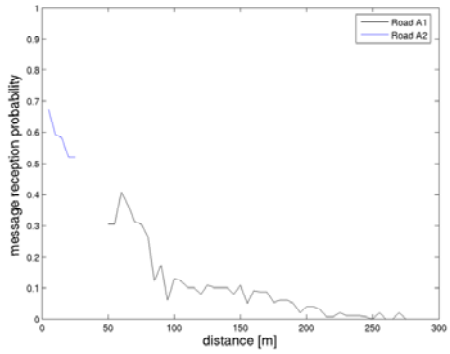


Figure 5-153: Reception Prob. of Emergency Messages – Scenario 13, Rd. A, Sender on Rd. A2

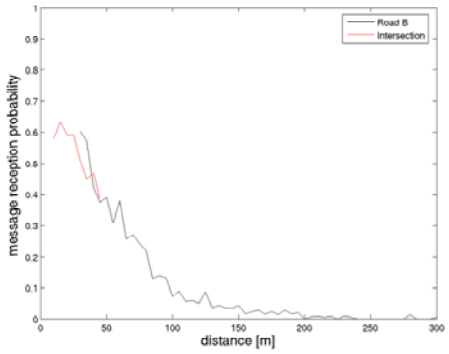


Figure 5-154: Reception Prob. of Emergency Messages – Scenario 13, Rd. B, Sender on Rd. A2

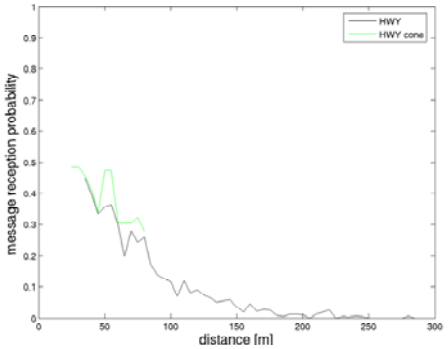


Figure 5-155: Reception Prob. of Emergency Messages – Scenario 13, HWY, Sender on Rd. A2

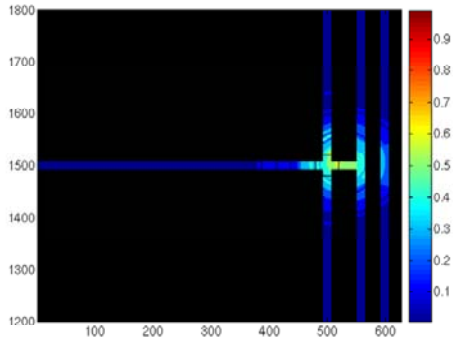


Figure 5-156: Reception Prob. of Emergency Messages-Scenario 13, Sender on Rd. A2

5.1.13.3 Reception Probability of Emergency MessagesFrom OBU on B

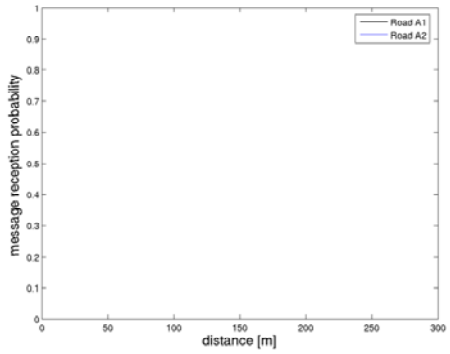


Figure 5-157: Reception Prob. of Emergency Messages – Scenario 13, Rd. A, Sender on Rd. B

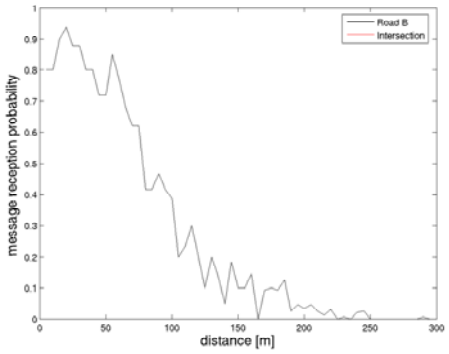


Figure 5-158: Reception Prob. of Emergency Messages – Scenario 13, Rd. B, Sender on Rd. B

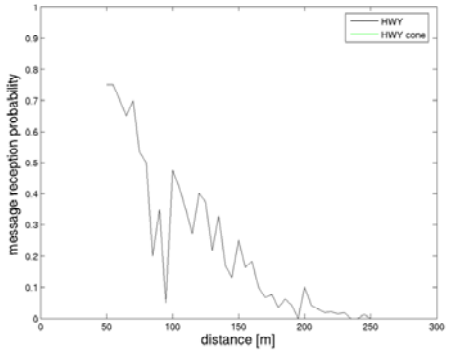


Figure 5-159: Reception Prob. of Emergency Messages – Scenario 13, HWY, Sender on Rd. B

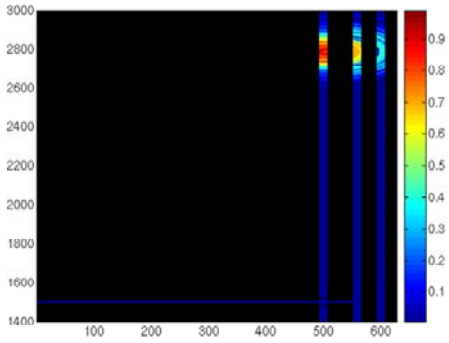


Figure 5-160: Reception Prob. of Emergency Messages-Scenario 13, Sender on Rd. B

5.1.13.4 Reception Probability of Emergency Messages From OBU on HWY

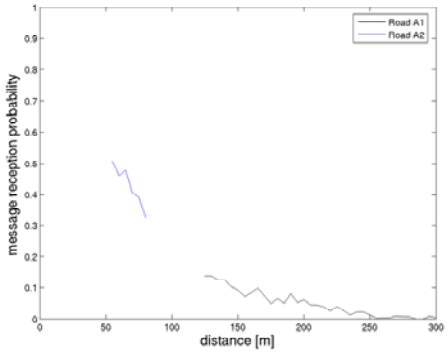


Figure 5-161: Reception Prob. of Emergency Messages - Scenario 13, Rd. A, Sender on HWY

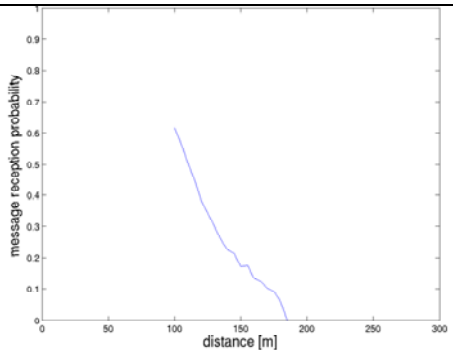


Figure 5-162: Reception Prob. of Emergency Messages - Scenario13, Rd. B, Sender on HWY

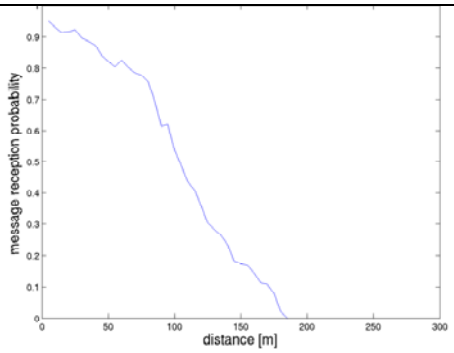


Figure 5-163: Reception Prob. of Emergency Messages - Scenario13, HWY, Sender on HWY

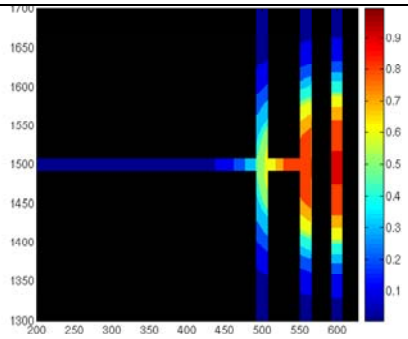


Figure 5-164: Reception Prob. of Emergency Messages-Scenario 13, Sender on HWY

5.1.14 Scenario 14

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	No building
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.14.1 Reception Probability of Emergency Messages From OBU on A1

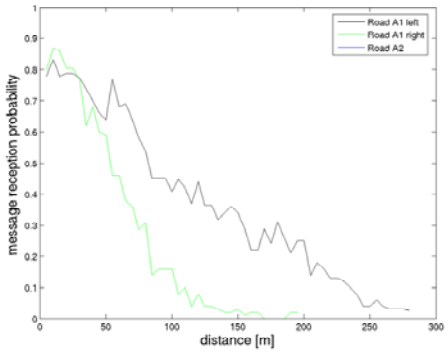


Figure 5-165: Reception Prob. of Emergency Messages - Scenario14, Rd. A, Sender on Rd. A1

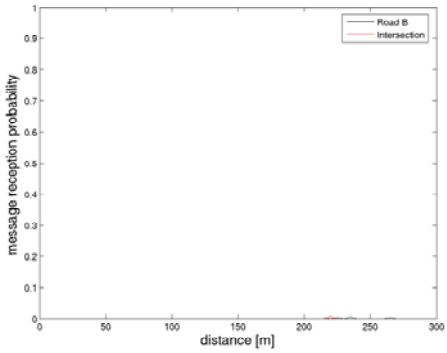


Figure 5-166: Reception Prob. of Emergency Messages - Scenario14, Rd. B, Sender on Rd. A1

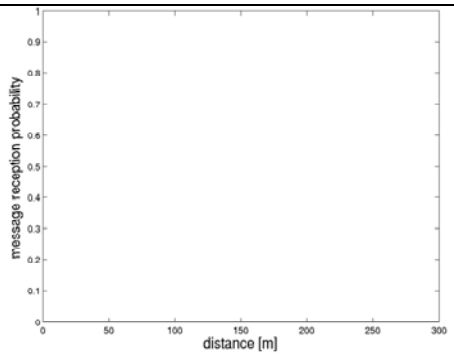


Figure 5-167: Reception Prob. of Emergency Messages - Scenario14, HWY, Sender on Rd. A1

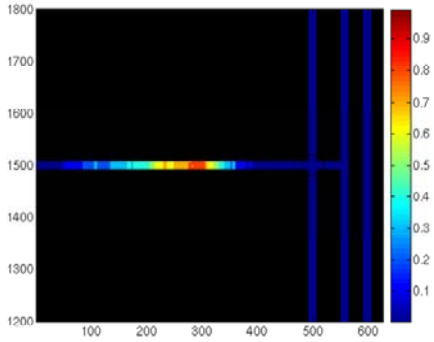


Figure 5-168: Reception Prob. of Emergency Messages-Scenario 14, Sender on Rd. A1

5.1.14.2 Reception Probability of Emergency Messages From OBU on A2

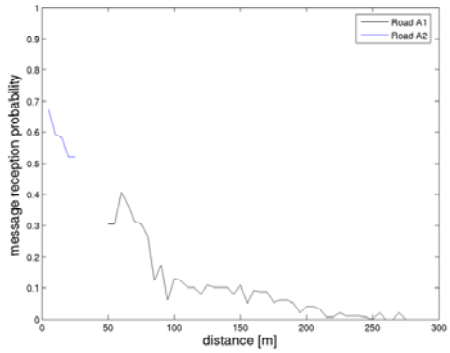


Figure 5-169: Reception Prob. of Emergency Messages - Scenario14, Rd. A, Sender on Rd. A2

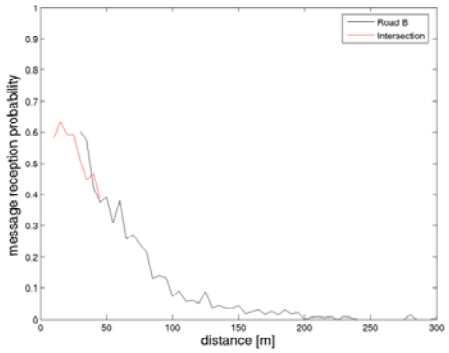


Figure 5-170: Reception Prob. of Emergency Messages - Scenario14, Rd. B, Sender on Rd. A2

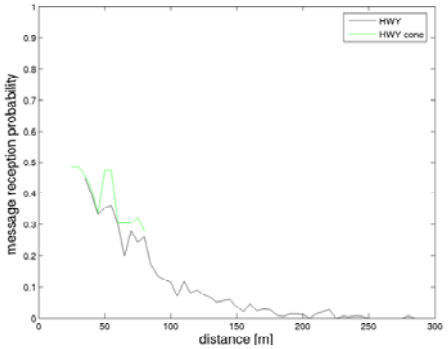


Figure 5-171: Reception Prob. of Emergency Messages - Scenario14, HWY, Sender on Rd. A2

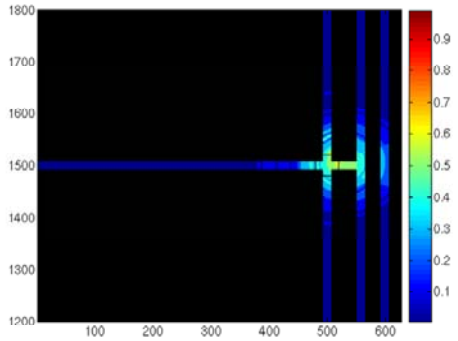


Figure 5-172: Reception Prob. of Emergency Messages-Scenario 14, Sender on Rd. A2

5.1.14.3 Reception Probability of Emergency Messages from OBU on B

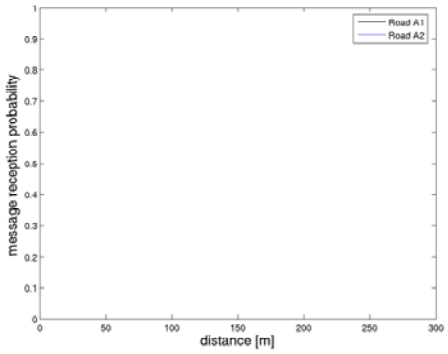


Figure 5-173: Reception Prob. of Emergency Messages - Scenario14, Rd. A, Sender on Rd. B

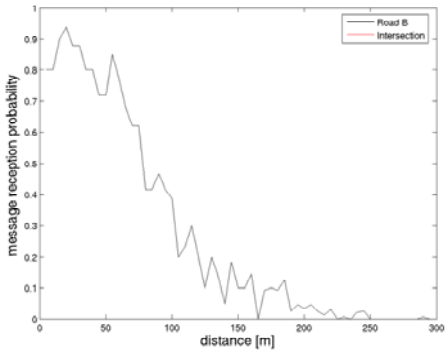


Figure 5-174: Reception Prob. of Emergency Messages - Scenario14, Rd. B, Sender on Rd. B

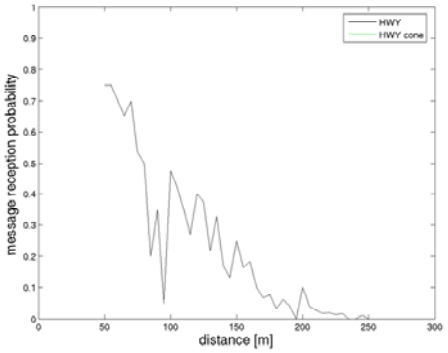


Figure 5-175: Reception Prob. of Emergency Messages - Scenario14, HWY, Sender on Rd. B

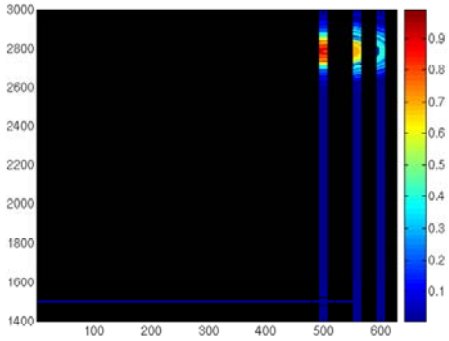


Figure 5-176: Reception Prob. of Emergency Messages-Scenario 14, Sender on Rd. B

5.1.14.4 Reception Probability of Emergency Messages From OBU on HWY

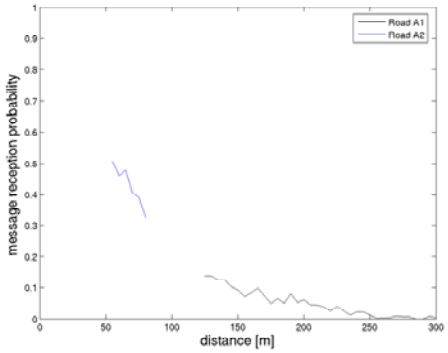


Figure 5-177: Reception Prob. of Emergency Messages - Scenario14, Rd. A, Sender on HWY

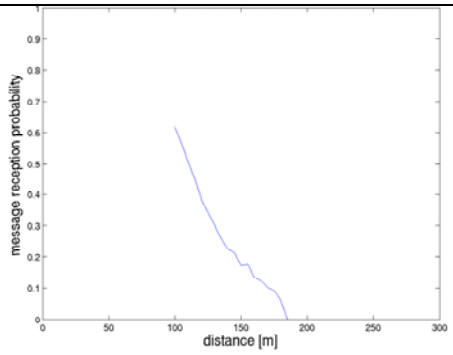


Figure 5-178: Reception Prob. of Emergency Messages - Scenario14, Rd. B, Sender on HWY

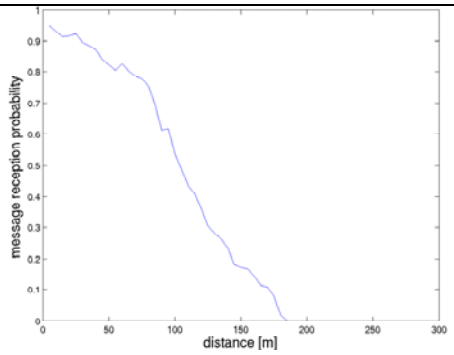


Figure 5-179: Reception Prob. of Emergency Messages - Scenario14, HWY, Sender on HWY

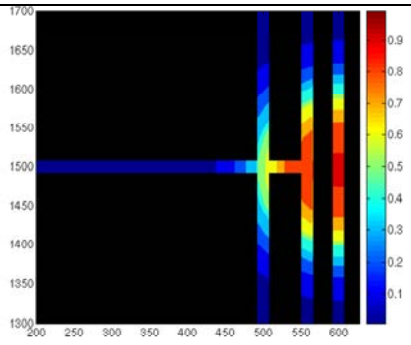


Figure 5-180: Reception Prob. of Emergency Messages-Scenario 14, Sender on HWY

5.1.15 Scenario 15

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	Tall building
Commercial RSU	On, 500bytes/ 2Hz/ 200m
Routine Messages	200byte /10Hz /200m

5.1.15.1 Reception Probability of Emergency Msgs From OBU on A1

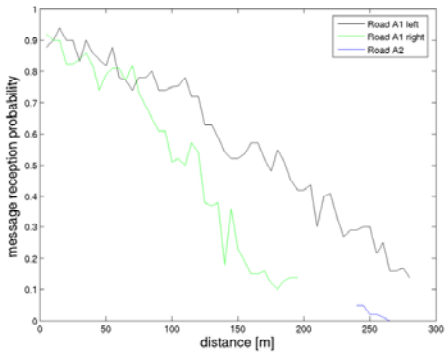


Figure 5-181: Reception Prob. of Emergency Messages - Scenario15, Rd. A, Sender on Rd. A1

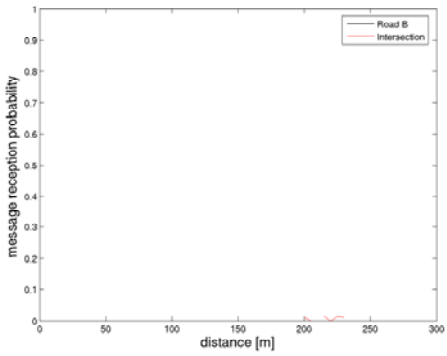


Figure 5-182: Reception Prob. of Emergency Messages - Scenario15, Rd. B, Sender on Rd. A1

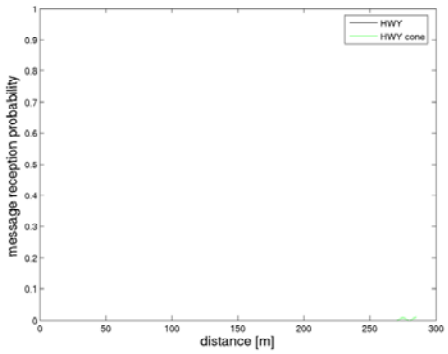


Figure 5-183: Reception Prob. of Emergency Messages - Scenario15, HWY, Sender on Rd. A1

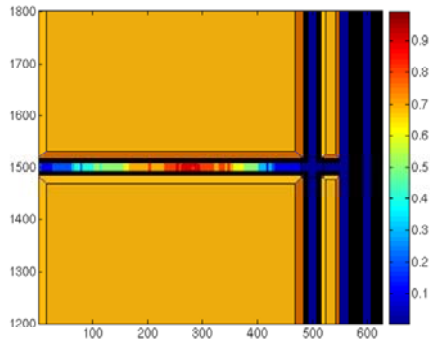


Figure 5-184: Reception Prob. of Emergency Messages-Scenario 15, Sender on Rd. A1

5.1.15.2 Reception Probability of Emergency Messages From OBU on A2

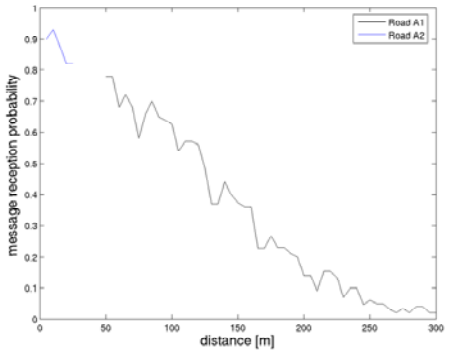


Figure 5-185: Reception Prob. of Emergency Messages - Scenario15, Rd. A, Sender on Rd. A2

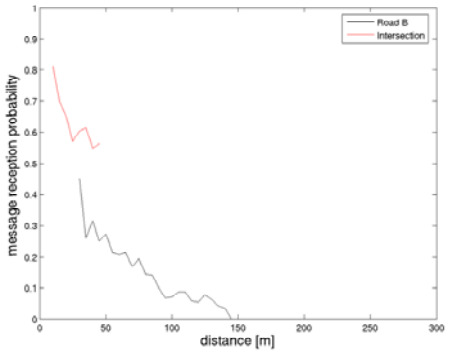


Figure 5-186: Reception Prob. of Emergency Messages - Scenario15, Rd. B, Sender on Rd. A2

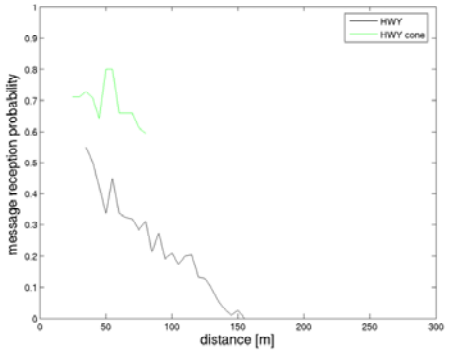


Figure 5-187: Reception Prob. of Emergency Messages - Scenario15, HWY, Sender on Rd. A2

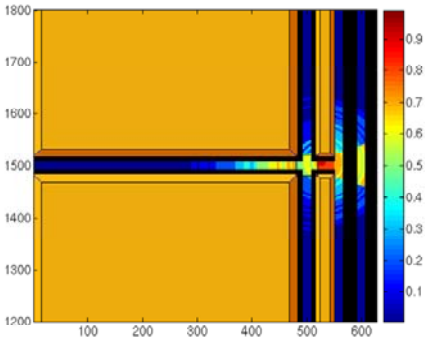


Figure 5-188: Reception Prob. of Emergency Messages-Scenario 15, Sender on Rd. A2

5.1.15.3 Reception Probability of Emergency Messages From OBU on B

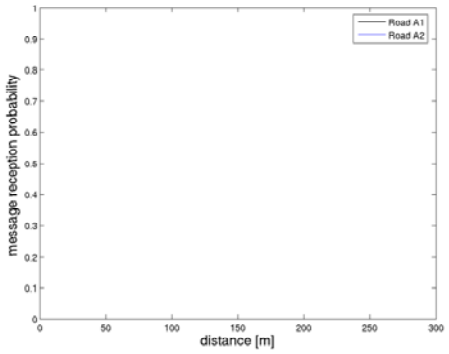


Figure 5-189: Reception Prob. of Emergency Messages - Scenario15, Rd. A, Sender on Rd. B

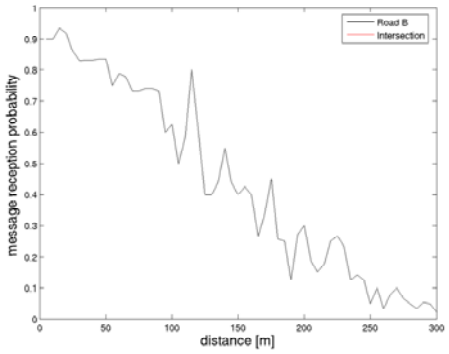


Figure 5-190: Reception Prob. of Emergency Messages - Scenario15, Rd. B, Sender on Rd. B

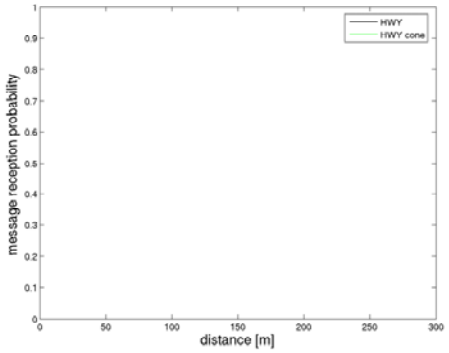


Figure 5-191: Reception Prob. of Emergency Messages - Scenario15, HWY, Sender on Rd. B

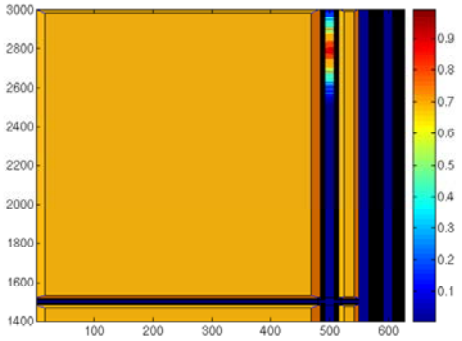


Figure 5-192: Reception Prob. of Emergency Messages-Scenario 15, Sender on Rd. B

5.1.15.4 Reception Probability of Emergency Messages From OBU on HWY

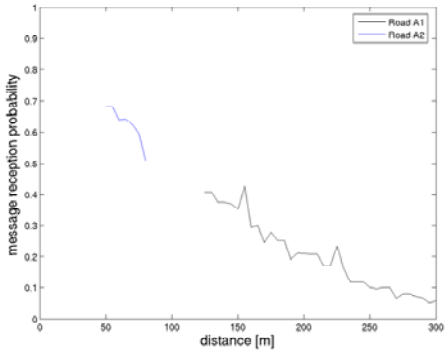


Figure 5-193: Reception Prob. of Emergency Messages - Scenario15, Rd. A, Sender on HWY

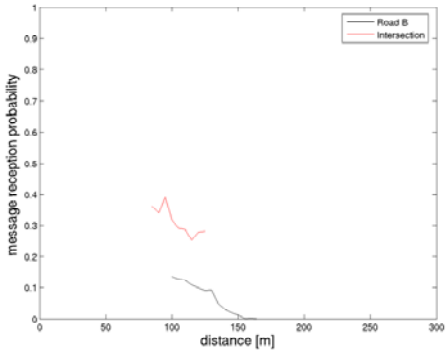


Figure 5-194: Reception Prob. of Emergency Messages - Scenario15, Rd. B, Sender on HWY

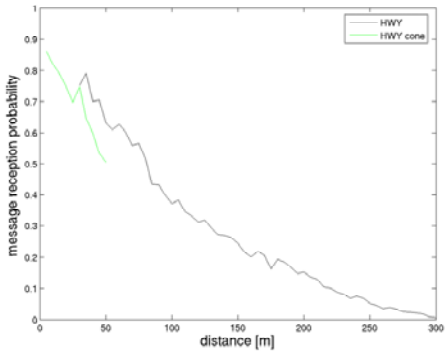


Figure 5-195: Reception Prob. of Emergency Messages - Scenario15, HWY, Sender on HWY

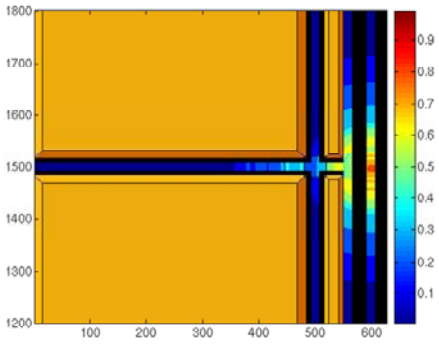


Figure 5-196: Reception Prob. of Emergency Messages-Scenario 15, Sender on HWY

5.1.16 Scenario 16

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B 500 bytes/ 10Hz/200m on HWY 200 bytes/ 50Hz/200m
Corner Model	Tall building
Commercial RSU	OFF
Routine Messages	200byte /10Hz /200m

5.1.16.1 Reception Probability of Emergency Messages From OBU on A1

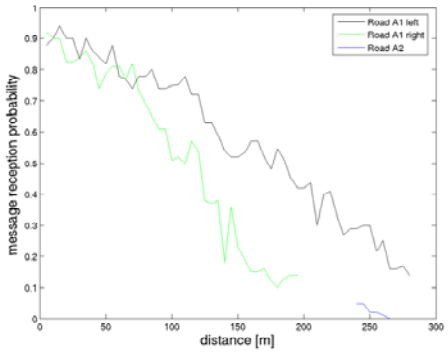


Figure 5-197: Reception Prob. of Emergency Messages - Scenario16, Rd. A, Sender on Rd. A1

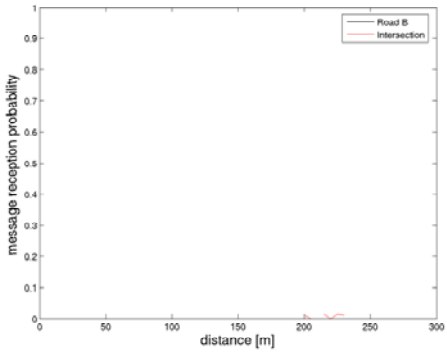


Figure 5-198: Reception Prob. of Emergency Messages - Scenario16, Rd. B, Sender on Rd. A1

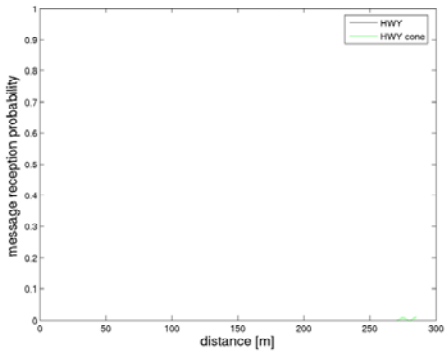


Figure 5-199: Reception Prob. of Emergency Messages - Scenario16, HWY, Sender on Rd. A1

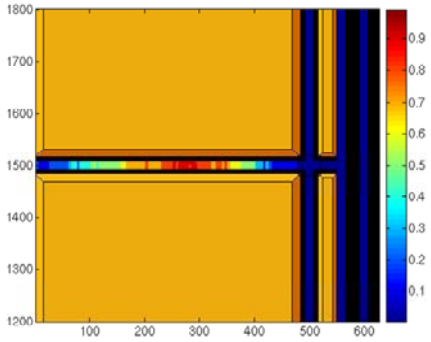


Figure 5-200: Reception Prob. of Emergency Messages-Scenario 16, Sender on Rd. A1

5.1.16.2 Reception Probability of Emergency Messages From OBU on A2

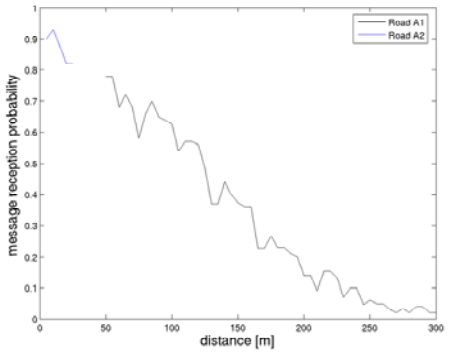


Figure 5-201: Reception Prob. of Emergency Messages - Scenario16, Rd. A, Sender on Rd. A2

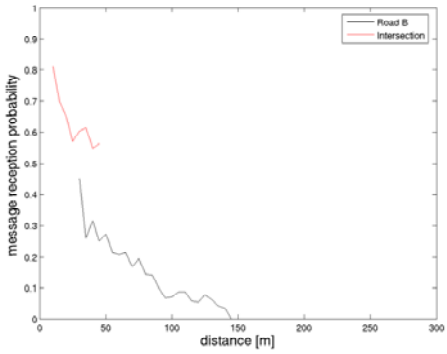


Figure 5-202: Reception Prob. of Emergency Messages - Scenario16, Rd. B, Sender on Rd. A2

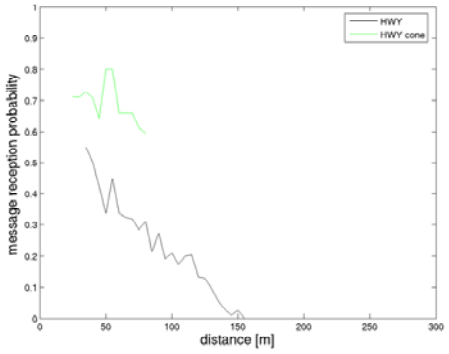


Figure 5-203: Reception Prob. of Emergency Messages - Scenario16, HWY, Sender on Rd. A2

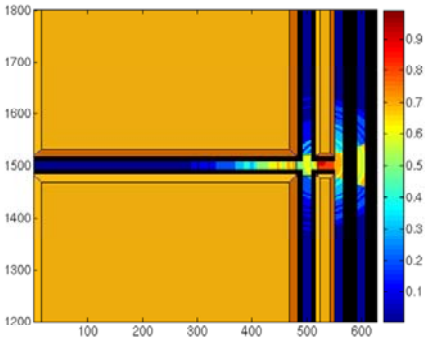


Figure 5-204: Reception Prob. of Emergency Messages-Scenario 16, Sender on Rd. A2

5.1.16.3 Reception Probability of Emergency Messages From OBU on B

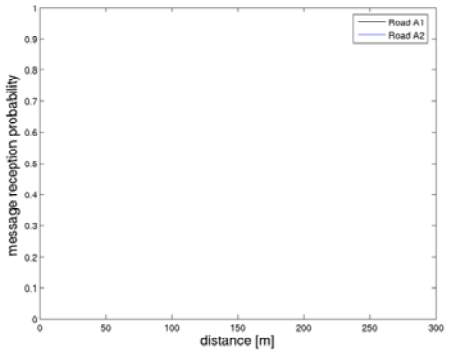


Figure 5-205: Reception Prob. of Emergency Messages - Scenario16, Rd. A, Sender on Rd. B

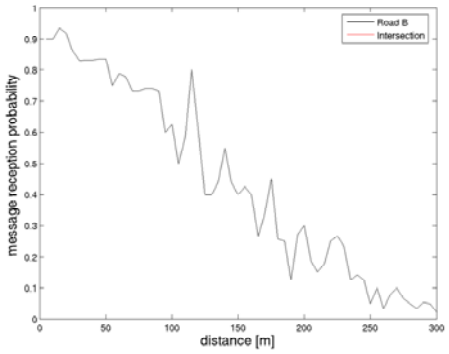


Figure 5-206: Reception Prob. of Emergency Messages - Scenario16, Rd. B, Sender on Rd. B

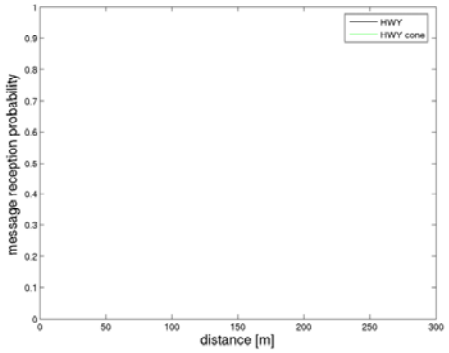


Figure 5-207: Reception Prob. of Emergency Messages - Scenario16, HWY, Sender on Rd. B

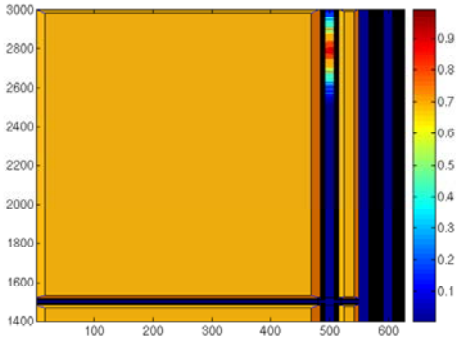


Figure 5-208: Reception Prob. of Emergency Messages-Scenario 16, Sender on Rd. B

5.1.16.4 Reception Probability of Emergency Messages From OBU on HWY

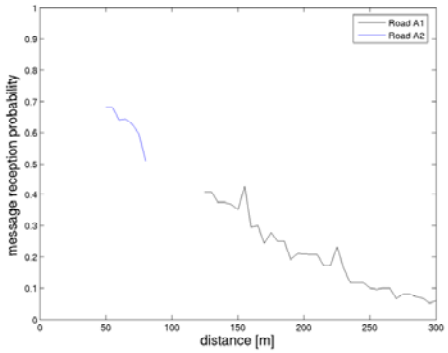


Figure 5-209: Reception Prob. of Emergency Messages - Scenario16, Rd. A, Sender on HWY

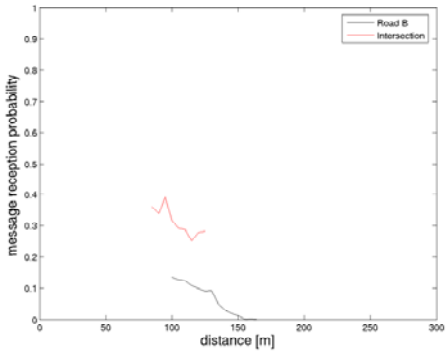


Figure 5-210: Reception Prob. of Emergency Messages - Scenario16, Rd. B, Sender on HWY

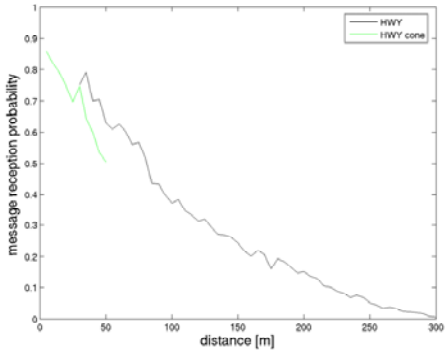


Figure 5-211: Reception Prob. of Emergency Messages - Scenario16, HWY, Sender on HWY

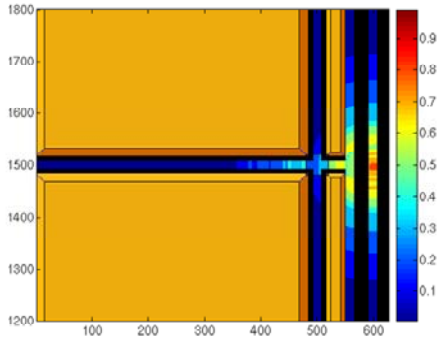


Figure 5-212: Reception Prob. of Emergency Messages-Scenario 16, Sender on HWY

5.2 Batch 2, Routine and Emergency Safety Messaging in Less Stressful Channel

5.2.1 Scenario 17

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	200m coverage
Routine Message Frequency	2Hz

5.2.1.1 Reception Probability of Emergency Messages

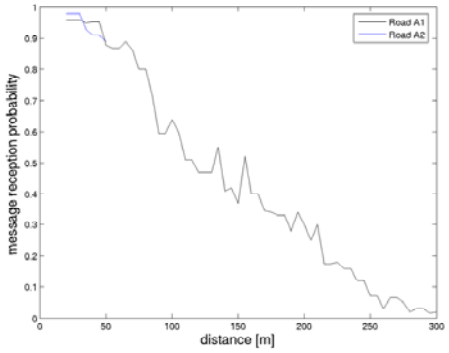


Figure 5-213: Reception Probability of Emergency Messages-Scenario17, Road A, Sender RSU

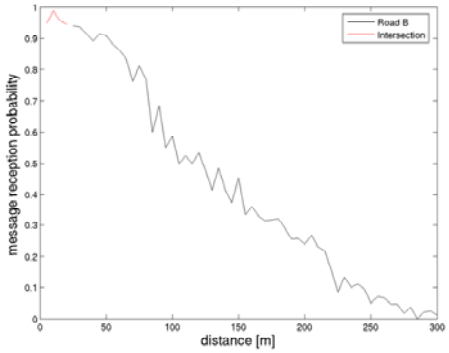


Figure 5-214: Reception Probability of Emergency Messages-Scenario17, Road B, Sender RSU

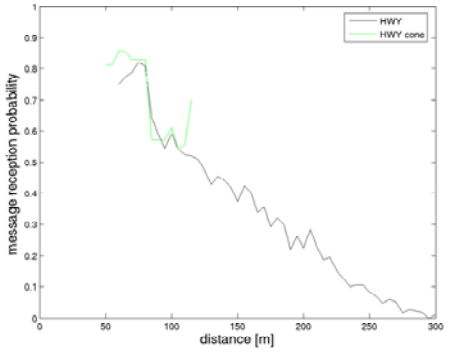


Figure 5-215: Reception Probability of Emergency Messages-Scenario17, HWY, Sender RSU

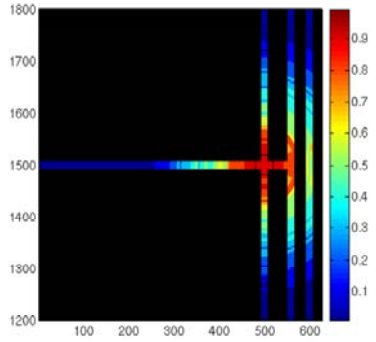


Figure 5-216: Reception Probability of Emergency Messages-Scenario17, Sender RSU

5.2.1.2 Reception Probability of Routine Messages

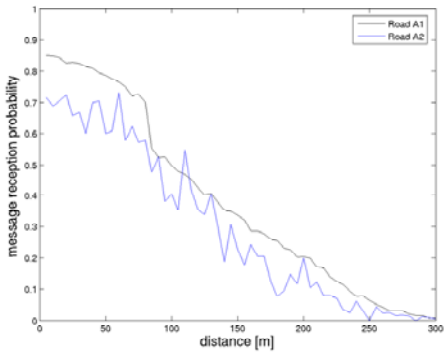


Figure 5-217: Reception Probability of Routine Messages on Road A, Scenario17

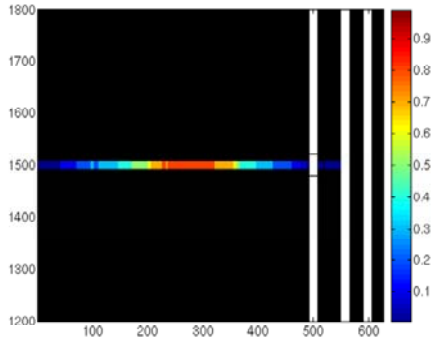


Figure 5-218: Reception Probability of Routine Messages on Road A, Scenario 17

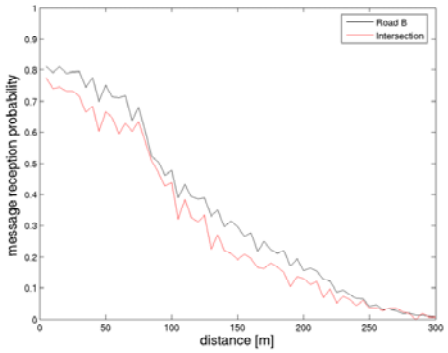


Figure 5-219: Reception Probability of Routine Messages on Road B, Scenario17

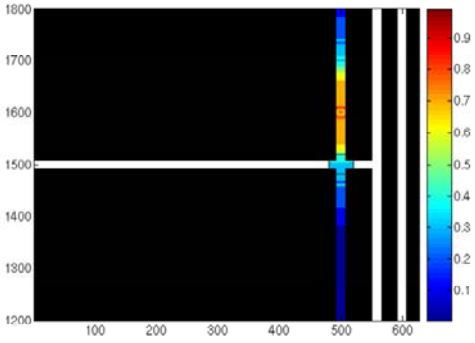


Figure 5-220: Reception Probability of Routine Messages on Road B, Scenario 17

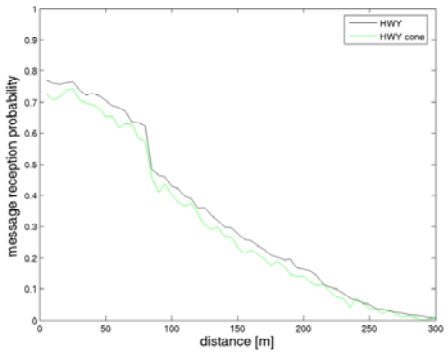


Figure 5-221: Reception Probability of Routine Messages on HWY, Scenario17

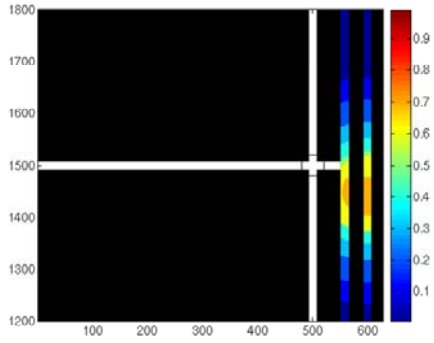


Figure 5-222: Reception Probability of Routine Messages on HWY, Scenario 17

5.2.2 Scenario 18

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	200m coverage
Routine Message Frequency	2Hz

5.2.2.1 Reception Probability of Emergency Messages From OBU on A1

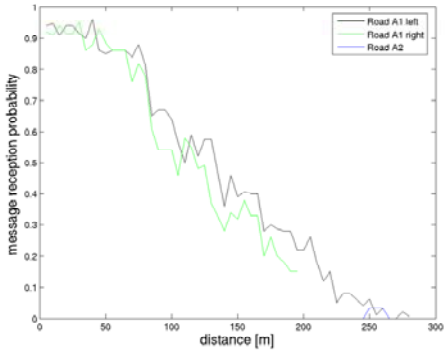


Figure 5-223: Reception Prob. of Emergency Messages - Scenario18, Rd. A, Sender on Rd. A1

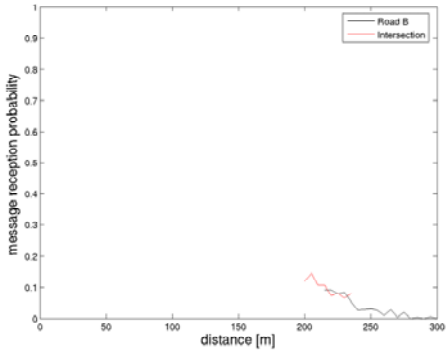


Figure 5-224: Reception Prob. of Emergency Messages - Scenario18, Rd. B, Sender on Rd. A1

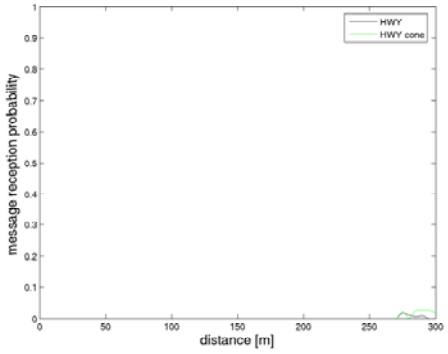


Figure 5-225: Reception Prob. of Emergency Messages - Scenario18, HWY, Sender on Rd. A1

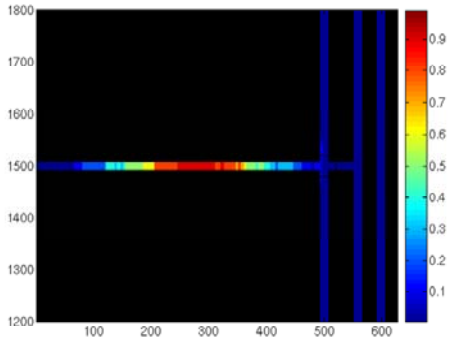


Figure 5-226: Reception Prob. of Emergency Messages-Scenario 18, Sender on Rd. A1

5.2.2.2 Reception Probability of Emergency Messages From OBU on A2

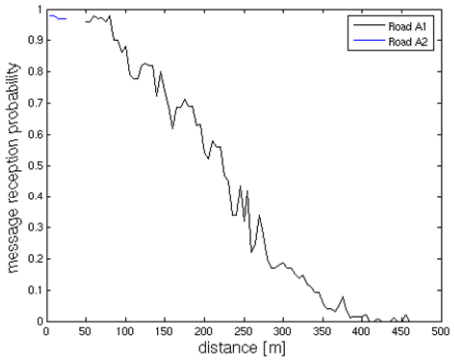


Figure 5-227: Reception Prob. of Emergency Messages – Scenario 18, Rd. A, Sender on Rd. A2

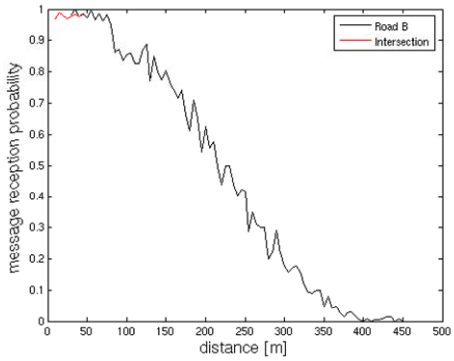


Figure 5-228: Reception Prob. of Emergency Messages - Scenario18, Rd. B, Sender on Rd. A2

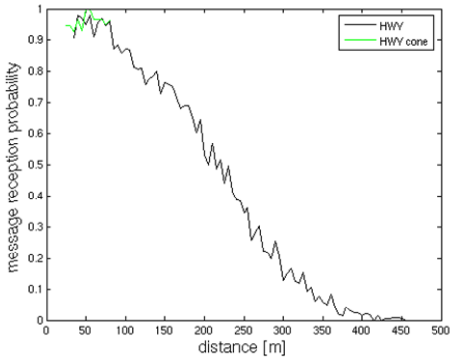


Figure 5-229: Reception Prob. of Emergency Messages – Scenario 18, HWY, Sender on Rd. A2

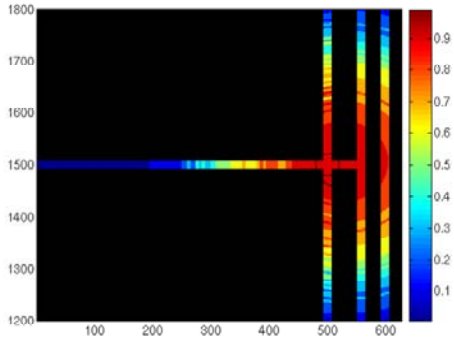


Figure 5-230: Reception Prob. of Emergency Messages-Scenario 18, Sender on Rd. A2

5.2.2.3 Reception Probability of Emergency Messages From OBU on B

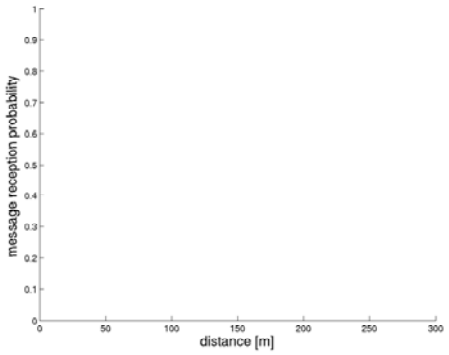


Figure 5-231: Reception Prob. of Emergency Messages - Scenario18, Rd. A, Sender on Rd. B

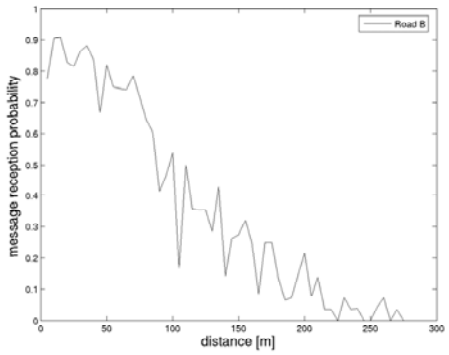


Figure 5-232: Reception Prob. of Emergency Messages - Scenario18, Rd. B, Sender on Rd. B

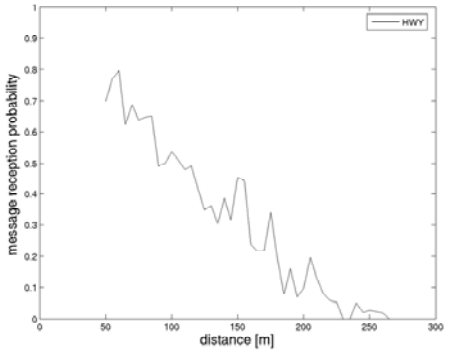


Figure 5-233: Reception Prob. of Emergency Messages - Scenario18, HWY, Sender on Rd. B

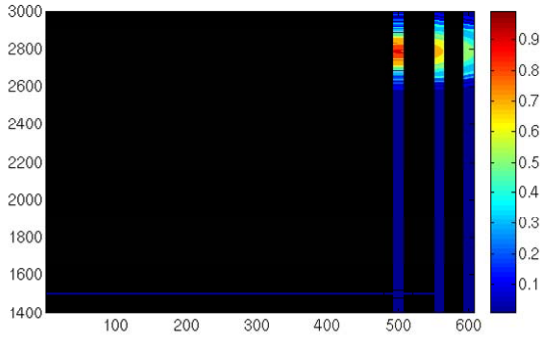


Figure 5-234: Reception Prob. of Emergency Messages-Scenario 18, Sender on Rd. B

5.2.2.4 Reception Probability of Emergency Messages From OBU on HWY

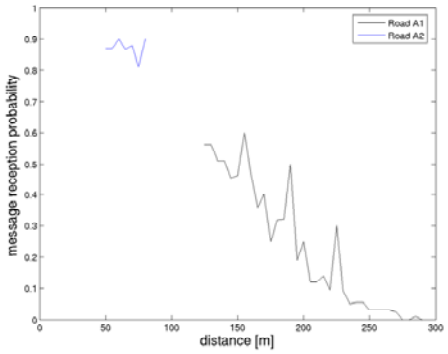


Figure 5-235: Reception Prob. of Emergency Messages - Scenario18, Rd. A, Sender on HWY

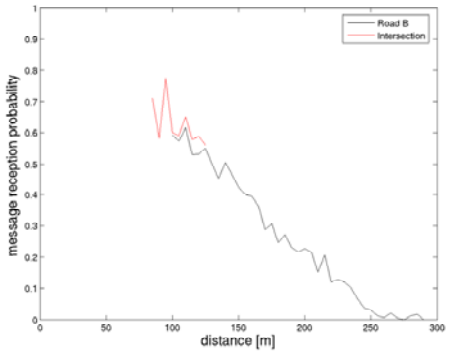


Figure 5-236: Reception Prob. of Emergency Messages - Scenario18, Rd. B, Sender on HWY

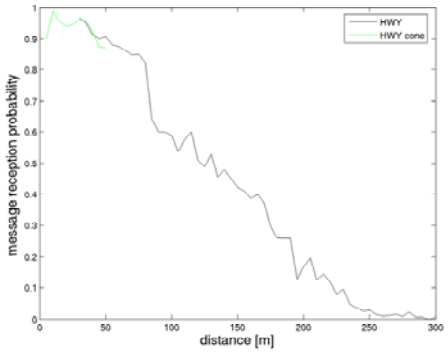


Figure 5-237: Reception Prob. of Emergency Messages - Scenario18, HWY, Sender on HWY

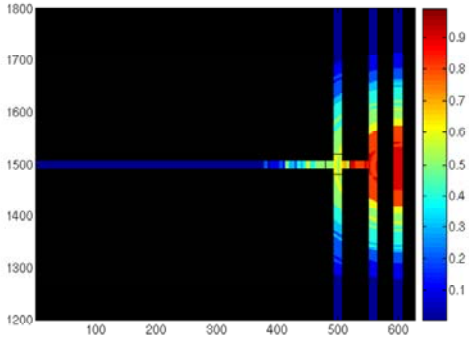


Figure 5-238: Reception Prob. of Emergency Messages-Scenario 18, Sender on HWY

5.2.3 Scenario 19

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	tall buildings
Pt	200m coverage
Routine Message Frequency	2Hz

5.2.3.1 Reception Probability of Emergency Messages

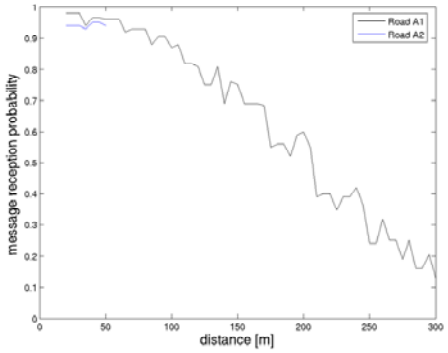


Figure 5-239: Reception Probability of Emergency Messages-Scenario19, Road A, Sender RSU

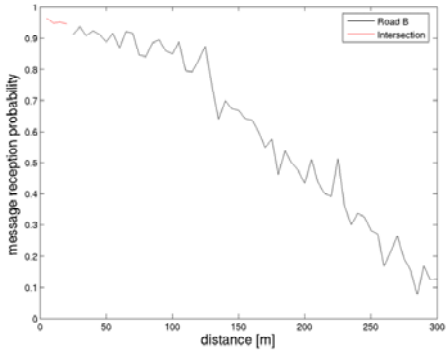


Figure 5-240: Reception Probability of Emergency Messages-Scenario19, Road B, Sender RSU

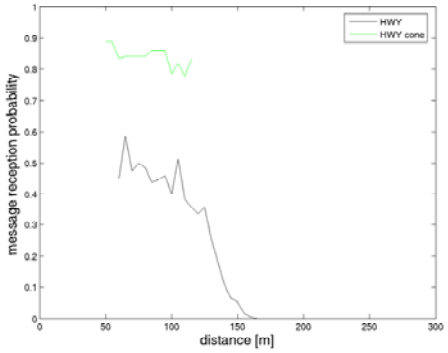


Figure 5-241: Reception Probability of Emergency Messages-Scenario19, HWY, Sender RSU

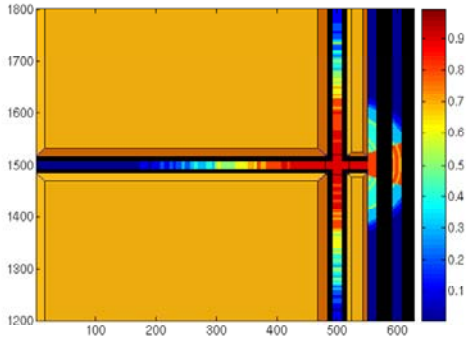


Figure 5-242: Reception Probability of Emergency Messages-Scenario19, Sender RSU

5.2.3.2 Reception Probability of Routine Messages

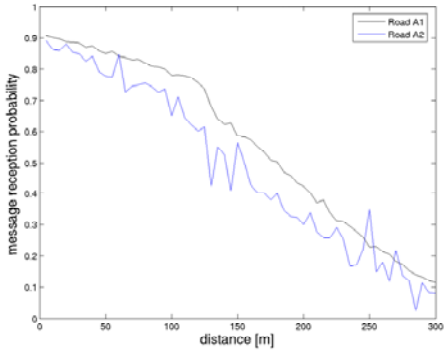


Figure 5-243: Reception Probability of Routine Messages on Road A, Scenario 19

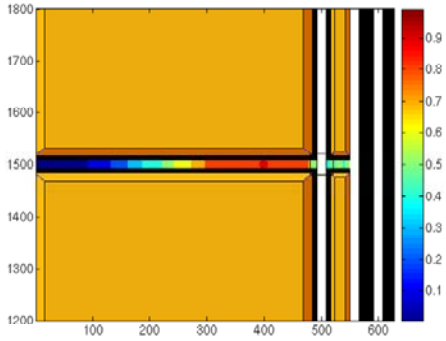


Figure 5-244: Reception Probability of Routine Messages on Road A, Scenario 19

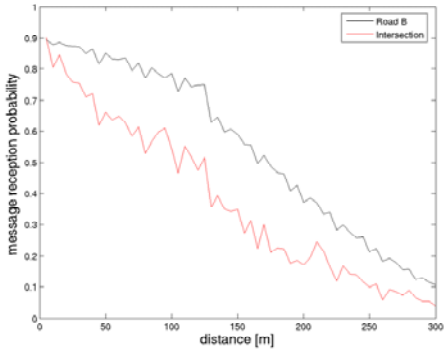


Figure 5-245: Reception Probability of Routine Messages on Road B, Scenario 19

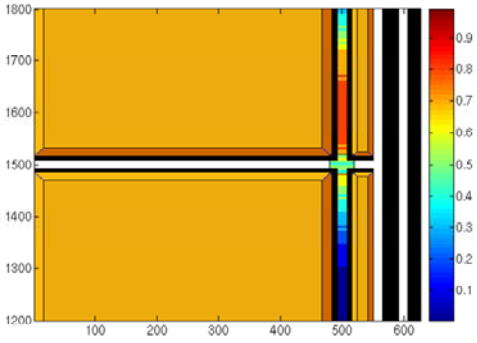


Figure 5-246: Reception Probability of Routine Messages on Road B, Scenario 19

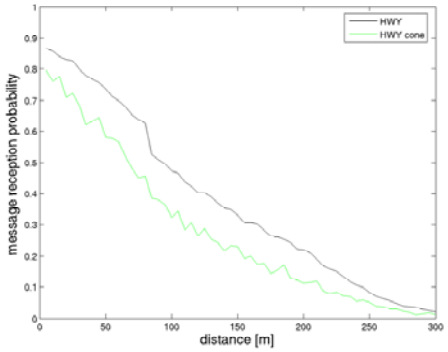


Figure 5-247: Reception Probability of Routine Messages on HWY, Scenario 19

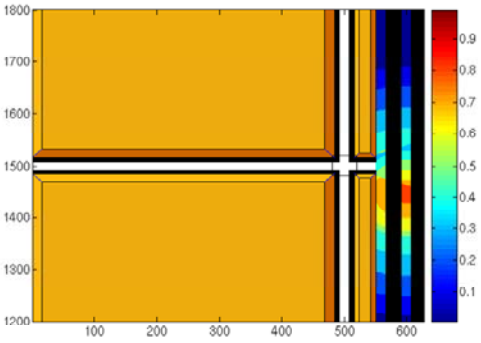


Figure 5-248: Reception Probability of Routine Messages on HWY, Scenario 19

5.2.4 Scenario 20

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	200m coverage
Routine Message Frequency	2Hz

5.2.4.1 Reception Probability of Emergency Messages From OBU on A1

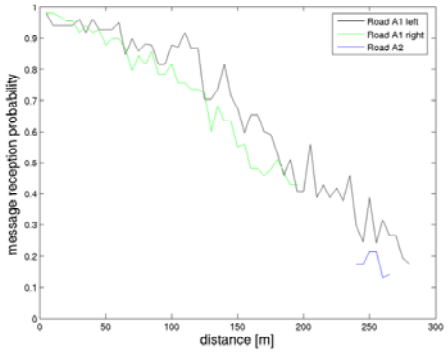


Figure 5-249: Reception Prob. of Emergency Messages - Scenario20, Rd. A, Sender on Rd. A1

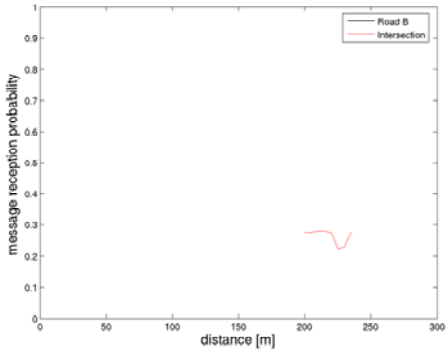


Figure 5-250: Reception Prob. of Emergency Messages - Scenario20, Rd. B, Sender on Rd. A1

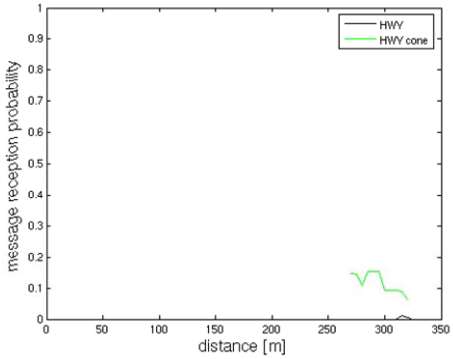


Figure 5-251: Reception Prob. of Emergency Messages - Scenario20, HWY, Sender on Rd. A1

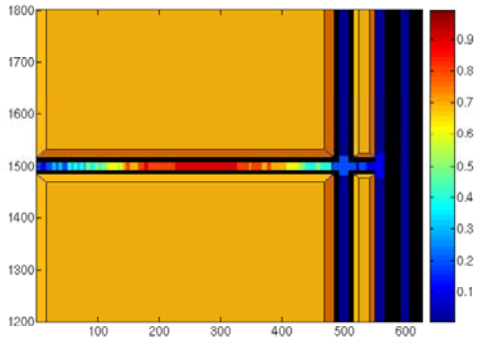


Figure 5-252: Reception Prob. of Emergency Messages-Scenario 20, Sender on Rd. A1

5.2.4.2 Reception Probability of Emergency Messages From OBU on A2

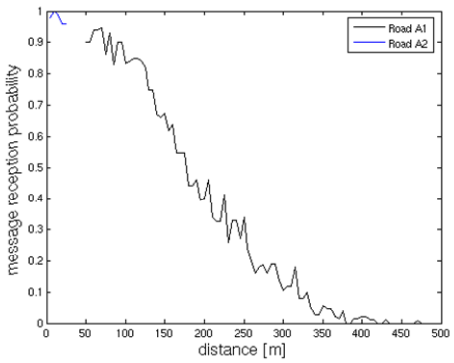


Figure 5-253: Reception Prob. of Emergency Messages - Scenario20, Rd. A, Sender on Rd. A2

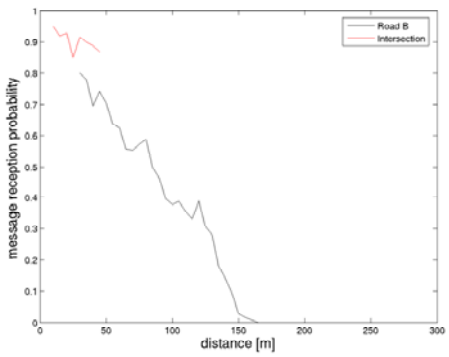


Figure 5-254: Reception Prob. of Emergency Messages - Scenario20, Rd. B, Sender on Rd. A2

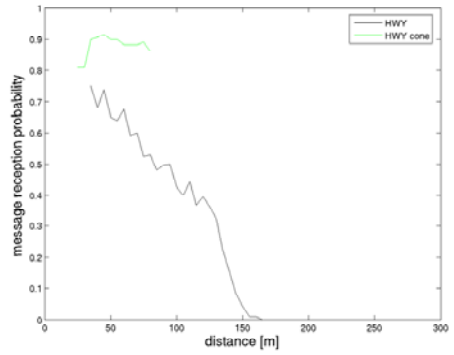


Figure 5-255: Reception Prob. of Emergency Messages - Scenario20, HWY, Sender on Rd. A2

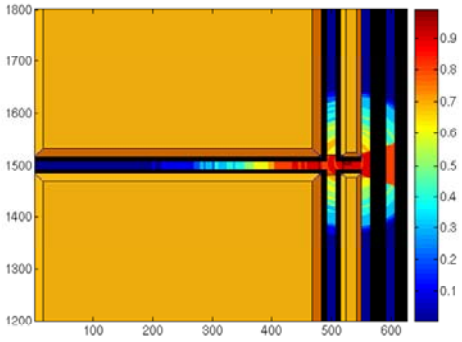


Figure 5-256: Reception Prob. of Emergency Messages-Scenario 20, Sender on Rd. A2

5.2.4.3 Reception Probability of Emergency Messages From OBU on B

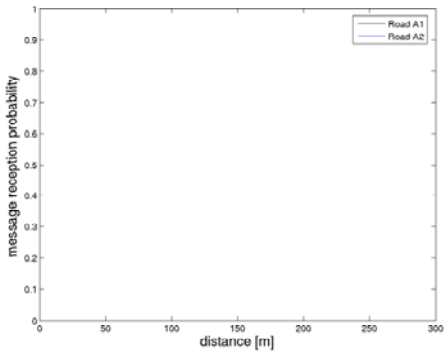


Figure 5-257: Reception Prob. of Emergency Messages - Scenario20, Rd. A, Sender on Rd. B

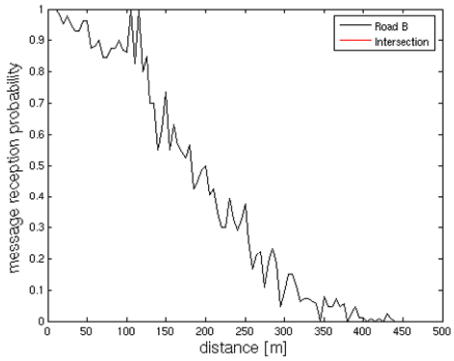


Figure 5-258: Reception Prob. of Emergency Messages - Scenario20, Rd. B, Sender on Rd. B

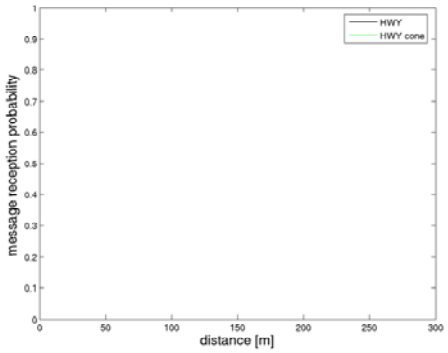


Figure 5-259: Reception Prob. of Emergency Messages - Scenario20, HWY, Sender on Rd. B

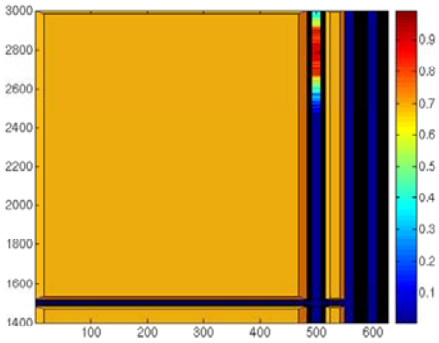


Figure 5-260: Reception Prob. of Emergency Messages - Scenario 20, Sender on Rd. B

5.2.4.4 Reception Probability of Emergency Messages From OBU on HWY

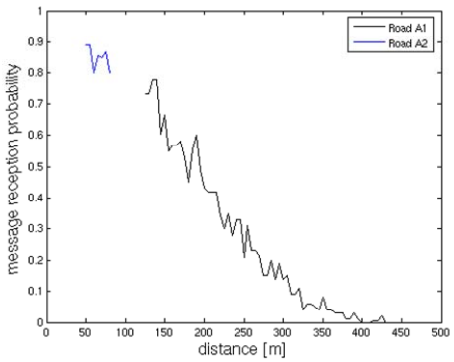


Figure 5-261: Reception Prob. of Emergency Messages - Scenario20, Rd. A, Sender on HWY

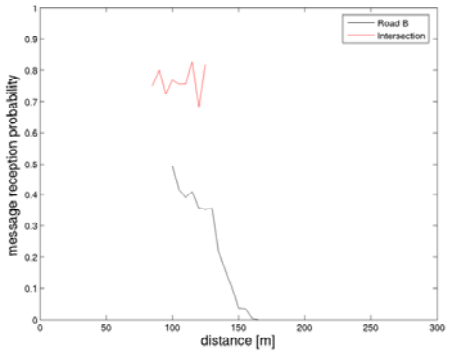


Figure 5-262: Reception Prob. of Emergency Messages - Scenario20, Rd. B, Sender on HWY

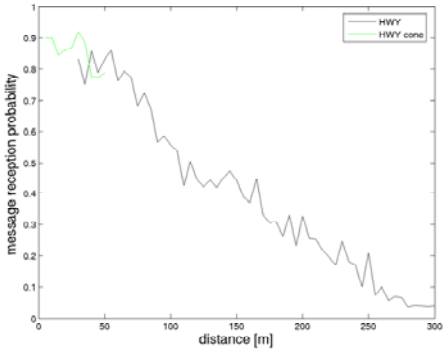


Figure 5-263: Reception Prob. of Emergency Messages - Scenario20, HWY, Sender on HWY

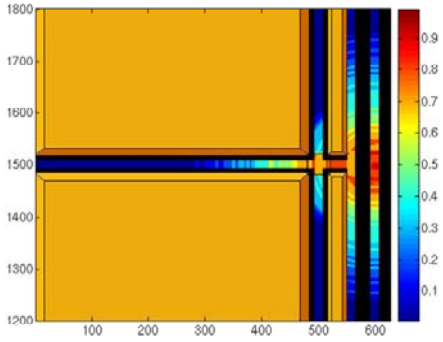


Figure 5-264: Reception Prob. of Emergency Messages-Scenario 20, Sender on HWY

5.2.5 Scenario 21

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	300m coverage
Routine Message Frequency	2Hz

5.2.5.1 Reception Probability of Emergency Messages

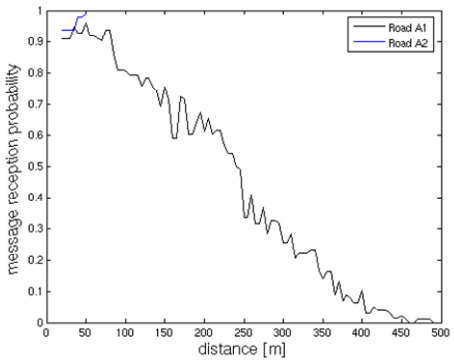


Figure 5-265: Reception Probability of Emergency Messages-Scenario21, Road A, Sender RSU

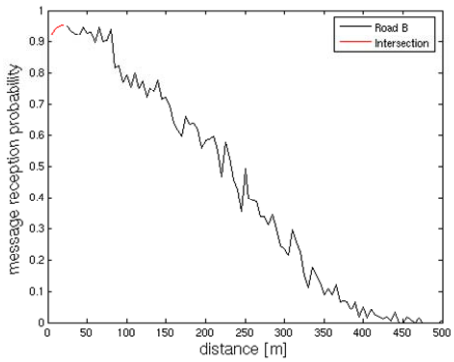


Figure 5-266: Reception Probability of Emergency Messages-Scenario21, Road B, Sender RSU

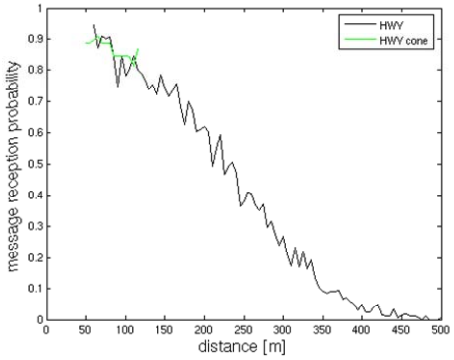


Figure 5-267: Reception Probability of Emergency Messages-Scenario21, HWY, Sender RSU

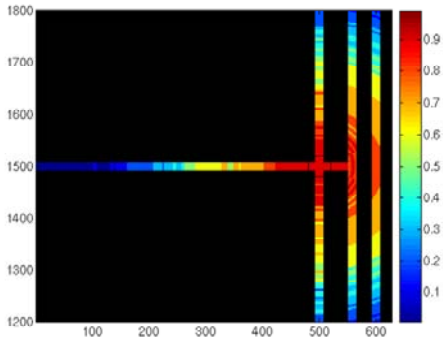


Figure 5-268: Reception Probability of Emergency Messages-Scenario21, Sender RSU

5.2.6 Scenario 22

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	300m coverage
Routine Message Frequency	2Hz

5.2.6.1 Reception Probability of Emergency Messages From OBU on A1

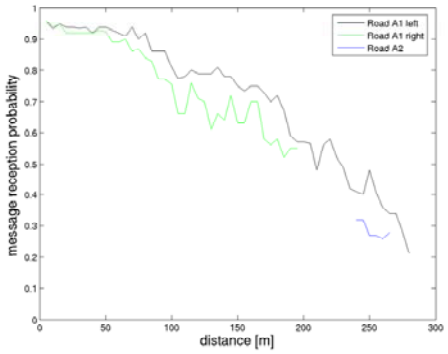


Figure 5-269: Reception Prob. of Emergency Messages - Scenario22, Rd. A, Sender on Rd. A1

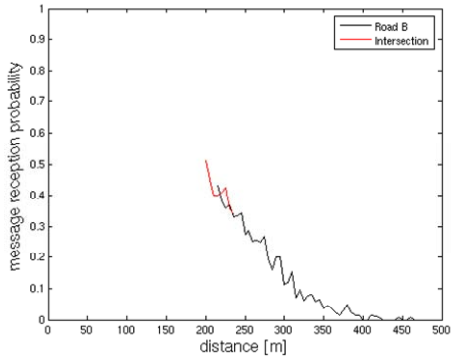


Figure 5-270: Reception Prob. of Emergency Messages - Scenario22, Rd. B, Sender on Rd. A1

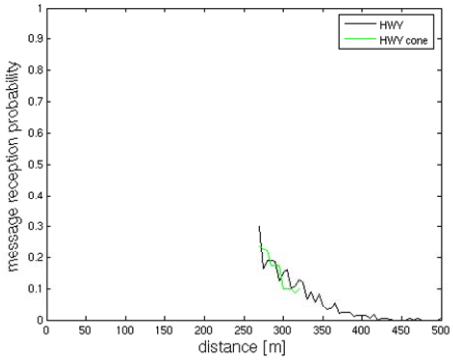


Figure 5-271: Reception Prob. of Emergency Messages - Scenario22, HWY, Sender on Rd. A1

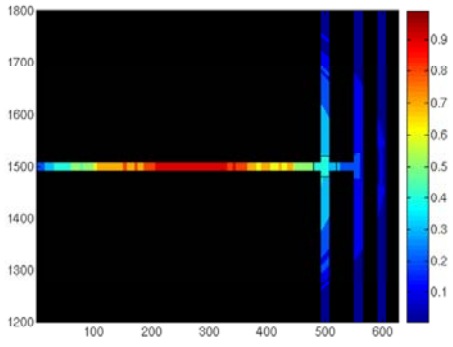


Figure 5-272: Reception Prob. of Emergency Messages-Scenario 22, Sender on Rd. A1

5.2.6.2 Reception Probability of Emergency Messages From OBU on A2

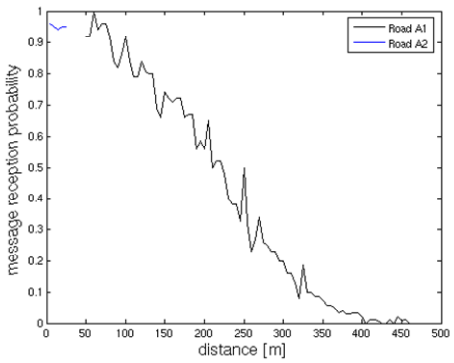


Figure 5-273: Reception Prob. of Emergency Messages - Scenario22, Rd. A, Sender on Rd. A2

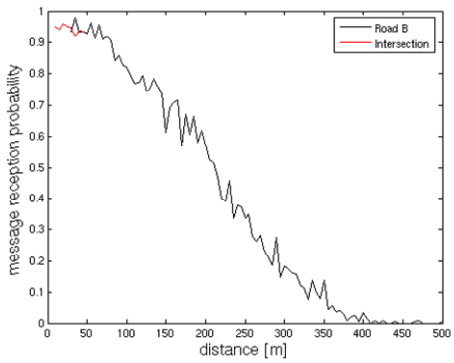


Figure 5-274: Reception Prob. of Emergency Messages - Scenario22, Rd. B, Sender on Rd. A2

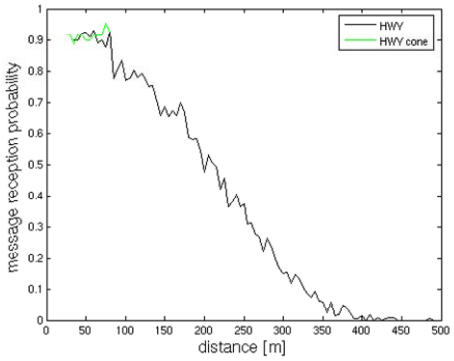


Figure 5-275: Reception Prob. of Emergency Messages - Scenario22, HWY, Sender on Rd. A2

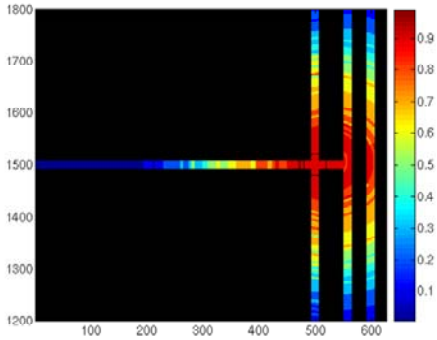


Figure 5-276: Reception Prob. of Emergency Messages-Scenario 22, Sender on Rd. A2

5.2.6.3 Reception Probability of Emergency Messages From OBU on B

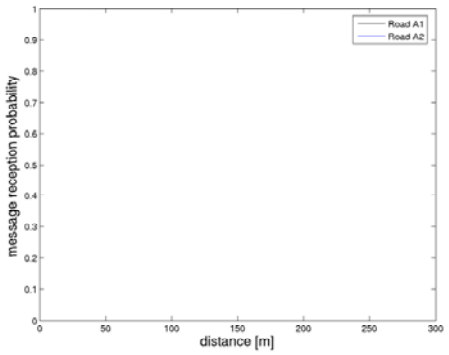


Figure 5-277: Reception Prob. of Emergency Messages - Scenario22, Rd. A, Sender on Rd. B

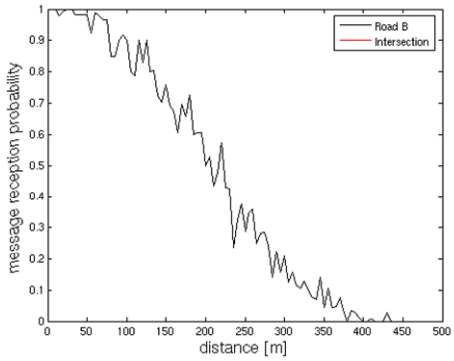


Figure 5-278: Reception Prob. of Emergency Messages - Scenario22, Rd. B, Sender on Rd. B

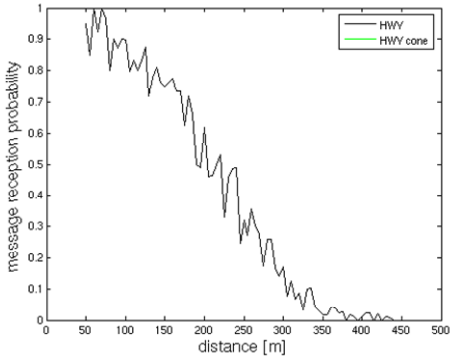


Figure 5-279: Reception Prob. of Emergency Messages - Scenario22, HWY, Sender on Rd. B

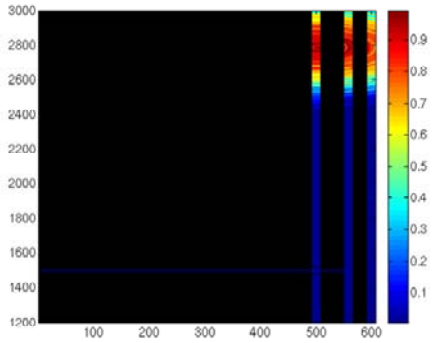


Figure 5-280: Reception Prob. of Emergency Messages-Scenario 22, Sender on Rd. B

5.2.6.4 Reception Probability of Emergency Messages From OBU on HWY

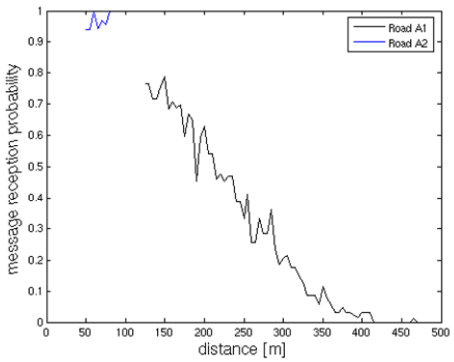


Figure 5-281: Reception Prob. of Emergency Messages - Scenario22, Rd. A, Sender on HWY

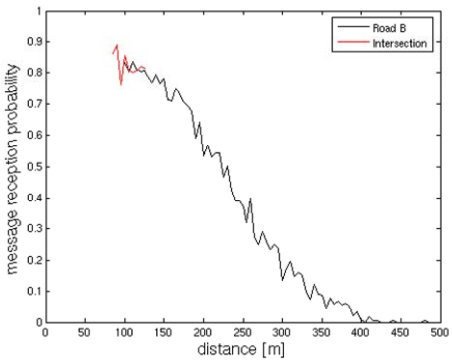


Figure 5-282: Reception Prob. of Emergency Messages - Scenario22, Rd. B, Sender on HWY

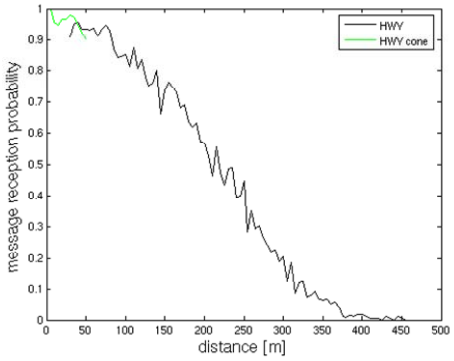


Figure 5-283: Reception Prob. of Emergency Messages - Scenario22, HWY, Sender on HWY

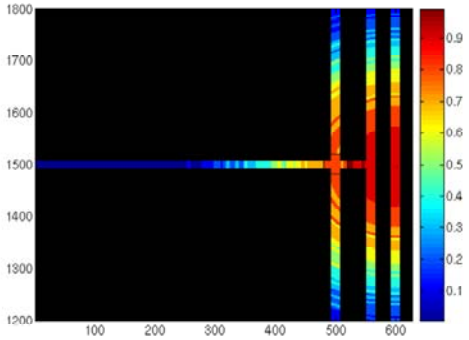


Figure 5-284: Reception Prob. of Emergency Messages - Scenario 22, Sender on HWY

5.2.7 Scenario 23

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	Tall building
Pt	300m coverage
Routine Message Frequency	2Hz

5.2.7.1 Reception Probability of Emergency Messages

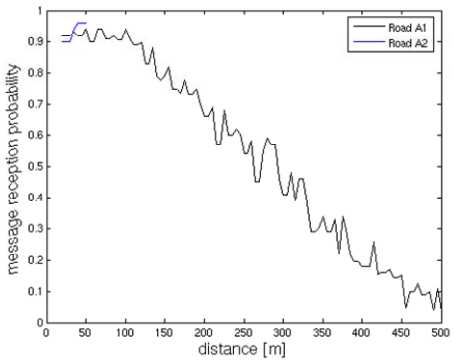


Figure 5-285: Reception Probability of Emergency Messages-Scenario 23, Road A, Sender RSU

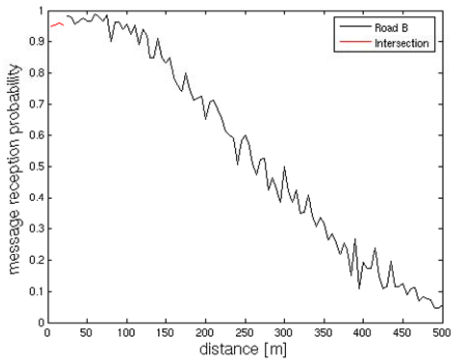


Figure 5-286: Reception Probability of Emergency Messages-Scenario 23, Road B, Sender RSU

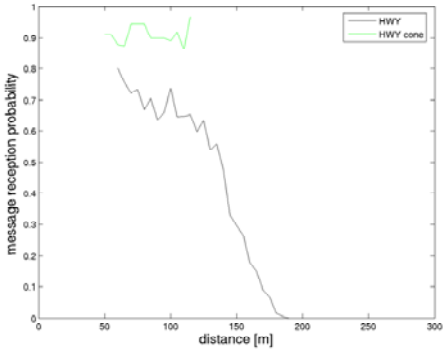


Figure 5-287: Reception Probability of Emergency Messages-Scenario 23, HWY, Sender RSU

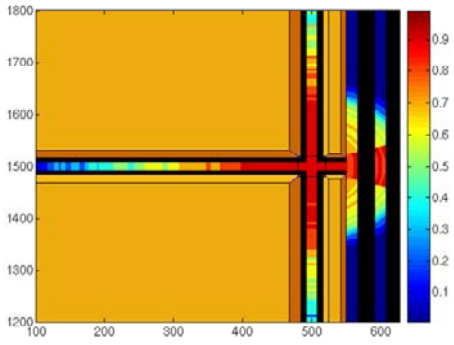


Figure 5-288: Reception Probability of Emergency Messages-Scenario 23, Sender RSU

5.2.8 Scenario 24

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	300m coverage
Routine Message Frequency	2Hz

5.2.8.1 Reception Probability of Emergency Messages from OBU on A1

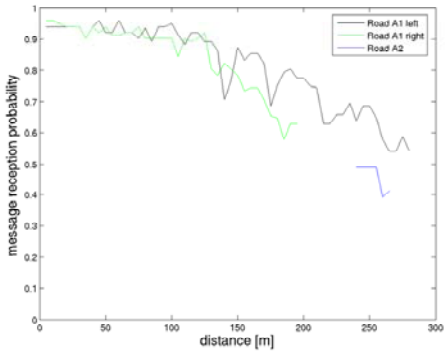


Figure 5-289: Reception Prob. of Emergency Messages – Scenario 24, Rd. A, Sender on Rd. A1

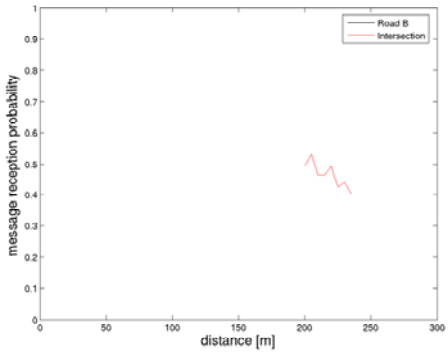


Figure 5-290: Reception Prob. of Emergency Messages – Scenario 24, Rd. B, Sender on Rd. A1

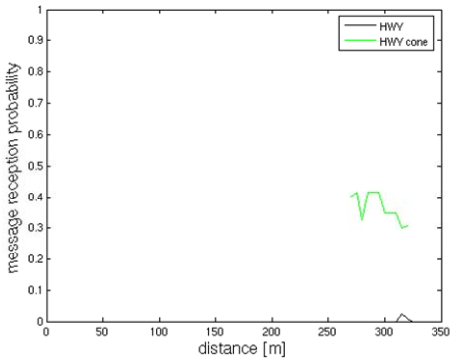


Figure 5-291: Reception Prob. of Emergency Messages – Scenario 24, HWY, Sender on Rd. A1

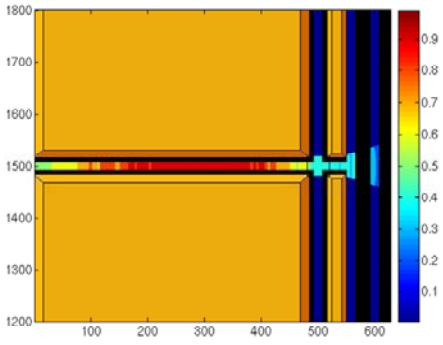


Figure 5-292: Reception Prob. of Emergency Messages-Scenario 24, Sender on Rd. A1

5.2.8.2 Reception Probability of Emergency Messages From OBU on A2

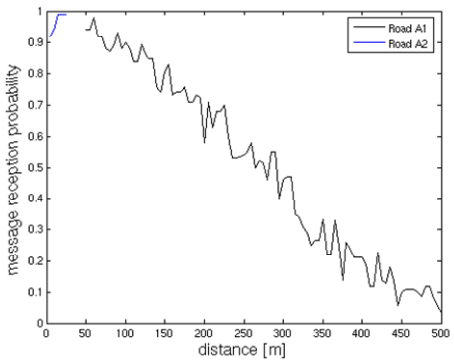


Figure 5-293: Reception Prob. of Emergency Messages – Scenario 24, Rd. A, Sender on Rd. A2

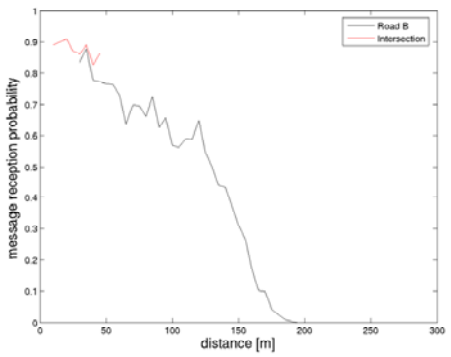


Figure 5-294: Reception Prob. of Emergency Messages – Scenario 24, Rd. B, Sender on Rd. A2

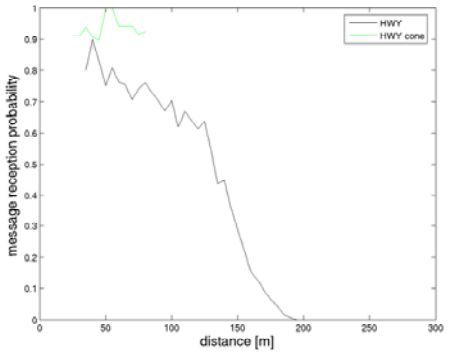


Figure 5-295: Reception Prob. of Emergency Messages – Scenario 24, HWY, Sender on Rd. A2

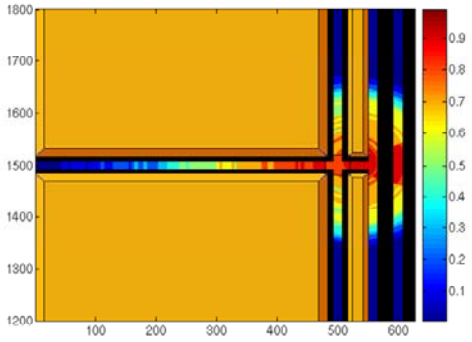


Figure 5-296: Reception Prob. of Emergency Messages-Scenario 24, Sender on Rd. A2

5.2.8.3 Reception Probability of Emergency Messages From OBU on B

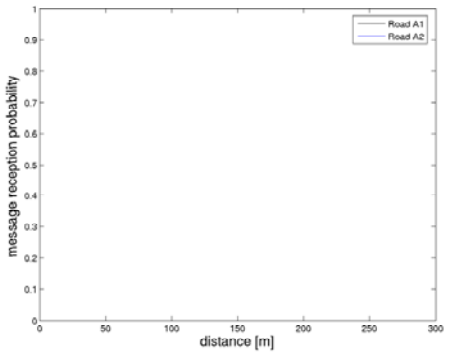


Figure 5-297: Reception Prob. of Emergency Messages - Scenario24, Rd. A, Sender on Rd. B

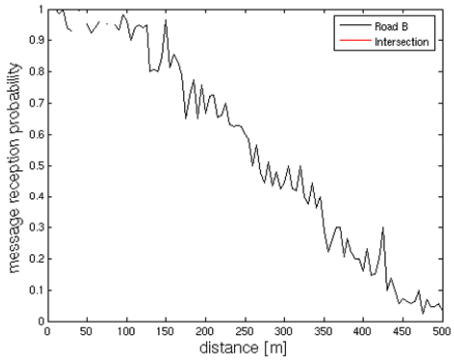


Figure 5-298: Reception Prob. of Emergency Messages - Scenario24, Rd. B, Sender on Rd. B

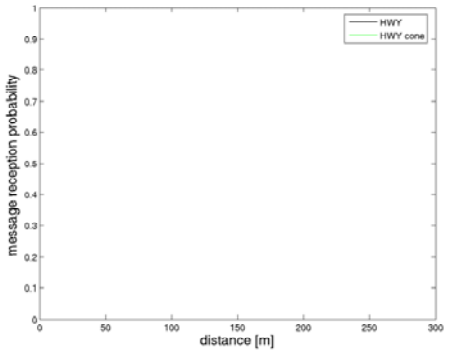


Figure 5-299: Reception Prob. of Emergency Messages - Scenario24, HWY, Sender on Rd. B

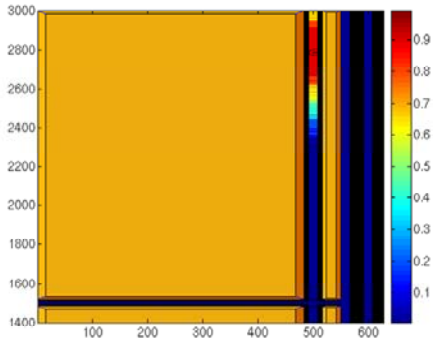


Figure 5-300: Reception Prob. of Emergency Messages-Scenario 24, Sender on Rd. B

5.2.8.4 Reception Probability of Emergency Messages From OBU on HWY

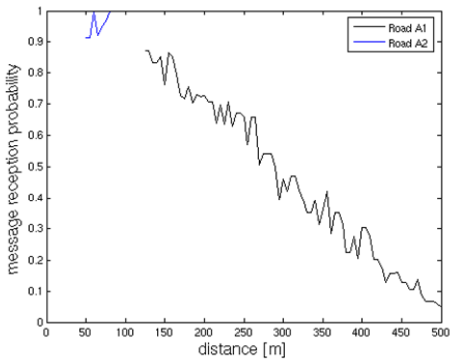


Figure 5-301: Reception Prob. of Emergency Messages - Scenario24, Rd. A, Sender on HWY

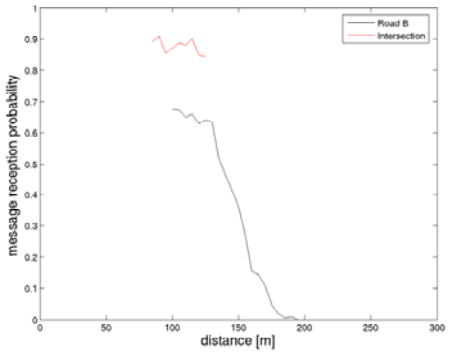


Figure 5-302: Reception Prob. of Emergency Messages - Scenario24, Rd. B, Sender on HWY

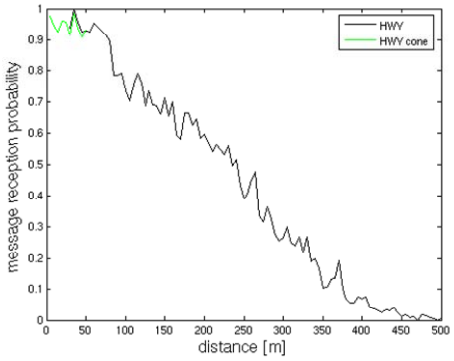


Figure 5-303: Reception Prob. of Emergency Messages - Scenario24, HWY, Sender on HWY

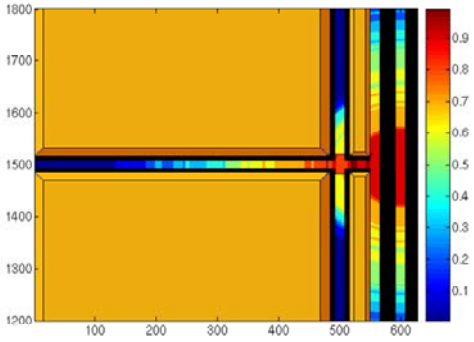


Figure 5-304: Reception Prob. of Emergency Messages-Scenario 24, Sender on HWY

5.2.9 Scenario 25

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	200m coverage
Routine Message Frequency	1 Hz

5.2.9.1 Reception Probability of Emergency Messages

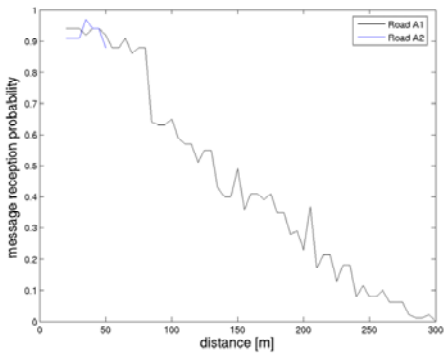


Figure 5-305: Reception Probability of Emergency Messages-Scenario 25, Road A, Sender RSU

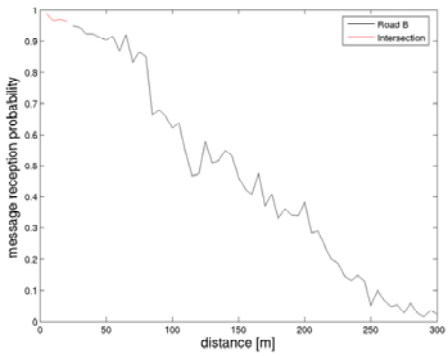


Figure 5-306: Reception Probability of Emergency Messages-Scenario 25, Road B, Sender RSU

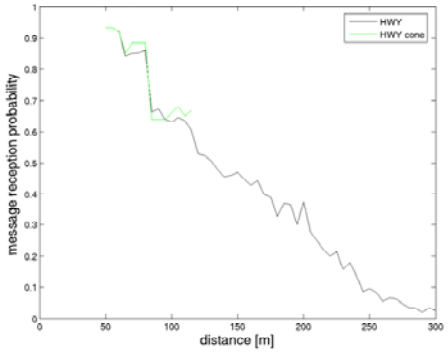


Figure 5-307: Reception Probability of Emergency Messages-Scenario 25, HWY, Sender RSU

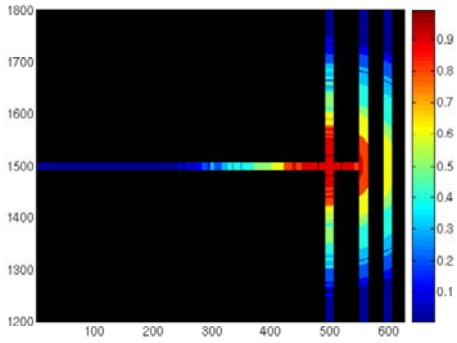


Figure 5-308: Reception Probability of Emergency Messages-Scenario 25, Sender RSU

5.2.9.2 Routine Message Reception Probability

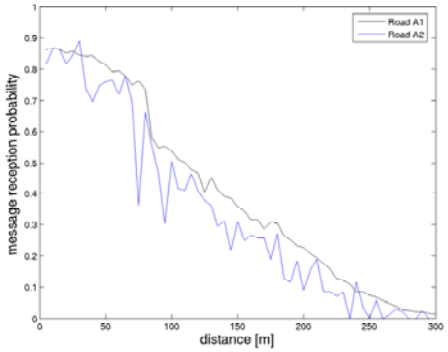


Figure 5-309: Reception Probability of Routine Messages on Road A Scenario 25

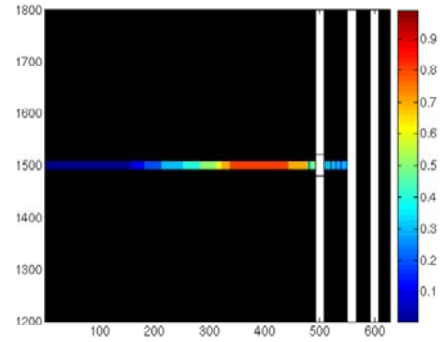


Figure 5-310: Reception Probability of Routine Messages on Road A Scenario 25

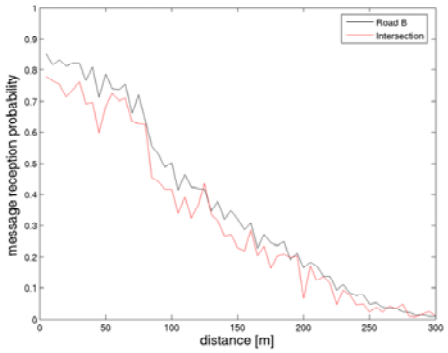


Figure 5-311: Reception Probability of Routine Messages on Road B Scenario 25

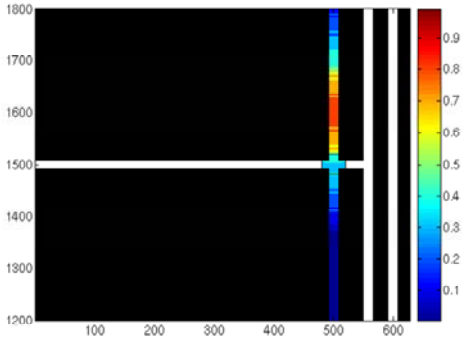


Figure 5-312: Reception Probability of Routine Messages on Road B Scenario 25

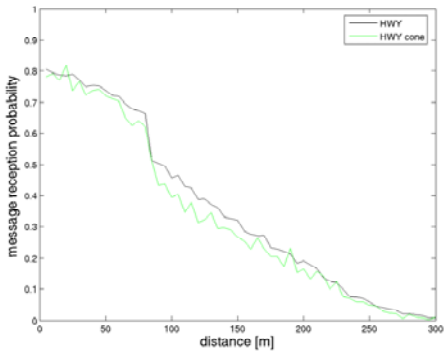


Figure 5-313: Reception Probability of Routine Messages on HWY Scenario 25

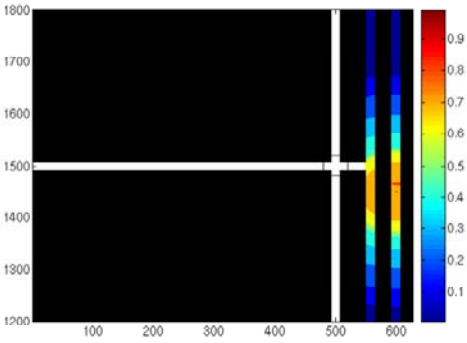


Figure 5-314: Reception Probability of Routine Messages on HWY Scenario 25

5.2.10 Scenario 26

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	200m coverage
Routine Message Frequency	1Hz

5.2.10.1 Reception Probability of Emergency Messages From OBU on A1

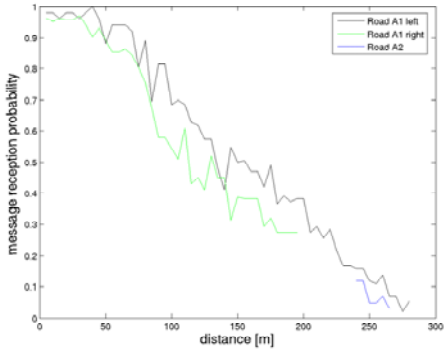


Figure 5-315: Reception Prob. of Emergency Messages – Scenario 26, Rd. A, Sender on Rd. A1

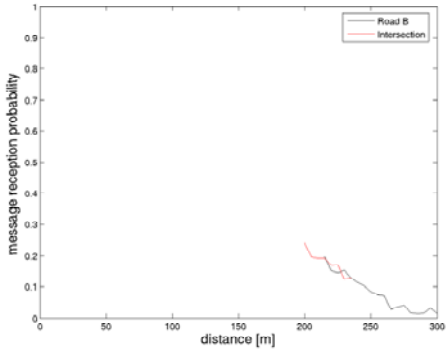


Figure 5-316: Reception Prob. of Emergency Messages – Scenario 26, Rd. B, Sender on Rd. A1

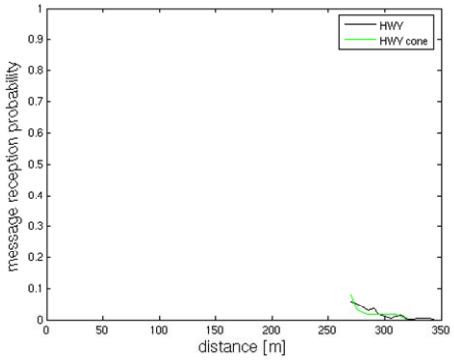


Figure 5-317: Reception Prob. of Emergency Messages – Scenario 26, HWY, Sender on Rd. A1

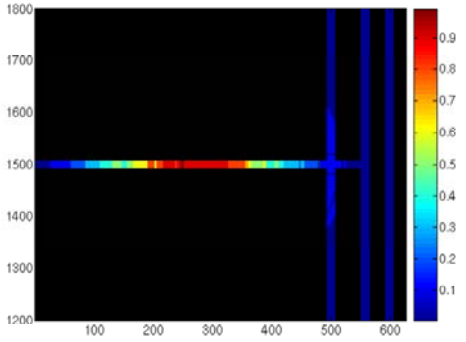


Figure 5-318: Reception Prob. of Emergency Messages-Scenario 26, Sender on Rd. A1

5.2.10.2 Reception Probability of Emergency Messages From OBU on A2

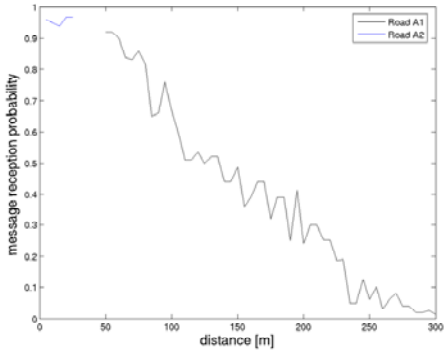


Figure 5-319: Reception Prob. of Emergency Messages - Scenario26, Rd. A, Sender on Rd. A2

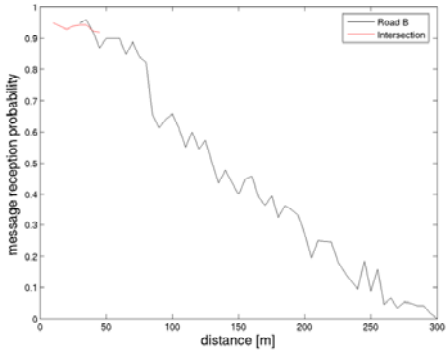


Figure 5-320: Reception Prob. of Emergency Messages - Scenario26, Rd. B, Sender on Rd. A2

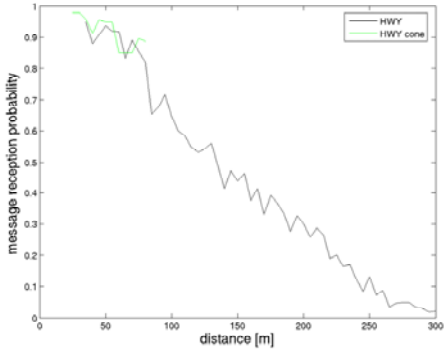


Figure 5-321: Reception Prob. of Emergency Messages - Scenario26, HWY, Sender on Rd. A2

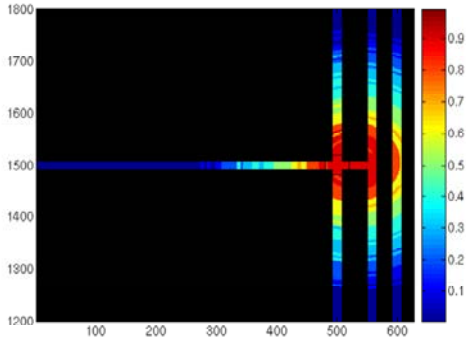


Figure 5-322: Reception Prob. of Emergency Messages-Scenario 26, Sender on Rd. A2

5.2.10.3 Reception Probability of Emergency Messages From OBU on B

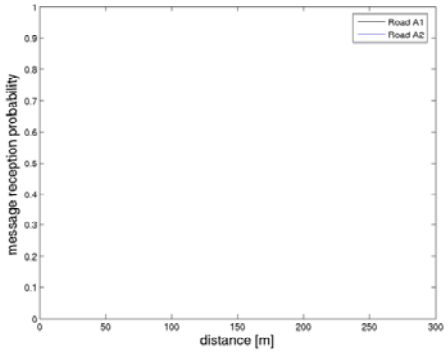


Figure 5-323: Reception Prob. of Emergency Messages – Scenario 26, Rd. A, Sender on Rd. B

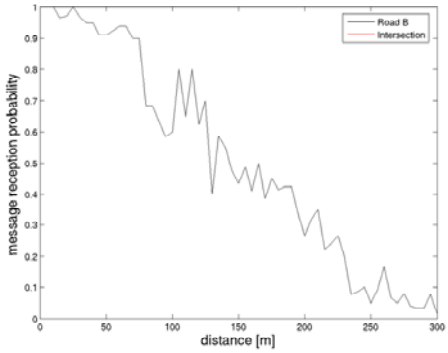


Figure 5-324: Reception Prob. of Emergency Messages – Scenario 26, Rd. B, Sender on Rd. B

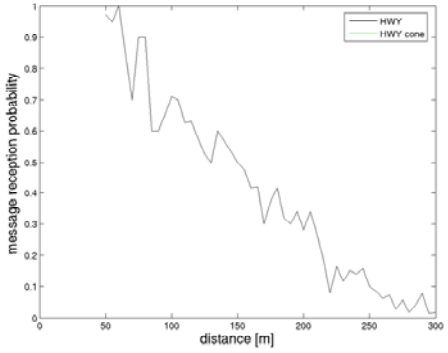


Figure 5-325: Reception Prob. of Emergency Messages – Scenario 26, HWY, Sender on Rd. B

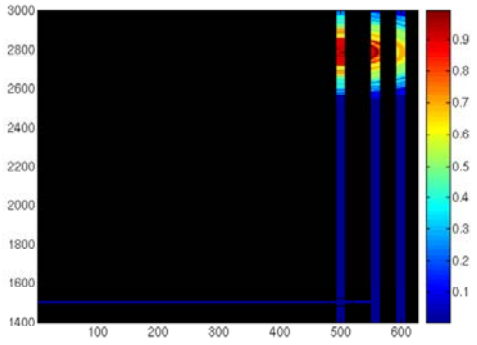


Figure 5-326: Reception Prob. of Emergency Messages-Scenario 26, Sender on Rd. B

5.2.10.4 Reception Probability of Emergency Messages From OBU on HWY

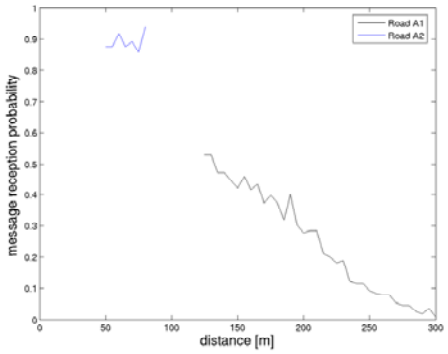


Figure 5-327: Reception Prob. of Emergency Messages – Scenario 26, Rd. A, Sender on HWY

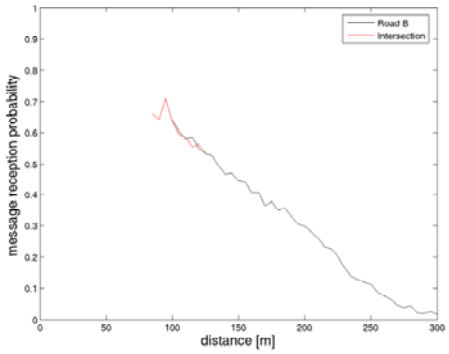


Figure 5-328: Reception Prob. of Emergency Messages – Scenario 26, Rd. B, Sender on HWY

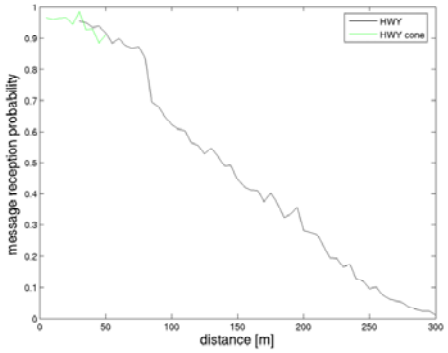


Figure 5-329: Reception Prob. of Emergency Messages – Scenario 26, HWY, Sender on HWY

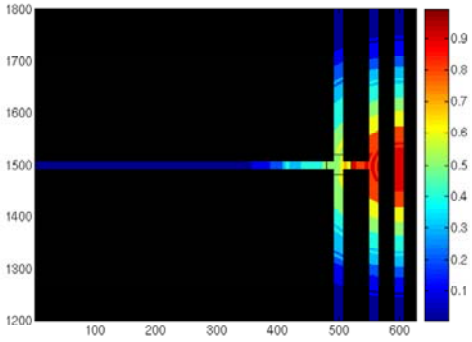


Figure 5-330: Reception Prob. of Emergency Messages-Scenario 26, Sender on HWY

5.2.11 Scenario 27

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	200m coverage
Routine Message Frequency	1 Hz

5.2.11.1 Reception Probability of Emergency Messages

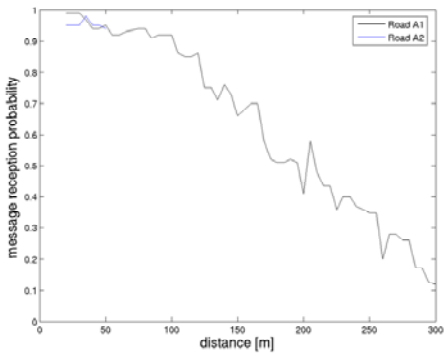


Figure 5-331: Reception Probability of Emergency Messages-Scenario 27, Road A, Sender RSU

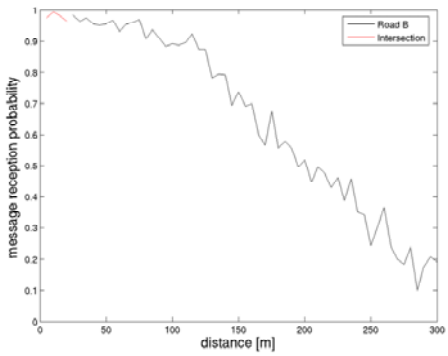


Figure 5-332: Reception Probability of Emergency Messages-Scenario 27, Road B, Sender RSU

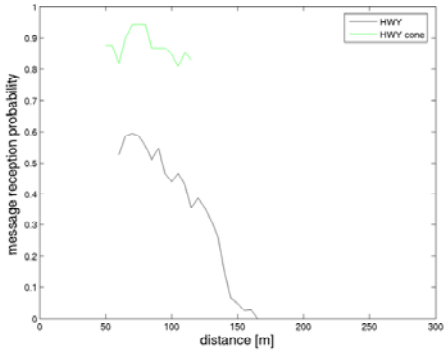


Figure 5-333: Reception Probability of Emergency Messages-Scenario 27, HWY, Sender RSU

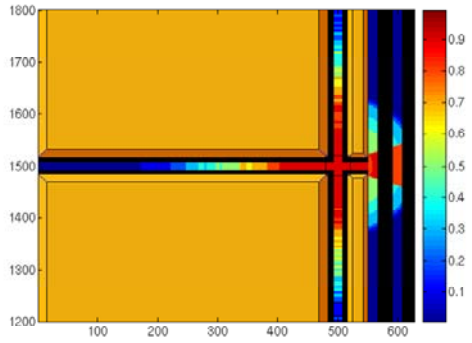


Figure 5-334: Reception Probability of Emergency Messages-Scenario 27, Sender RSU

5.2.11.2 Reception Probability of Routine Messages

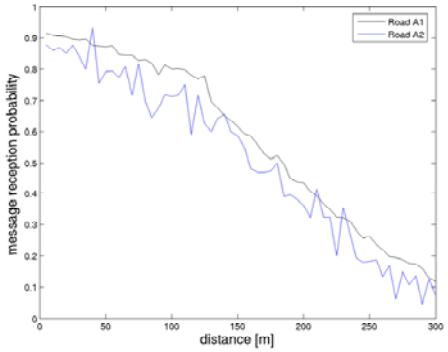


Figure 5-335: Reception Probability of Routine Messages on Road A, Scenario 27

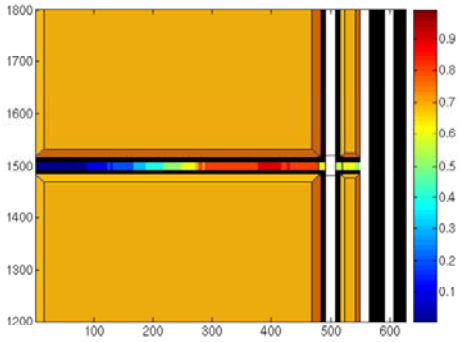


Figure 5-336: Reception Probability of Routine Messages on Road A, Scenario 27

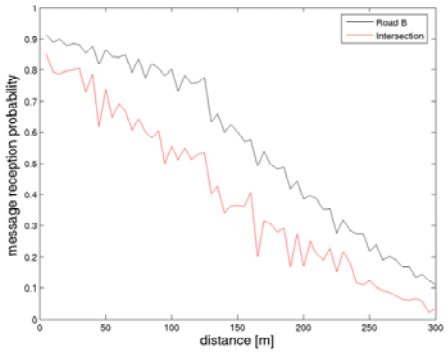


Figure 5-337: Reception Probability of Routine Messages on Road B, Scenario 27

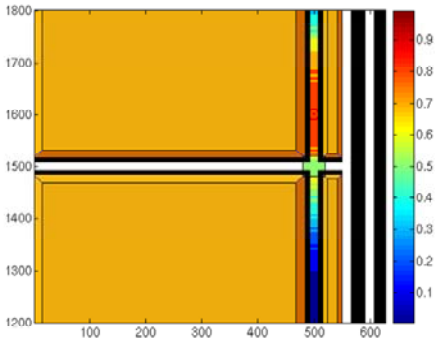


Figure 5-338: Reception Probability of Routine Messages on Road B, Scenario 27

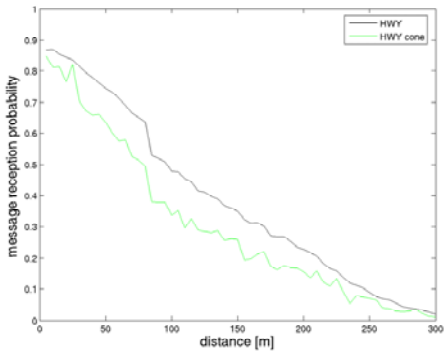


Figure 5-339: Reception Probability of Routine Messages on HWY, Scenario 27

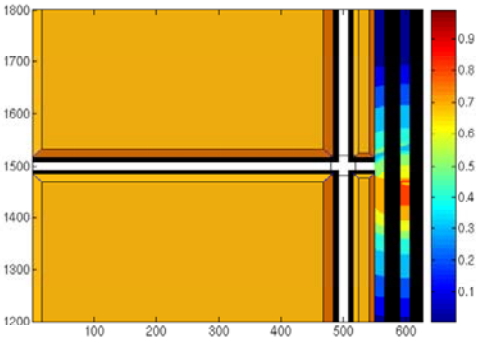


Figure 5-340: Reception Probability of Routine Messages on HWY, Scenario 27

5.2.12 Scenario 28

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	200m coverage
Routine Message Frequency	1Hz

5.2.12.1 Reception Probability of Emergency Messages from OBU on A1

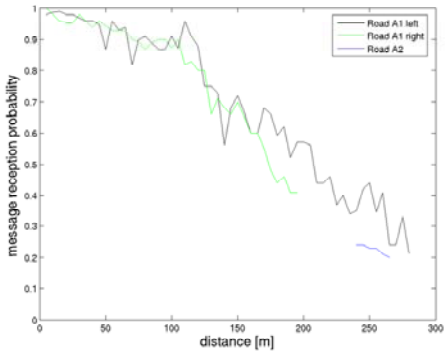


Figure 5-341: Reception Prob. of Emergency Messages – Scenario 28, Rd. A, Sender on Rd. A1

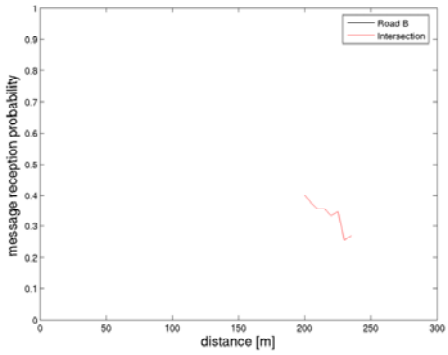


Figure 5-342: Reception Prob. of Emergency Messages – Scenario 28, Rd. B, Sender on Rd. A1

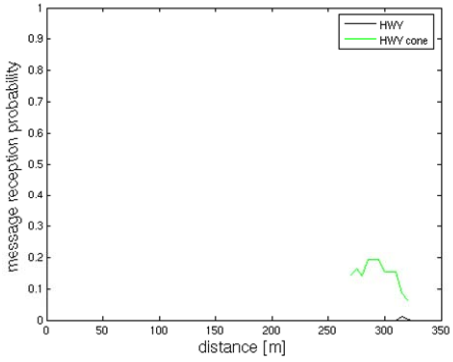


Figure 5-343: Reception Prob. of Emergency Messages – Scenario 28, HWY, Sender on Rd. A1

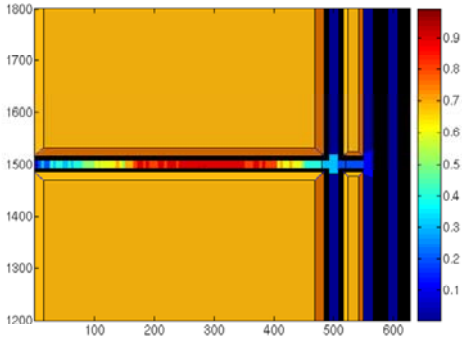


Figure 5-344: Reception Prob. of Emergency Messages-Scenario 28, Sender on Rd. A1

5.2.12.2 Reception Probability of Emergency Messages from OBU on A2

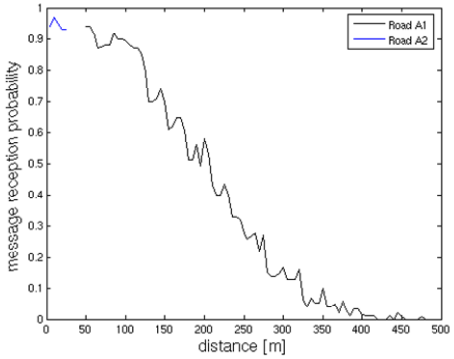


Figure 5-345: Reception Prob. of Emergency Messages – Scenario 28, Rd. A, Sender on Rd. A2

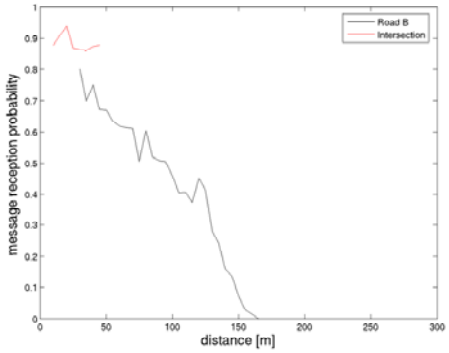


Figure 5-346: Reception Prob. of Emergency Messages – Scenario 28, Rd. B, Sender on Rd. A2

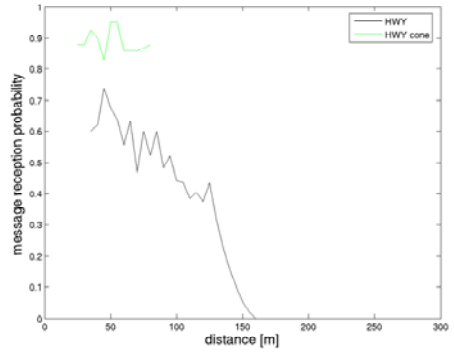


Figure 5-347: Reception Prob. of Emergency Messages – Scenario 28, HWY, Sender on Rd. A2

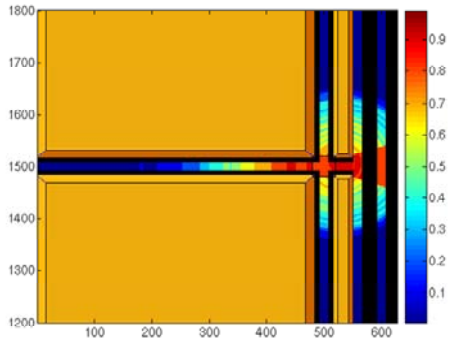


Figure 5-348: Reception Prob. of Emergency Messages – Scenario 28, Sender on Rd. A2

5.2.12.3 Reception Probability of Emergency Messages From OBU on B

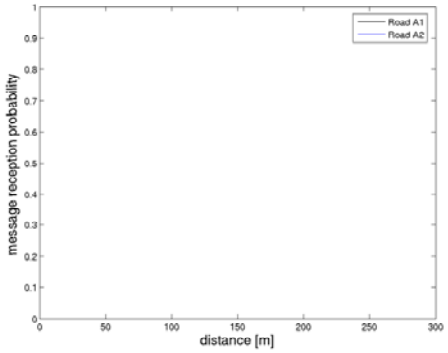


Figure 5-349: Reception Prob. of Emergency Messages – Scenario 28, Rd. A, Sender on Rd. B

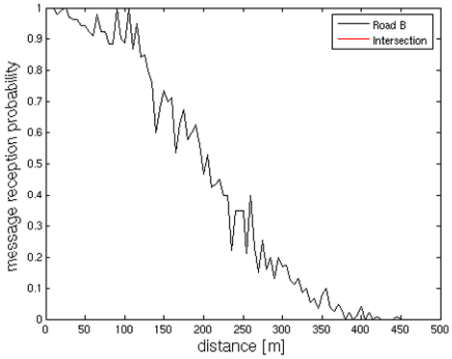


Figure 5-350: Reception Prob. of Emergency Messages – Scenario 28, Rd. B, Sender on Rd. B

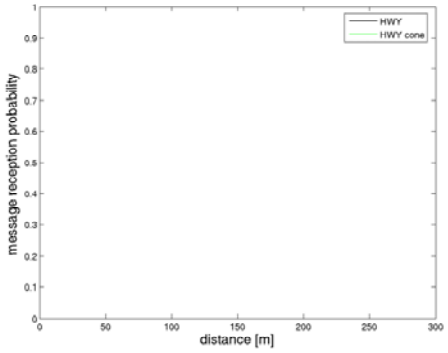


Figure 5-351: Reception Prob. of Emergency Messages – Scenario 28, HWY, Sender on Rd. B

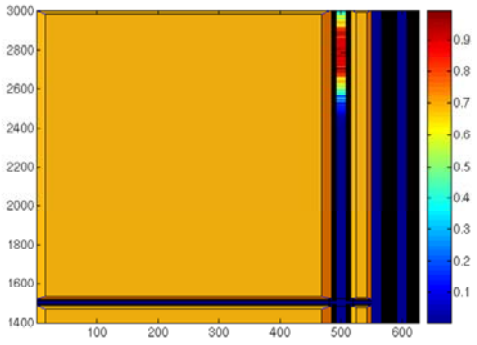


Figure 5-352: Reception Prob. of Emergency Messages-Scenario 28, Sender on Rd. B

5.2.12.4 Reception Probability of Emergency Messages From OBU on HWY

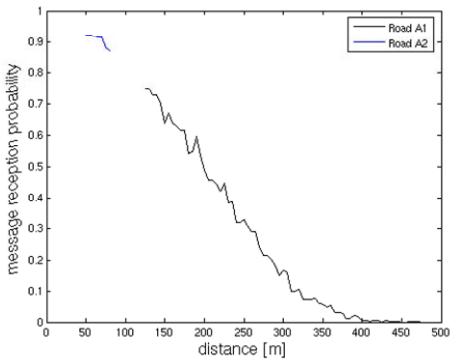


Figure 5-353: Reception Prob. of Emergency Messages – Scenario 28, Rd. A, Sender on HWY

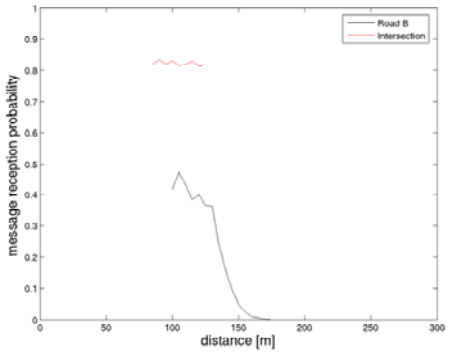


Figure 5-354: Reception Prob. of Emergency Messages – Scenario 28, Rd. B, Sender on HWY

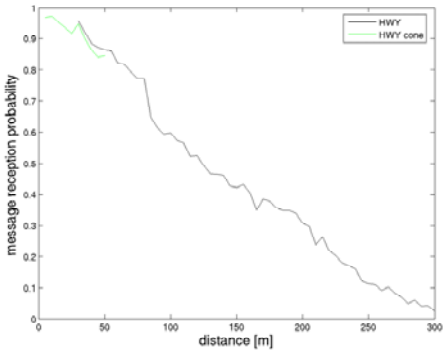


Figure 5-355: Reception Prob. of Emergency Messages – Scenario 28, HWY, Sender on HWY

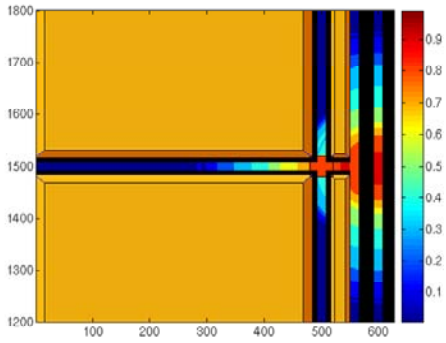


Figure 5-356: Reception Prob. of Emergency Messages-Scenario 28, Sender on HWY

5.2.13 Scenario 29

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	300m coverage
Routine Message Frequency	1Hz

5.2.13.1 Reception Probability of Emergency Messages

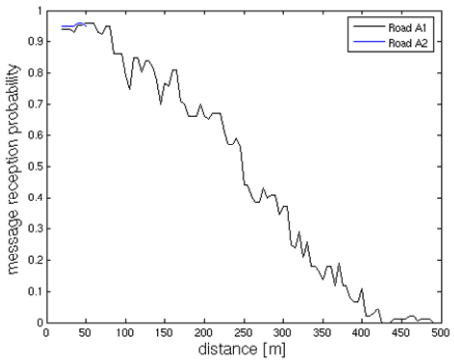


Figure 5-357: Reception Probability of Emergency Messages-Scenario 29, Road A, Sender RSU

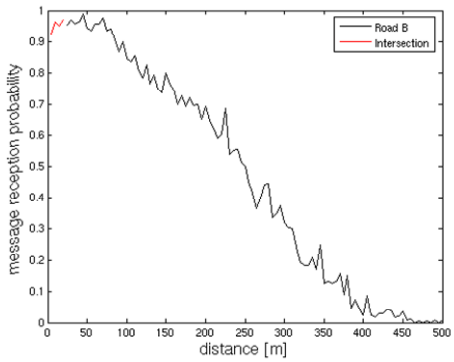


Figure 5-358: Reception Probability of Emergency Messages-Scenario 29, Road B, Sender RSU

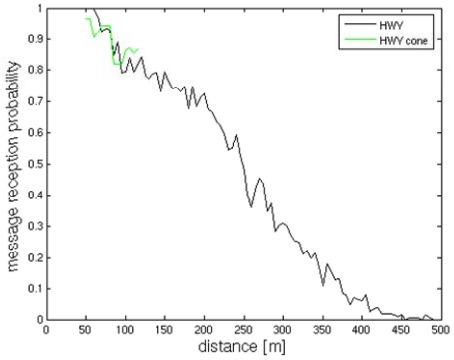


Figure 5-359: Reception Probability of Emergency Messages-Scenario 29, HWY, Sender RSU

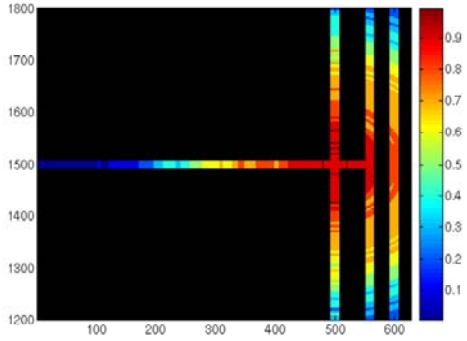


Figure 5-360: Reception Probability of Emergency Messages-Scenario 29, Sender RSU

5.2.14 Scenario 30

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	300m coverage
Routine Message Frequency	1Hz

5.2.14.1 Reception Probability of Emergency Messages From OBU on A1

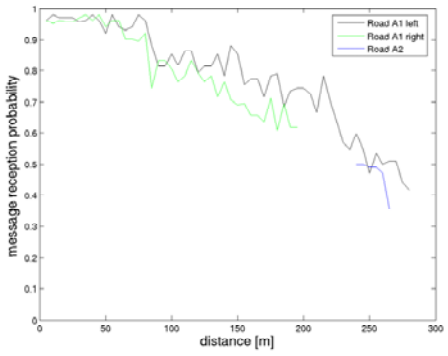


Figure 5-361: Reception Prob. of Emergency Messages – Scenario 30, Rd. A, Sender on Rd. A1

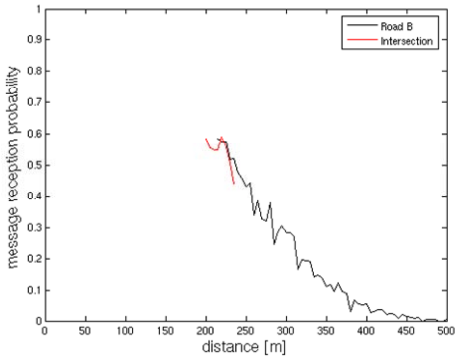


Figure 5-362: Reception Prob. of Emergency Messages – Scenario 30, Rd. B, Sender on Rd. A1

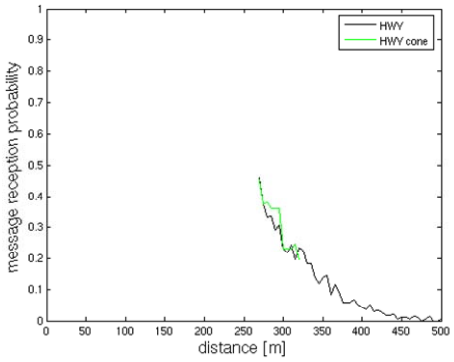


Figure 5-363: Reception Prob. of Emergency Messages – Scenario 30, HWY, Sender on Rd. A1

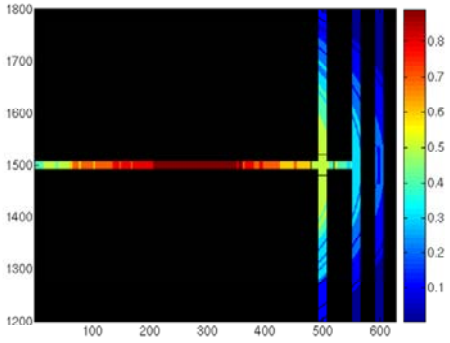


Figure 5-364: Reception Prob. of Emergency Messages-Scenario 30, Sender on Rd. A1

5.2.14.2 Reception Probability of Emergency Messages From OBU on A2

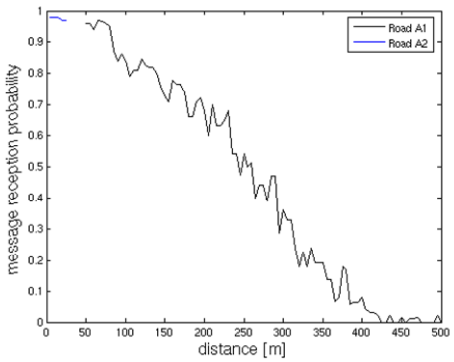


Figure 5-365: Reception Prob. of Emergency Messages – Scenario 30, Rd. A, Sender on Rd. A2

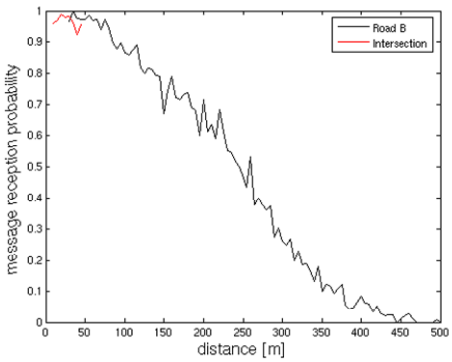


Figure 5-366: Reception Prob. of Emergency Messages – Scenario 30, Rd. B, Sender on Rd. A2

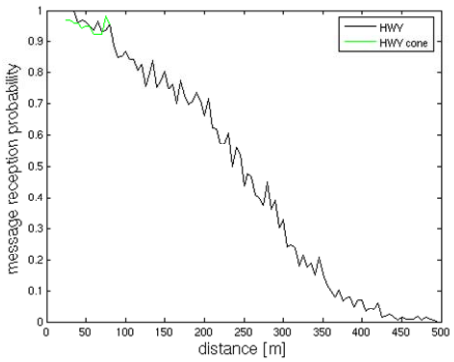


Figure 5-367: Reception Prob. of Emergency Messages – Scenario 30, HWY, Sender on Rd. A2

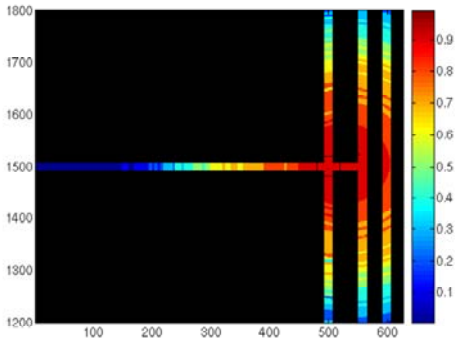


Figure 5-368: Reception Prob. of Emergency Messages-Scenario 30, Sender on Rd. A2

5.2.14.3 Reception Probability of Emergency Messages From OBU on B

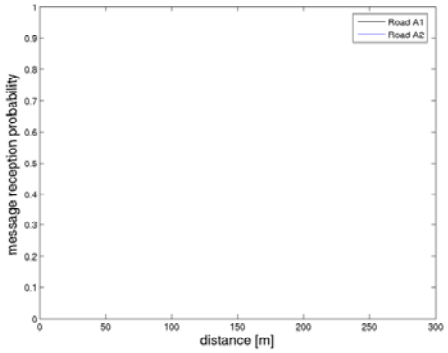


Figure 5-369: Reception Prob. of Emergency Messages – Scenario 30, Rd. A, Sender on Rd. B

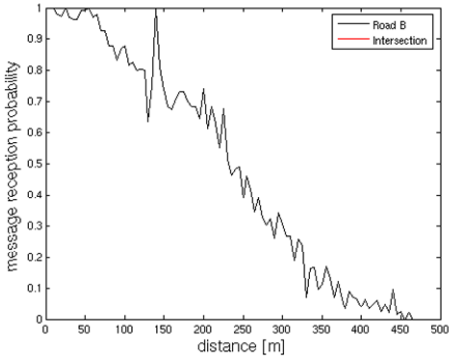


Figure 5-370: Reception Prob. of Emergency Messages – Scenario 30, Rd. B, Sender on Rd. B

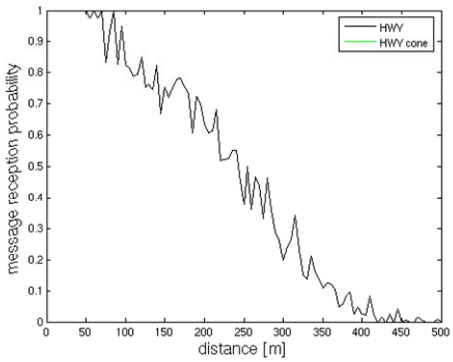


Figure 5-371: Reception Prob. of Emergency Messages – Scenario 30, HWY, Sender on Rd. B

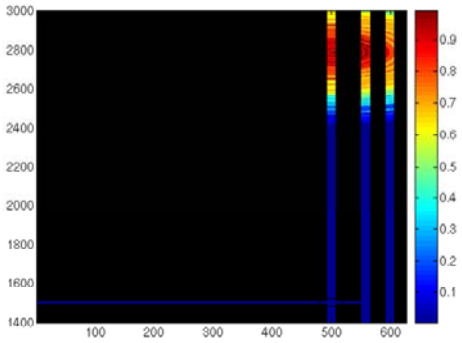


Figure 5-372: Reception Prob. of Emergency Messages-Scenario 30, Sender on Rd. B

5.2.14.4 Reception Probability of Emergency Messages From OBU on HWY

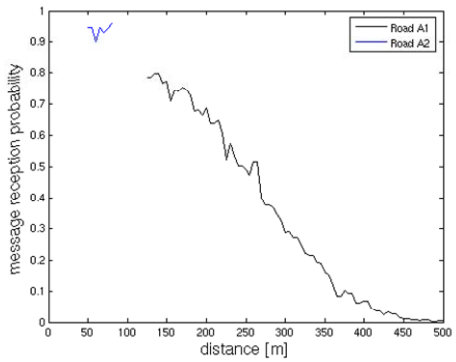


Figure 5-373: Reception Prob. of Emergency Messages – Scenario 30, Rd. A, Sender on HWY

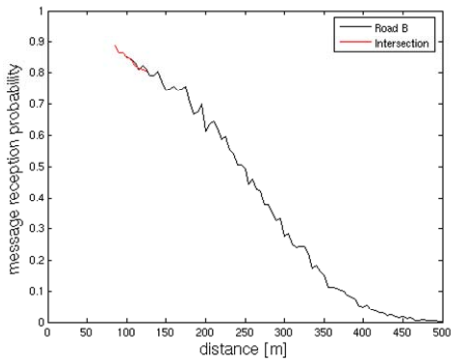


Figure 5-374: Reception Prob. of Emergency Messages – Scenario 30, Rd. B, Sender on HWY

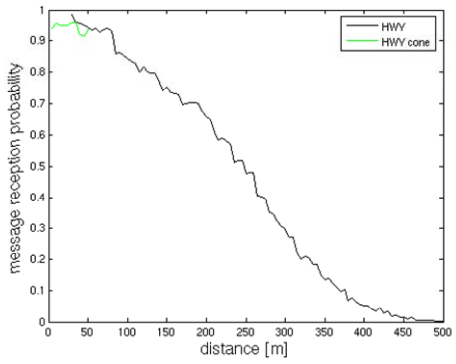


Figure 5-375: Reception Prob. of Emergency Messages – Scenario 30, HWY, Sender on HWY

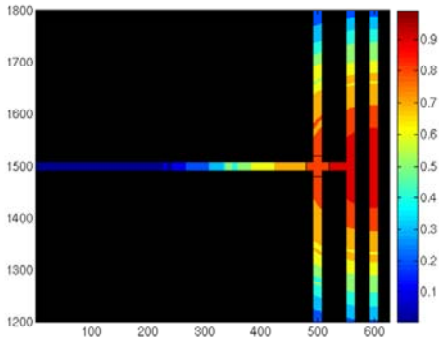


Figure 5-376: Reception Prob. of Emergency Messages-Scenario 30, Sender on HWY

5.2.15 Scenario 31

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	Tall building
Pt	300m coverage
Routine Message Frequency	1Hz

5.2.15.1 Reception Probability of Emergency Messages

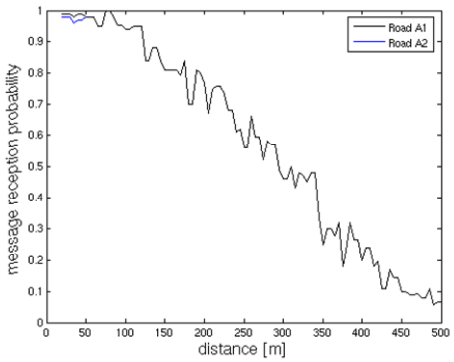


Figure 5-377: Reception Probability of Emergency Messages-Scenario 31, Road A, Sender RSU

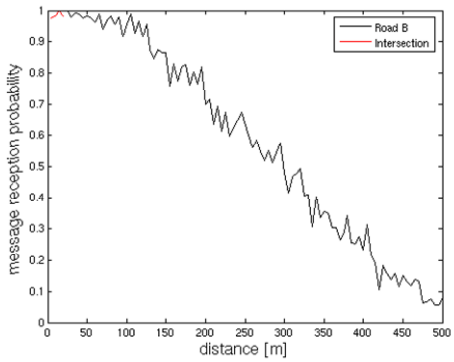


Figure 5-378: Reception Probability of Emergency Messages-Scenario 31, Road B, Sender RSU

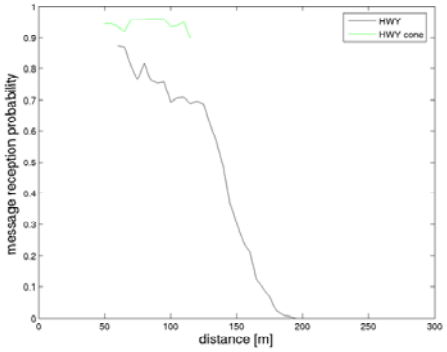


Figure 5-379: Reception Probability of Emergency Messages-Scenario 31, HWY, Sender RSU

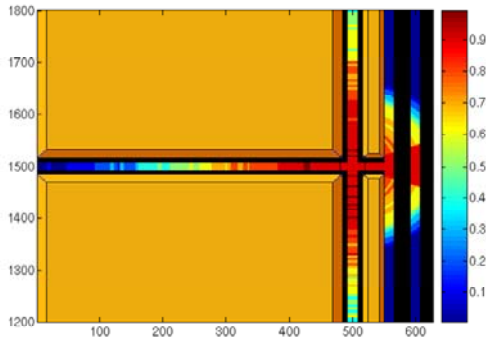


Figure 5-380: Reception Probability of Emergency Messages-Scenario 31, Sender RSU

5.2.16 Scenario 32

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	300m coverage
Routine Message Frequency	1Hz

5.2.16.1 Reception Probability of Emergency Messages From OBU on A1

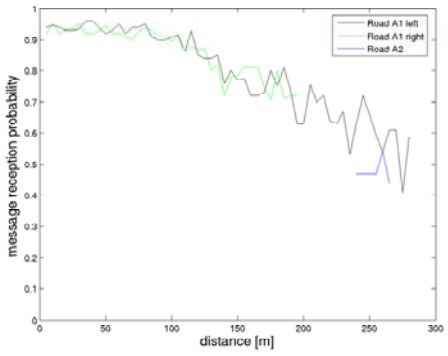


Figure 5-381: Reception Prob. of Emergency Messages – Scenario 32, Rd. A, Sender on Rd. A1

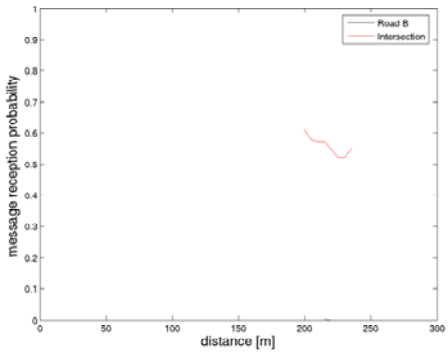


Figure 5-382: Reception Prob. of Emergency Messages – Scenario 32, Rd. B, Sender on Rd. A1

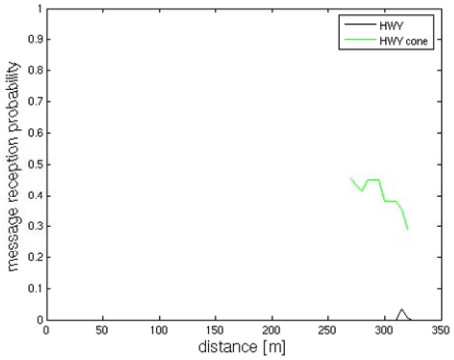


Figure 5-383: Reception Prob. of Emergency Messages – Scenario 32, HWY, Sender on Rd. A1

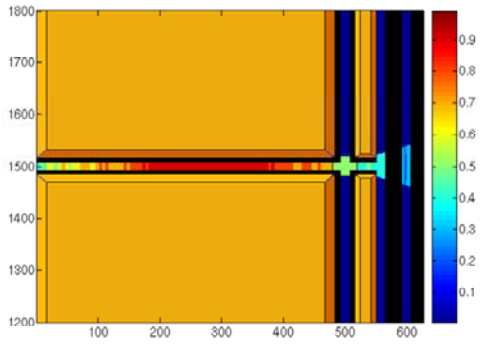


Figure 5-384: Reception Prob. of Emergency Messages-Scenario 32, Sender on Rd. A1

5.2.16.2 Reception Probability of Emergency Messages From OBU on A2

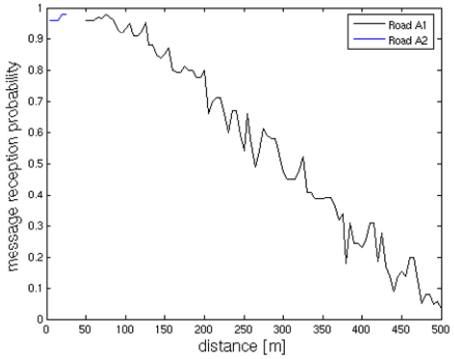


Figure 5-385: Reception Prob. of Emergency Messages – Scenario 32, Rd. A, Sender on Rd. A2

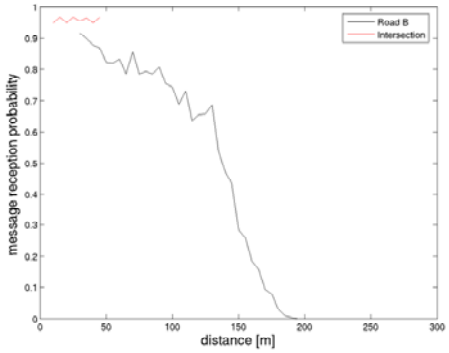


Figure 5-386: Reception Prob. of Emergency Messages – Scenario 32, Rd. B, Sender on Rd. A2

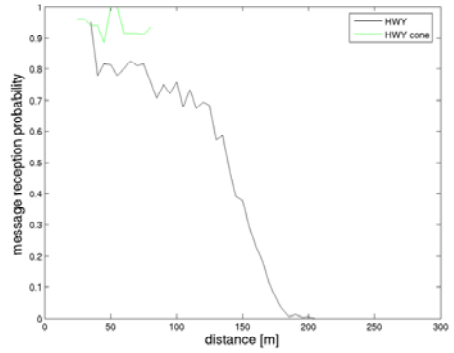


Figure 5-387: Reception Prob. of Emergency Messages – Scenario 32, HWY, Sender on Rd. A2

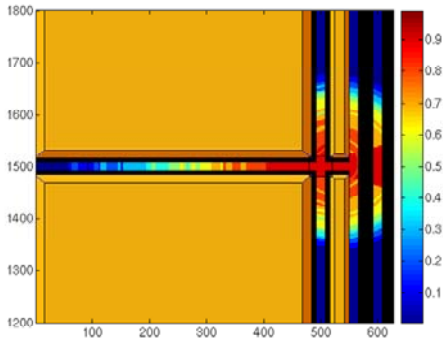


Figure 5-388: Reception Prob. of Emergency Messages-Scenario 32, Sender on Rd. A2

5.2.16.3 Reception Probability of Emergency Messages From OBU on B

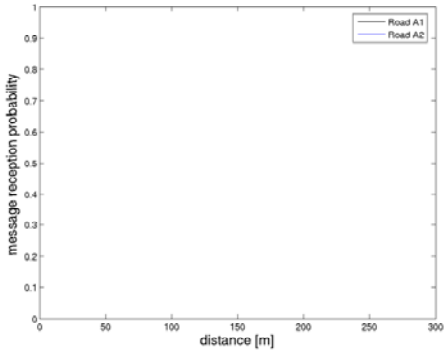


Figure 5-389: Reception Prob. of Emergency Messages – Scenario 32, Rd. A, Sender on Rd. B

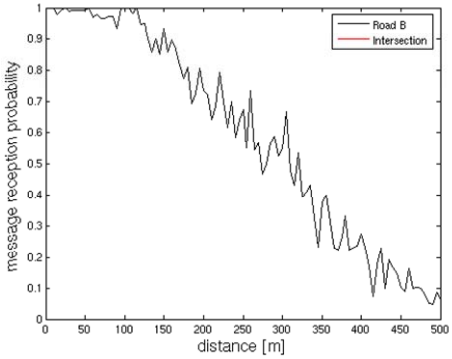


Figure 5-390: Reception Prob. of Emergency Messages – Scenario 32, Rd. B, Sender on Rd. B

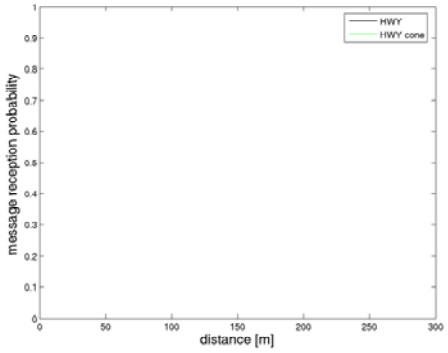


Figure 5-391: Reception Prob. of Emergency Messages – Scenario 32, HWY, Sender on Rd. B

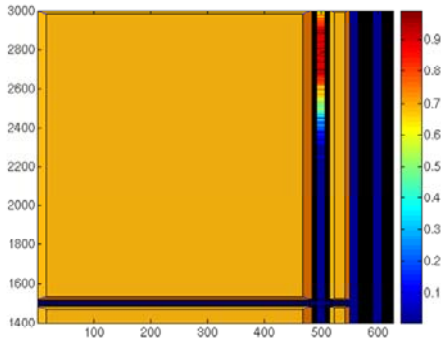


Figure 5-392: Reception Prob. of Emergency Messages-Scenario 32, Sender on Rd. B

5.2.16.4 Reception Probability of Emergency Messages From OBU on HWY

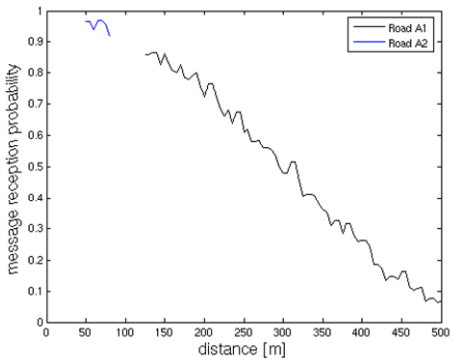


Figure 5-393: Reception Prob. of Emergency Messages – Scenario 32, Rd. A, Sender on HWY

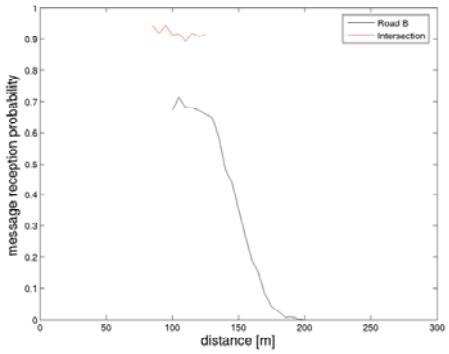


Figure 5-394: Reception Prob. of Emergency Messages – Scenario 32, Rd. B, Sender on HWY

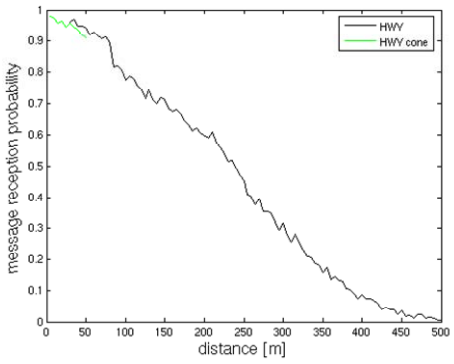


Figure 5-395: Reception Prob. of Emergency Messages – Scenario 32, HWY, Sender on HWY

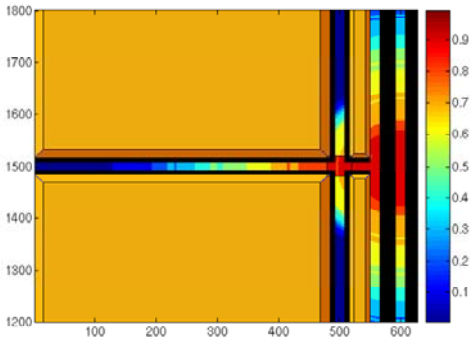


Figure 5-396: Reception Prob. of Emergency Messages-Scenario 32, Sender on HWY

5.2.17 Scenario 33

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	200m coverage
Routine Message Frequency	5Hz

5.2.17.1 Reception Probability of Emergency Messages

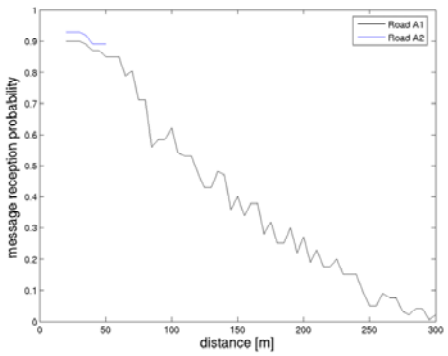


Figure 5-397: Reception Probability of Emergency Messages-Scenario 33, Road A, Sender RSU

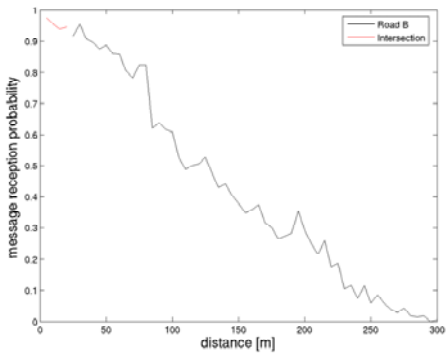


Figure 5-398: Reception Probability of Emergency Messages-Scenario 33, Road B, Sender RSU

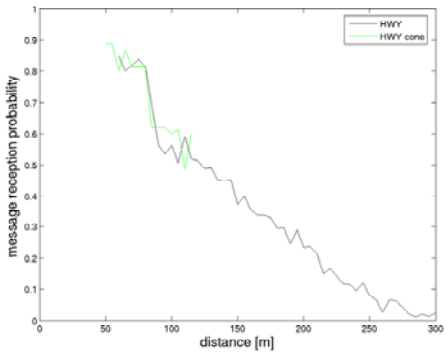


Figure 5-399: Reception Probability of Emergency Messages-Scenario 33, HWY, Sender RSU

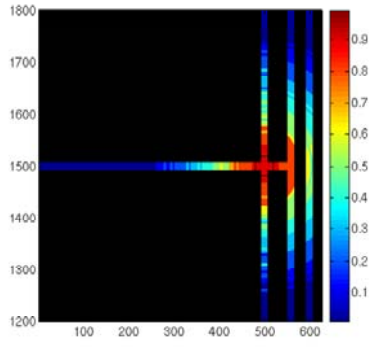


Figure 5-400: Reception Probability of Emergency Messages-Scenario 33, Sender RSU

5.2.17.2 Reception Probability of Routine Messages

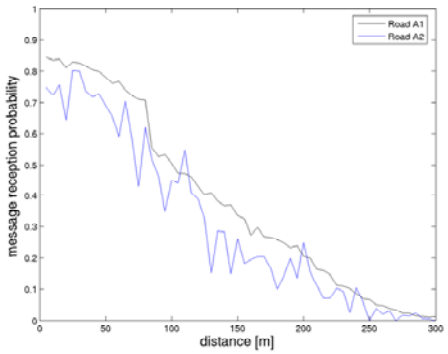


Figure 5-401: Reception Probability of Routine Messages on Road A, Scenario 33

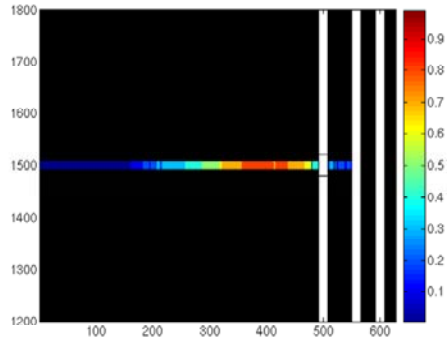


Figure 5-402: Reception Probability of Routine Messages on Road A, Scenario 33

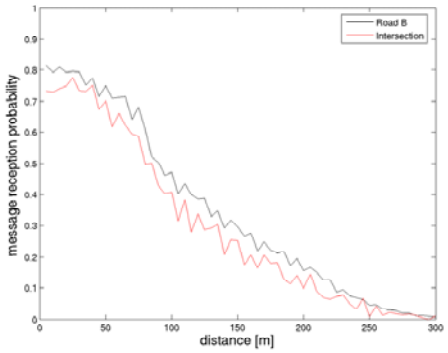


Figure 5-403: Reception Probability of Routine Messages on Road B, Scenario 33

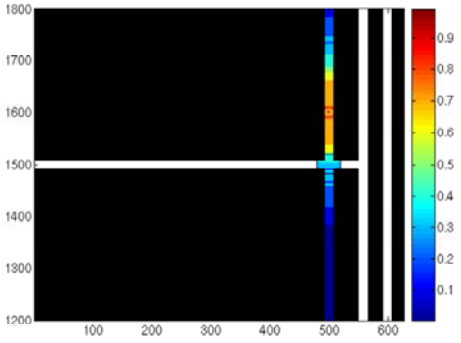


Figure 5-404: Reception Probability of Routine Messages on Road B, Scenario 33

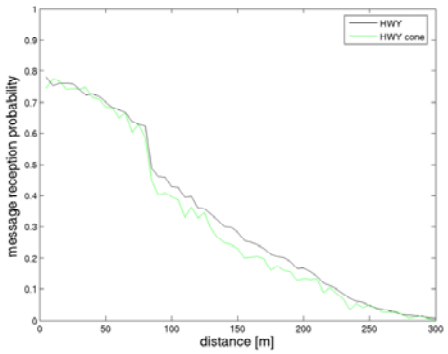


Figure 5-405: Reception Probability of Routine Messages on HWY, Scenario 33

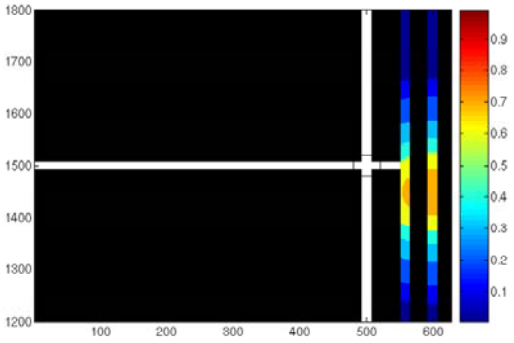


Figure 5-406: Reception Probability of Routine Messages on HWY, Scenario 33

5.2.18 Scenario 34

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	200m coverage
Routine Message Frequency	5Hz

5.2.18.1 Reception Probability of Emergency Messages From OBU on A1

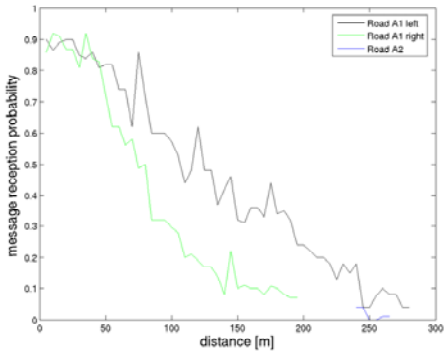


Figure 5-407: Reception Prob. of Emergency Messages – Scenario 34, Rd. A, Sender on Rd. A1

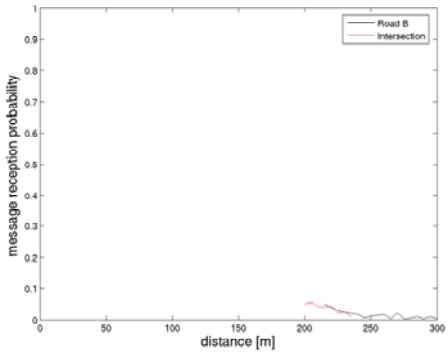


Figure 5-408: Reception Prob. of Emergency Messages – Scenario 34, Rd. B, Sender on Rd. A1

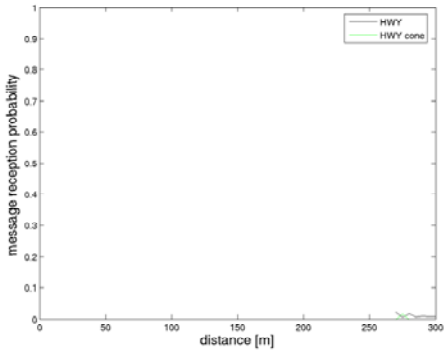


Figure 5-409: Reception Prob. of Emergency Messages – Scenario 34, HWY, Sender on Rd. A1

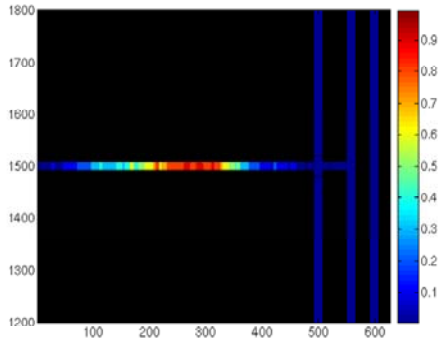


Figure 5-410: Reception Prob. of Emergency Messages-Scenario 34, Sender on Rd. A1

5.2.18.2 Reception Probability of Emergency Messages From OBU on A2

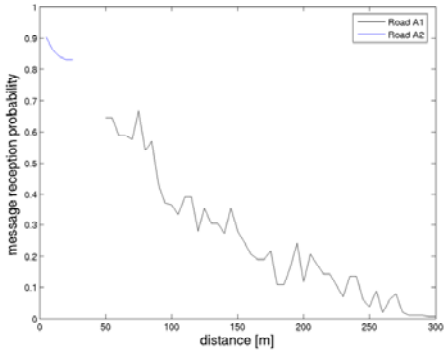


Figure 5-411: Reception Prob. of Emergency Messages – Scenario 34, Rd. A, Sender on Rd. A2

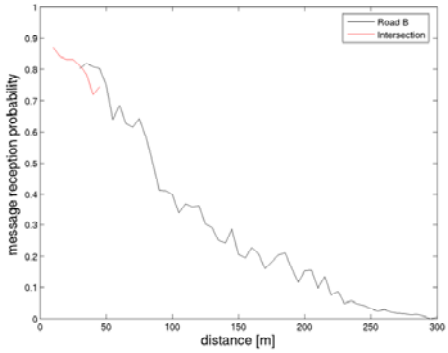


Figure 5-412: Reception Prob. of Emergency Messages – Scenario 34, Rd. B, Sender on Rd. A2

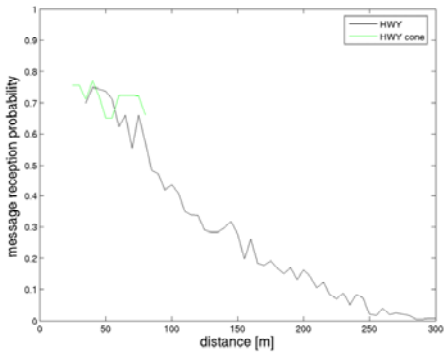


Figure 5-413: Reception Prob. of Emergency Messages – Scenario 34, HWY, Sender on Rd. A2

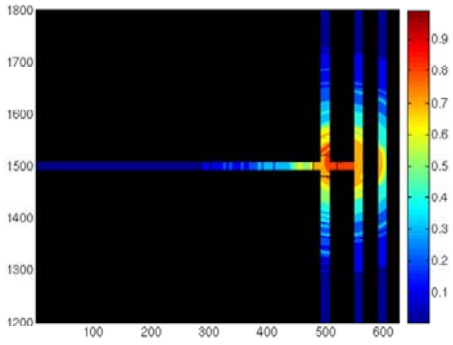


Figure 5-414: Reception Prob. of Emergency Messages-Scenario 34, Sender on Rd. A2

5.2.18.3 Reception Probability of Emergency Messages From OBU on B

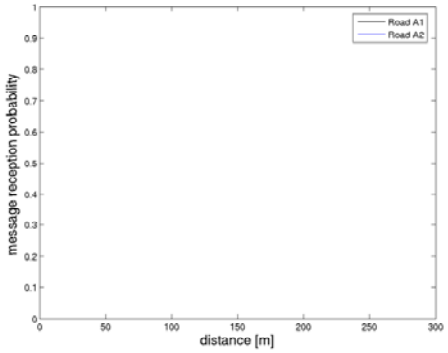


Figure 5-415: Reception Prob. of Emergency Messages – Scenario 34, Rd. A, Sender on Rd. B

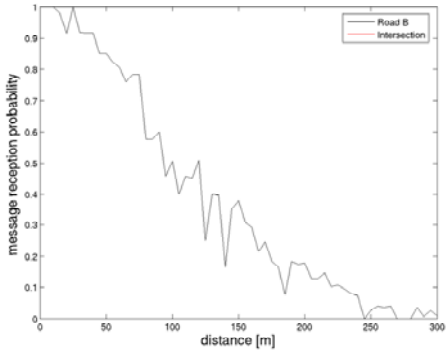


Figure 5-416: Reception Prob. of Emergency Messages – Scenario 34, Rd. B, Sender on Rd. B

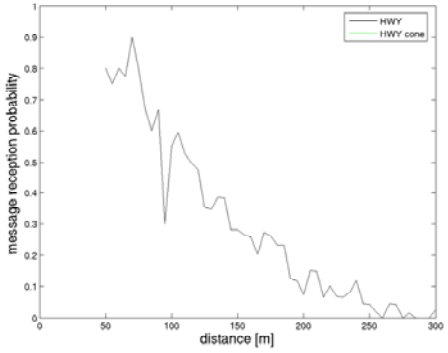


Figure 5-417: Reception Prob. of Emergency Messages – Scenario 34, HWY, Sender on Rd. B

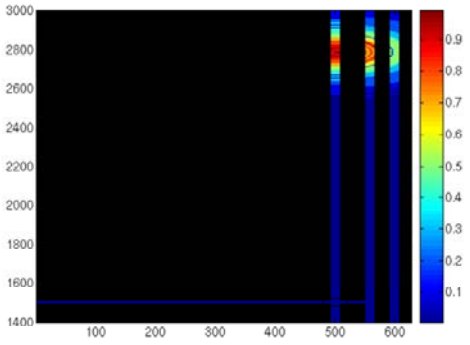


Figure 5-418: Reception Prob. of Emergency Messages-Scenario 34, Sender on Rd. B

5.2.18.4 Reception Probability of Emergency Messages From OBU on HWY

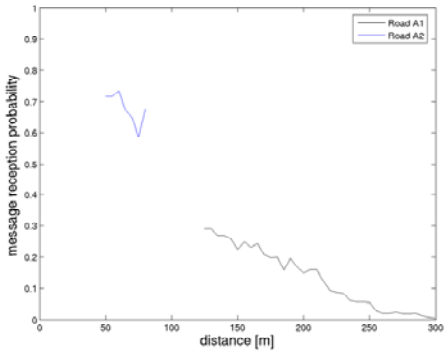


Figure 5-419: Reception Prob. of Emergency Messages – Scenario 34, Rd. A, Sender on HWY

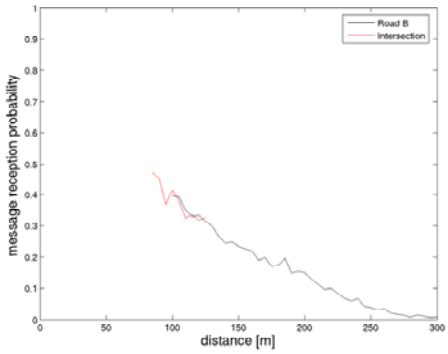


Figure 5-420: Reception Prob. of Emergency Messages – Scenario 34, Rd. B, Sender on HWY

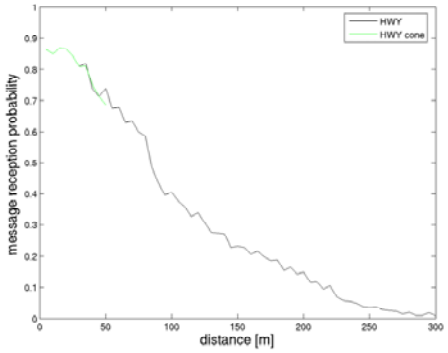


Figure 5-421: Reception Prob. of Emergency Messages – Scenario 34, HWY, Sender on HWY

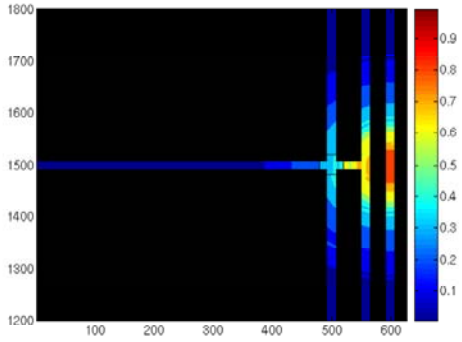


Figure 5-422: Reception Prob. of Emergency Messages-Scenario 34, Sender on HWY

5.2.19 Scenario 35

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	Tall building
Pt	200m coverage
Routine Message Frequency	5Hz

5.2.19.1 Reception Probability of Emergency Messages

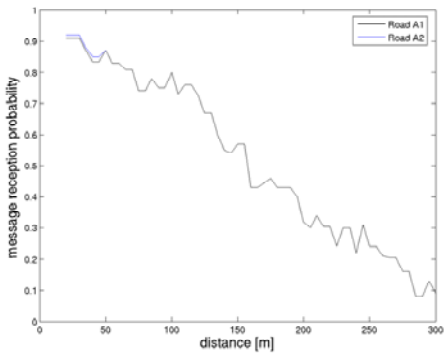


Figure 5-423: Reception Probability of Emergency Messages-Scenario 35, Road A, Sender RSU

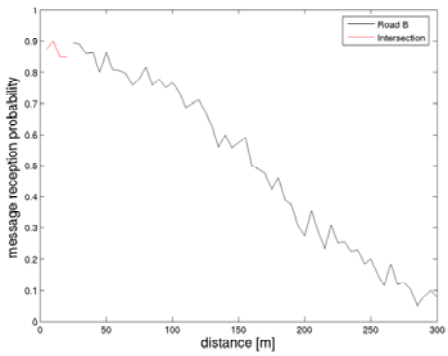


Figure 5-424: Reception Probability of Emergency Messages-Scenario 35, Road B, Sender RSU

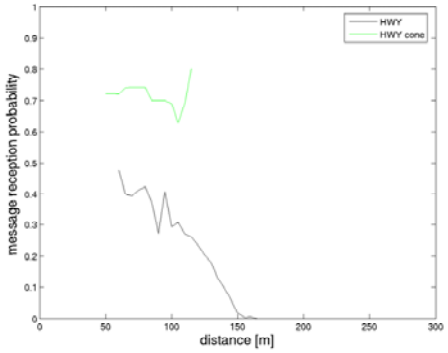


Figure 5-425: Reception Probability of Emergency Messages-Scenario 35, HWY, Sender RSU

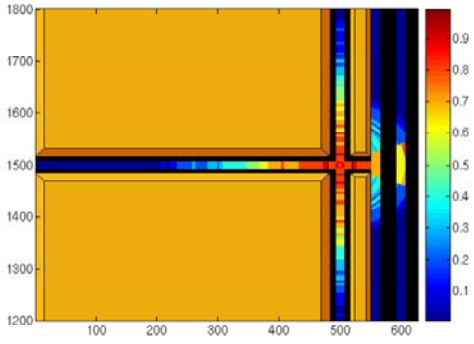


Figure 5-426: Reception Probability of Emergency Messages-Scenario 35, Sender RSU

5.2.19.2 Routine Message Reception Probability

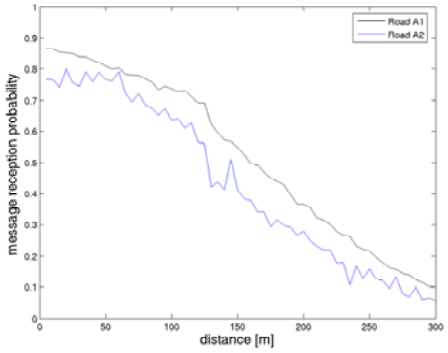


Figure 5-427: Reception Probability of Routine Messages on Road A Scenario 35

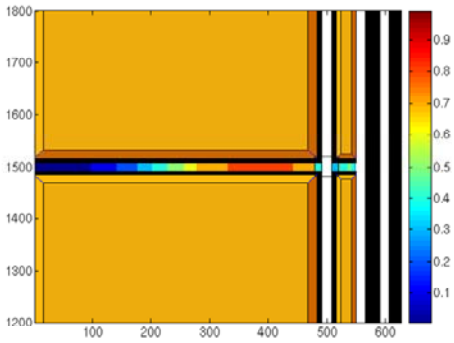


Figure 5-428: Reception Probability of Routine Messages on Road A Scenario 35

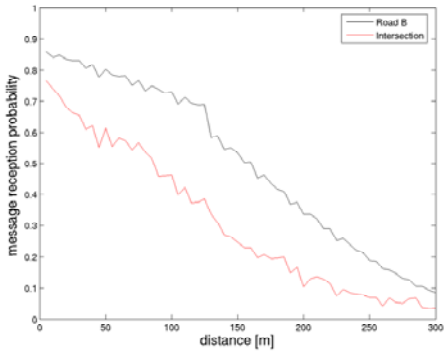


Figure 5-429: Reception Probability of Routine Messages on Road B Scenario 35

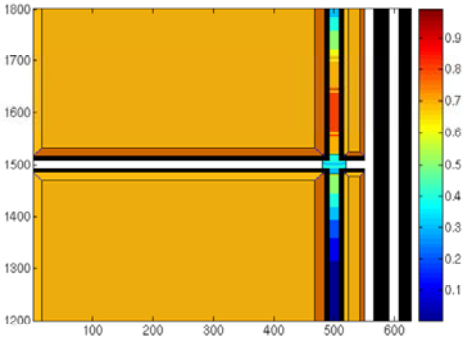


Figure 5-430: Reception Probability of Routine Messages on Road B Scenario 35

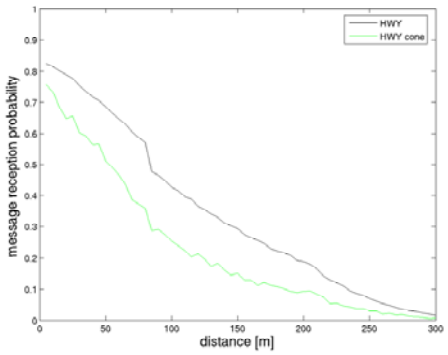


Figure 5-431: Reception Probability of Routine Messages on HWY Scenario 35

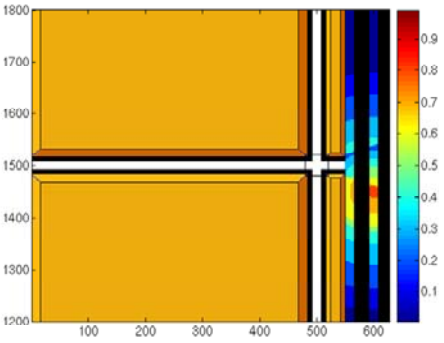


Figure 5-432: Reception Probability of Routine Messages on HWY Scenario 35

5.2.20 Scenario 36

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	200m coverage
Routine Message Frequency	5Hz

5.2.20.1 Reception Probability of Emergency Messages From OBU on A1

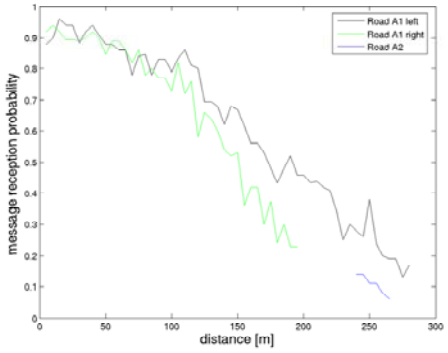


Figure 5-433: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on Rd. A1

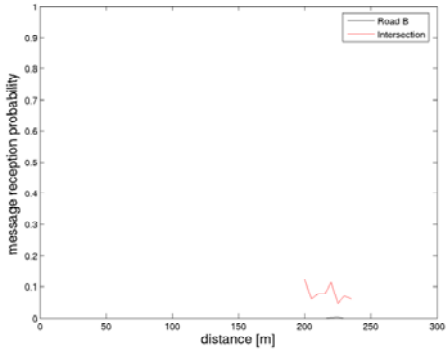


Figure 5-434: Reception Prob. of Emergency Messages – Scenario 36, Rd. B, Sender on Rd. A1

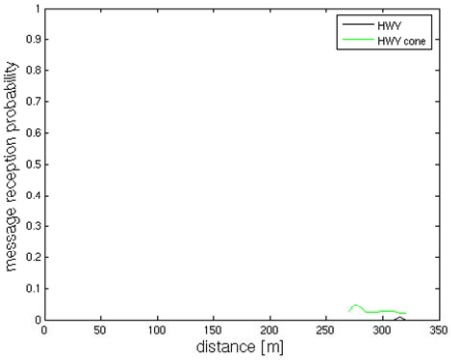


Figure 5-435: Reception Prob. of Emergency Messages – Scenario 36, HWY, Sender on Rd. A1

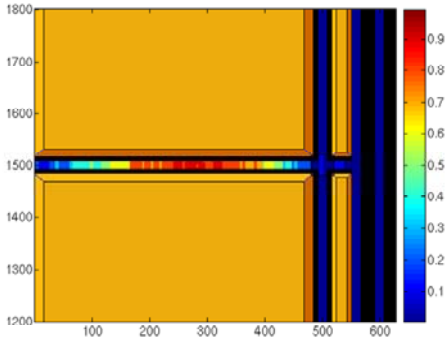


Figure 5-436: Reception Prob. of Emergency Messages-Scenario 36, Sender on Rd. A1

5.2.20.2 Reception Probability of Emergency Messages From OBU on A2

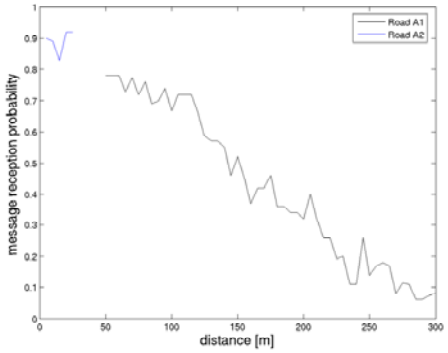


Figure 5-437: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on Rd. A2

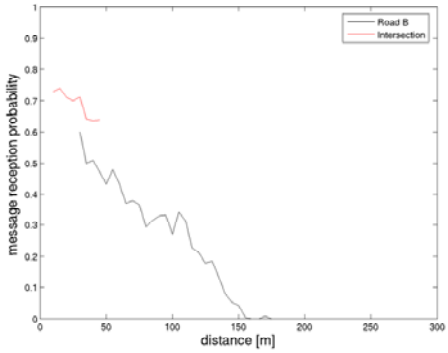


Figure 5-438: Reception Prob. of Emergency Messages – Scenario 36, Rd. B, Sender on Rd. A2

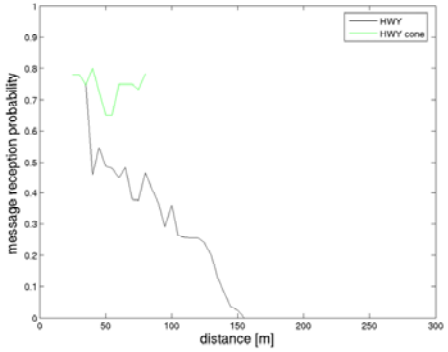


Figure 5-439: Reception Prob. of Emergency Messages – Scenario 36, HWY, Sender on Rd. A2

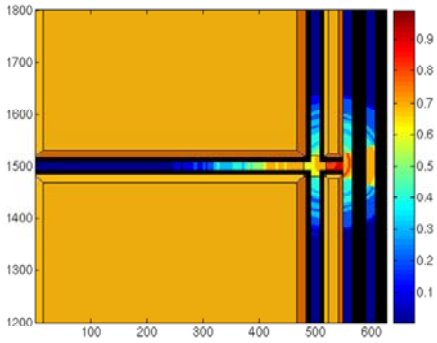


Figure 5-440: Reception Prob. of Emergency Messages-Scenario 36, Sender on Rd. A2

5.2.20.3 Reception Probability of Emergency Messages From OBU on B

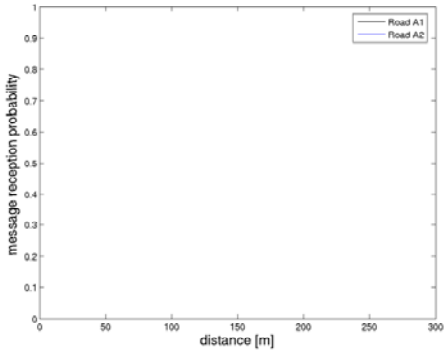


Figure 5-441: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on Rd. B

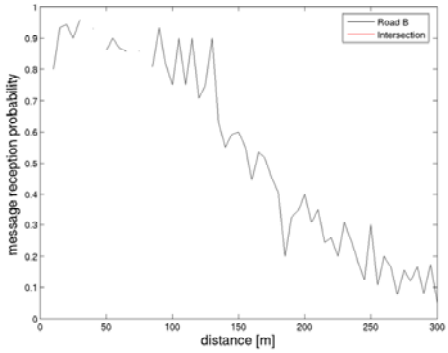


Figure 5-442: Reception Prob. of Emergency Messages – Scenario 36, Rd. B, Sender on Rd. B

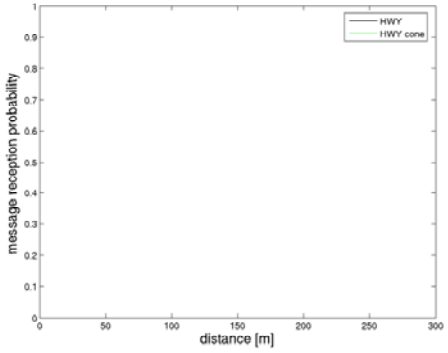


Figure 5-443: Reception Prob. of Emergency Messages – Scenario 36, HWY, Sender on Rd. B

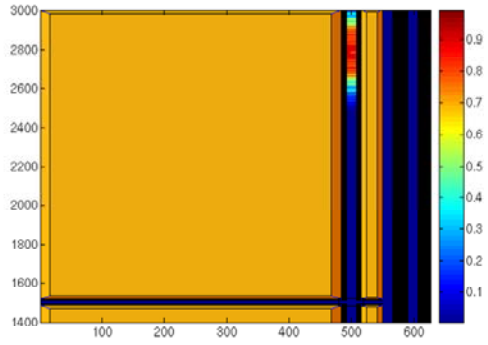


Figure 5-444: Reception Prob. of Emergency Messages-Scenario 36, Sender on Rd. B

5.2.20.4 Reception Probability of Emergency Messages From OBU on HWY

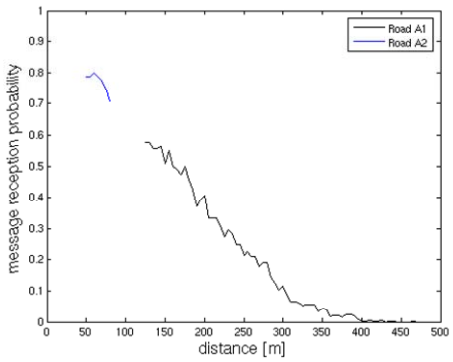


Figure 5-445: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on HWY

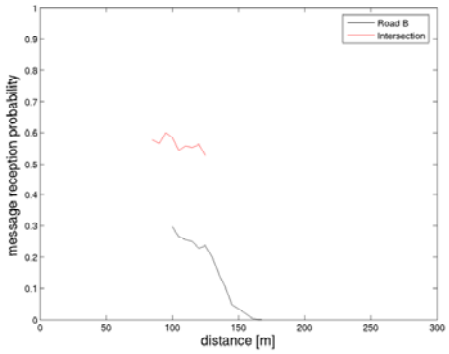


Figure 5-446: Reception Prob. of Emergency Messages – Scenario 36, Rd. B, Sender on HWY

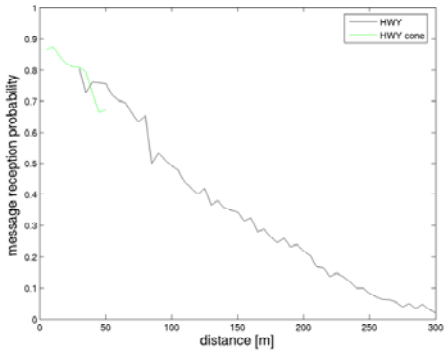


Figure 5-447: Reception Prob. of Emergency Messages – Scenario 36, HWY, Sender on HWY

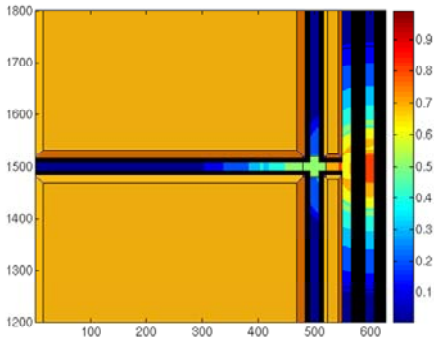


Figure 5-448: Reception Prob. of Emergency Messages-Scenario 36, Sender on HWY

5.2.21 Scenario 37

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Pt	300m coverage
Routine Message Frequency	5Hz

5.2.21.1 Reception Probability of Emergency Messages

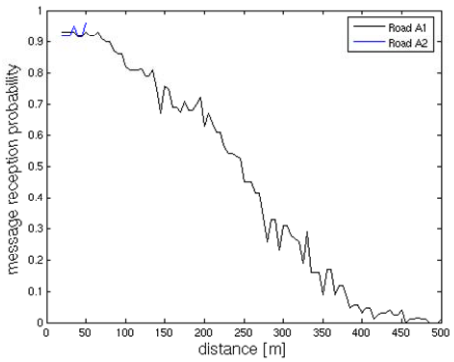


Figure 5-449: Reception Probability of Emergency Messages-Scenario 37, Road A, Sender RSU

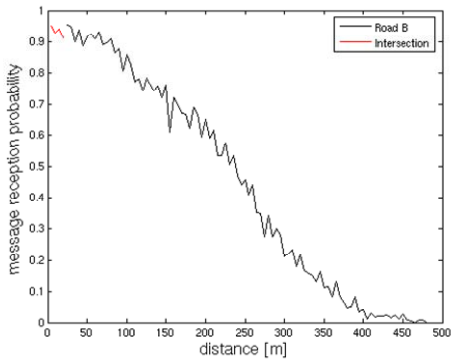


Figure 5-450: Reception Probability of Emergency Messages-Scenario 37, Road B, Sender RSU

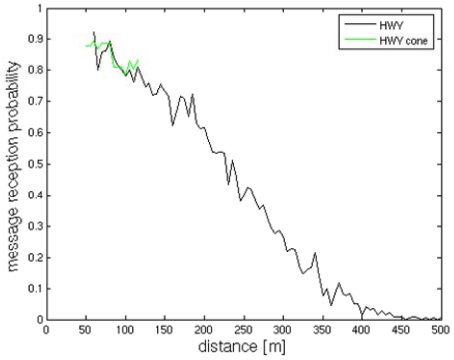


Figure 5-451: Reception Probability of Emergency Messages-Scenario 37, HWY, Sender RSU

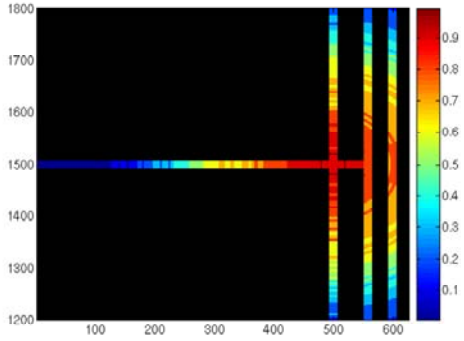


Figure 5-452: Reception Probability of Emergency Messages-Scenario 37, Sender RSU

5.2.22 Scenario 38

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	no building
Pt	300m coverage
Routine Message Frequency	5Hz

5.2.22.1 Reception Probability of Emergency Messages From OBU on A1

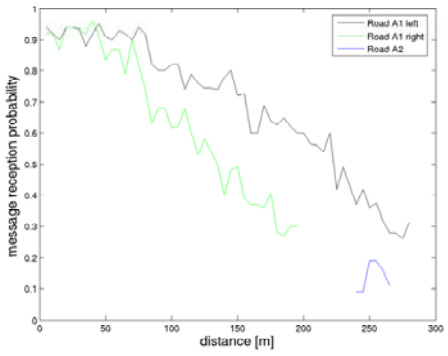


Figure 5-453: Reception Prob. of Emergency Messages – Scenario 38, Rd. A, Sender on Rd. A1

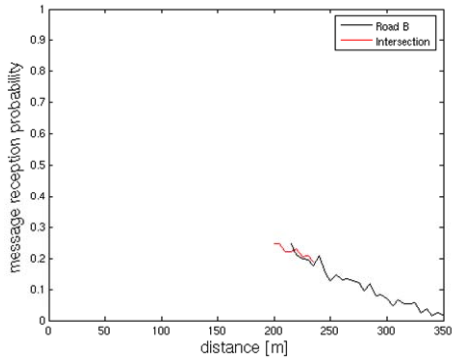


Figure 5-454: Reception Prob. of Emergency Messages – Scenario 38, Rd. B, Sender on Rd. A1

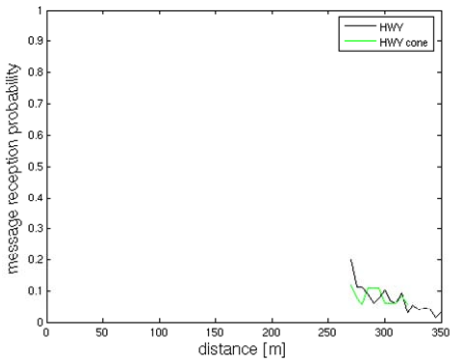


Figure 5-455: Reception Prob. of Emergency Messages – Scenario 38, HWY, Sender on Rd. A1

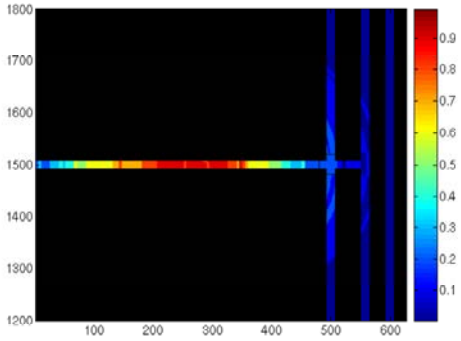


Figure 5-456: Reception Prob. of Emergency Messages-Scenario 38, Sender on Rd. A1

5.2.22.2 Reception Probability of Emergency Messages From OBU on A2

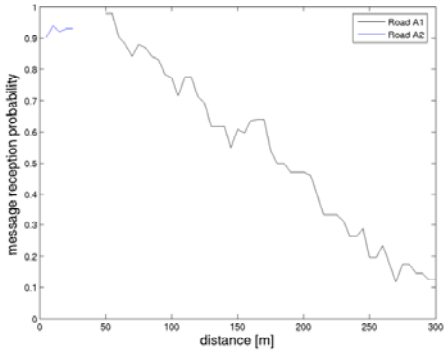


Figure 5-457: Reception Prob. of Emergency Messages – Scenario 38, Rd. A, Sender on Rd. A2

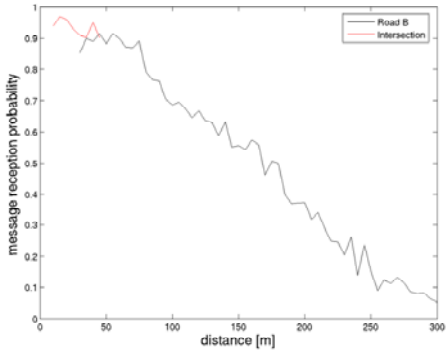


Figure 5-458: Reception Prob. of Emergency Messages – Scenario 38, Rd. B, Sender on Rd. A2

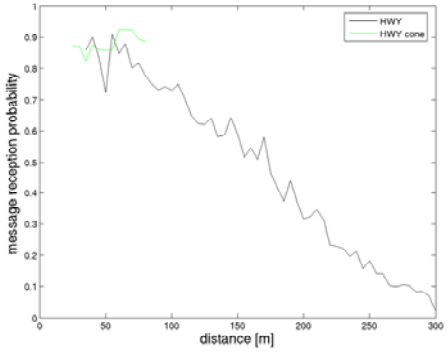


Figure 5-459: Reception Prob. of Emergency Messages – Scenario 38, HWY, Sender on Rd. A2

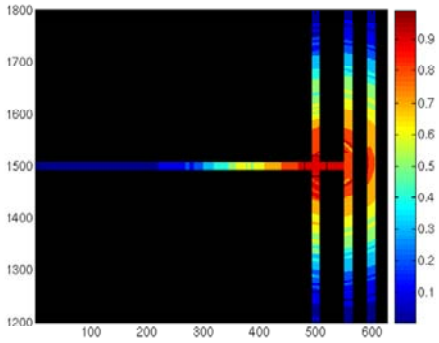


Figure 5-460: Reception Prob. of Emergency Messages-Scenario 38, Sender on Rd. A2

5.2.22.3 Reception Probability of Emergency Messages From OBU on B

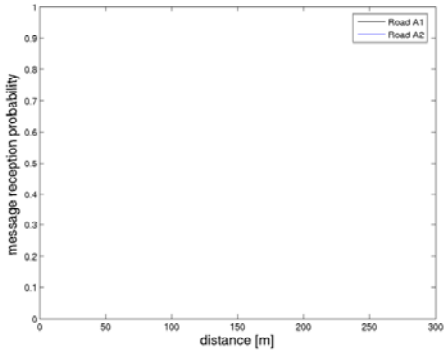


Figure 5-461: Reception Prob. of Emergency Messages – Scenario 38, Rd. A, Sender on Rd. B

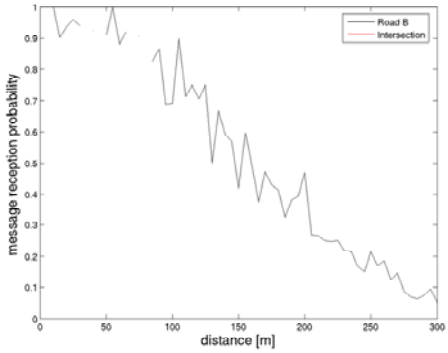


Figure 5-462: Reception Prob. of Emergency Messages – Scenario 38, Rd. B, Sender on Rd. B

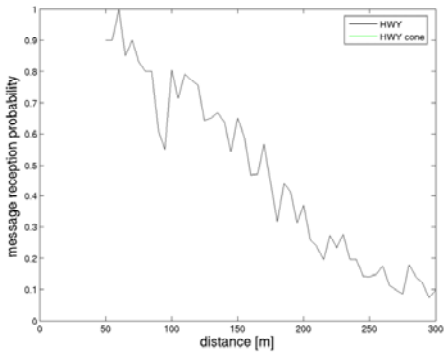


Figure 5-463: Reception Prob. of Emergency Messages – Scenario 38, HWY, Sender on Rd. B

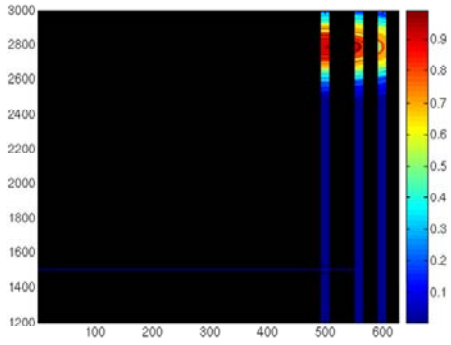


Figure 5-464: Reception Prob. of Emergency Messages-Scenario 38, Sender on Rd. B

5.2.22.4 Reception Probability of Emergency Messages From OBU on HWY

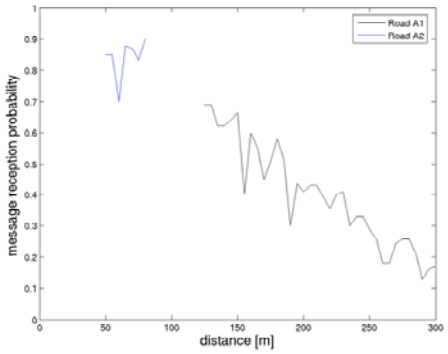


Figure 5-465: Reception Prob. of Emergency Messages – Scenario 38, Rd. A, Sender on HWY

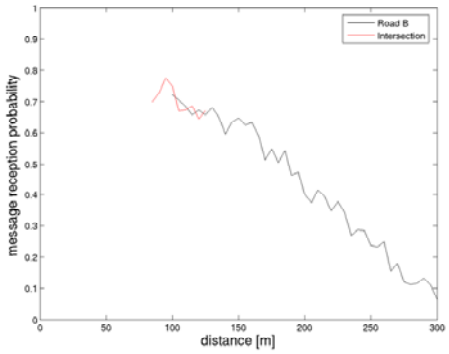


Figure 5-466: Reception Prob. of Emergency Messages – Scenario 38, Rd. B, Sender on HWY

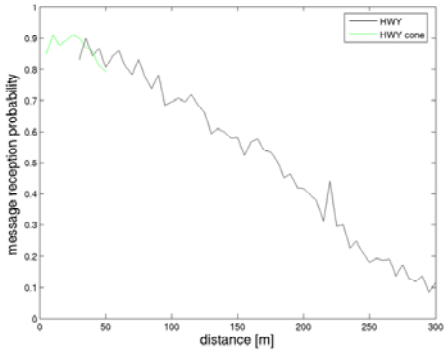


Figure 5-467: Reception Prob. of Emergency Messages – Scenario 38, HWY, Sender on HWY

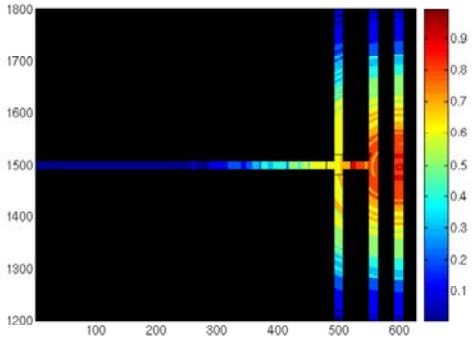


Figure 5-468: Reception Prob. of Emergency Messages-Scenario 38, Sender on HWY

5.2.23 Scenario 39

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	Tall building
Pt	300m coverage
Routine Message Frequency	5Hz

5.2.23.1 Reception Probability of Emergency Messages

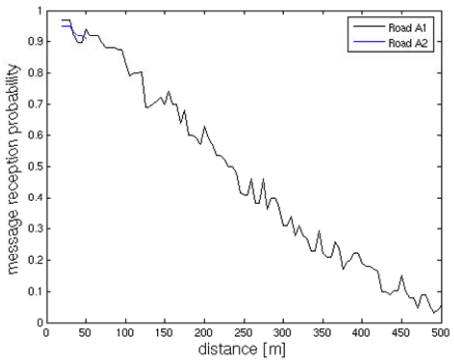


Figure 5-469: Reception Probability of Emergency Messages-Scenario 39, Road A, Sender RSU

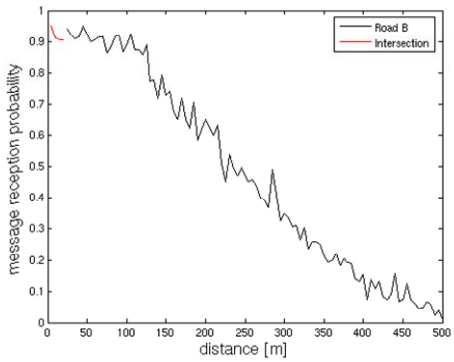


Figure 5-470: Reception Probability of Emergency Messages-Scenario 39, Road B, Sender RSU

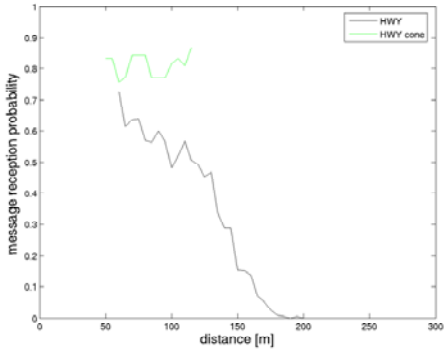


Figure 5-471: Reception Probability of Emergency Messages-Scenario 39, HWY, Sender RSU

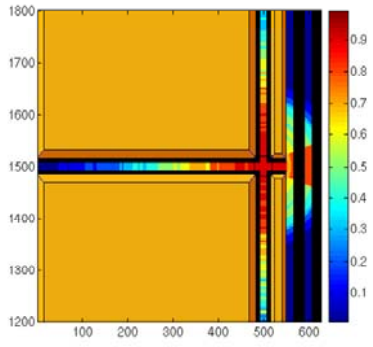


Figure 5-472: Reception Probability of Emergency Messages-Scenario 39, Sender RSU

5.2.24 Scenario 40

Simulation Scenario Setting:

RF Model	Distributed
Emergency Message Sender	OBUs on Road A1, A2, B and HWY
Corner Model	tall building
Pt	300m coverage
Routine Message Frequency	5Hz

5.2.24.1 Reception Probability of Emergency Messages From OBU on A1

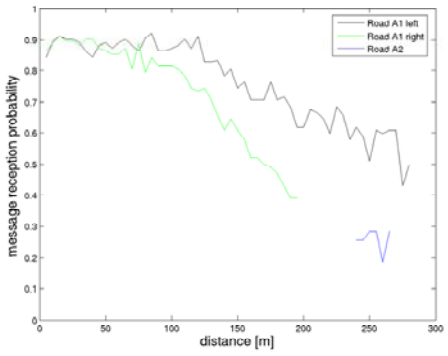


Figure 5-473: Reception Prob. of Emergency Messages – Scenario 40, Rd. A, Sender on Rd. A1

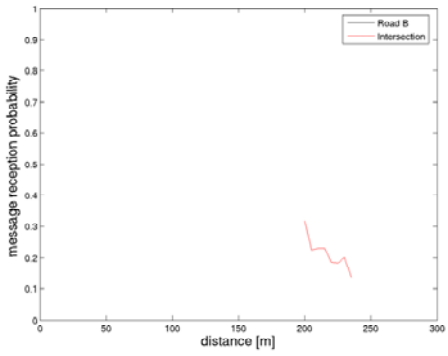


Figure 5-474: Reception Prob. of Emergency Messages – Scenario 40, Rd. B, Sender on Rd. A1

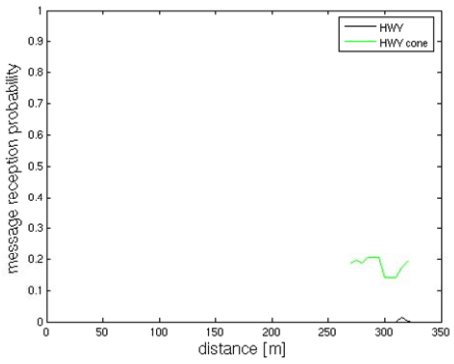


Figure 5-475: Reception Prob. of Emergency Messages – Scenario 40, HWY, Sender on Rd. A1

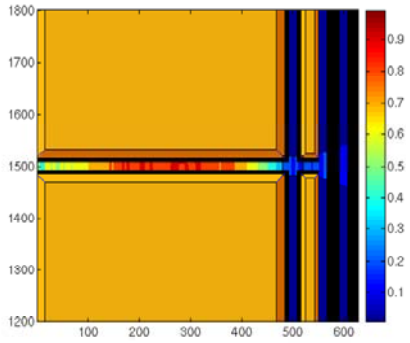


Figure 5-476: Reception Prob. of Emergency Messages-Scenario 40, Sender on Rd. A1

5.2.24.2 Reception Probability of Emergency Messages From OBU on A2

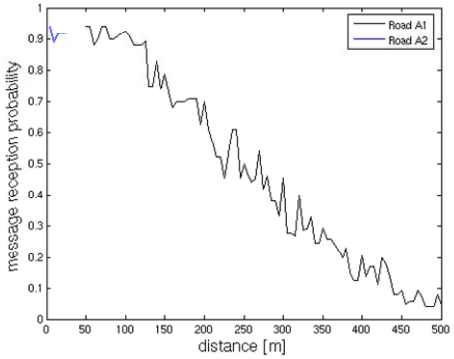


Figure 5-477: Reception Prob. of Emergency Messages – Scenario 40, Rd. A, Sender on Rd. A2

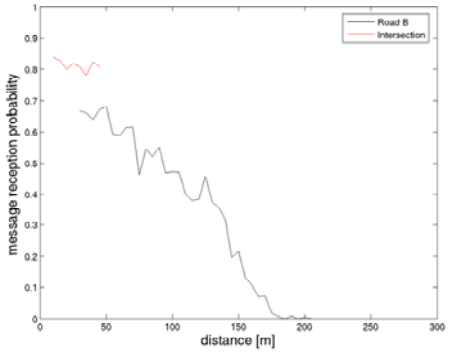


Figure 5-478: Reception Prob. of Emergency Messages – Scenario 40, Rd. B, Sender on Rd. A2

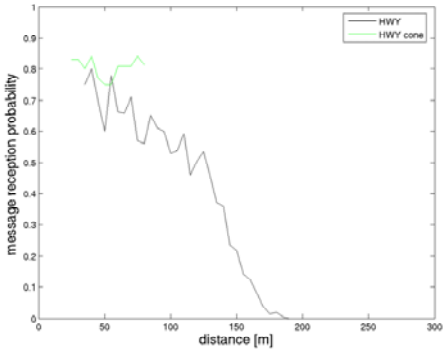


Figure 5-479: Reception Prob. of Emergency Messages – Scenario 40, HWY, Sender on Rd. A2

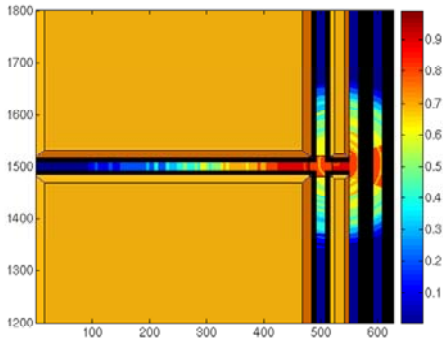


Figure 5-480: Reception Prob. of Emergency Messages-Scenario 40, Sender on Rd. A2

5.2.24.3 Reception Probability of Emergency Messages From OBU on B

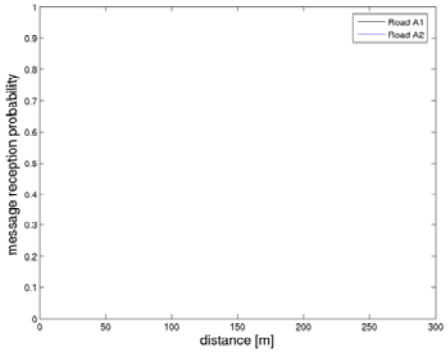


Figure 5-481: Reception Prob. of Emergency Messages – Scenario 40, Rd. A, Sender on Rd. B

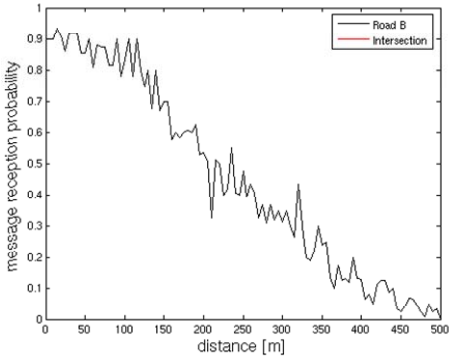


Figure 5-482: Reception Prob. of Emergency Messages – Scenario 40, Rd. B, Sender on Rd. B

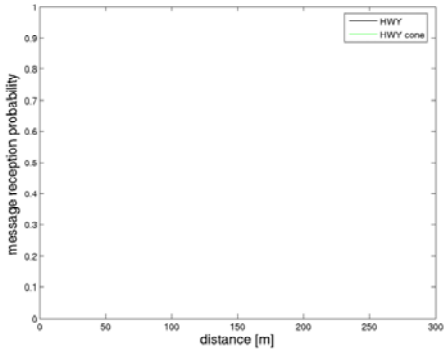


Figure 5-483: Reception Prob. of Emergency Messages – Scenario 40, HWY, Sender on Rd. B

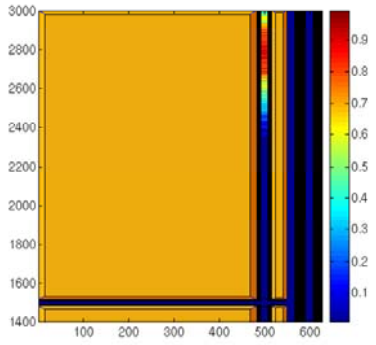


Figure 5-484: Reception Prob. of Emergency Messages-Scenario 40, Sender on Rd. B

5.2.24.4 Reception Probability of Emergency Messages From OBU on HWY

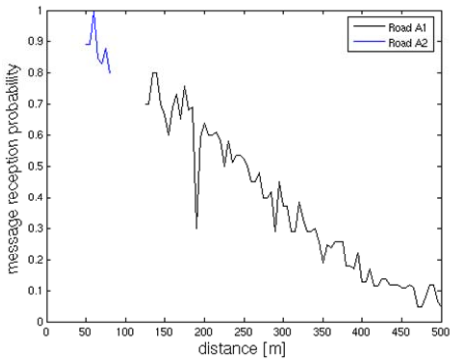


Figure 5-485: Reception Prob. of Emergency Messages – Scenario 40, Rd. A, Sender on HWY

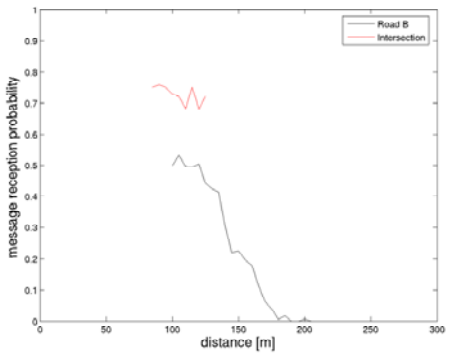


Figure 5-486: Reception Prob. of Emergency Messages – Scenario 40, Rd. B, Sender on HWY

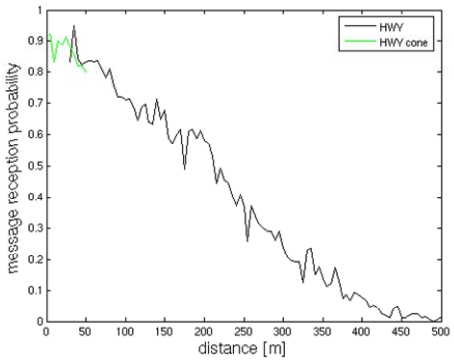


Figure 5-487: Reception Prob. of Emergency Messages – Scenario 40, HWY, Sender on HWY

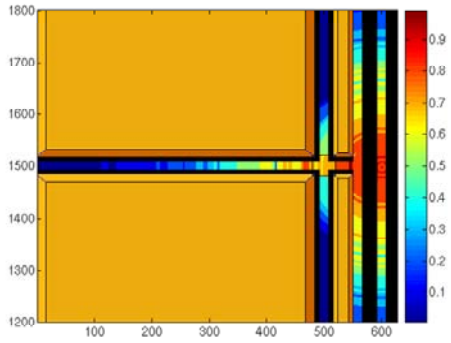


Figure 5-488: Reception Prob. of Emergency Messages-Scenario 40, Sender on HWY

5.3 Batch 3, Intersection RSU Retransmission of Routine Safety Messages

5.3.1 Scenario 41

Routine messages	2Hz 200byte 200m
RF Model	Distributed
Corner Model	tall building
Emergency Message	None, RSU forwarding routine message

Sender on A1

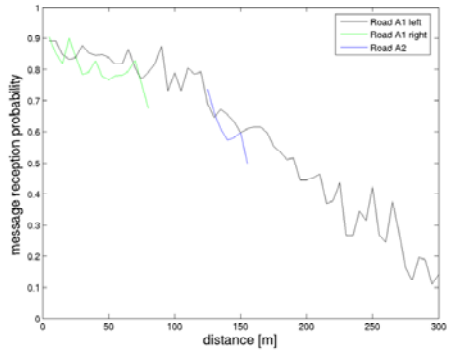


Figure 5-489: Reception Prob. of Routine Message Scenario 41, Rd. A, Sender on Rd. A1

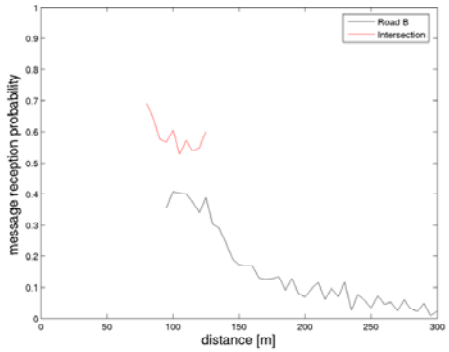


Figure 5-490: Reception Prob. of Routine Message Scenario 41, Rd. B, Sender on Rd. A1

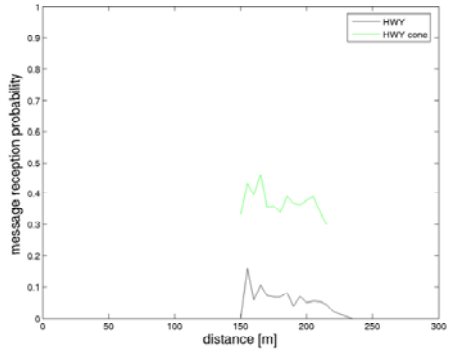


Figure 5-491: Reception Prob. of Routine Message Scenario 41, HWY, Sender on Rd. A1

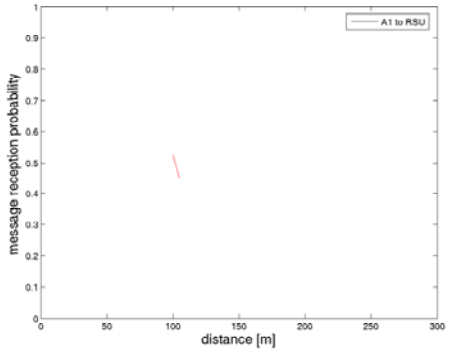


Figure 5-492: Reception Prob. of Routine Message Scenario 41, RSU, Sender on Rd. A1

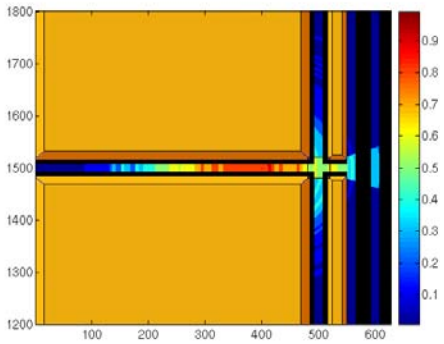


Figure 5-493: Reception Probability of Emergency Messages-Scenario 41, Sender on Rd. A1

Sender on Road A2

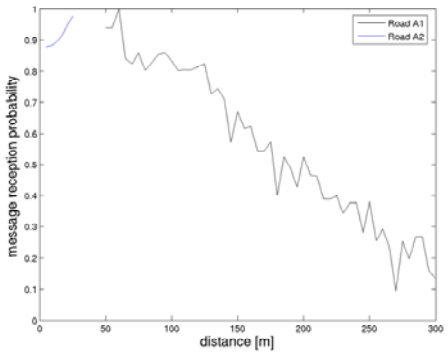


Figure 5-494: Reception Prob. of Routine Message Scenario 41, Rd. A, Sender on Rd. A2

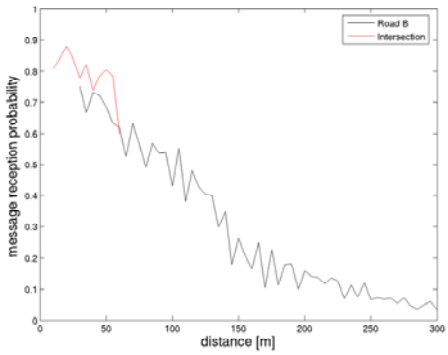


Figure 5-495: Reception Prob. of Routine Message Scenario 41, Rd. B, Sender on Rd. A2

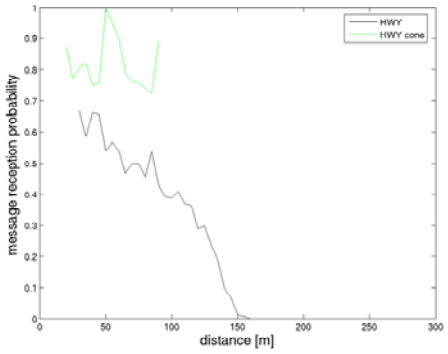


Figure 5-496: Reception Prob. of Routine Message Scenario 41, HWY, Sender on Rd. A2

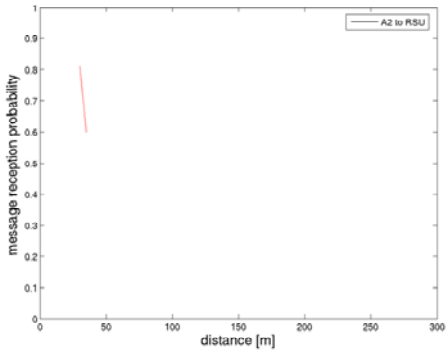


Figure 5-497: Reception Prob. of Routine Message Scenario 41, RSU, Sender on Rd. A2

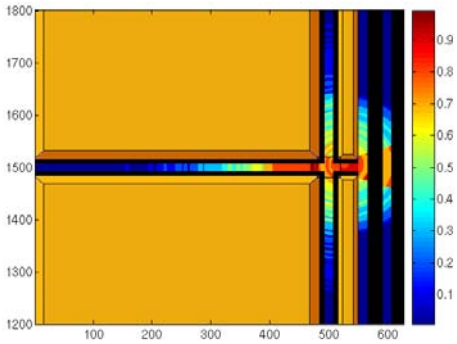


Figure 5-498: Reception Probability of Emergency Messages-Scenario41, Sender on Rd. A2

Sender on HWY

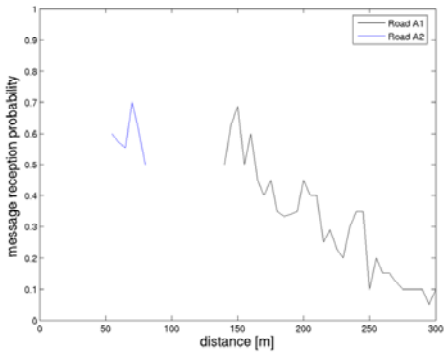


Figure 5-499: Reception Prob. of Routine Message Scenario 41, Rd. A, Sender on HWY

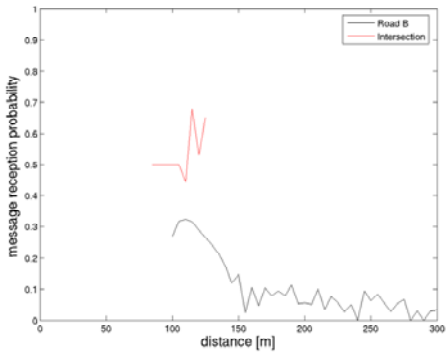


Figure 5-500: Reception Prob. of Routine Message Scenario 41, Rd. B, Sender on HWY

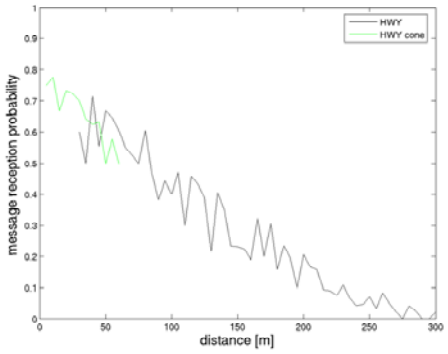


Figure 5-501: Reception Prob. of Routine Message Scenario 41, HWY, Sender on HWY

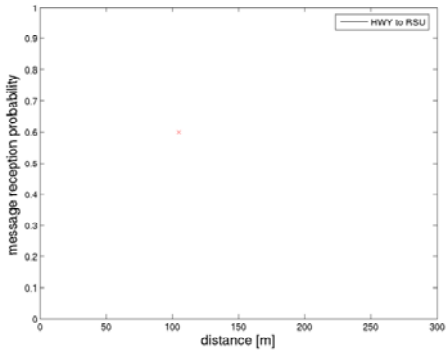


Figure 5-502: Reception Prob. of Routine Message Scenario 41, RSU, Sender on HWY

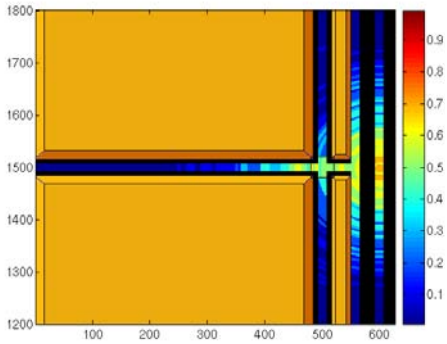


Figure 5-503: Reception Probability of Emergency Messages-Scenario 41, Sender on HWY

5.3.2 Scenario 42

Routine messages	10Hz 200byte 200m
RF Model	Distributed
Corner Model	tall building
Emergency Message	None , RSU forwarding routine messages

Sender on A1

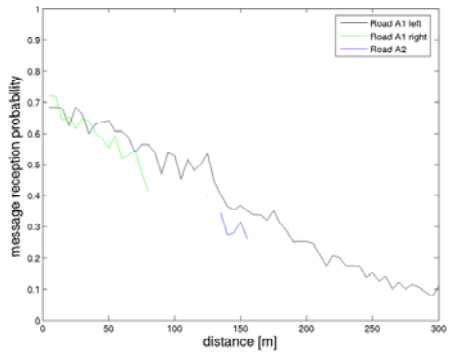


Figure 5-504: Reception Prob. of Routine Message Scenario 42, Rd. A, Sender on Rd. A1

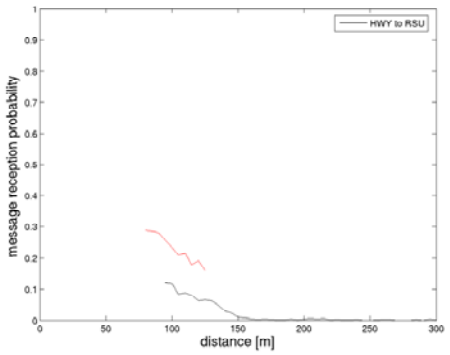


Figure 5-505: Reception Prob. of Routine Message Scenario 42, Rd. B, Sender on Rd. A1

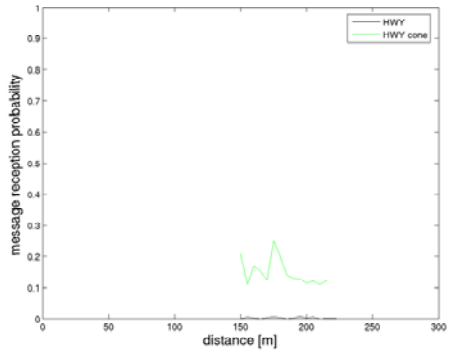


Figure 5-506: Reception Prob. of Routine Message Scenario 42, HWY, Sender on Rd. A1

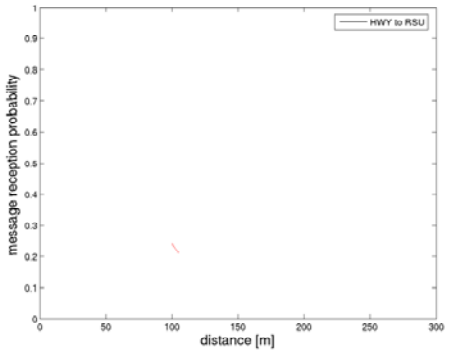


Figure 5-507: Reception Prob. of Routine Message Scenario 42, RSU, Sender on Rd. A1

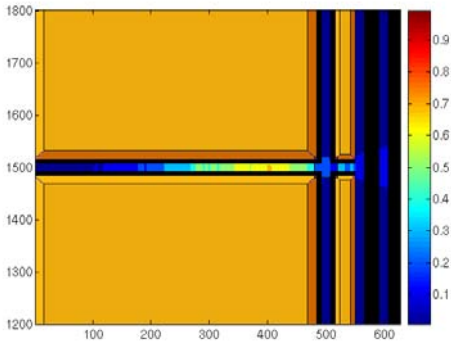


Figure 5-508: Reception Probability of Emergency Messages-Scenario 42, Sender on Rd. A1

Sender on Road A2

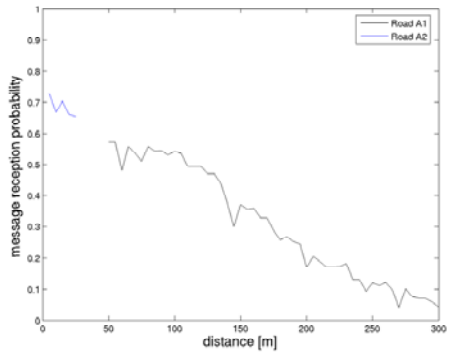


Figure 5-509: Reception Prob. of Routine Message Scenario 42, Rd. A, Sender on Rd. A2

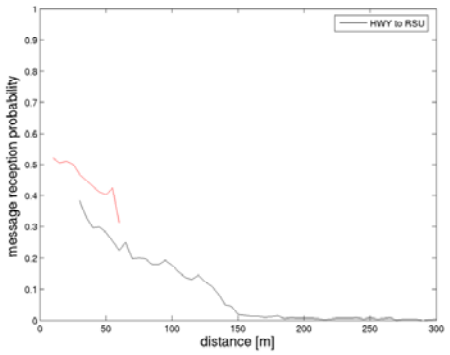


Figure 5-510: Reception Prob. of Routine Message Scenario 42, Rd. B, Sender on Rd. A2

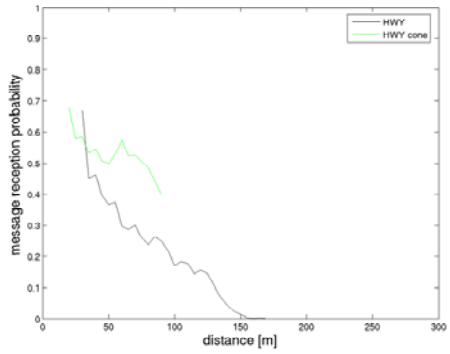


Figure 5-511: Reception Prob. of Routine Message Scenario 42, HWY, Sender on Rd. A2

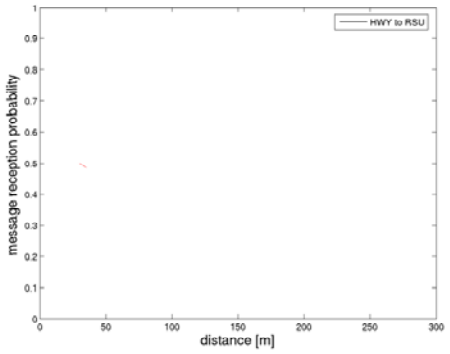


Figure 5-512: Reception Prob. of Routine Message Scenario 42, RSU, Sender on Rd. A2

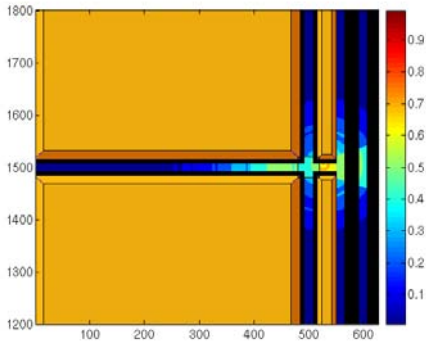


Figure 5-513: Reception Probability of Emergency Messages-Scenario42, Sender on Rd. A1

Sender on HWY

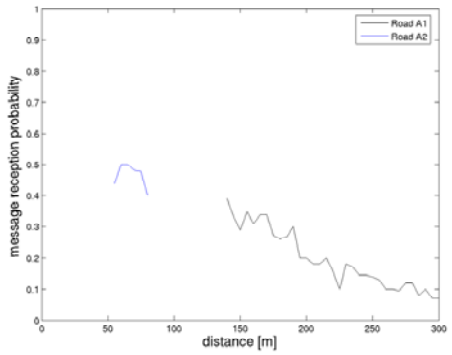


Figure 5-514: Reception Prob. of Routine Message Scenario 42, Rd. A, Sender on HWY

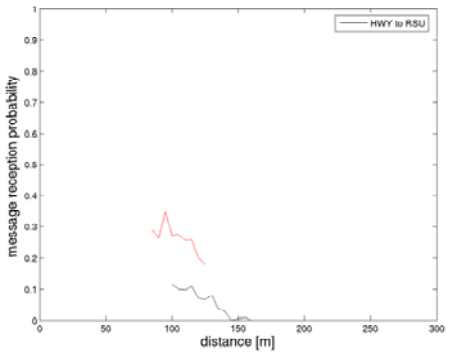


Figure 5-515: Reception Prob. of Routine Message Scenario 42, Rd. B, Sender on HWY

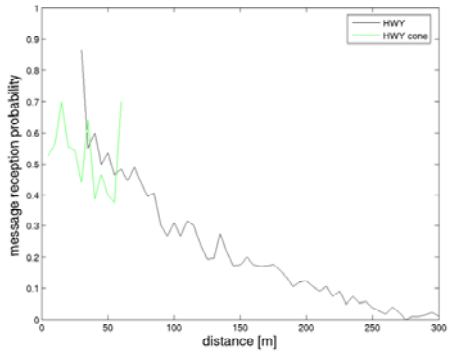


Figure 5-516: Reception Prob. of Routine Message Scenario 42, HWY, Sender on HWY

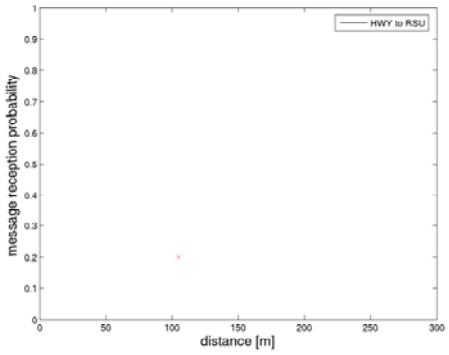


Figure 5-517: Reception Prob. of Routine Message Scenario 42, RSU, Sender on HWY

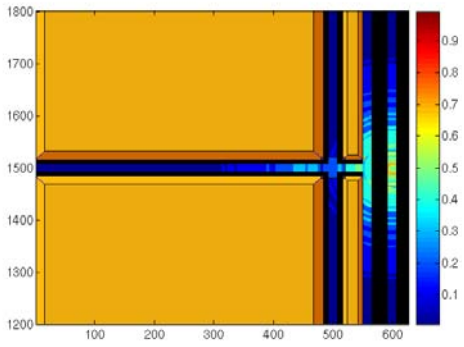


Figure 5-518: Reception Probability of Emergency Messages-Scenario 42, Sender on HWY

5.4 Batch 4, Cascading Emergency Messages From Intersection

5.4.1 Scenario 43

Cascading message on Road A1, based on Cascading protocol 1, repetition

Routine messages	5Hz 200byte 200m
RF Model	Distributed
Corner Model	Tall building

Retransmission interval T=0.02s;

Triggering Event happens at the intersection, cascading to the end of road A1, node density on Rd. A1 is 7m/car

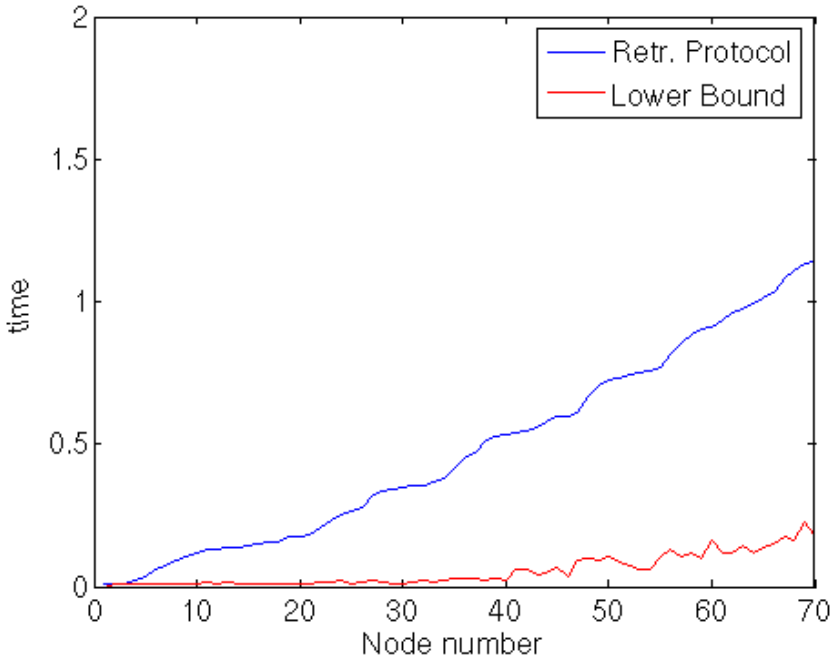


Figure 5-519: Propagation time over nodes, cascading protocol 1

5.4.2 Scenario 44

Cascading message on Road A1, based on Cascading protocol 2, feedback

Routine messages	5Hz 200byte 200m
RF Model	Distributed
Corner Model	Tall building

Retransmission interval T=0.02s;
Triggering Event happens at the intersection, cascading to the end of road A1, node density on Rd. A1 is 7m/car

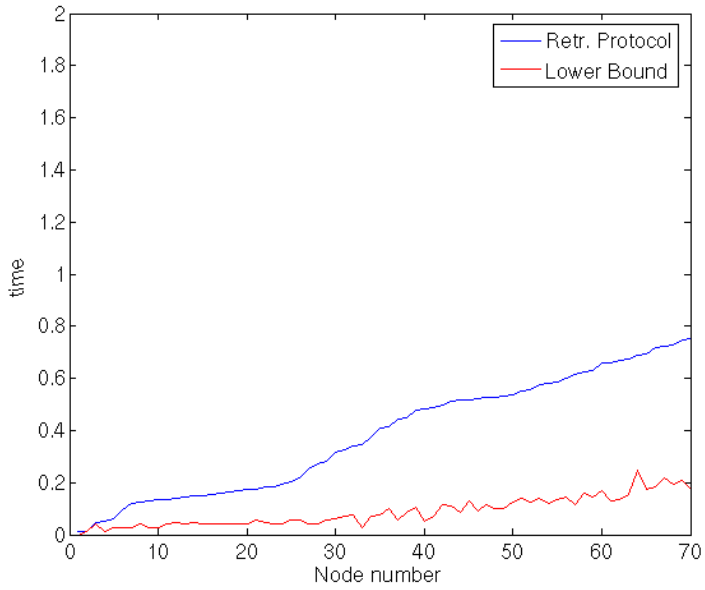


Figure 5-520: Propagation Time Over Nodes, Cascading Protocol 2

5.4.3 Scenario 45

Cascading message on Road A1, based on Cascading protocol 1, repetition

Routine messages	10Hz 200byte 200m
RF Model	Distributed
Corner Model	Tall building

Retransmission interval T=0.02s;
Triggering Event happens at the intersection, cascading to the end of road A1, node density on Rd. A1 is 7m/car

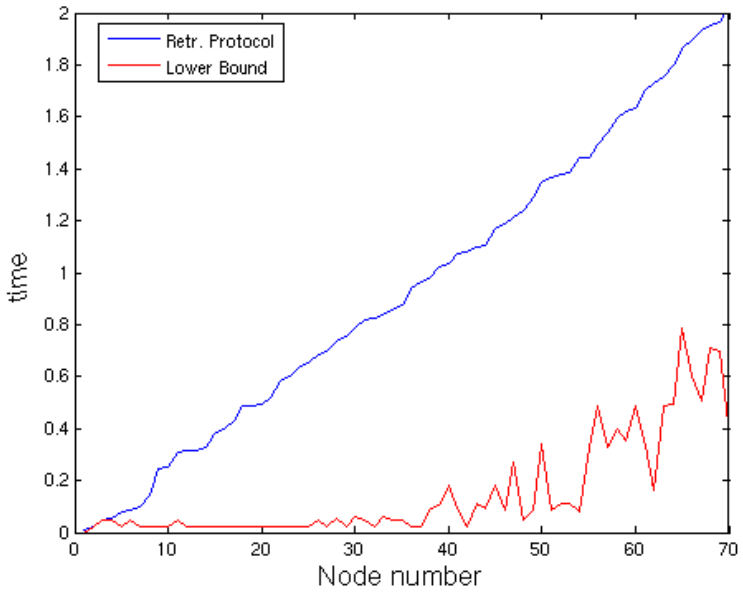


Figure 5-521: Propagation Time Over Nodes, Cascading Protocol 1

5.4.4 Scenario 46

Cascading message on Road A1, based on Cascading protocol 2, feedback

Routine messages	10Hz 200byte 200m
RF Model	Distributed
Corner Model	Tall building

Retransmission interval T=0.02s;
Triggering Event happens at the intersection, cascading to the end of road A1, node density on Rd. A1 is 7m/car

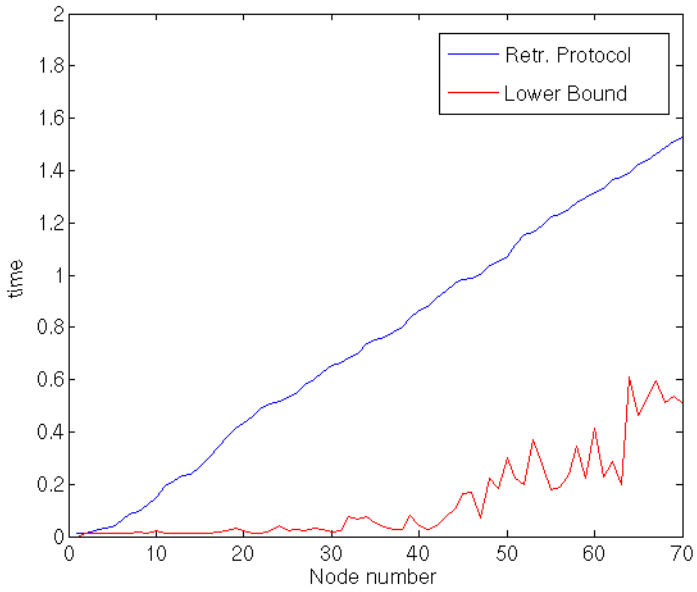


Figure 5-522: Propagation Time Over Nodes, Cascading Protocol 2

5.5 Batch 5, Additional Simulation Tests

5.5.1 Scenario 47

Simulation Scenario Setting:

Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Routine Message Frequency	none

5.5.1.1 Reception Probability of Emergency Messages

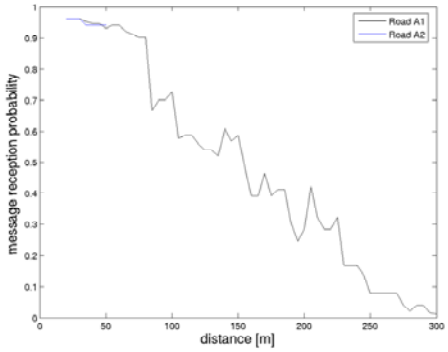


Figure 5-523: Reception Probability of Emergency Messages-Scenario 47, Road A, Sender RSU

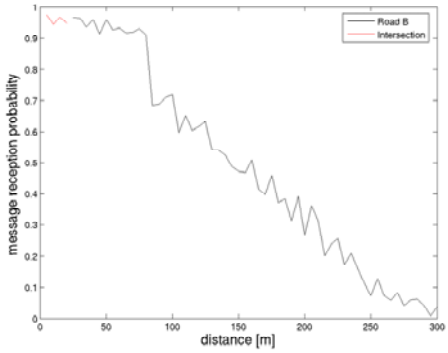


Figure 5-524: Reception Probability of Emergency Messages-Scenario 47, Road B, Sender RSU

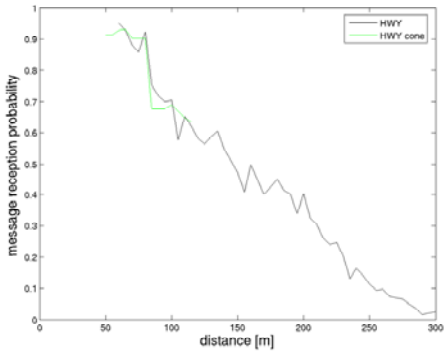


Figure 5-525: Reception Probability of Emergency Messages-Scenario 47, HWY, Sender RSU

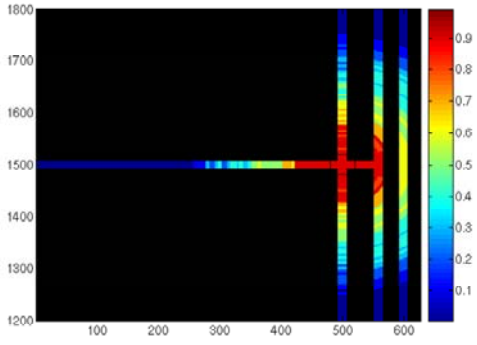


Figure 5-526: Reception Probability of Emergency Messages-Scenario 47, Sender RSU

5.5.2 Scenario 48

Simulation Scenario Setting:

Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	tall building
Routine Message Frequency	none

5.5.2.1 Reception Probability of Emergency Messages

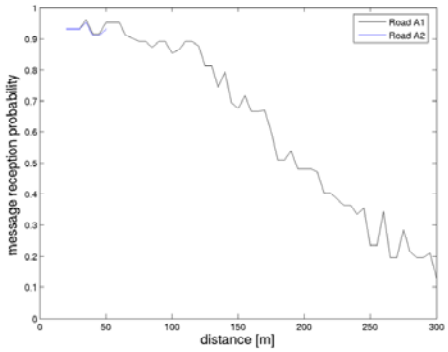


Figure 5-527: Reception Probability of Emergency Messages-Scenario 48, Road A, Sender RSU

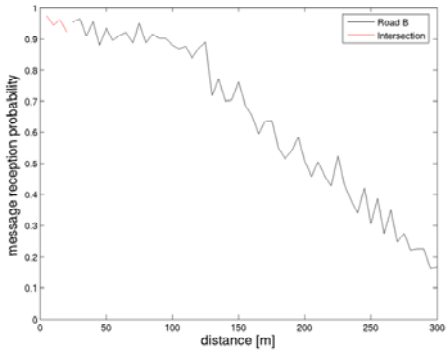


Figure 5-528: Reception Probability of Emergency Messages-Scenario 48, Road B, Sender RSU

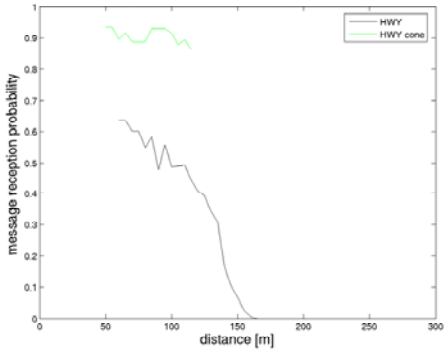


Figure 5-529: Reception Probability of Emergency Messages-Scenario 48, HWY, Sender RSU

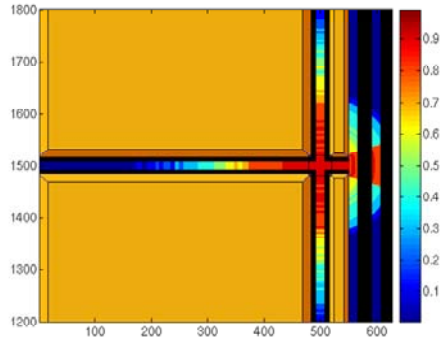


Figure 5-530: Reception Probability of Emergency Messages-Scenario 48, Sender RSU

5.5.3 Scenario 49

Simulation Scenario Setting:

Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	no buildings
Routine Message Frequency	2Hz

5.5.3.1 Reception Probability of Emergency Messages

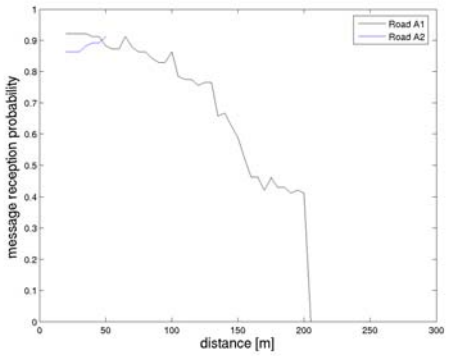


Figure 5-531: Reception Probability of Emergency Messages-Scenario 49, Road A, Sender RSU

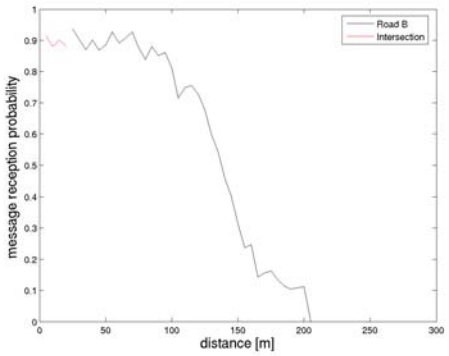


Figure 5-532: Reception Probability of Emergency Messages-Scenario 49, Road B, Sender RSU

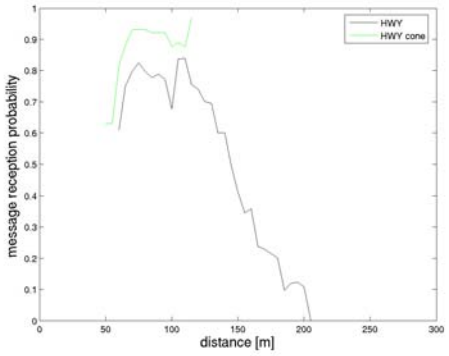


Figure 5-533: Reception Probability of Emergency Messages-Scenario 49, HWY, Sender RSU

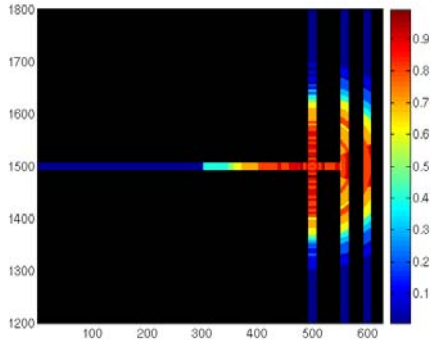


Figure 5-534: Reception Probability of Emergency Messages-Scenario 49, Sender RSU

5.5.4 Scenario 50

Simulation Scenario Setting:

Emergency Message Sender	RSU, 10Hz/ 500 bytes/ 200m
Corner Model	Tall buildings
Pt for emergency message	200m coverage
Pt for routine message	100m coverage
Routine Message Frequency	10Hz

5.5.4.1 Reception Probability of Emergency Messages

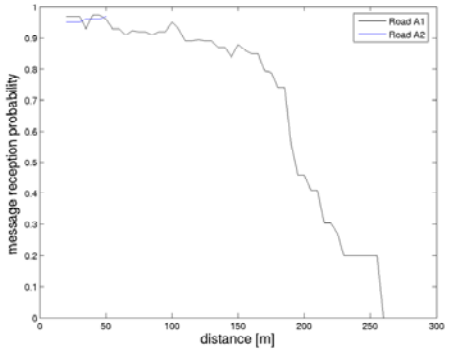


Figure 5-535: Reception Probability of Emergency Messages-Scenario 50, Road A, Sender RSU

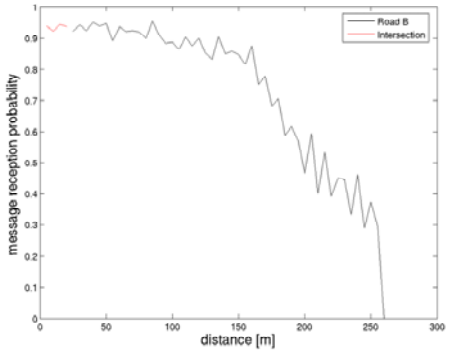


Figure 5-536: Reception Probability of Emergency Messages-Scenario 50, Road B, Sender RSU

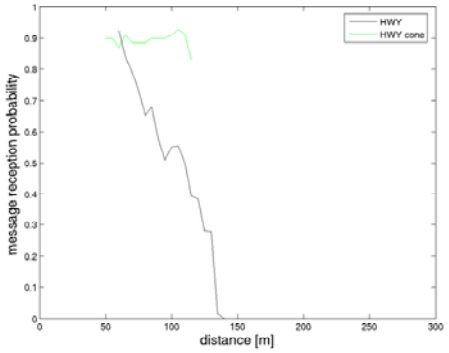


Figure 5-537: Reception Probability of Emergency Messages-Scenario 50, HWY, Sender RSU

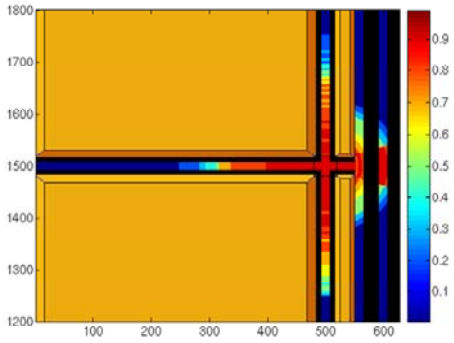


Figure 5-538: Reception Probability of Emergency Messages-Scenario 50, Sender RSU

6 Further Messaging Performance Analysis

The simulations results listed in the previous chapter provide figures of DSRC communication performance in various scenarios. However, it takes more than just a reception probability over distance figure for one to understand the implication of such communication performance for safety applications. For example, it could be better for a safety application to transmit 5 messages each at 50 percent reception probability than to deliver 1 message reliably in the same time frame.

This chapter provides further analysis figures based on the communication performance results of some selected scenarios. The new figures show the time period necessary for a sender to be confident to a certain degree that at least one message would be received by a receiver at a particular distance. All such figures have the X-axis set at 200 meters, and the Y-axis set at 2 seconds. Three confidence levels are shown, at 90 percent, 95 percent, and 99 percent.

The figures are produced in the following manner: Let p be the reception probability at distance d. Now find the number N so that after N transmission, the probability of receiving at least one of the messages should be greater than a given confidence level α.

$$p(at\ least\ 1\ success\ in\ N\ tries) = 1 - p(all\ \ failures\ in\ N\ tries) = 1 - (1-p)^N \geq \alpha$$

$$\longrightarrow (1-p)^N \leq 1-\alpha$$

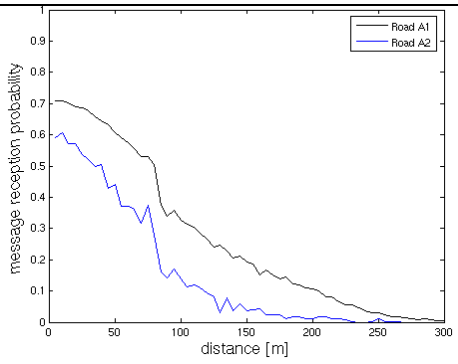
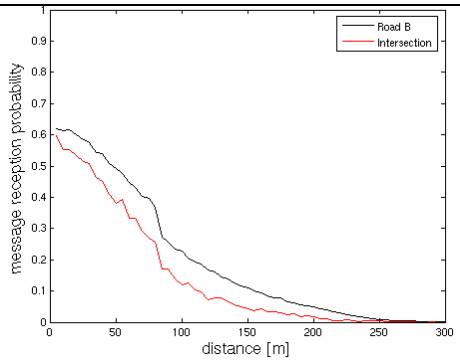
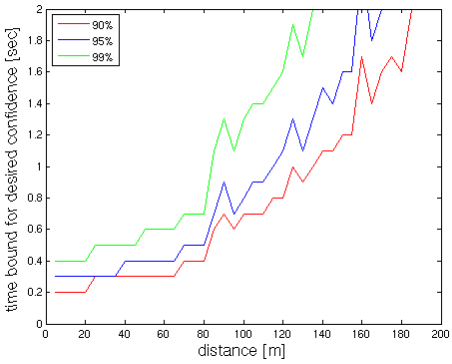
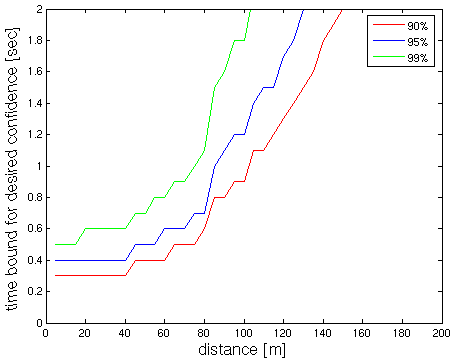
$$\longrightarrow N \geq \frac{\log(1-\alpha)}{\log(1-p)}$$

Therefore the time bound for a given confidence α is *N*Transmission Interval.*

6.1 Routine Safety Messages

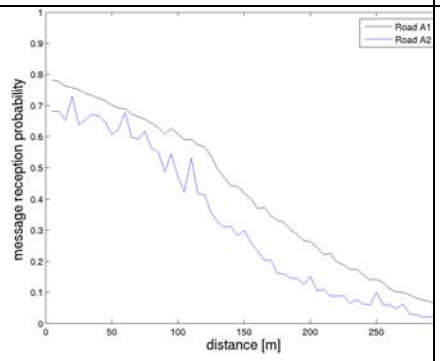
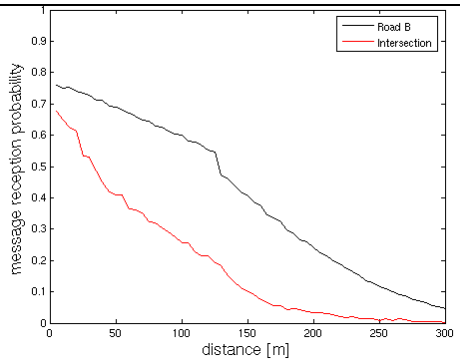
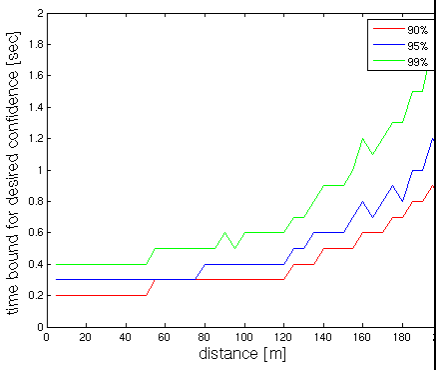
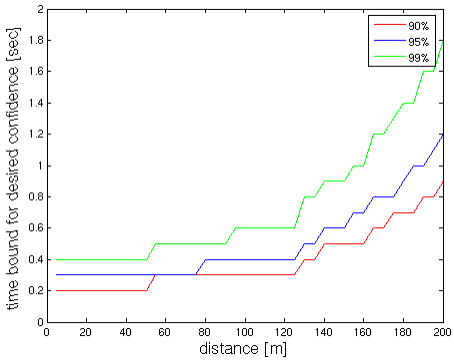
6.1.1 Scenario 9

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
	Distributed	Open	RSU	200m	ON	10Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability		
	Figure 6-1: Reception Probability of Routine Messages – Scenario 9, Road A	**Figure 6-2: Reception Probability of Routine Messages – Scenario 9, Road A**
Time bound for needed confidence		
	Figure 6-3: Time Bound for desired Confidence, Routine Messages - Scenario 9, Road A	**Figure 6-4: Time Bound for desired Confidence, Routine Messages - Scenario 9, Road B**

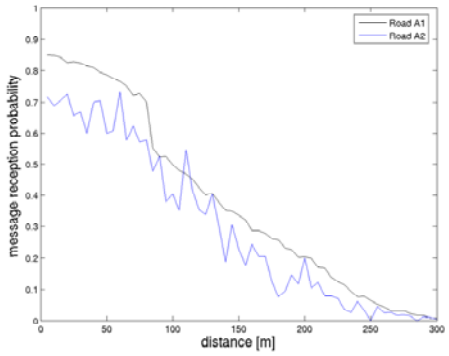
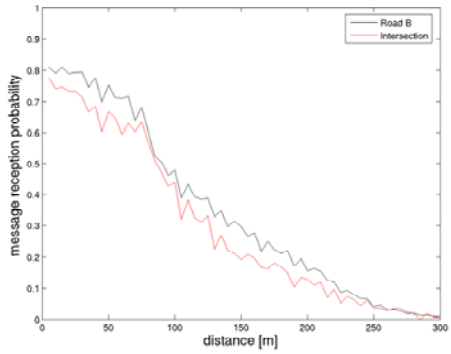
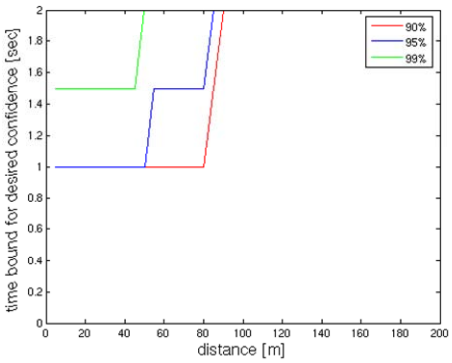
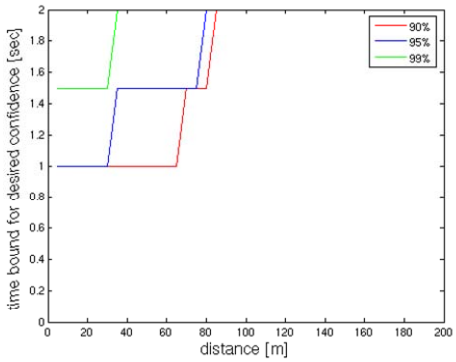
6.1.2 Scenario 11

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability		
	Figure 6-5: Reception Probability of Routine Messages on Road A, Scenario 11	**Figure 6-6: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence		
	Figure 6-7: Time Bound for desired Confidence, Routine Messages - Scenario 11, Road A	**Figure 6-8: Time Bound for desired Confidence, Routine Messages - Scenario 11, Road B**

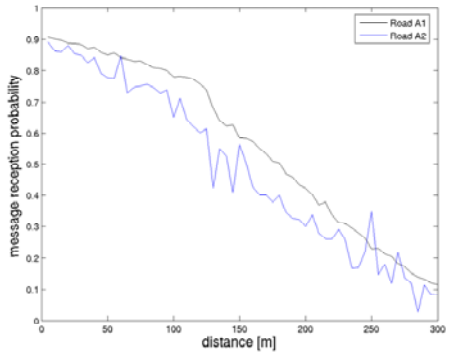
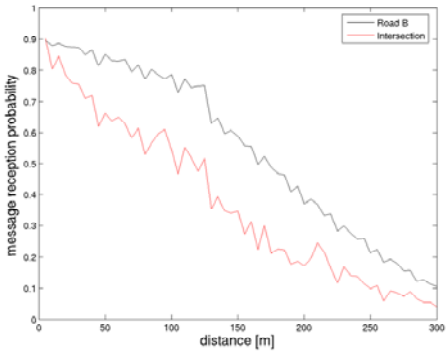
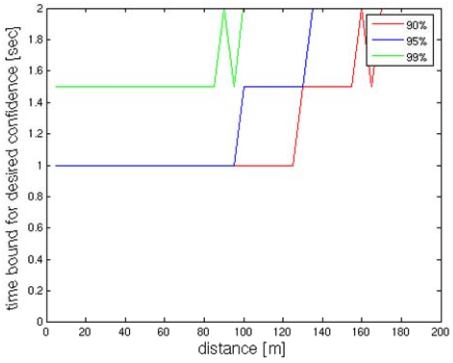
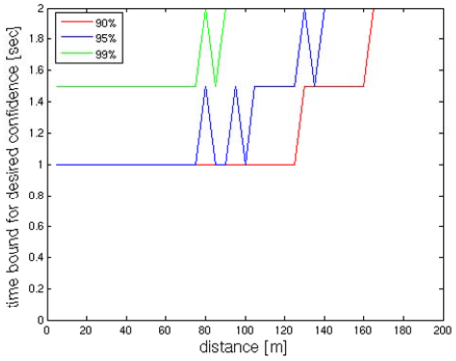
6.1.3 Scenario 17

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
17	Distributed	Open	RSU	200m	ON	2Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-9: Reception Probability of Routine Messages on Road A, Scenario 17**	 **Figure 6-10: Reception Probability of Routine Messages on Road B, Scenario 17**
Time bound for needed confidence	 **Figure 6-11: Time Bound for desired Confidence, Routine Messages - Scenario 17, Road A**	 **Figure 6-12: Time Bound for desired Confidence, Routine Messages - Scenario 17, Road B**

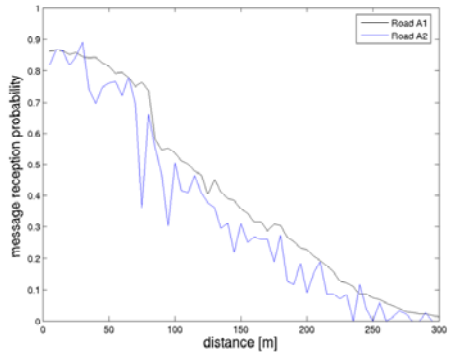
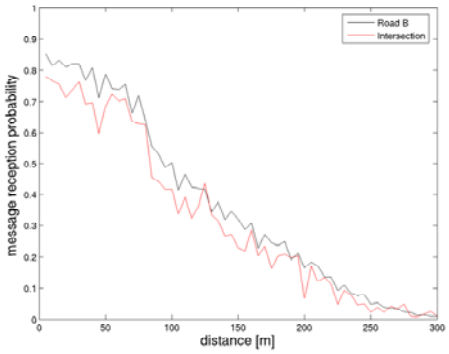
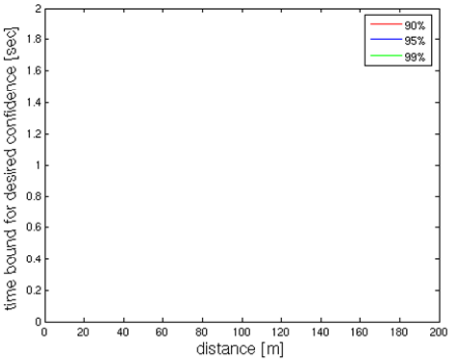
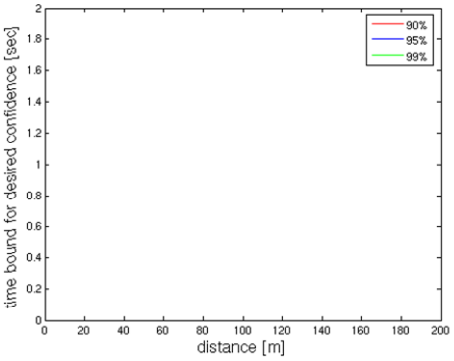
6.1.4 Scenario 19

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
19	Distributed	Building	RSU	200m	ON	2Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-13: Reception Probability of Routine Messages on Road A, Scenario 19**	 **Figure 6-14: Reception Probability of Routine Messages on Road B, Scenario 19**
Time bound for needed confidence	 **Figure 6-15: Time Bound for desired Confidence, Routine Messages - Scenario 19, Road A**	 **Figure 6-16: Time Bound for desired Confidence, Routine Messages - Scenario 19, Road B**

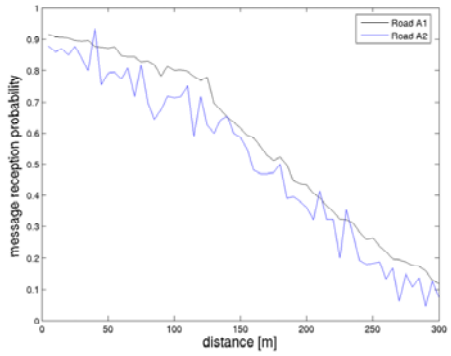
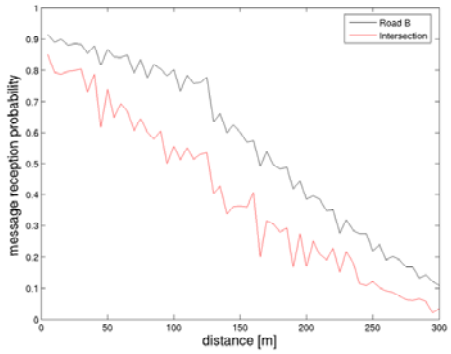
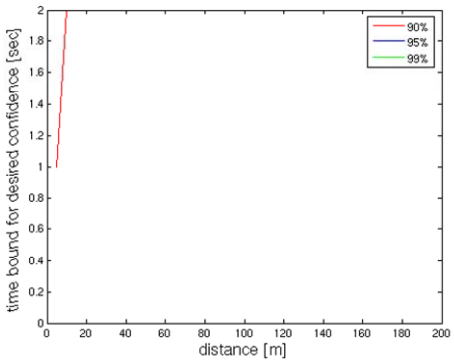
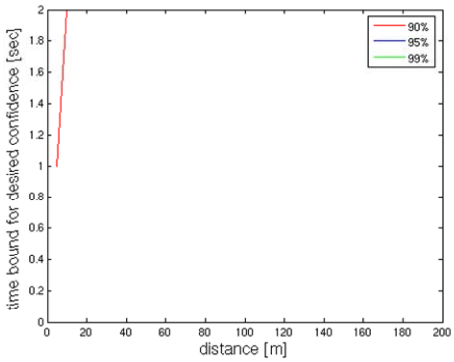
6.1.5 Scenario 25

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
25	Distributed	Open	RSU	200m	ON	1Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-17: Reception Probability of Routine Messages on Road A Scenario 25**	 **Figure 6-18: Reception Probability of Routine Messages on Road B Scenario 25**
Time bound for needed confidence	 **Figure 6-19: Time Bound for desired Confidence, Routine Messages - Scenario 25, Road A**	 **Figure 6-20: Time Bound for desired Confidence, Routine Messages - Scenario 25, Road B**

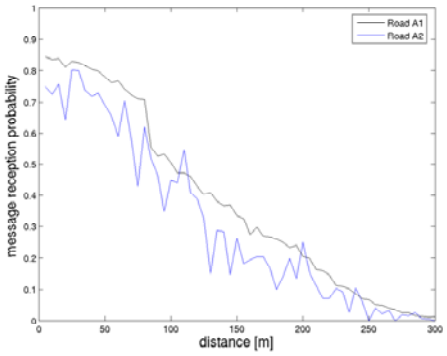
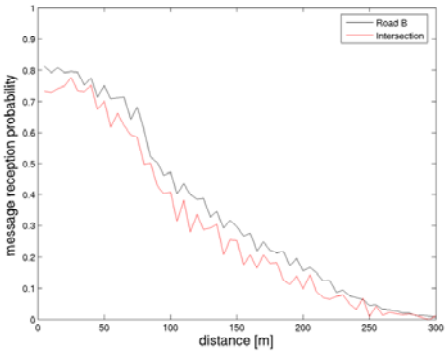
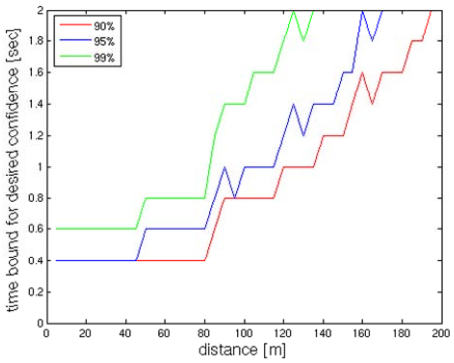
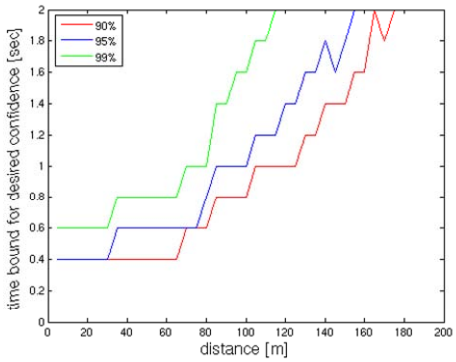
6.1.6 Scenario 27

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
27	Distributed	Building	RSU	200m	ON	1Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-21: Reception Probability of Routine Messages on Road A, Scenario 27**	 **Figure 6-22: Reception Probability of Routine Messages on Road B, Scenario 27**
Time bound for needed confidence	 **Figure 6-23: Time Bound for desired Confidence, Routine Messages - Scenario 27, Road A**	 **Figure 6-24: Time Bound for desired Confidence, Routine Messages - Scenario 27, Road B**

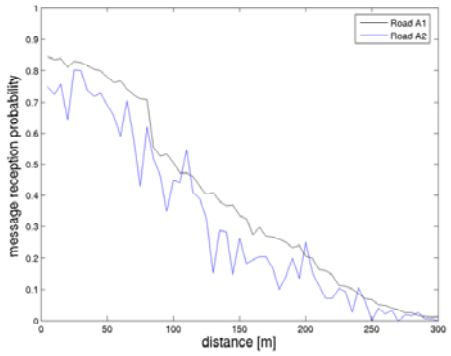
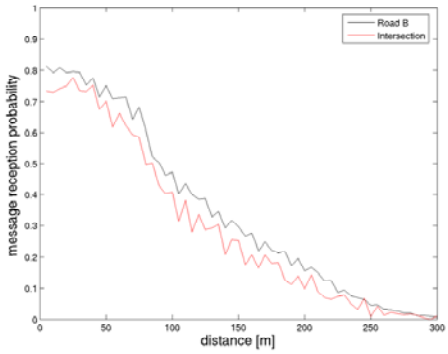
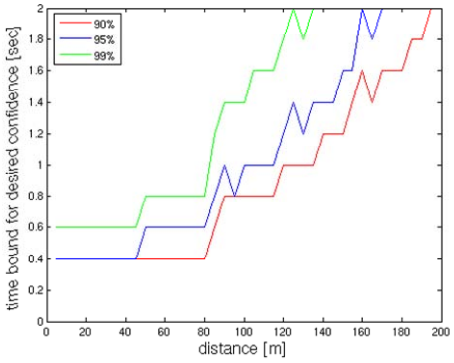
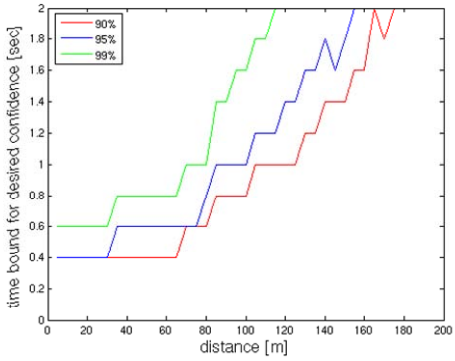
6.1.7 Scenario 33

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
33	Distributed	Open	RSU	200m	ON	5Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-25: Reception Probability of Routine Messages on Road A, Scenario 33**	 **Figure 6-26: Reception Probability of Routine Messages on Road B, Scenario 33**
Time bound for needed confidence	 **Figure 6-27: Time Bound for desired Confidence, Routine Messages - Scenario 33, Road A**	 **Figure 6-28: Time Bound for desired Confidence, Routine Messages - Scenario 33, Road B**

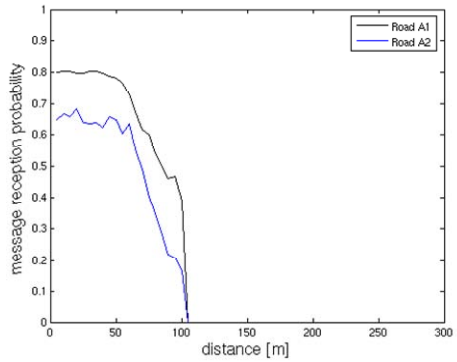
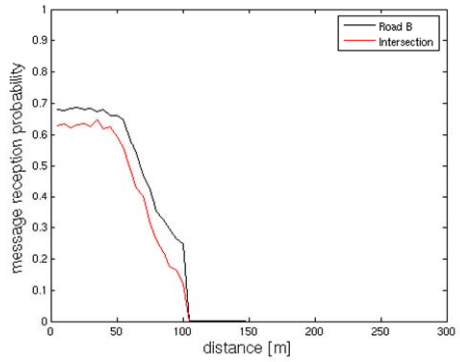
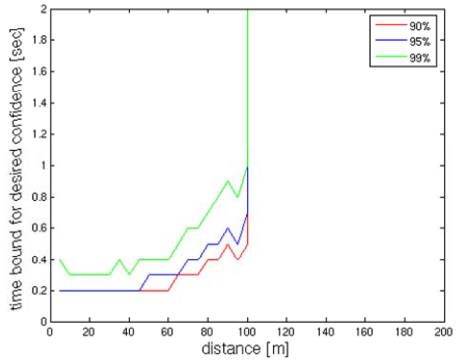
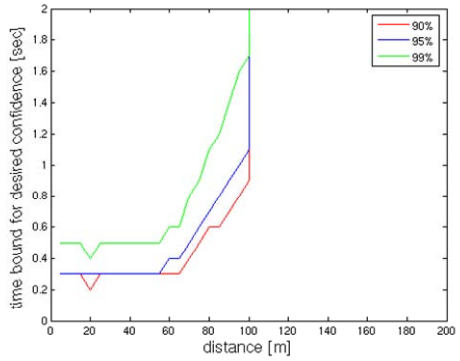
6.1.8 Scenario 35

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
35	Distributed	Building	RSU	200m	ON	5Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-29: Reception Probability of Routine Messages on Road A Scenario 35**	 **Figure 6-30: Reception Probability of Routine Messages on Road B Scenario 35**
Time bound for needed confidence	 **Figure 6-31: Time Bound for desired Confidence, Routine Messages - Scenario 35, Road A**	 **Figure 6-32: Time Bound for desired Confidence, Routine Messages - Scenario 35, Road B**

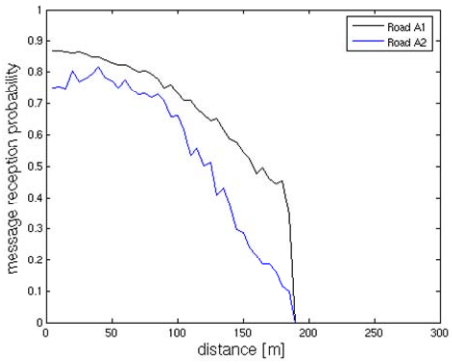
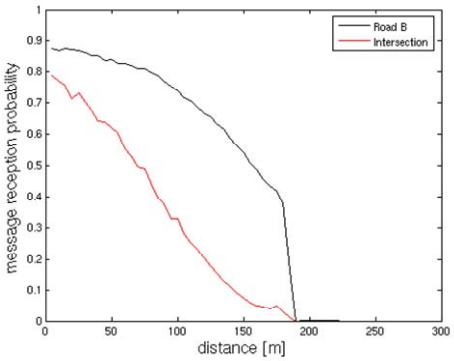
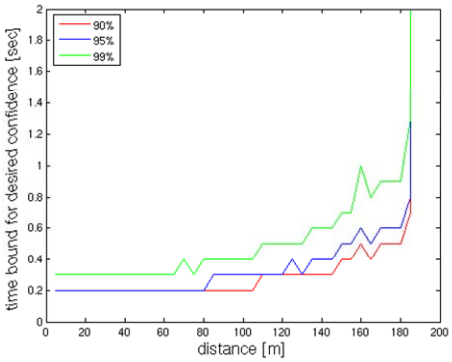
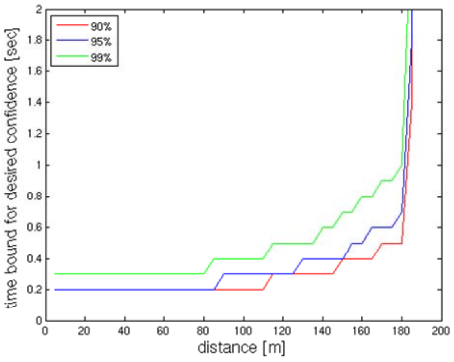
6.1.9 Scenario 49

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
35	Deterministic	Open Building	RSU	200m	ON	10Hz	100m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-33: Reception Probability of Routine Messages on Road A, Scenario 49**	 **Figure 6-34: Reception Probability of Routine Messages on Road B, Scenario 49**
Time bound for needed confidence	 **Figure 6-35: Time Bound for desired Confidence, Routine Messages - Scenario 49, Road A**	 **Figure 6-36: Time Bound for desired Confidence, Routine Messages - Scenario 49, Road B**

6.1.10 Scenario 50

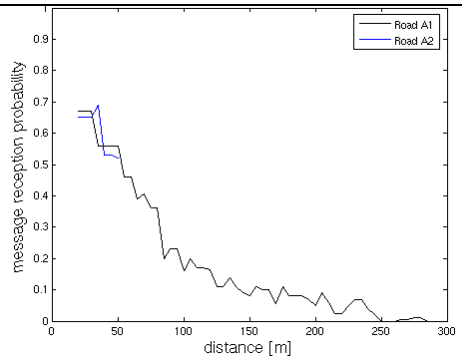
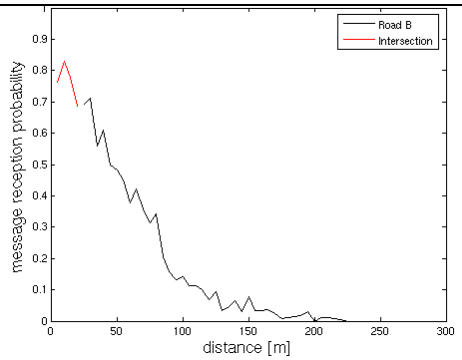
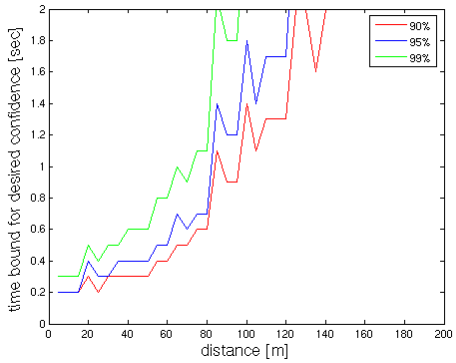
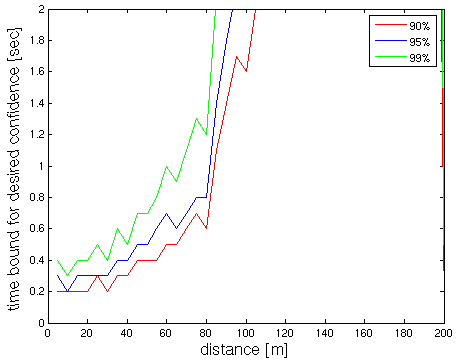
Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
35	Deterministic	Building	RSU	200m	ON	10Hz	100m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 6-37: Reception Probability of Routine Messages on Road A, Scenario 50**	 **Figure 6-38: Reception Probability of Routine Messages on Road B, Scenario 50**
Time bound for needed confidence	 **Figure 6-39: Time Bound for desired Confidence, Routine Messages - Scenario 50, Road A**	 **Figure 6-40: Time Bound for desired Confidence, Routine Messages - Scenario 50, Road B**

6.2 High Priority Emergency Messages

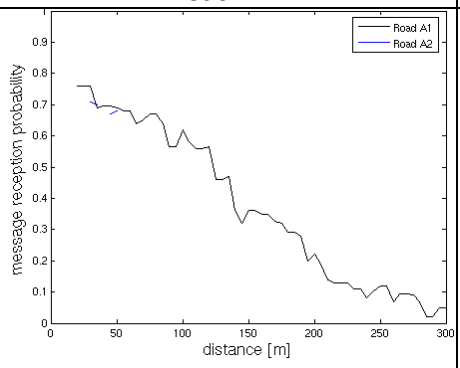
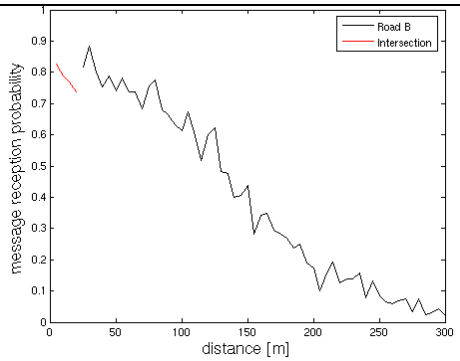
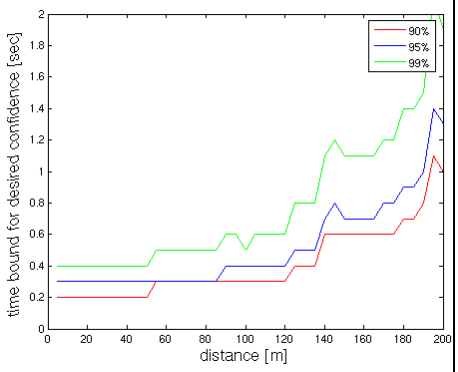
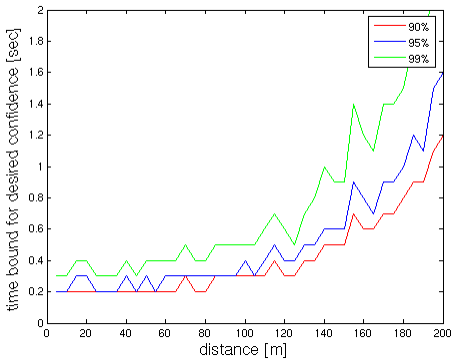
6.2.1 Scenario 9

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
9	Distributed	Open	RSU	200m	ON	10Hz	200m	

	Emergency messages	
	Road A	Road B
Reception probability		
	Figure 6-41: Reception Probability of Emergency Messages-Scenario 9, Road A, Sender RSU	**Figure 6-42: Reception Probability of Emergency Messages-Scenario 9, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 6-43: Time Bound for desired Confidence, Emergency Messages - Scenario 9, Road A, Sender RSU	**Figure 6-44: Time Bound for desired Confidence, Emergency Messages - Scenario 9, Road B, Sender RSU**

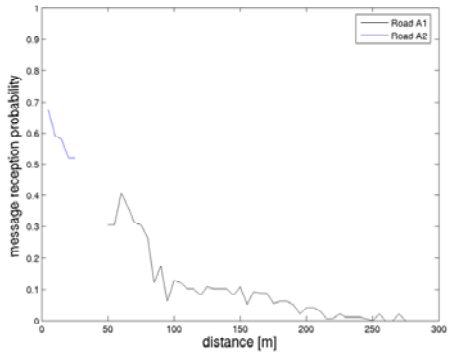
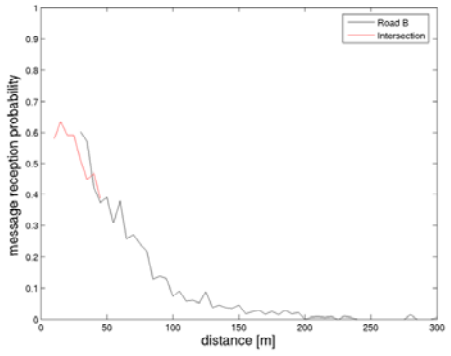
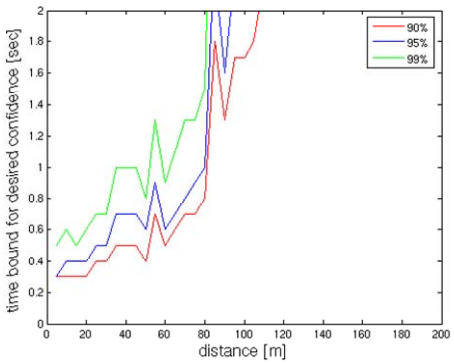
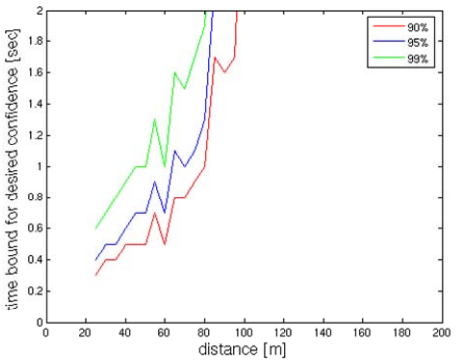
6.2.2 Scenario 11

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz	200m	

	Emergency messages	
	Road A	Road B
Reception probability		
	Figure 6-45: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 6-46: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 6-47: Time Bound for desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 6-48: Time Bound for desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

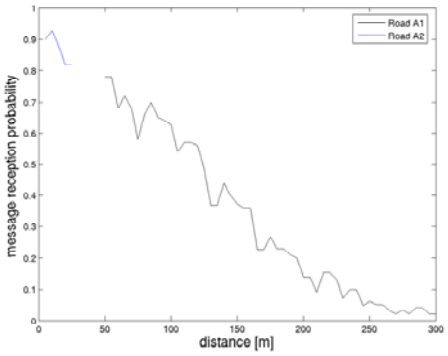
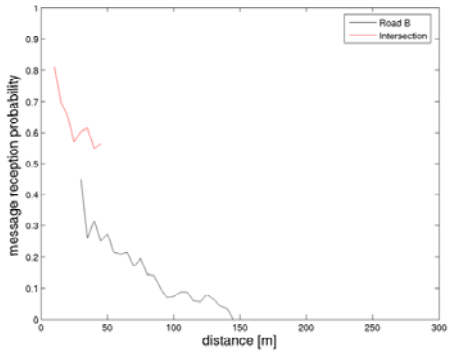
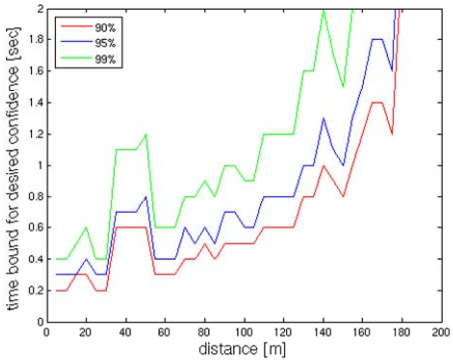
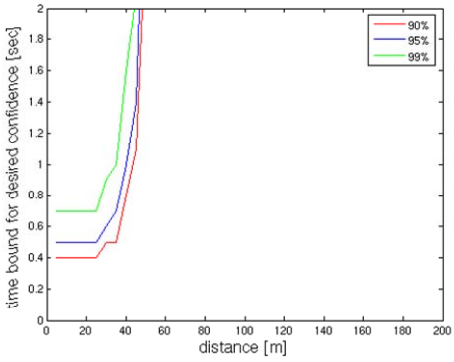
6.2.3 Scenario 13

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
13	Distributed	Open	OBU	200m	ON	10Hz	200m	

	Emergency Messages	
	OBU at A2 Reception on Road A	OBU at A2 Reception on Road B
Reception probability	 **Figure 6-49: Reception Prob. of Emergency Messages – Scenario 13, Rd. A, Sender on Rd. A2**	 **Figure 6-50: Reception Prob. of Emergency Messages – Scenario 13, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-51: Time Bound for desired Confidence, Emergency Messages – Scenario 13, Road A, Sender on Road A2**	 **Figure 6-52: Time Bound for desired Confidence, Emergency Messages - Scenario 13, Road B, Sender on Road A2**

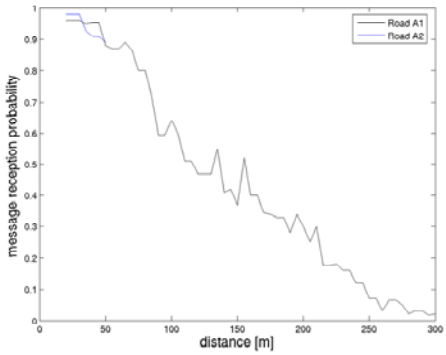
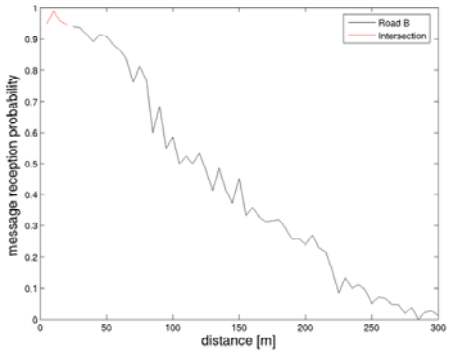
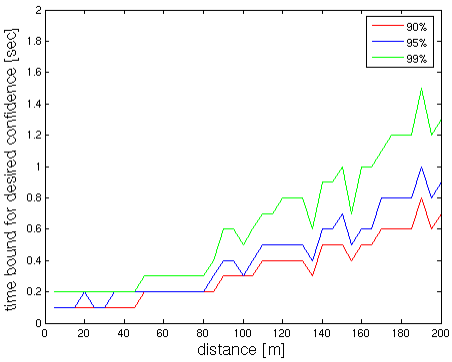
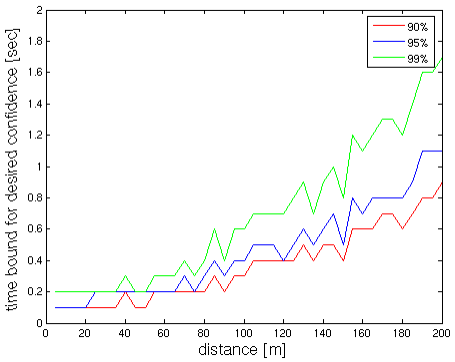
6.2.4 Scenario 15

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
15	Distributed	Building	OBU	200m	ON	10Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-53: Reception Prob. of Emergency Messages – Scenario 15, Rd. A, Sender on Rd. A2**	 **Figure 6-54: Reception Prob. of Emergency Messages – Scenario 15, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-55: Time Bound for desired Confidence, Emergency Messages - Scenario 15, Road A, Sender on Road A2**	 **Figure 6-56: Time Bound for desired Confidence, Emergency Messages - Scenario 15, Road B, Sender on Road A2**

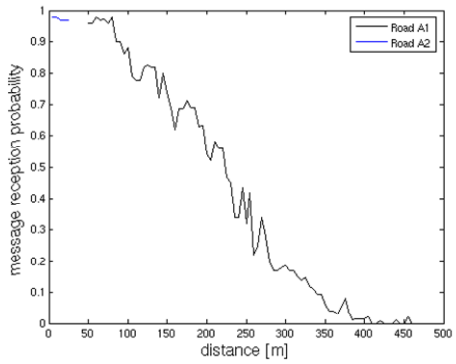
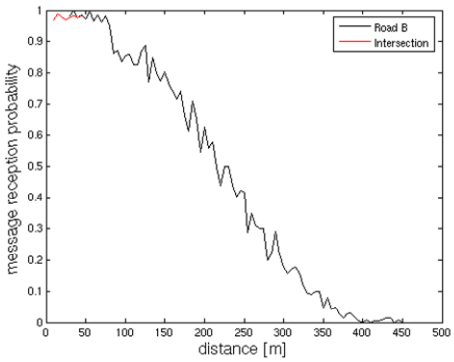
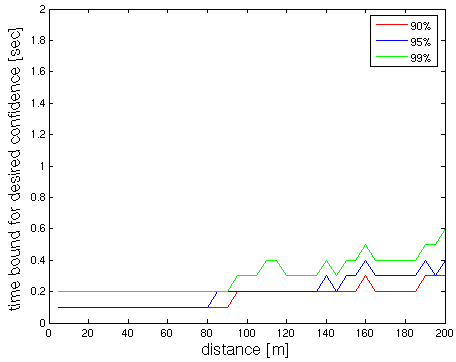
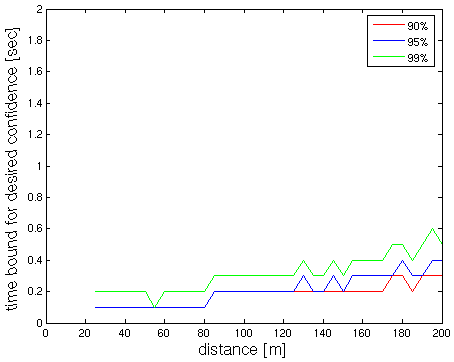
6.2.5 Scenario 17

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
17	Distributed	Open	RSU	200m	ON	2Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-57: Reception Probability of Emergency Messages-Scenario17, Road A, Sender RSU**	 **Figure 6-58: Reception Probability of Emergency Messages-Scenario 17, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-59: Time Bound for desired Confidence, Emergency Messages – Scenario 17, Road A, Sender RSU**	 **Figure 6-60: Time Bound for desired Confidence, Emergency Messages – Scenario 17, Road B, Sender RSU**

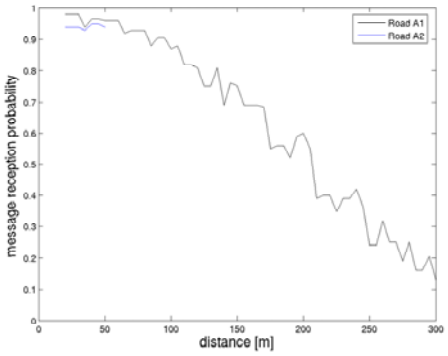
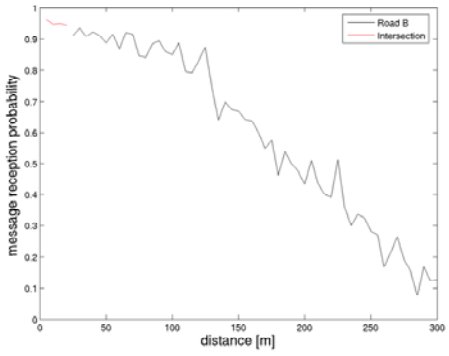
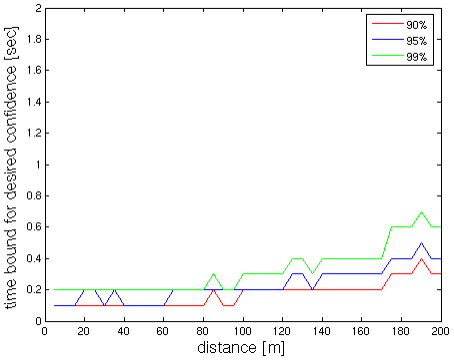
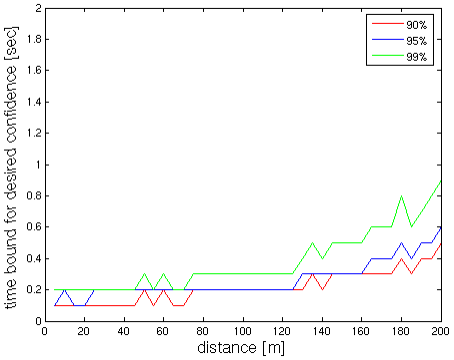
6.2.6 Scenario 18

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
18	Distributed	Open	OBU	200m	ON	2Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability		
	Figure 6-61: Reception Prob. of Emergency Messages – Scenario 18, Rd. A, Sender on Rd. A2	**Figure 6-62: Reception Prob. of Emergency Messages – Scenario 18, Rd. B, Sender on Rd. A2**
Time bound for needed confidence		
	Figure 6-63: Time Bound for desired Confidence, Emergency Messages - Scenario 18, Road A, Sender on Road A2	**Figure 6-64: Time Bound for desired Confidence, Emergency Messages - Scenario 18, Road B, Sender on Road A2**

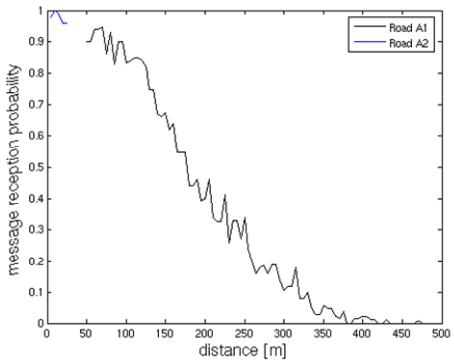
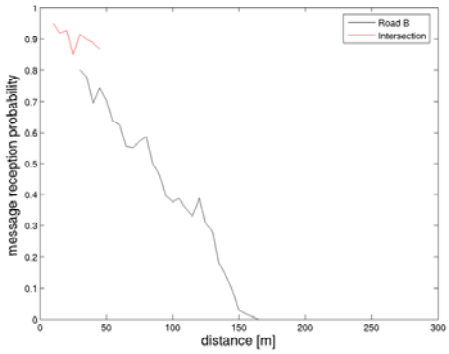
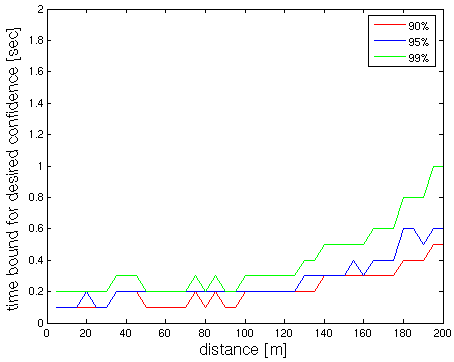
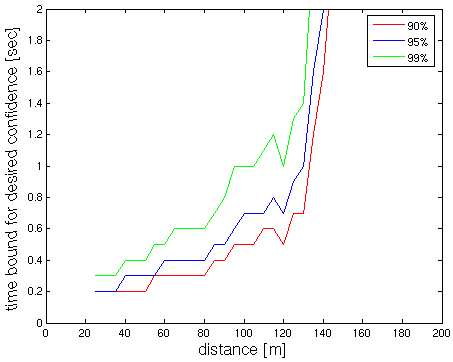
6.2.7 Scenario 19

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
19	Distributed	Building	RSU	200m	ON	2Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-65: Reception Probability of Emergency Messages-Scenario19, Road A, Sender RSU**	 **Figure 6-66: Reception Probability of Emergency Messages-Scenario19, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-67: Time Bound for desired Confidence, Emergency Messages - Scenario 19, Road A, Sender RSU**	 **Figure 6-68: Time Bound for desired Confidence, Emergency Messages - Scenario 19, Road B, Sender RSU**

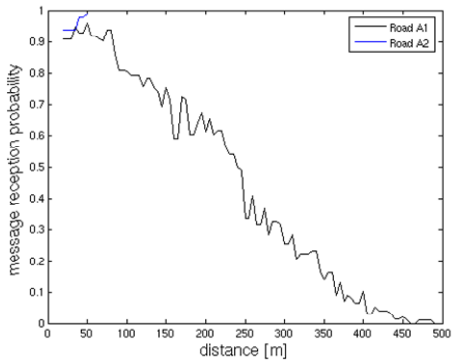
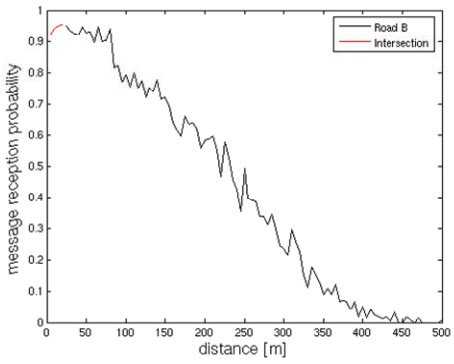
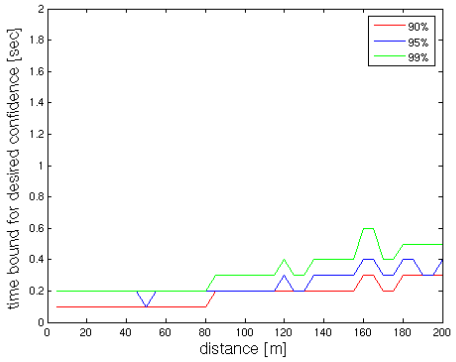
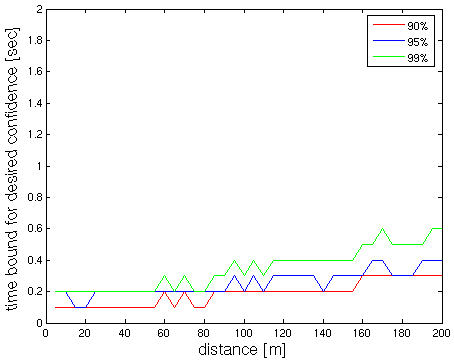
6.2.8 Scenario 20

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
20	Distributed	Building	OBU	200m	ON	2Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-69: Reception Prob. of Emergency Messages – Scenario 20, Rd. A, Sender on Rd. A2**	 **Figure 6-70: Reception Prob. of Emergency Messages – Scenario 20, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-71: Time Bound for desired Confidence, Emergency Messages - Scenario 20, Road A, Sender on Road A2**	 **Figure 6-72: Time Bound for desired Confidence, Emergency Messages - Scenario 20, Road B, Sender on Road A2**

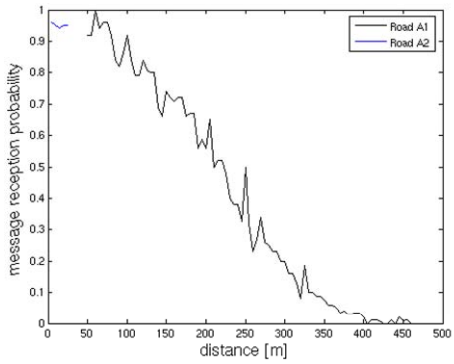
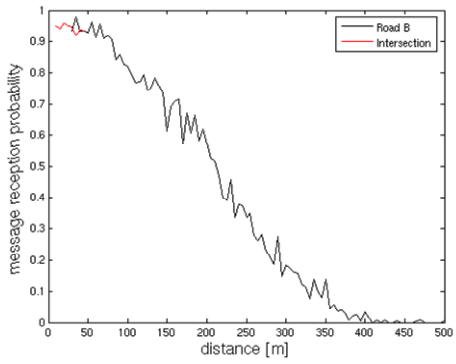
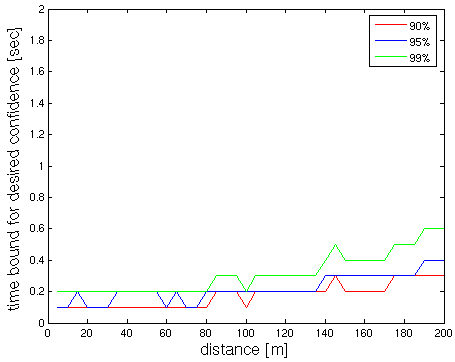
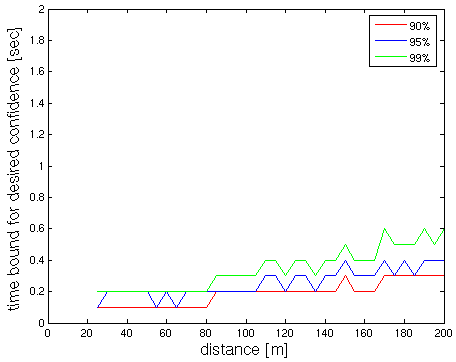
6.2.9 Scenario 21

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
21	Distributed	Open	RSU	300m	ON	2Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-73: Reception Probability of Emergency Messages-Scenario 21, Road A, Sender RSU**	 **Figure 6-74: Reception Probability of Emergency Messages-Scenario 21, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-75: Time Bound for desired Confidence, Emergency Messages - Scenario 21, Road A, Sender RSU**	 **Figure 6-76: Time Bound for desired Confidence, Emergency Messages - Scenario 21, Road B, Sender RSU**

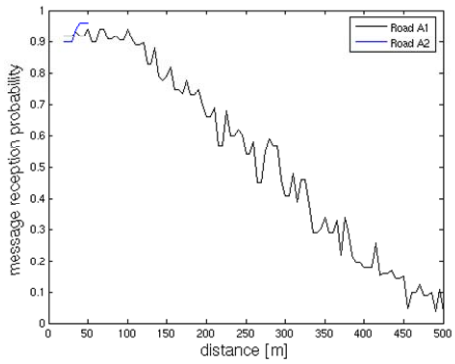
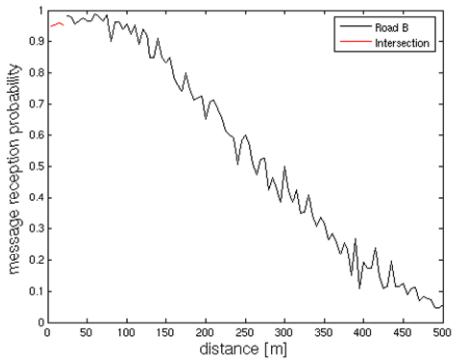
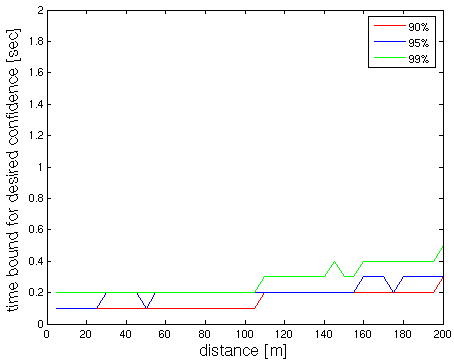
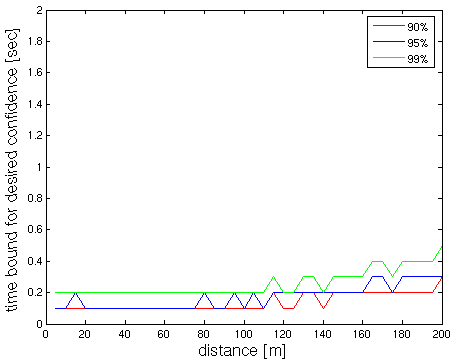
6.2.10 Scenario 22

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
22	Distributed	Open	OBU	300m	ON	2Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-77: Reception Prob. of Emergency Messages – Scenario 22, Rd. A, Sender on Rd. A2**	 **Figure 6-78: Reception Prob. of Emergency Messages – Scenario 22, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-79: Time Bound for desired Confidence, Emergency Messages - Scenario 22, Road A, Sender on Road A2**	 **Figure 6-80: Time Bound for desired Confidence, Emergency Messages - Scenario 22, Road B, Sender on Road A2**

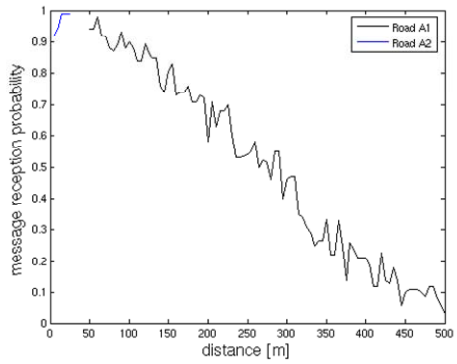
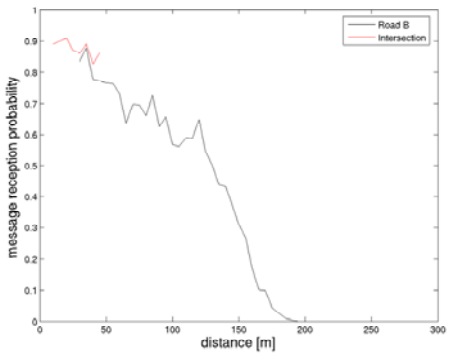
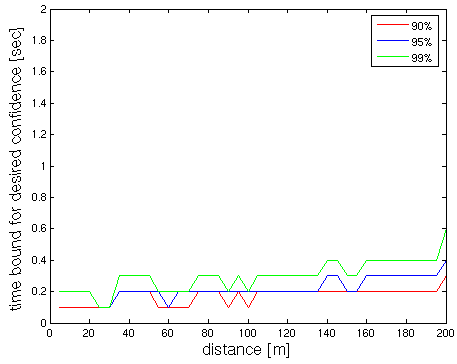
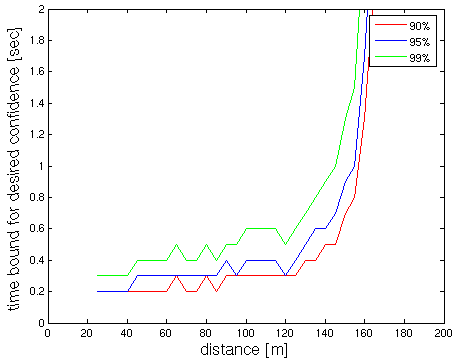
6.2.11 Scenario 23

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
23	Distributed	Building	RSU	300m	ON	2Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-81: Reception Probability of Emergency Messages-Scenario 23, Road A, Sender RSU**	 **Figure 6-82: Reception Probability of Emergency Messages-Scenario 23, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-83: Time Bound for desired Confidence, Emergency Messages - Scenario 23, Road A, Sender RSU**	 **Figure 6-84: Time Bound for desired Confidence, Emergency Messages - Scenario 23, Road B, Sender RSU**

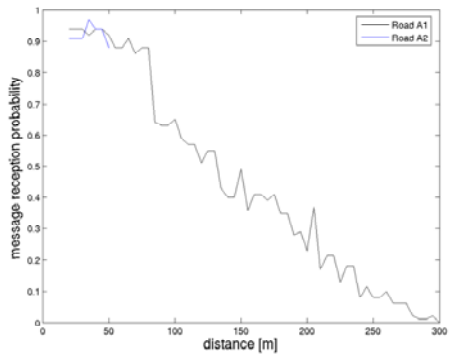
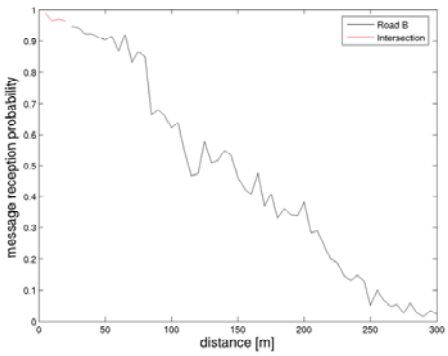
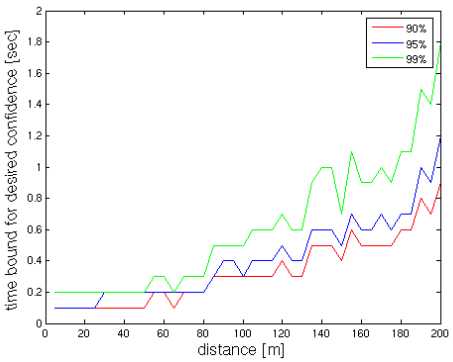
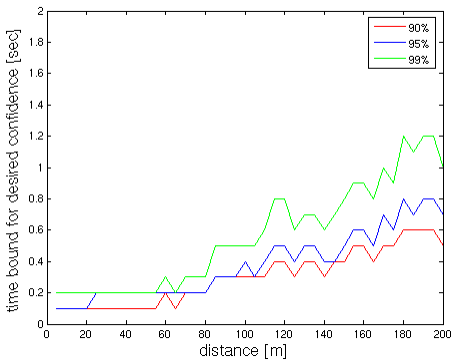
6.2.12 Scenario 24

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
24	Distributed	Building	OBU	300m	ON	2Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-85: Reception Prob. of Emergency Messages – Scenario 24, Rd. A, Sender on Rd. A2**	 **Figure 6-86: Reception Prob. Of Emergency Messages –Scenario 24, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-87: Time Bound for desired Confidence, Emergency Messages - Scenario 24, Road A, Sender on Road A2**	 **Figure 6-88: Time Bound for desired Confidence, Emergency Messages - Scenario 24, Road B, Sender on Road A2**

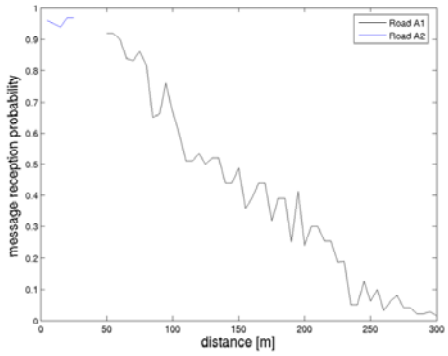
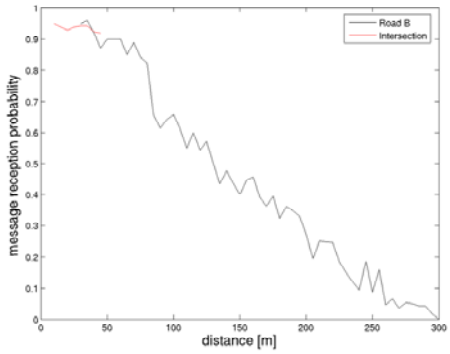
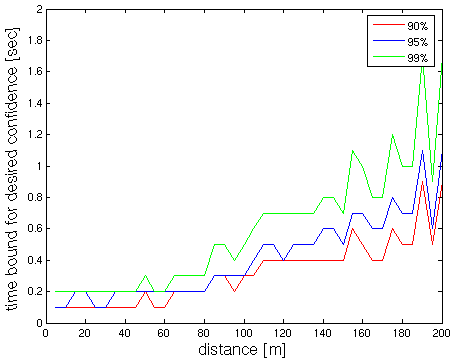
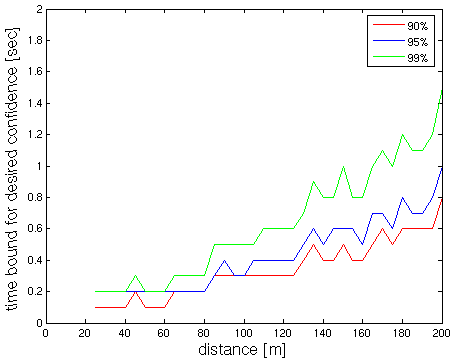
6.2.13 Scenario 25

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
25	Distributed	Open	RSU	200m	ON	1Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-89: Reception Probability of Emergency Messages-Scenario 25, Road A, Sender RSU**	 **Figure 6-90: Reception Probability of Emergency Messages-Scenario 25, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-91: Time Bound for desired Confidence, Emergency Messages - Scenario 25, Road A, Sender RSU**	 **Figure 6-92: Time Bound for desired Confidence, Emergency Messages - Scenario 25, Road B, Sender RSU**

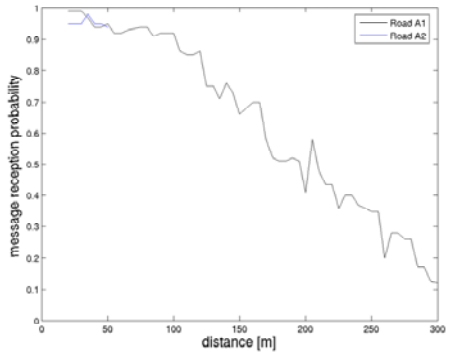
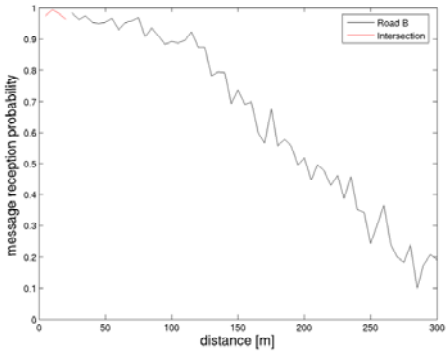
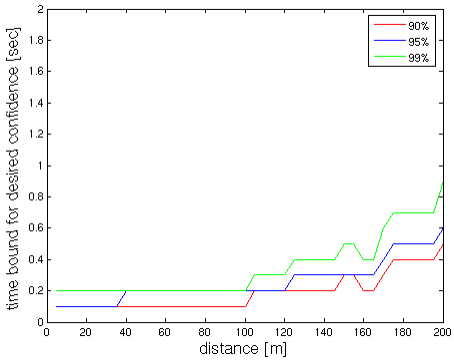
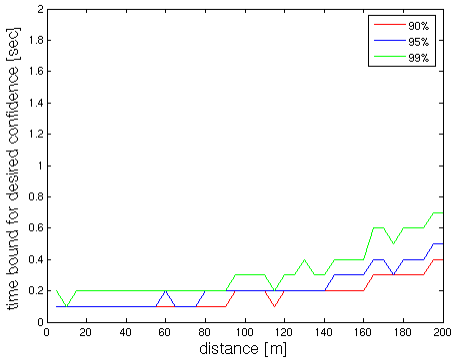
6.2.14 Scenario 26

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
26	Distributed	Open	OBU	200m	ON	1Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-93: Reception Prob. of Emergency Messages – Scenario 26, Rd. A, Sender on Rd. A2**	 **Figure 6-94: Reception Prob. of Emergency Messages – Scenario 26, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-95: Time Bound for desired Confidence, Emergency Messages - Scenario 26, Road A, Sender on Road A2**	 **Figure 6-96: Time Bound for desired Confidence, Emergency Messages - Scenario 26, Road B, Sender on Road A2**

6.2.15 Scenario 27

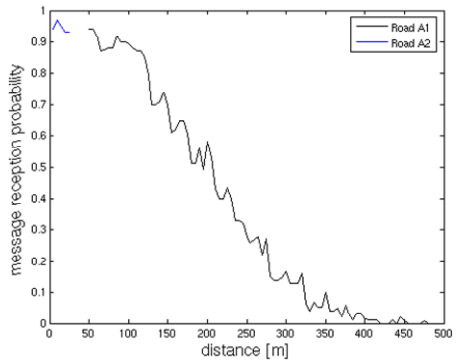
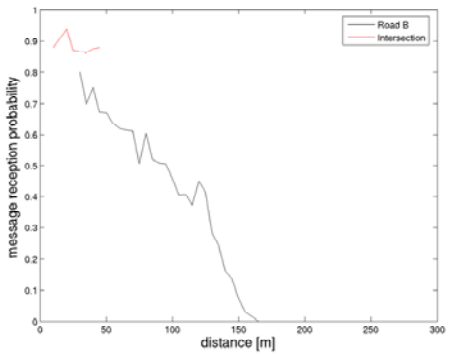
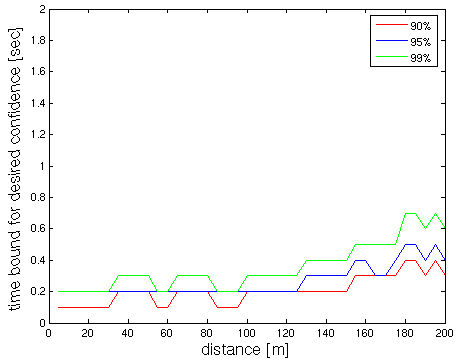
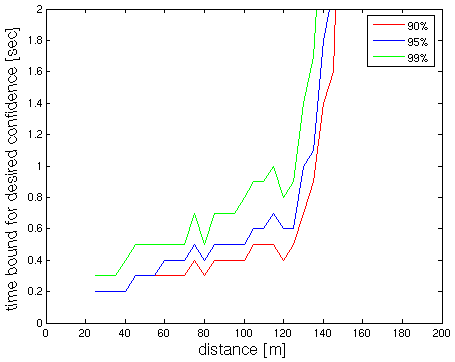
Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
27	Distributed	Building	RSU	200m	ON	1Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-97: Reception Probability of Emergency Messages-Scenario 27, Road A, Sender RSU**	 **Figure 6-98: Reception Probability of Emergency Messages-Scenario 27, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-99: Time Bound for desired Confidence, Emergency Messages - Scenario 27, Road A, Sender RSU**	 **Figure 6-100: Time Bound for desired Confidence, Emergency Messages – Scenario 27, Road B, Sender RSU**

6.2.16 Scenario 28

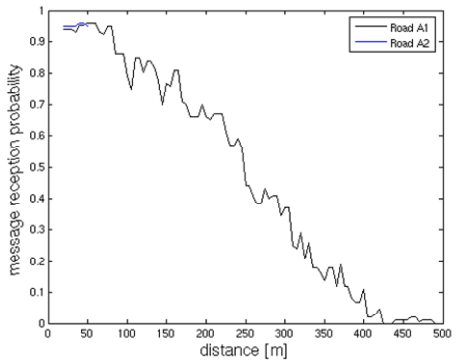
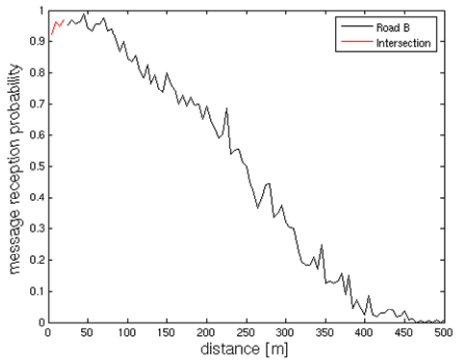
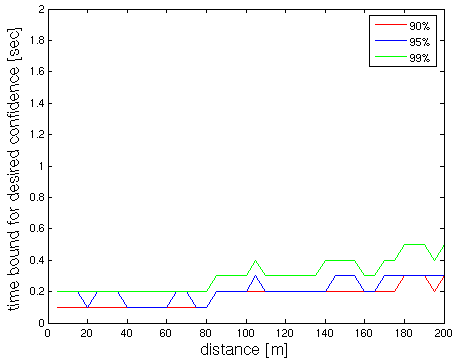
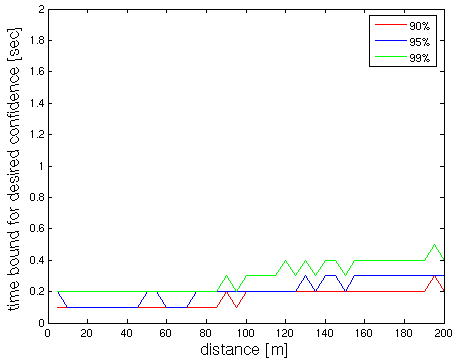
Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
28	Distributed	Building	OBU	200m	ON	1Hz	200m	

Emergency Messages

	Road A2	Road B
Reception probability	 **Figure 6-101: Reception Prob. of Emergency Messages – Scenario 28, Rd. A, Sender on Rd. A2**	 **Figure 6-102: Reception Prob. of Emergency Messages – Scenario 28, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-103: Time Bound for desired Confidence, Emergency Messages - Scenario 28, Road A, Sender on Road A2**	 **Figure 6-104: Time Bound for desired Confidence, Emergency Messages - Scenario 28, Road B, Sender on Road A2**

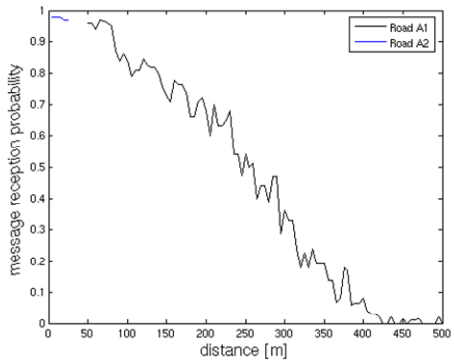
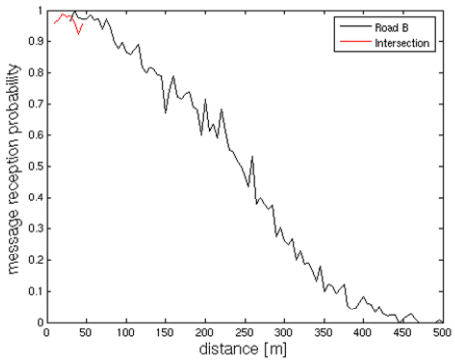
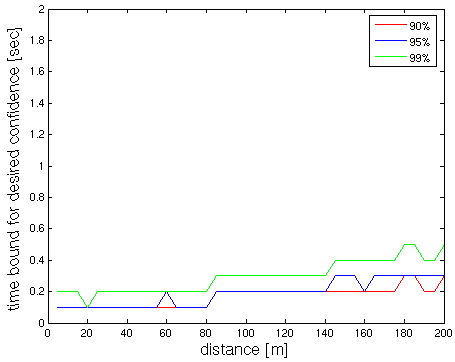
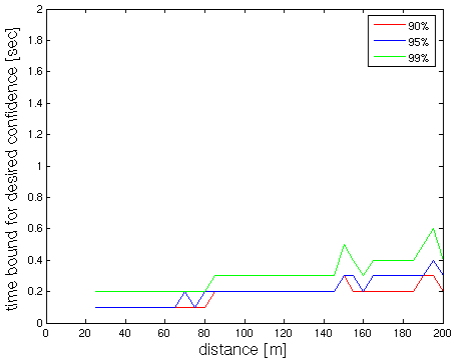
6.2.17 Scenario 29

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
29	Distributed	Open	RSU	300m	ON	1Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-105: Reception Probability of Emergency Messages-Scenario 29, Road A, Sender RSU**	 **Figure 6-106: Reception Probability of Emergency Messages-Scenario 29, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-107: Time Bound for desired Confidence, Emergency Messages - Scenario 29, Road A, Sender RSU**	 **Figure 6-108: Time Bound for desired Confidence, Emergency Messages - Scenario 29, Road B, Sender RSU**

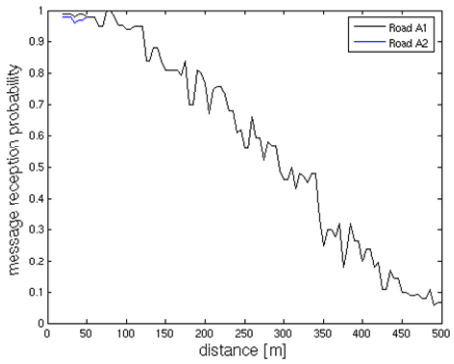
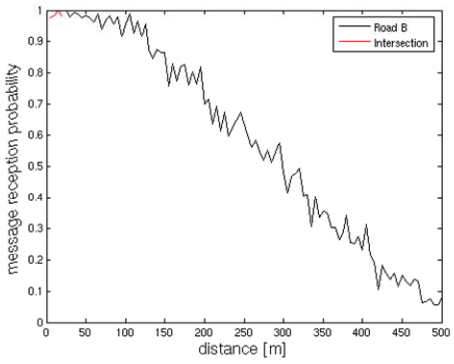
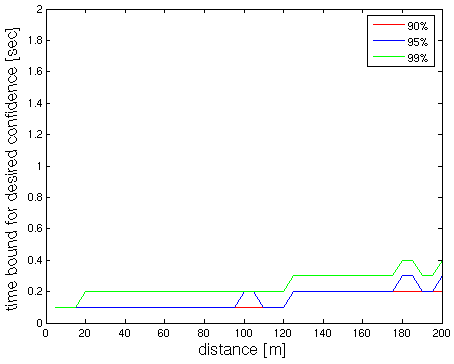
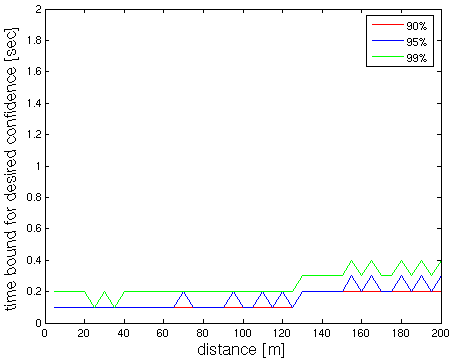
6.2.18 Scenario 30

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
30	Distributed	Open	OBU	300m	ON	1Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability		
	Figure 6-109: Reception Prob. of Emergency Messages – Scenario 30, Rd. A, Sender on Rd. A2	**Figure 6-110: Reception Prob. of Emergency Messages – Scenario 30, Rd. B, Sender on Rd A2**
Time bound for needed confidence		
	Figure 6-111: Time Bound for desired Confidence, Emergency Messages - Scenario 30, Road A, Sender on Road A2	**Figure 6-112: Time Bound for desired Confidence, Emergency Messages - Scenario 30, Road B, Sender on Road A2**

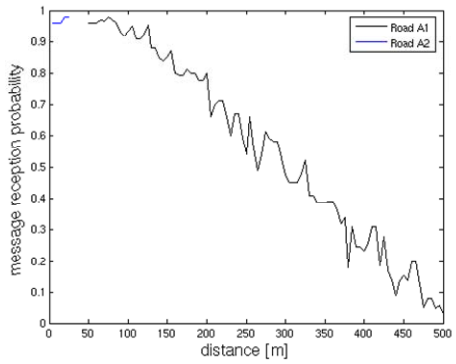
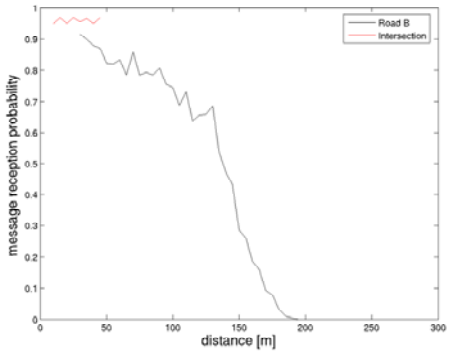
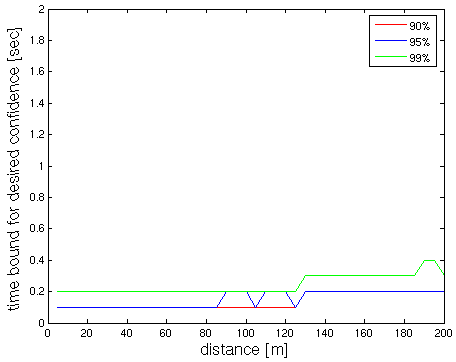
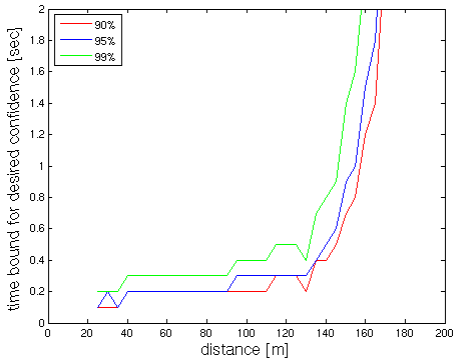
6.2.19 Scenario 31

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
31	Distributed	Building	RSU	300m	ON	1Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-113: Reception Probability of Emergency Messages-Scenario 31, Road A, Sender RSU**	 **Figure 6-114: Reception Probability of Emergency Messages-Scenario 31, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-115: Time Bound for desired Confidence, Emergency Messages - Scenario 31, Road A, Sender RSU**	 **Figure 6-116: Time Bound for desired Confidence, Emergency Messages - Scenario 31, Road B, Sender RSU**

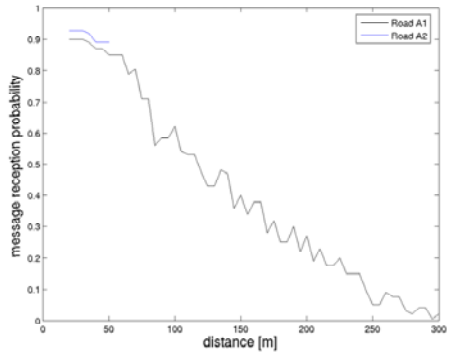
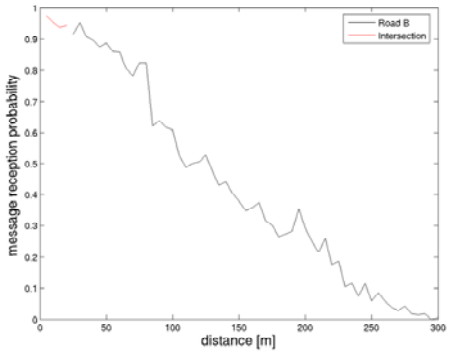
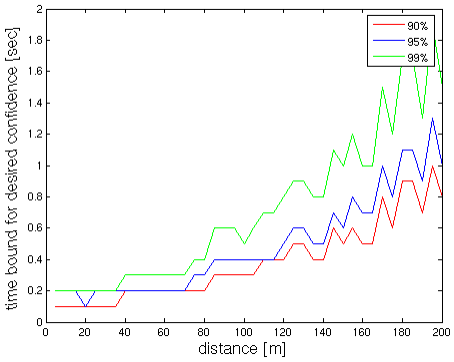
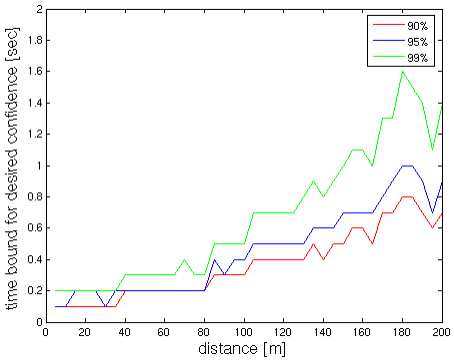
6.2.20 Scenario 32

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
32	Distributed	Building	OBU	300m	ON	1Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability		
	Figure 6-117: Reception Prob. of Emergency Messages – Scenario 32, Rd. A, Sender on Rd. A2	**Figure 6-118: Reception Prob. of Emergency Messages – Scenario 32, Rd. B, Sender on Rd A2**
Time bound for needed confidence		
	Figure 6-119: Time Bound for desired Confidence, Emergency Messages - Scenario 32, Road A, Sender on Road A2	**Figure 6-120: Time Bound for desired Confidence, Emergency Messages – Scenario 32, Road B, Sender on Road A2**

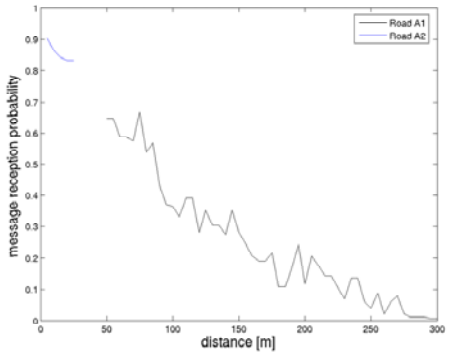
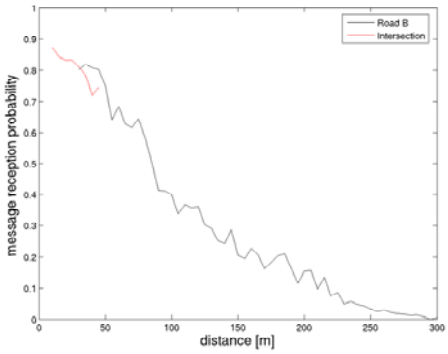
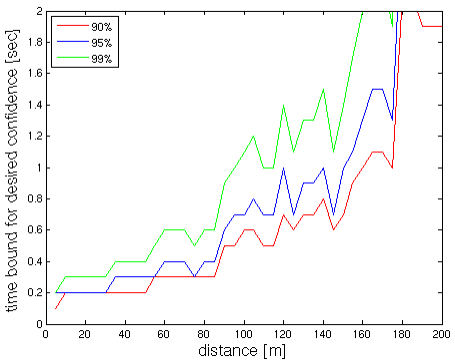
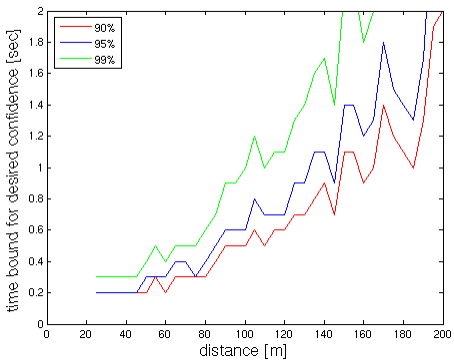
6.2.21 Scenario 33

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
33	Distributed	Open	RSU	200m	ON	5Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-121: Reception Probability of Emergency Messages-Scenario 33, Road A, Sender RSU**	 **Figure 6-122: Reception Probability of Emergency Messages-Scenario 33, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-123: Time Bound for desired Confidence, Emergency Messages - Scenario 33, Road A, Sender RSU**	 **Figure 6-124: Time Bound for desired Confidence, Emergency Messages – Scenario 33, Road B, Sender RSU**

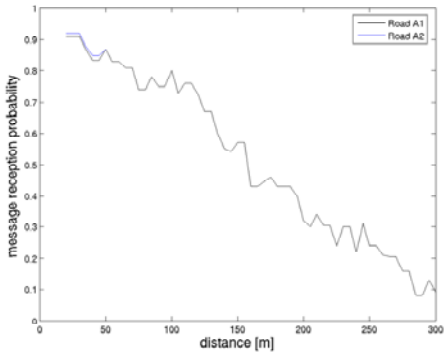
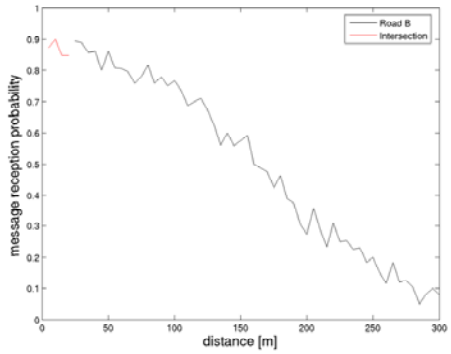
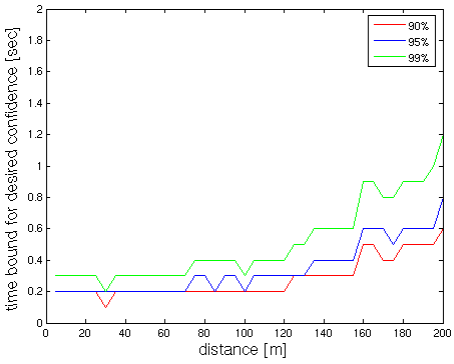
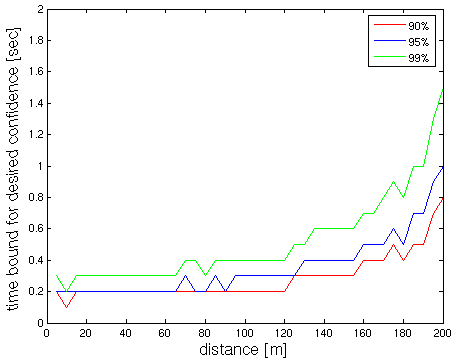
6.2.22 Scenario 34

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
34	Distributed	Open	OBU	200m	ON	5Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-125: Reception Prob. of Emergency Messages – Scenario 34, Rd. A, Sender on Rd. A2**	 **Figure 6-126: Reception Prob. of Emergency Messages – Scenario 34, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-127: Time Bound for desired Confidence, Emergency Messages - Scenario 34, Road A, Sender on Road A2**	 **Figure 6-128: Time Bound for desired Confidence, Emergency Messages - Scenario 34, Road B, Sender on Road A2**

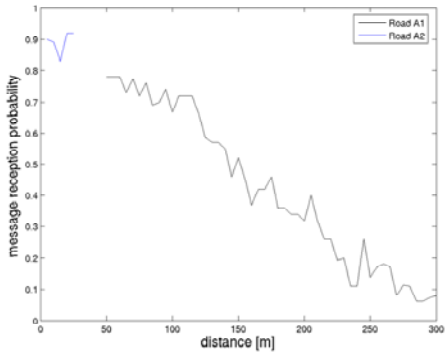
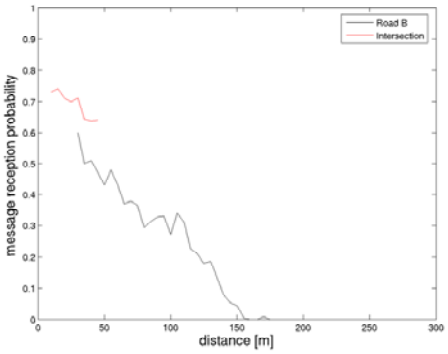
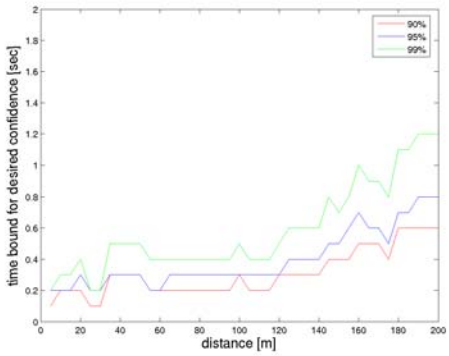
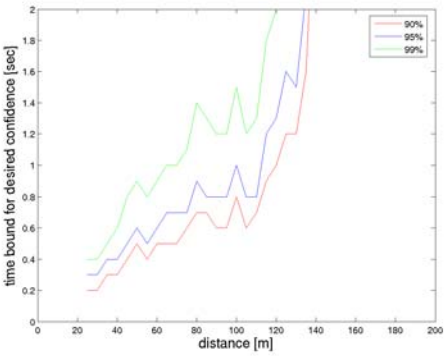
6.2.23 Scenario 35

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
35	Distributed	Building	RSU	200m	ON	5Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability		
	Figure 6-129: Reception Probability of Emergency Messages-Scenario 35, Road A, Sender RSU	**Figure 6-130: Reception Probability of Emergency Messages-Scenario 35, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 6-131: Time Bound for desired Confidence, Emergency Messages - Scenario 35, Road A, Sender RSU	**Figure 6-132: Time Bound for desired Confidence, Emergency Messages – Scenario 35, Road B, Sender RSU**

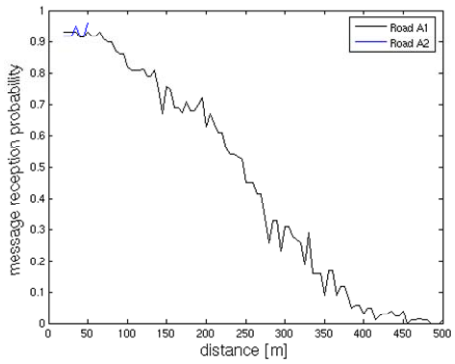
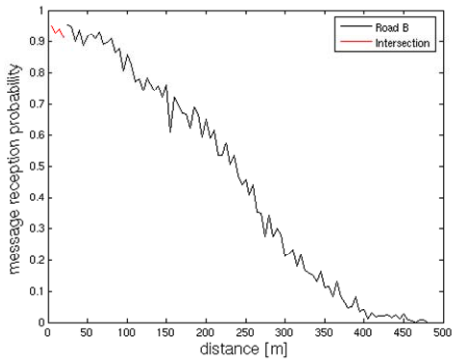
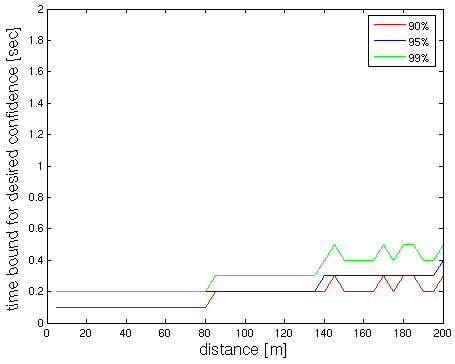
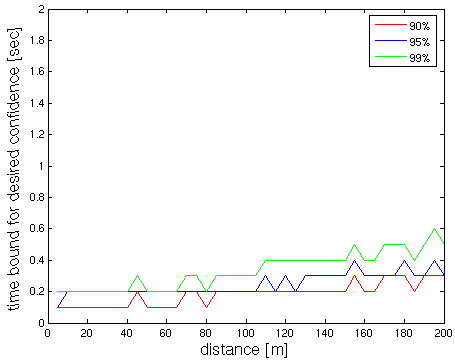
6.2.24 Scenario 36

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
36	Distributed	Building	OBU	200m	ON	5Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-133: Reception Prob. of Emergency Messages – Scenario 36, Rd. A, Sender on Rd. A2**	 **Figure 6-134: Reception Prob. of Emergency Messages – Scenario 36, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-135: Time Bound for desired Confidence, Emergency Messages - Scenario 36, Road A, Sender on Road A2**	 **Figure 6-136: Time Bound for desired Confidence, Emergency Messages - Scenario 36, Road B, Sender on Road A2**

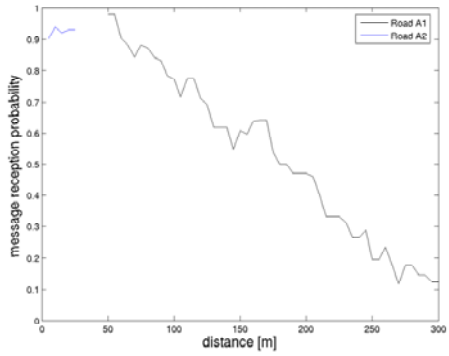
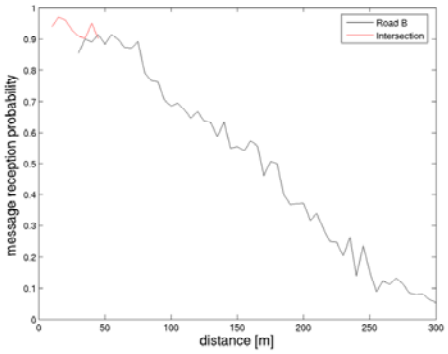
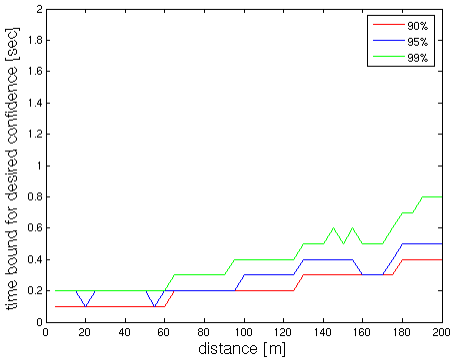
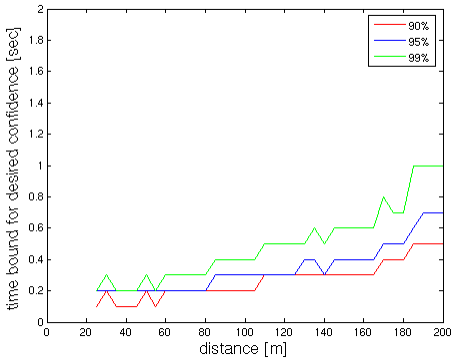
6.2.25 Scenario 37

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
37	Distributed	Open	RSU	300m	ON	5Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-137: Reception Probability of Emergency Messages-Scenario 37, Road A, Sender RSU**	 **Figure 6-138: Reception Probability of Emergency Messages-Scenario 37, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-139: Time Bound for desired Confidence, Emergency Messages - Scenario 37, Road A, Sender RSU**	 **Figure 6-140: Time Bound for desired Confidence, Emergency Messages - Scenario 37, Road B, Sender RSU**

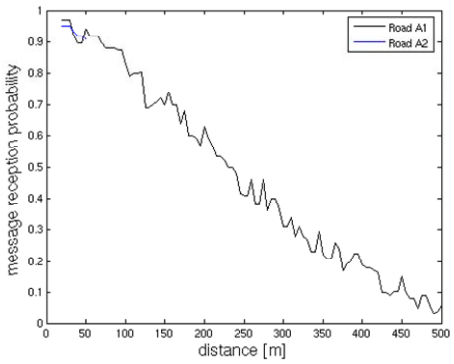
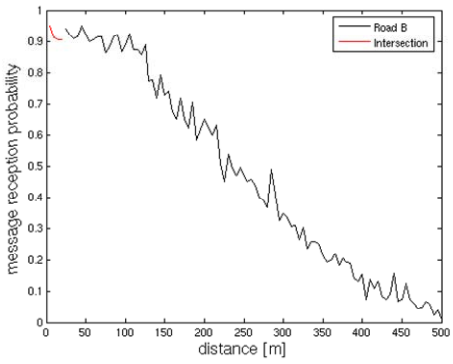
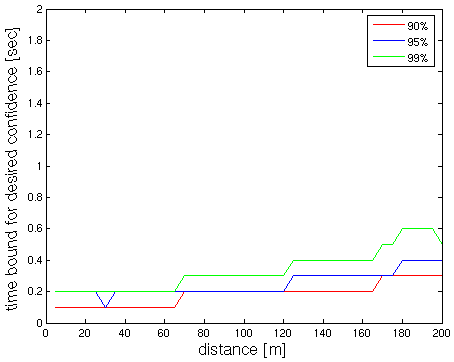
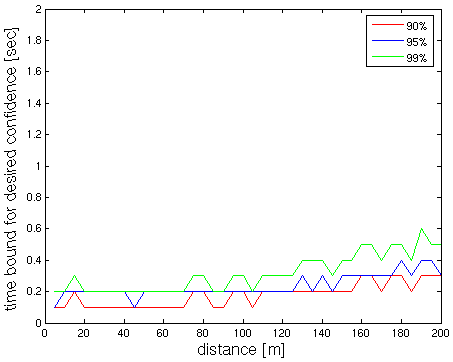
6.2.26 Scenario 38

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
38	Distributed	Open	OBU	300m	ON	5Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-141: Reception Prob. of Emergency Messages – Scenario 38, Rd. A, Sender on Rd. A2**	 **Figure 6-142: Reception Prob. of Emergency Messages –Scenario 38, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-143: Time Bound for desired Confidence, Emergency Messages - Scenario 38, Road A, Sender on Road A2**	 **Figure 6-144: Time Bound for desired Confidence, Emergency Messages - Scenario 38, Road B, Sender on Road A2**

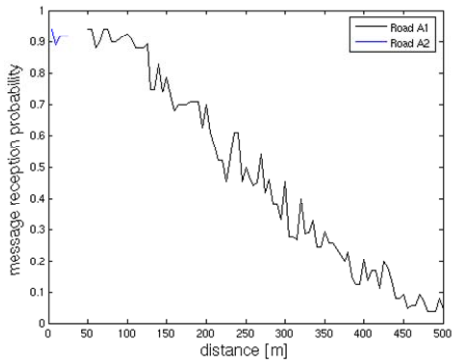
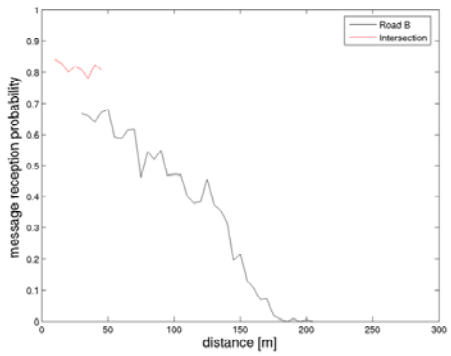
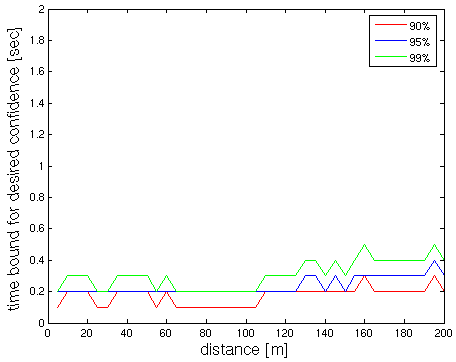
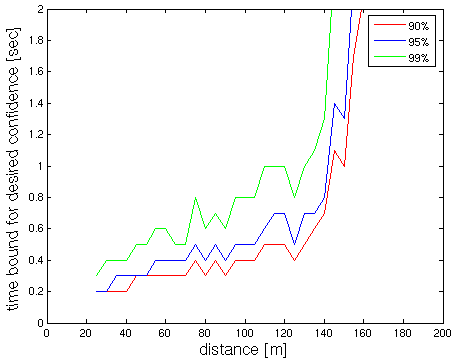
6.2.27 Scenario 39

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
39	Distributed	Building	RSU	300m	ON	5Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-145: Reception Probability of Emergency Messages-Scenario 39, Road A, Sender RSU**	 **Figure 6-146: Reception Probability of Emergency Messages-Scenario 39, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-147: Time Bound for desired Confidence, Emergency Messages - Scenario 39, Road A, Sender RSU**	 **Figure 6-148: Time Bound for desired Confidence, Emergency Messages - Scenario 39, Road B, Sender RSU**

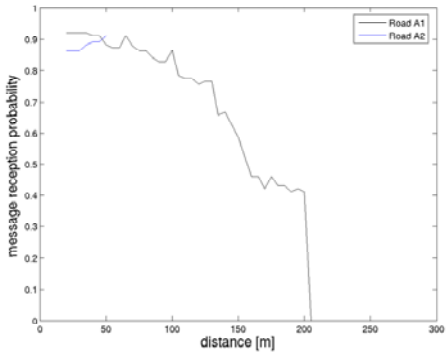
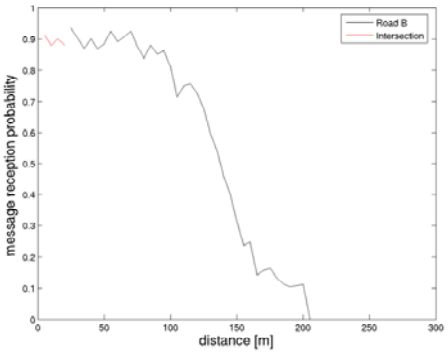
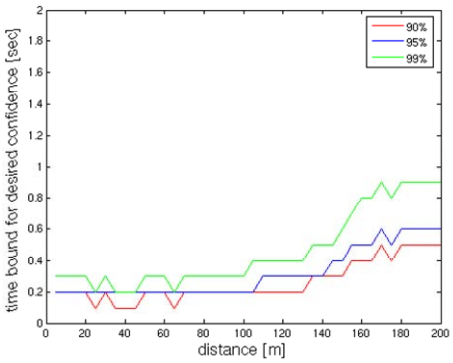
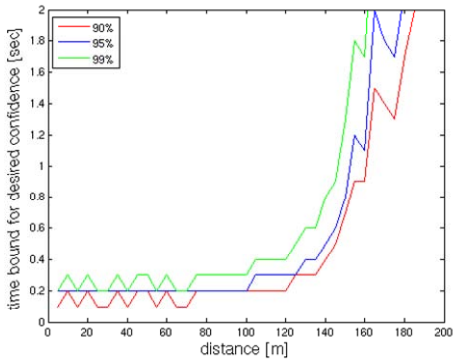
6.2.28 Scenario 40

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
40	Distributed	Building	OBU	300m	ON	5Hz	200m	

	Emergency Messages	
	Road A2	Road B
Reception probability	 **Figure 6-149: Reception Prob. of Emergency Messages – Scenario 40, Rd. A, Sender on Rd. A2**	 **Figure 6-150: Reception Prob. of Emergency Messages –Scenario 40, Rd. B, Sender on Rd. A2**
Time bound for needed confidence	 **Figure 6-151: Time Bound for desired Confidence, Emergency Messages - Scenario 40, Road A, Sender on Road A2**	 **Figure 6-152: Time Bound for desired Confidence, Emergency Messages - Scenario 40, Road B, Sender on Road A2**

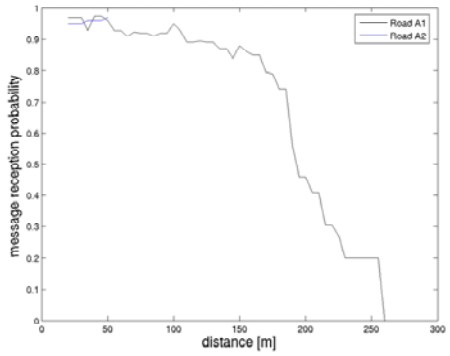
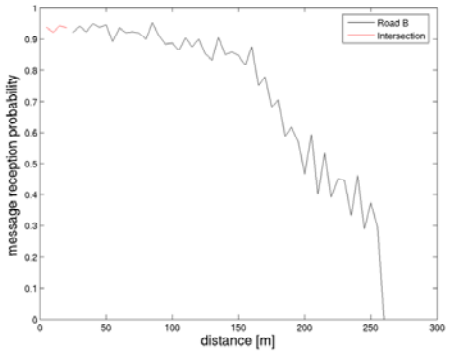
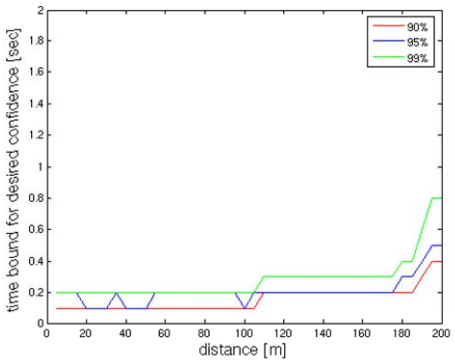
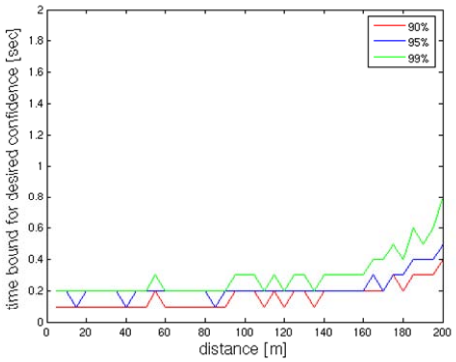
6.2.29 Scenario 49

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
49	Deterministic	Open	RSU	200m	ON	10Hz	100m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-153: Reception Probability of Emergency Messages-Scenario 49, Road A, Sender RSU**	 **Figure 6-154: Reception Probability of Emergency Messages-Scenario 49, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-155: Time Bound for desired Confidence, Emergency Messages - Scenario 49, Road A, Sender RSU**	 **Figure 6-156: Time Bound for desired Confidence, Emergency Messages – Scenario 49, Road B, Sender RSU**

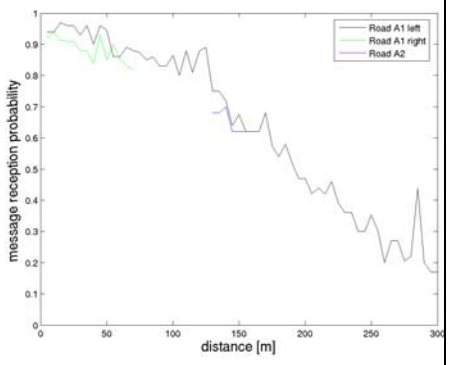
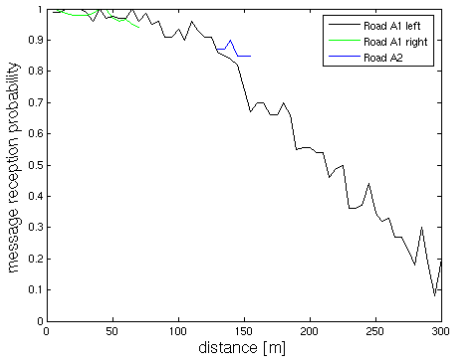
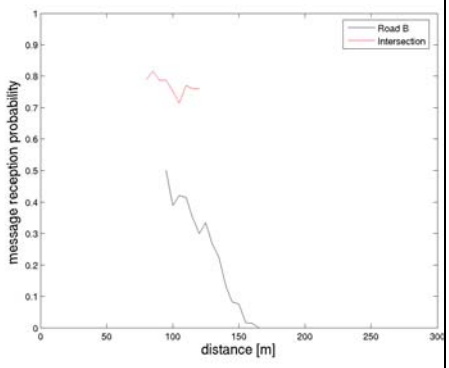
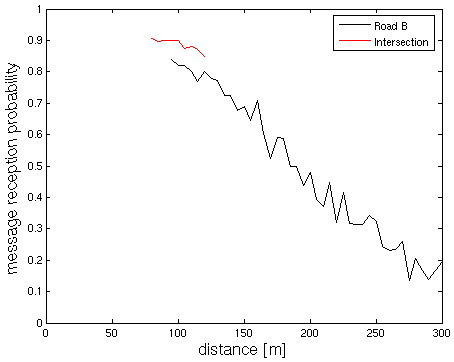
6.2.30 Scenario 50

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
50	Deterministic	Building	RSU	200m	ON	10Hz	100m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 6-157: Reception Probability of Emergency Messages-Scenario 50, Road A, Sender RSU**	 **Figure 6-158: Reception Probability of Emergency Messages-Scenario 50, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 6-159: Time Bound for desired Confidence, Emergency Messages - Scenario 50, Road A, Sender RSU**	 **Figure 6-160: Time Bound for desired Confidence, Emergency Messages – Scenario 50, Road B, Sender RSU**

7 Effects of RSU Rebroadcast of Emergency Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Additional 1	Distributed	Building	OBU	200m	ON	2Hz	200m	

	Emergency Messages **Without** ReTx	Emergency Messages **With** ReTx
Road A	 **Figure 7-1: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road A, Sender on Road A1**	 **Figure 7-2: Reception Probability of Emergency Messages** With **RSU Retransmission, Road A, Sender on Road A1**
Road B	 **Figure 7-3: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road B, Sender on Road A1**	 **Figure 7-4: Reception Probability of Emergency Messages** With **RSU Retransmission, Road B, Sender on Road A1**

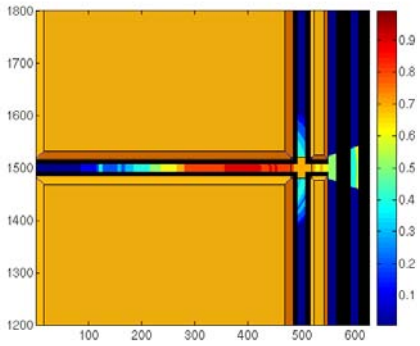
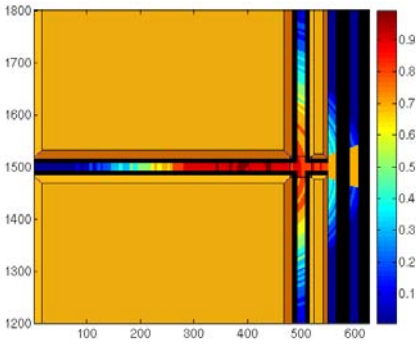
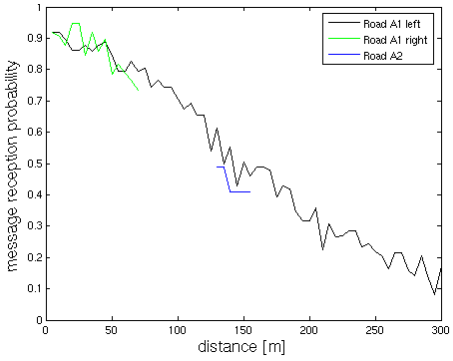
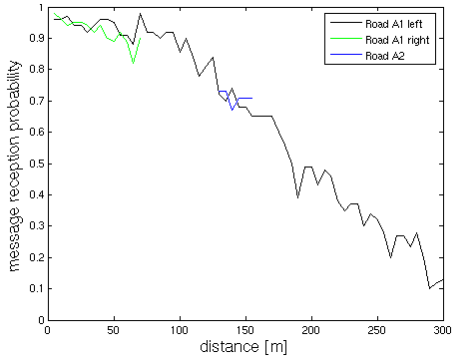
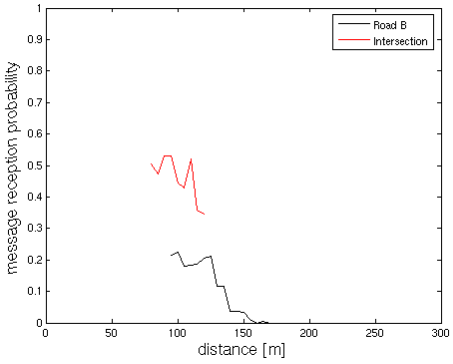
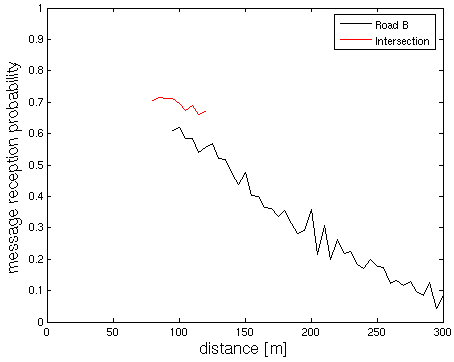
Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Visualization								

Figure 7-5: Visualization of the Reception Probability of Emergency Messages Without **RSU Retransmission, Sender on Road A1**

Figure 7-6: Visualization of the Reception Probability of Emergency Messages With **RSU Retransmission, Sender on Road A1**

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Additional 2	Distributed	Building	OBU	200m	ON	5Hz	200m	

	Emergency Messages **Without** ReTx	Emergency Messages **With** ReTx
Road A	 **Figure 7-7: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road A, Sender on Road A1**	 **Figure 7-8: Reception Probability of Emergency Messages** With **RSU Retransmission, Road A, Sender on Road A1**
Road B	 **Figure 7-9: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road B, Sender on Road A1**	 **Figure 7-10: Reception Probability of Emergency Messages** With **RSU Retransmission, Road B, Sender on Road A1**

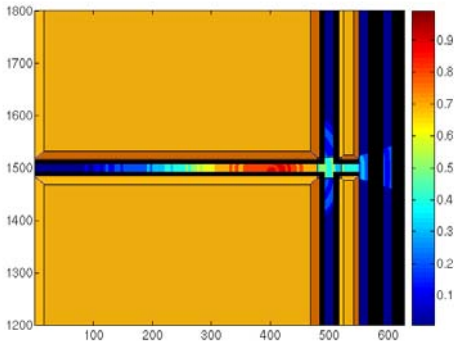
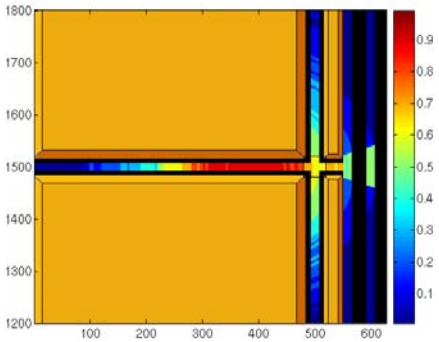
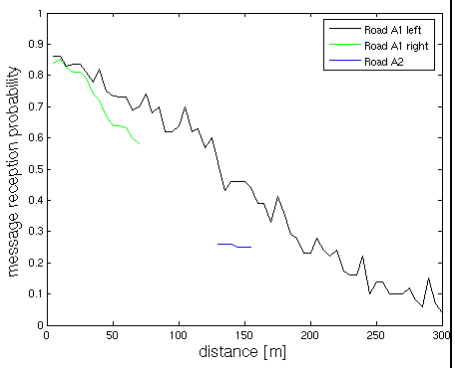
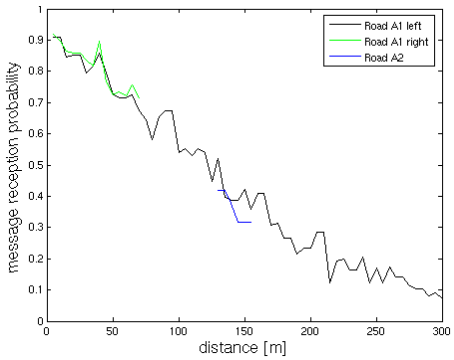
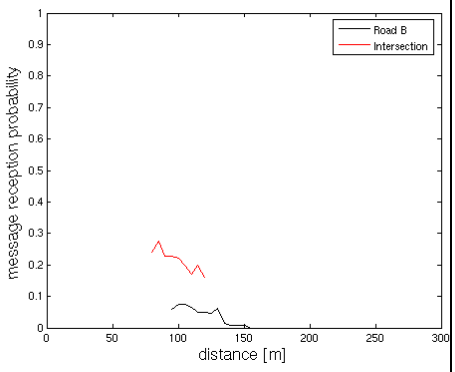
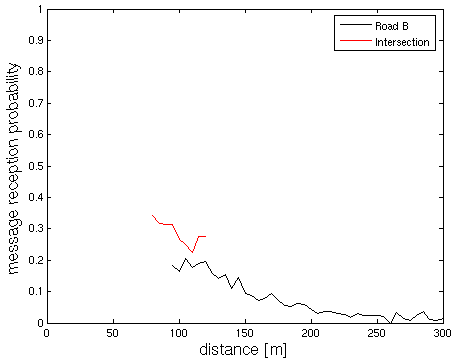
Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Visualization								

Figure 7-11: Visualization of the Reception Probability of Emergency Messages Without **RSU Retransmission, Sender on Road A1**

Figure 7-12: Visualization of the Reception Probability of Emergency Messages With **RSU Retransmission, Sender on Road A1**

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Additional 2	Distributed	Building	OBU	200m	ON	10Hz	200m	

	Emergency Messages **Without** ReTx	Emergency Messages **With** ReTx
Road A	 **Figure 7-13: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road A, Sender on Road A1**	 **Figure 7-14: Reception Probability of Emergency Messages** With **RSU Retransmission, Road A, Sender on Road A1**
Road B	 **Figure 7-15: Reception Probability of Emergency Messages** Without **RSU Retransmission, Road B, Sender on Road A1**	 **Figure 7-16: Reception Probability of Emergency Messages** With **RSU Retransmission, Road B, Sender on Road A1**

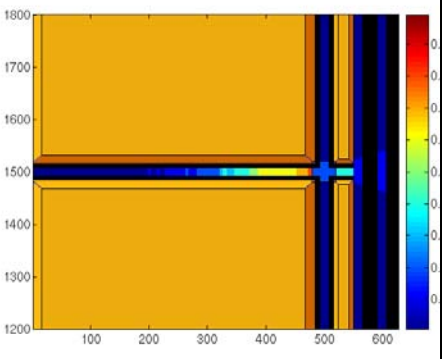
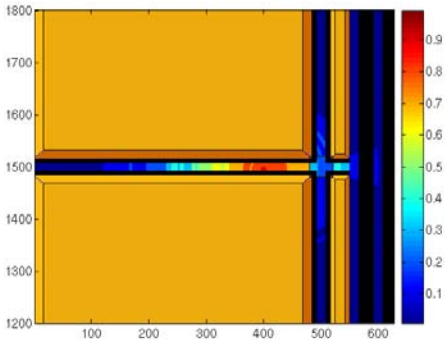
Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
Visualization								

Figure 7-17: Visualization of the Reception Probability of Emergency Messages Without **RSU Retransmission, Sender on Road A1**

Figure 7-18: Visualization of the Reception Probability of Emergency Messages With **RSU Retransmission, Sender on Road A1**

8 Additional Simulations Regarding Routine Safety Message at Intersection, Based on Scenario 11

8.1 Routine Messages at 6 Hz, Routine Message Size – 200 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /6Hz /200m

8.1.1 Reception Probability of Emergency Messages

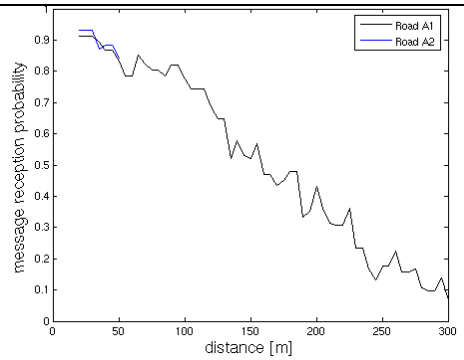


Figure 8-1: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

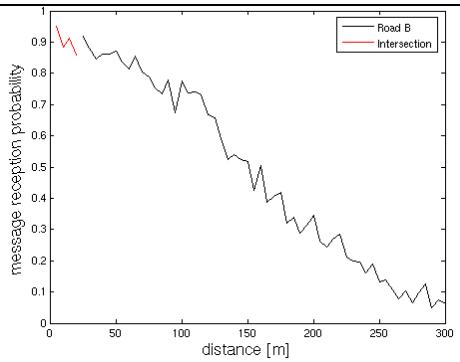


Figure 8-2: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

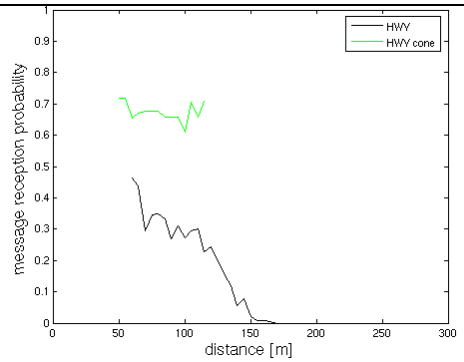


Figure 8-3: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

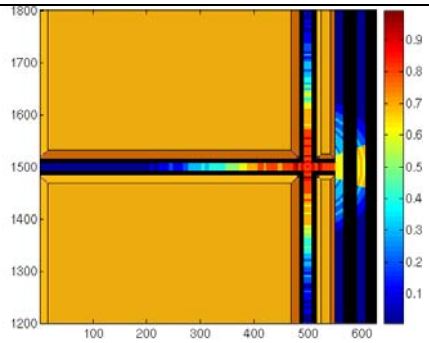
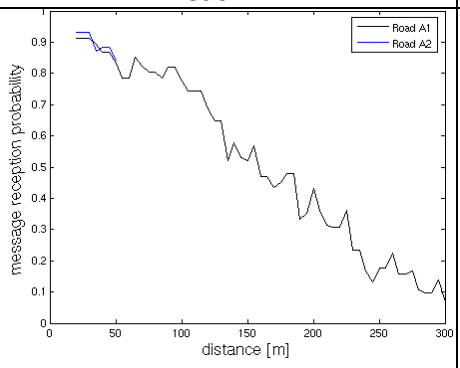
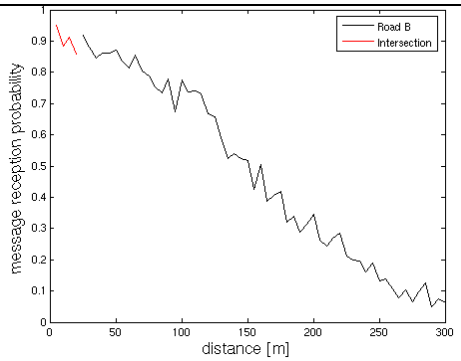
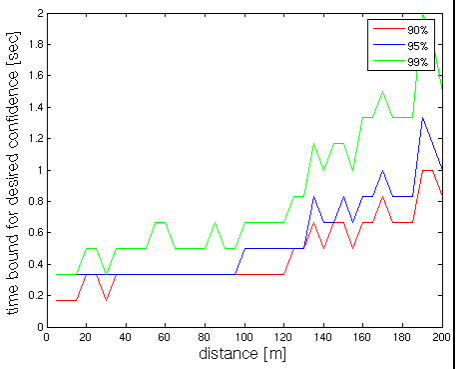
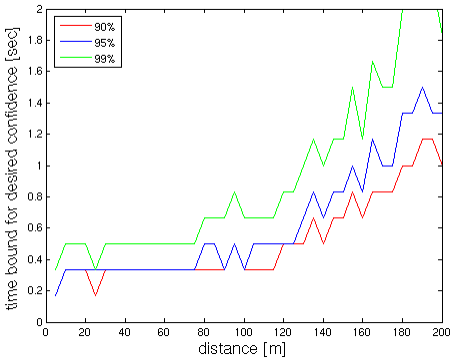


Figure 8-4: Reception Probability of Emergency Messages-Scenario11, Sender RSU

8.1.2 Time Bound for Emergency Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	6Hz	200m	

Emergency Messages

	Road A	Road B
Reception probability		
	Figure 8-5: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 8-6: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 8-7: Time Bound for desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 8-8: Time Bound for desired Confidence, Emergency Messages – Scenario 11, Road B, Sender RSU**

8.1.3 Reception Probability of Routine Messages

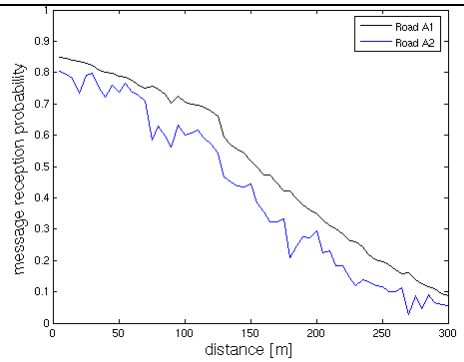


Figure 8-9: Reception Probability of Routine Messages on Road A, Scenario 11

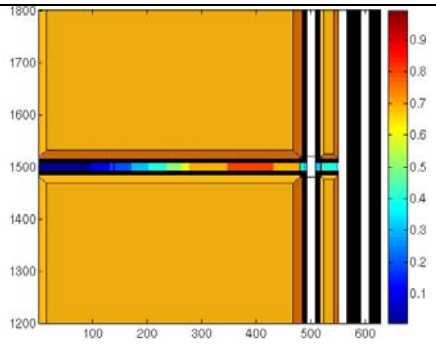


Figure 8-10: Reception Probability of Routine Messages on Road A, Scenario 11

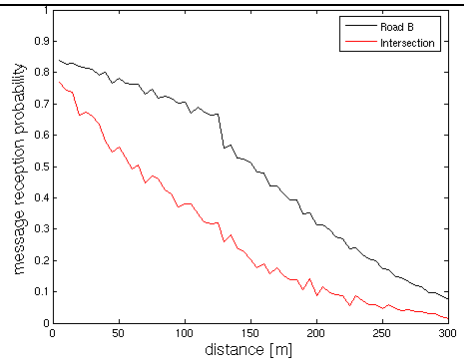


Figure 8-11: Reception Probability of Routine Messages on Road B, Scenario 11

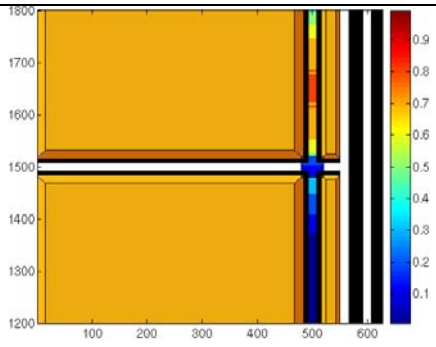


Figure 8-12: Reception Probability of Routine Messages on Road B, Scenario 11

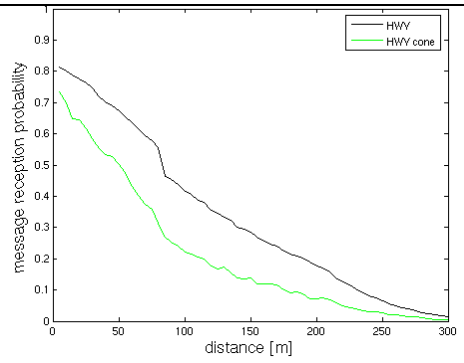


Figure 8-13: Reception Probability of Routine Messages on HWY, Scenario 11

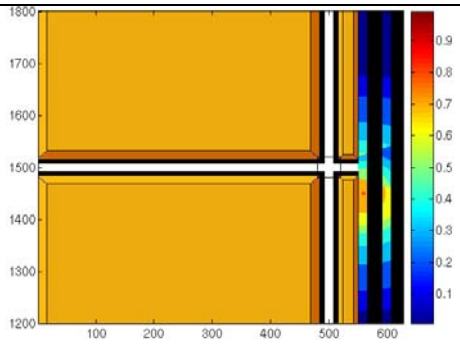
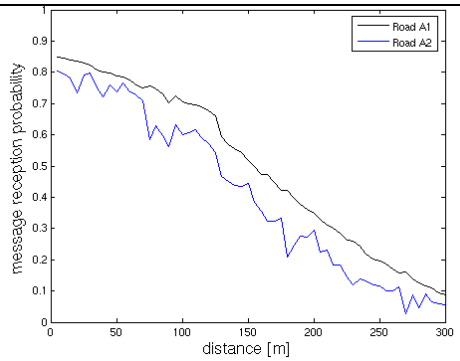
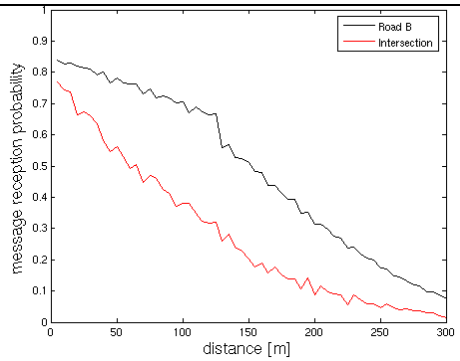
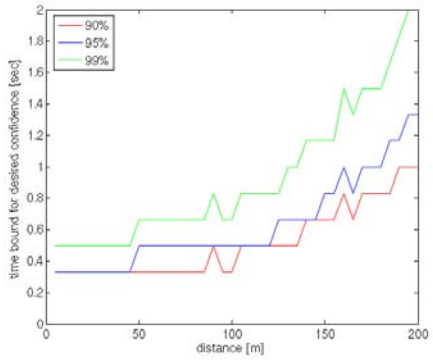
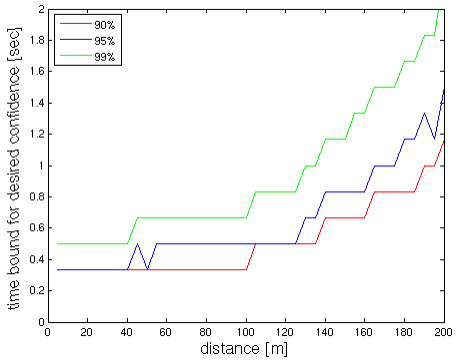


Figure 8-14: Reception Probability of Routine Messages on HWY, Scenario 11

8.1.4 Time Bound for Routine Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	6Hz	200m	

Routine Messages

	Road A	Road B
Reception probability	 **Figure 8-15: Reception Probability of Routine Messages on Road A, Scenario 11**	 **Figure 8-16: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence	 **Figure 8-17: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A**	 **Figure 8-18: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.2 Routine Messages at 7 Hz, Routine Message Size – 200 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /7Hz /200m

8.2.1 Reception Probability of Emergency Messages

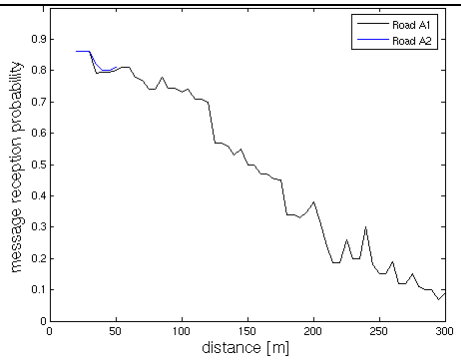


Figure 8-19: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

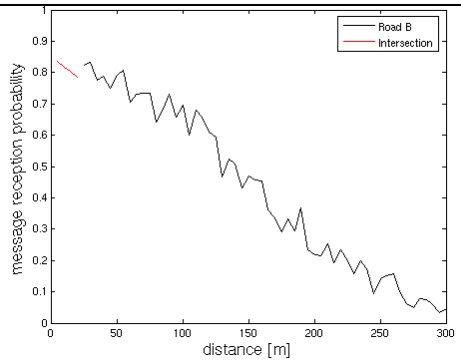


Figure 8-20: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

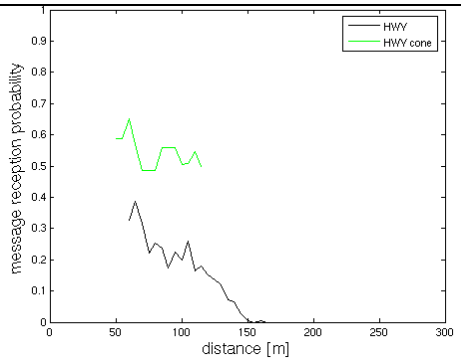


Figure 8-21: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

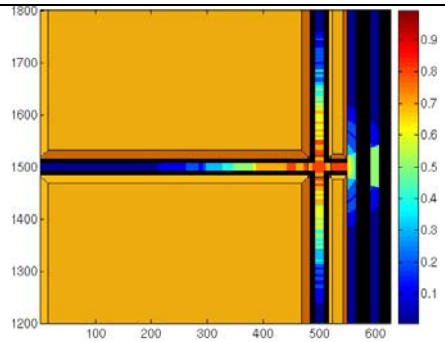
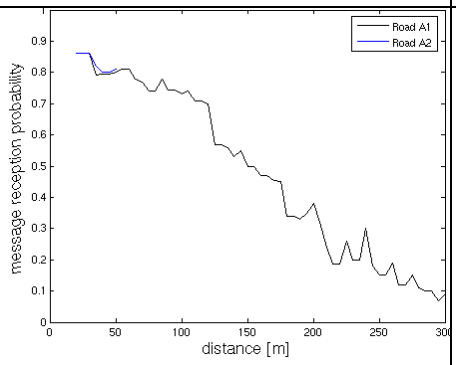
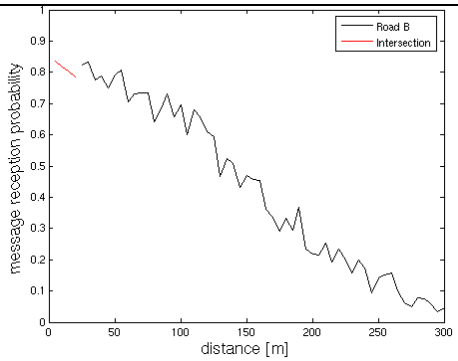
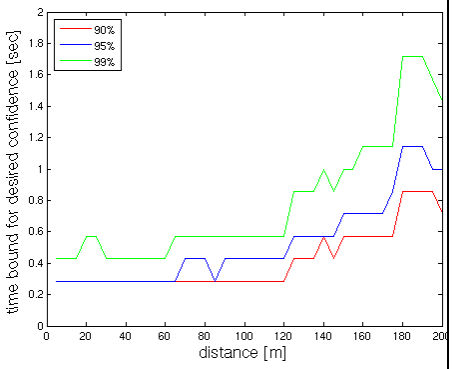
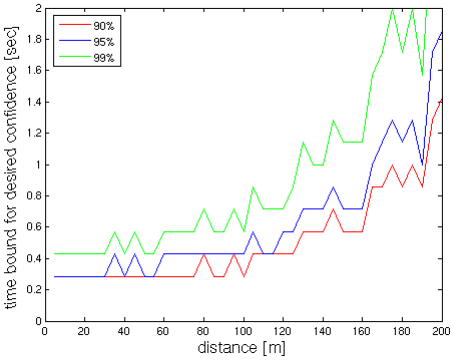


Figure 8-22: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

8.2.2 Time Bound for Emergency Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	7Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 8-23: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU**	 **Figure 8-24: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 8-25: Time Bound for desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU**	 **Figure 8-26: Time Bound for desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

8.2.3 Reception Probability of Routine Messages

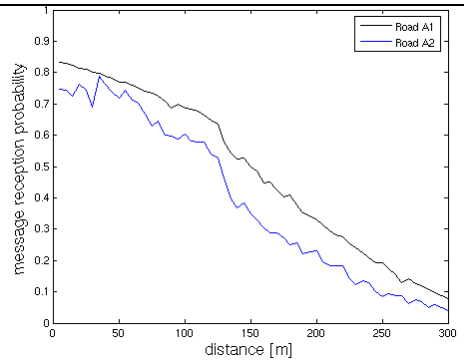


Figure 8-27: Reception Probability of Routine Messages on Road A, Scenario 11

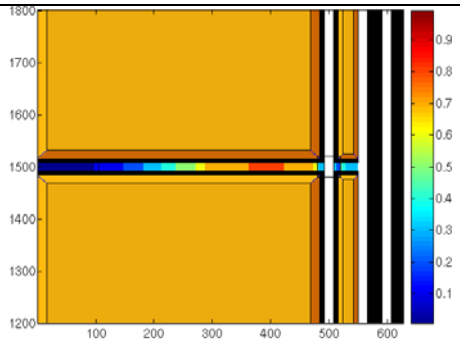


Figure 8-28: Reception Probability of Routine Messages on Road A, Scenario 11

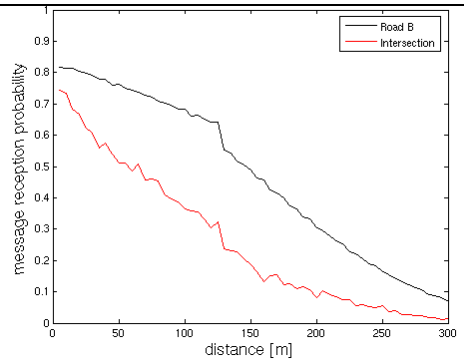


Figure 8-29: Reception Probability of Routine Messages on Road B, Scenario 11

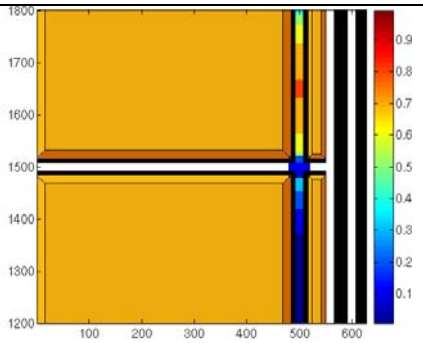


Figure 8-30: Reception Probability of Routine Messages on Road B, Scenario 11

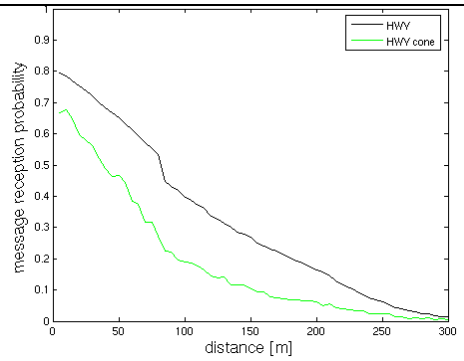


Figure 8-31: Reception Probability of Routine Messages on HWY, Scenario 11

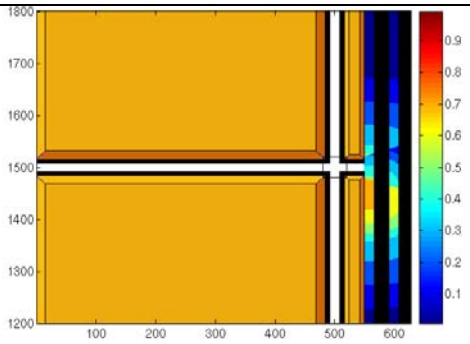
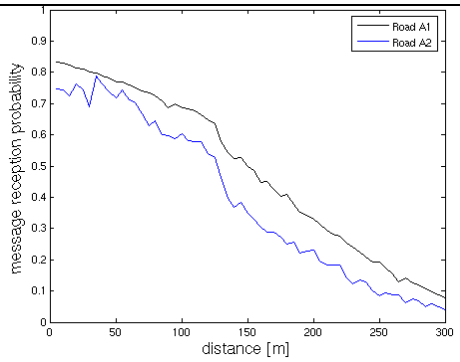
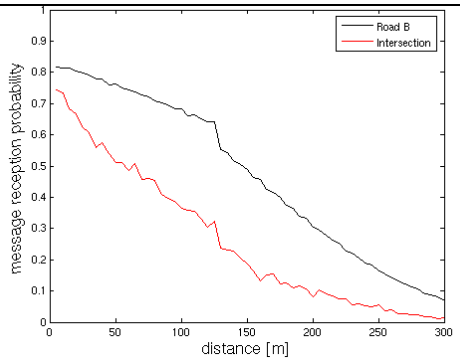
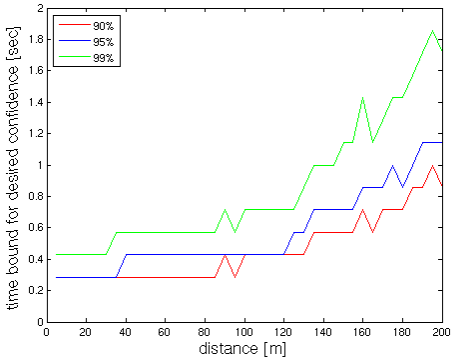
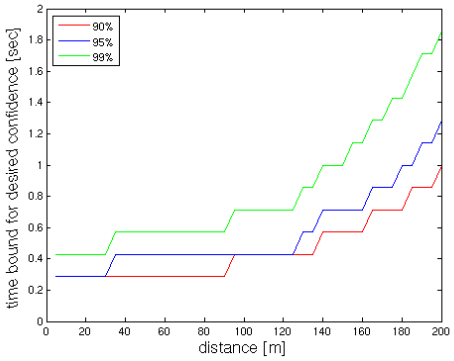


Figure 8-32: Reception Probability of Routine Messages on HWY, Scenario 11

8.2.4 Time Bound for Routine Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	7Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 8-33: Reception Probability of Routine Messages on Road A, Scenario 11**	 **Figure 8-34: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence	 **Figure 8-35: Time Bound for Desired Confidence, Routine Messages – Scenario 11, Road A**	 **Figure 8-36: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.3 Routine Messages at 8 Hz, Routine Message Size – 200 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /8Hz /200m

8.3.1 Reception Probability of Emergency Messages

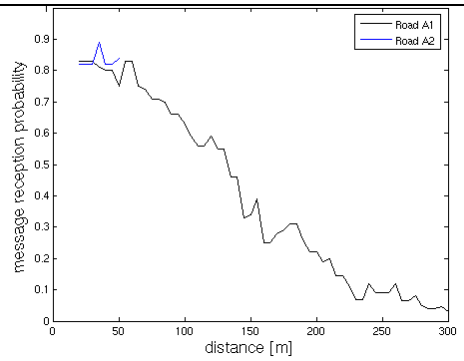


Figure 8-37: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

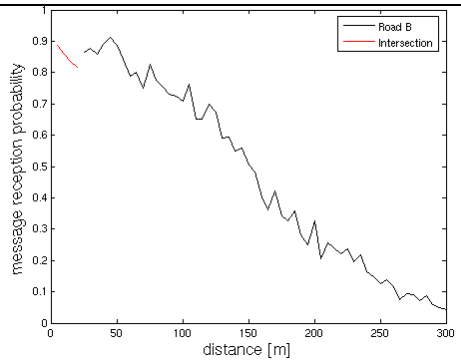


Figure 8-38: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

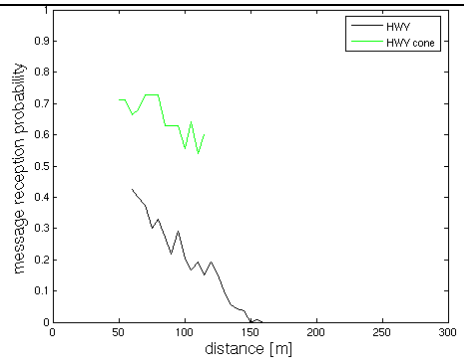


Figure 8-39: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

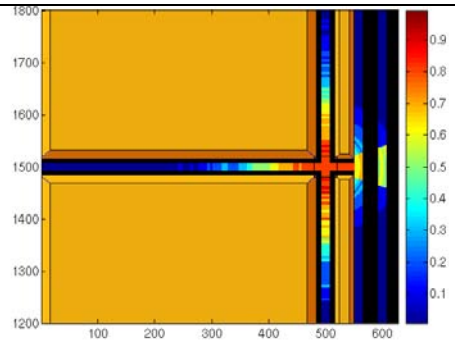
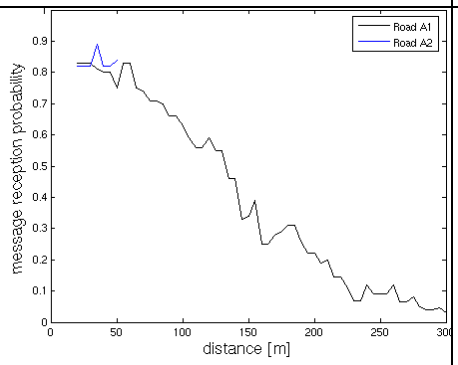
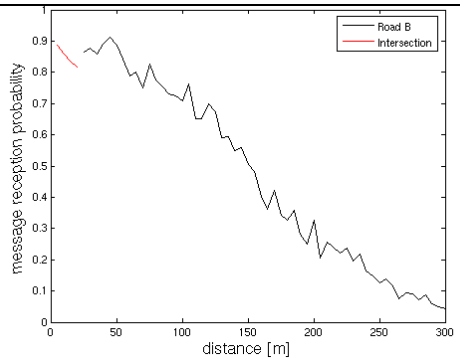
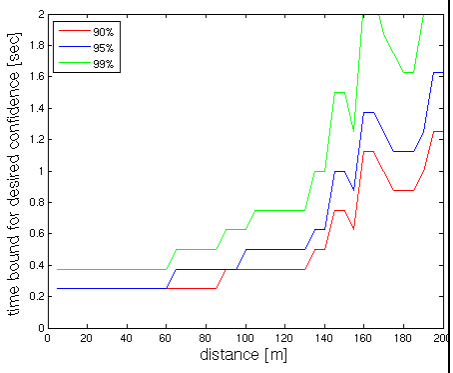
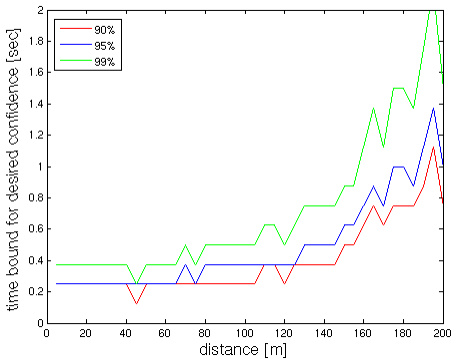


Figure 8-40: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

8.3.2 Time Bound for Emergency Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	8Hz	200m	

	Emergency Messages	
	Road A	Road B
Reception probability	 **Figure 8-41: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU**	 **Figure 8-42: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 8-43: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU**	 **Figure 8-44: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

8.3.3 Reception Probability of Routine Messages

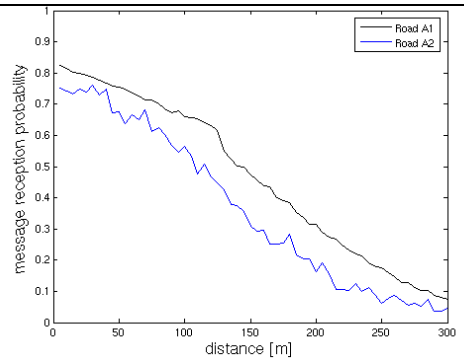


Figure 8-45: Reception Probability of Routine Messages on Road A, Scenario 11

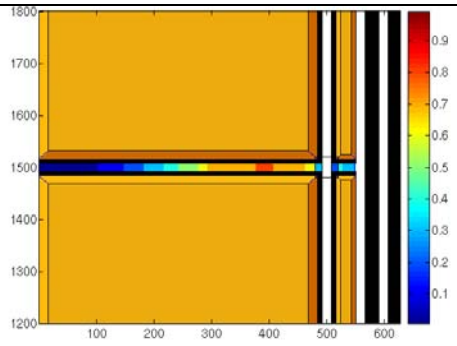


Figure 8-46: Reception Probability of Routine Messages on Road A, Scenario 11

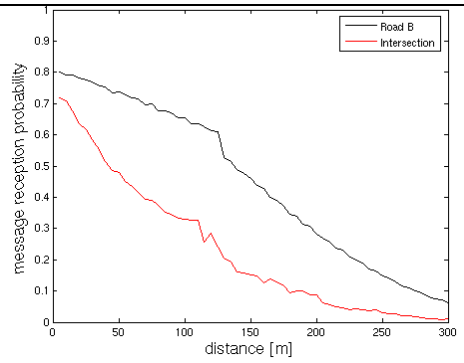


Figure 8-47: Reception Probability of Routine Messages on Road B, Scenario 11

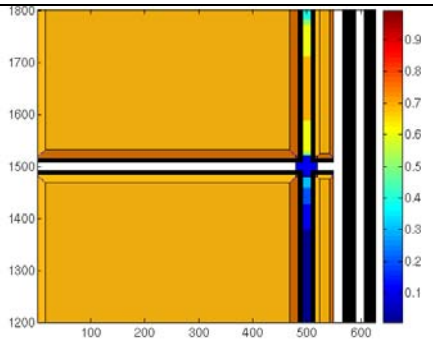


Figure 8-48: Reception Probability of Routine Messages on Road B, Scenario 11

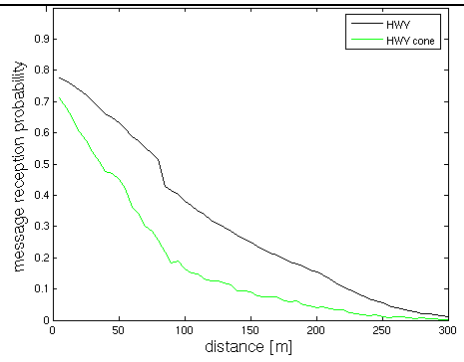


Figure 8-49: Reception Probability of Routine Messages on HWY, Scenario 11

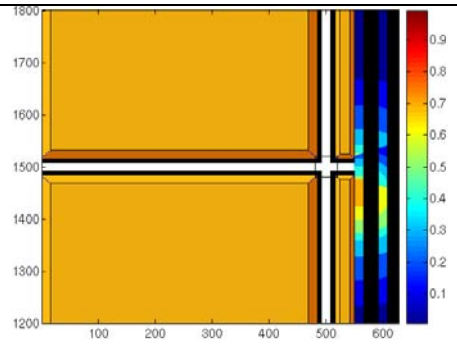
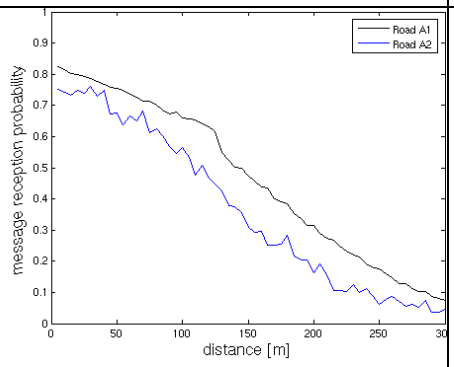
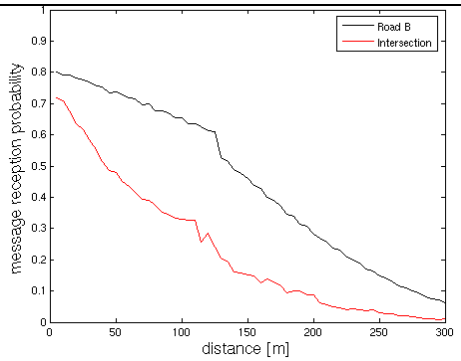
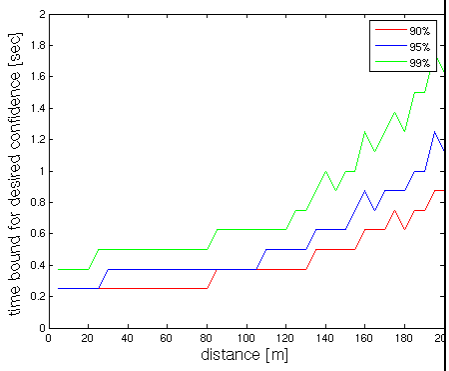
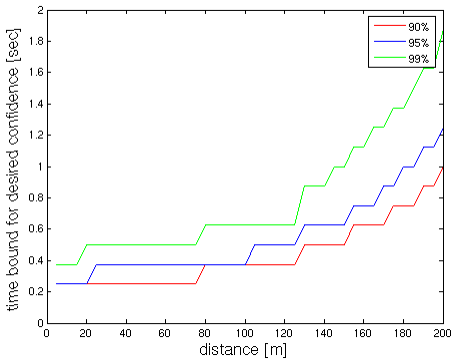


Figure 8-50: Reception Probability of Routine Messages on HWY, Scenario 11

8.3.4 Time Bound for Routine Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	8Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 8-51: Reception Probability of Routine Messages on Road A, Scenario 11**	 **Figure 8-52: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence	 **Figure 8-53: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A**	 **Figure 8-54: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.4 Routine Messages at 9 Hz, Routine Message Size – 200 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	200byte /9Hz /200m

8.4.1 Reception Probability of Emergency Messages

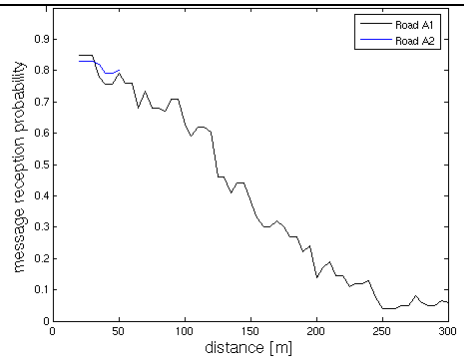


Figure 8-55: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

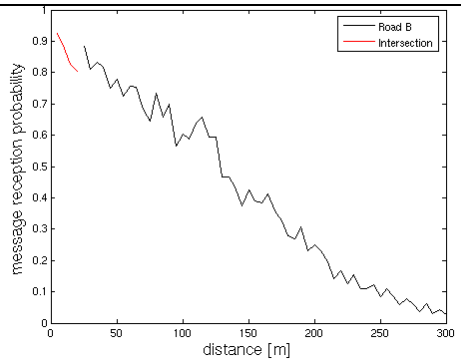


Figure 8-56: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

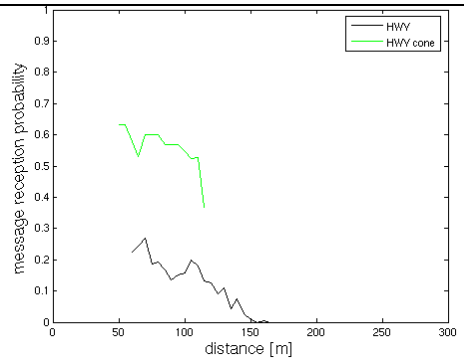


Figure 8-57: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

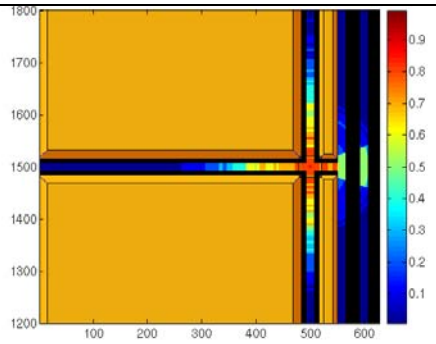
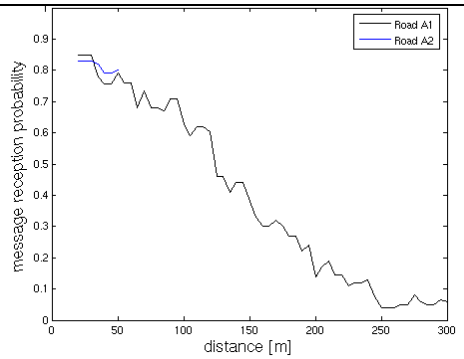
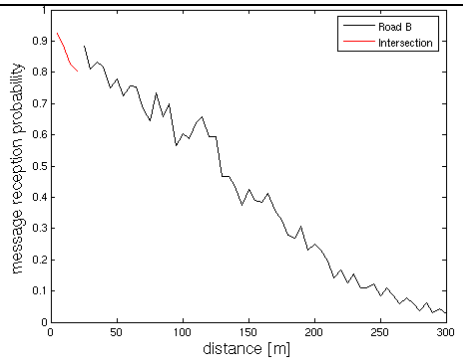
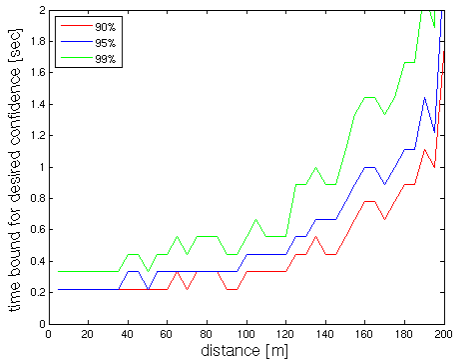
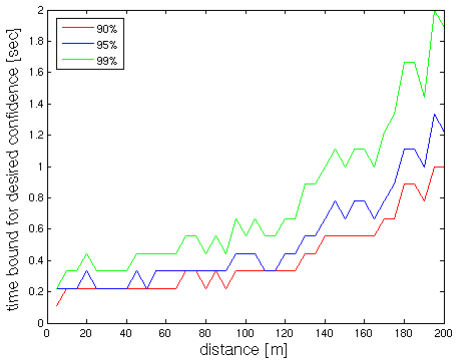


Figure 8-58: Reception Probability of Emergency Messages-Scenario11, Sender RSU

8.4.2 Time Bound for Emergency Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	9Hz	200m	

Emergency Messages

	Road A	Road B
Reception probability	 **Figure 8-59: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU**	 **Figure 8-60: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence	 **Figure 8-61: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU**	 **Figure 8-62: Time Bound for Desired Confidence, Emergency Messages – Scenario 11, Road B, Sender RSU**

8.4.3 Reception Probability of Routine Messages

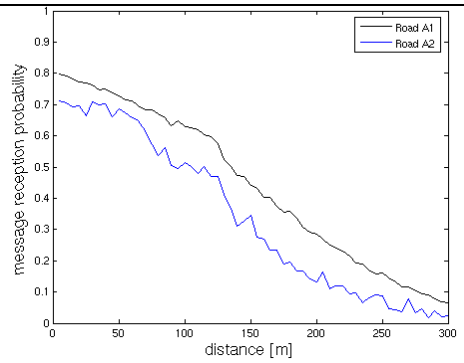


Figure 8-63: Reception Probability of Routine Messages on Road A, Scenario 11

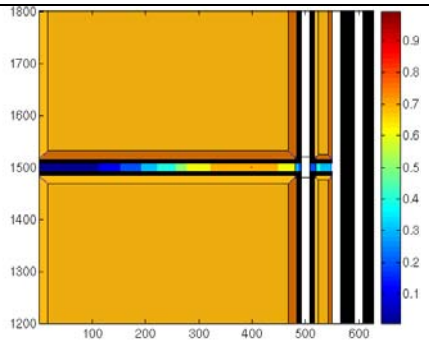


Figure 8-64: Reception Probability of Routine Messages on Road A, Scenario 11

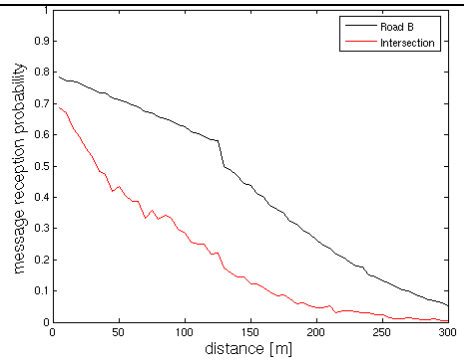


Figure 8-65: Reception Probability of Routine Messages on Road B, Scenario 11

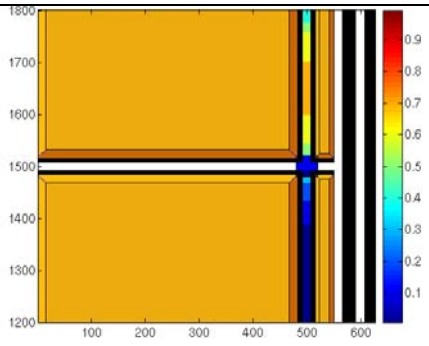


Figure 8-66: Reception Probability of Routine Messages on Road B, Scenario 11

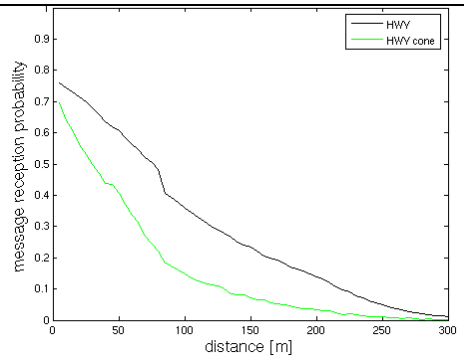


Figure 8-67: Reception Probability of Routine Messages on HWY, Scenario 11

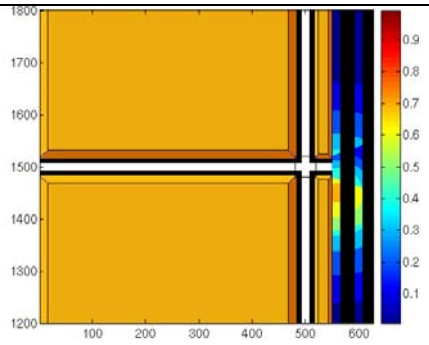
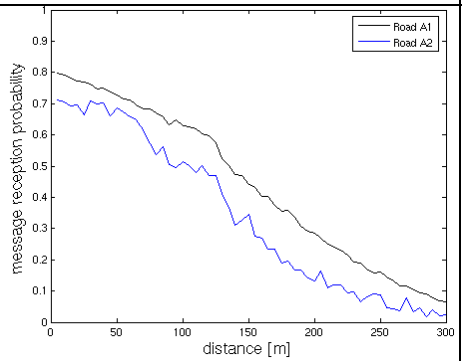
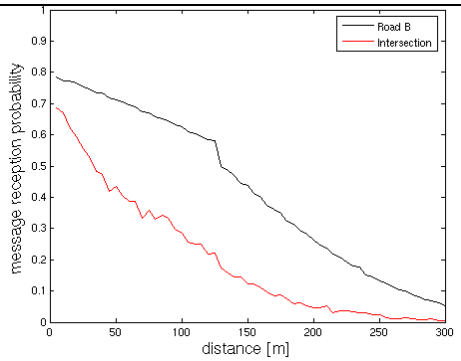
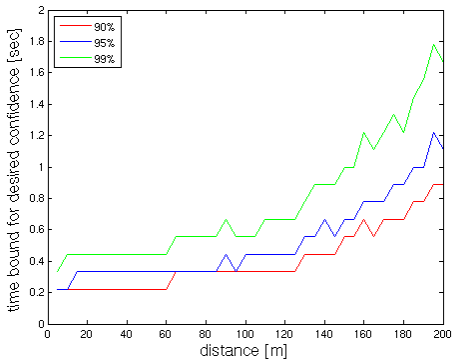
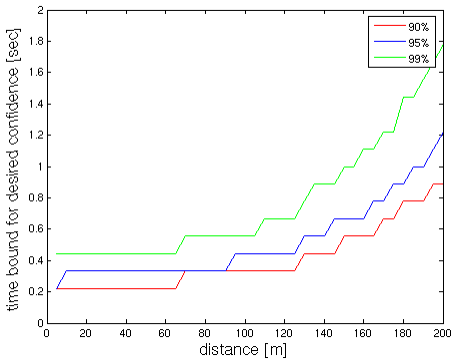


Figure 8-68: Reception Probability of Routine Messages on HWY, Scenario 11

8.4.4 Time Bound for Routine Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	9Hz	200m	

	Routine Messages	
	Road A	Road B
Reception probability		
	Figure 8-69: Reception Probability of Routine Messages on Road A, Scenario 11	**Figure 8-70: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence		
	Figure 8-71: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A	**Figure 8-72: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.5 Routine Messages at 5 Hz, Routine Message Size – 250 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	250byte /5Hz /200m

8.5.1 Reception Probability of Emergency Messages

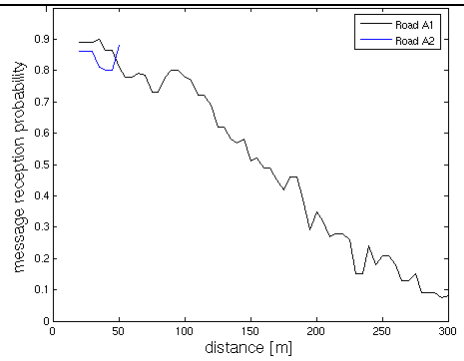


Figure 8-73: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

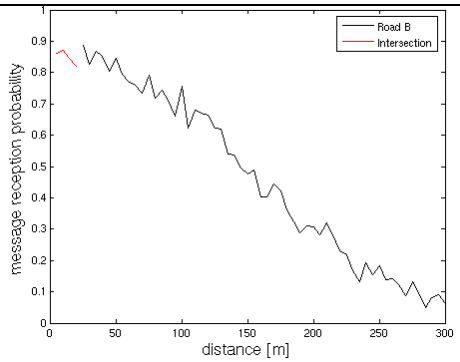


Figure 8-74: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

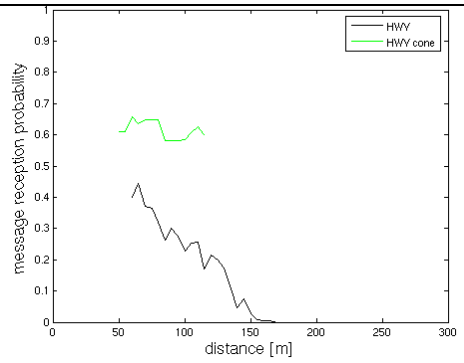


Figure 8-75: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

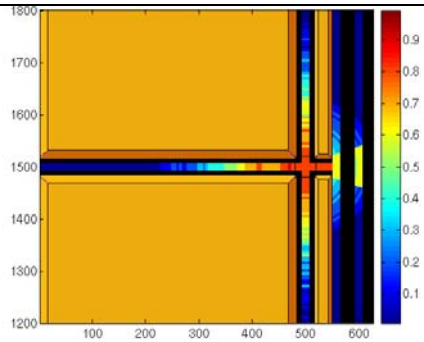
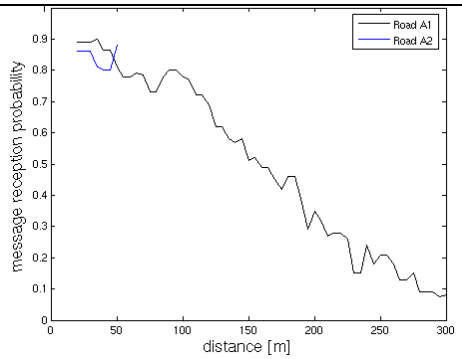
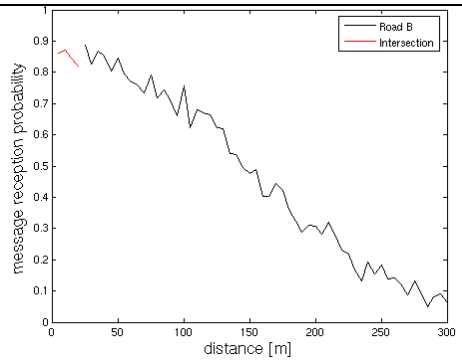
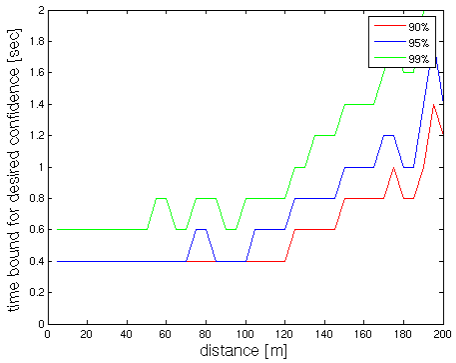
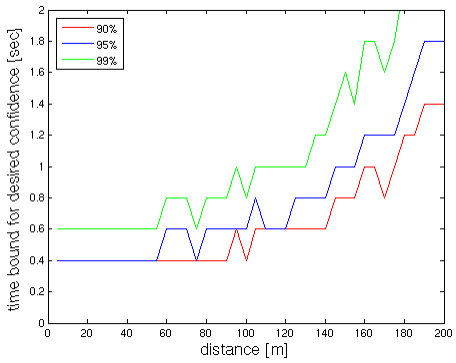


Figure 8-76: Reception Probability of Emergency Messages-Scenario11, Sender RSU

8.5.2 Time Bound for Emergency Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	5Hz, 250 byte	200m	

	Emergency Messages	
	Road A	Road B
Reception probability		
	Figure 8-77: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 8-78: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 8-79: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 8-80: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

8.5.3 Reception Probability of Routine Messages

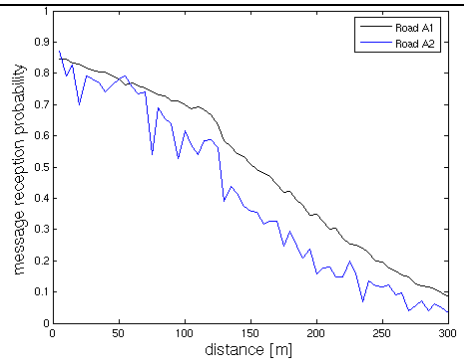


Figure 8-81: Reception Probability of Routine Messages on Road A, Scenario 11

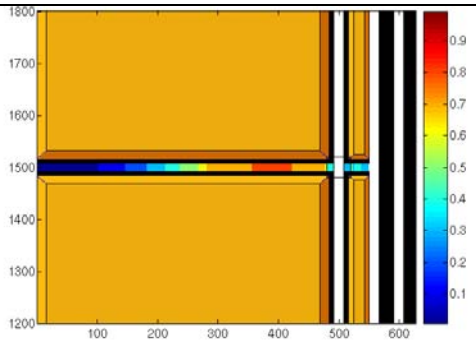


Figure 8-82: Reception Probability of Routine Messages on Road A, Scenario 11

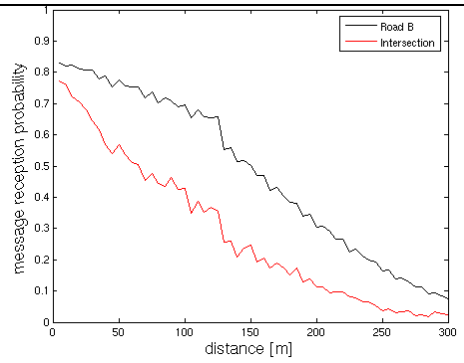


Figure 8-83: Reception Probability of Routine Messages on Road B, Scenario 11

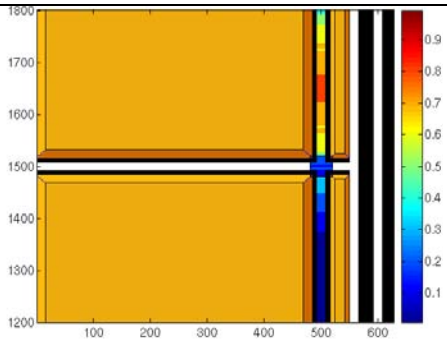


Figure 8-84: Reception Probability of Routine Messages on Road B, Scenario 11

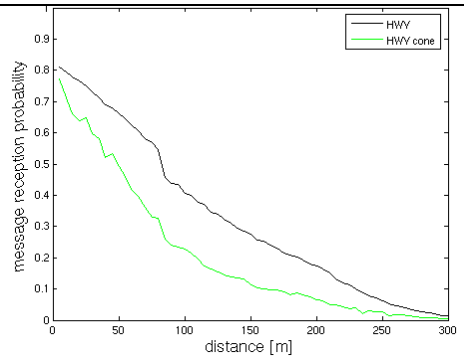


Figure 8-85: Reception Probability of Routine Messages on HWY, Scenario 11

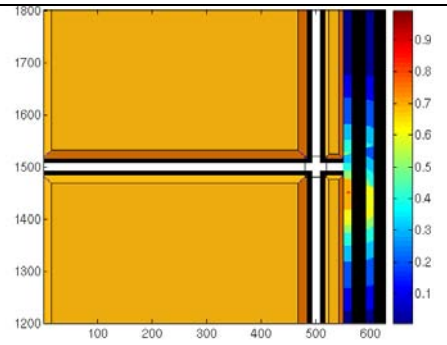
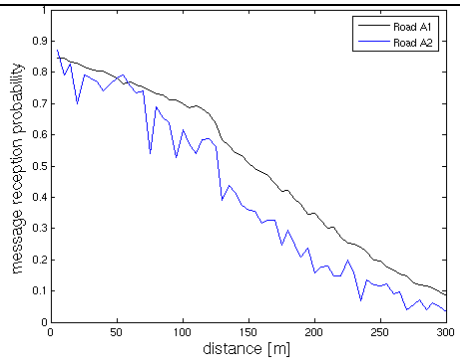
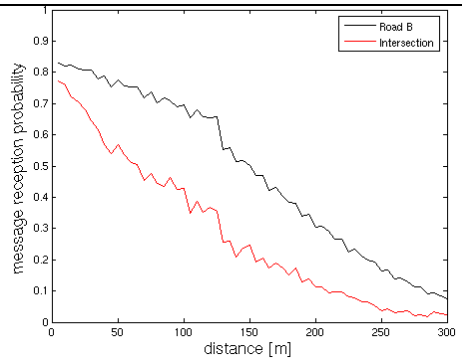
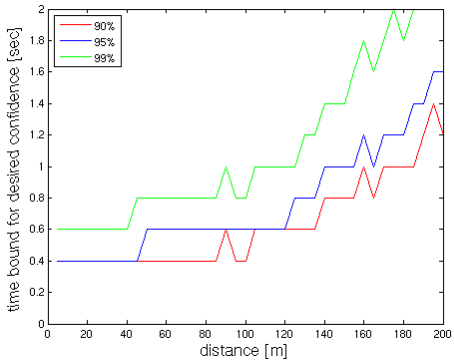
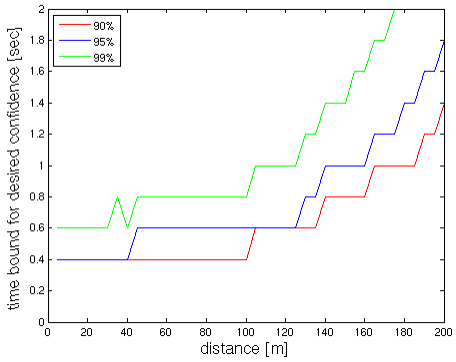


Figure 8-86: Reception Probability of Routine Messages on HWY, Scenario 11

8.5.4 Time Bound for Routine Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	5Hz, 250 byte	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 8-87: Reception Probability of Routine Messages on Road A, Scenario 11**	 **Figure 8-88: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence	 **Figure 8-89: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A**	 **Figure 8-90: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.6 Routine Messages at 10 Hz, Routine Message Size – 250 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	250byte /10Hz /200m

8.6.1 Reception Probability of Emergency Messages

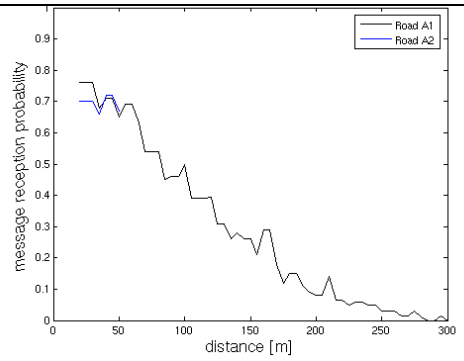


Figure 8-91: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

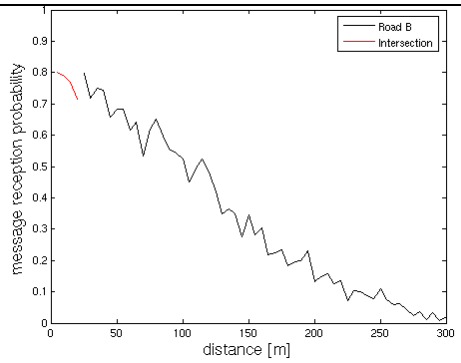


Figure 8-92: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

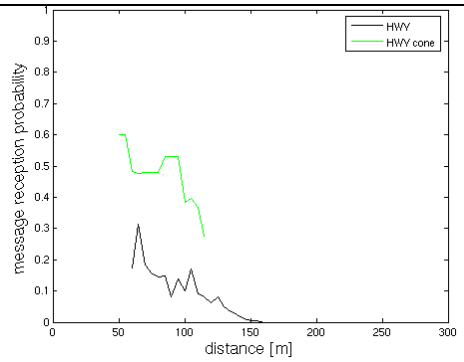


Figure 8-93: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

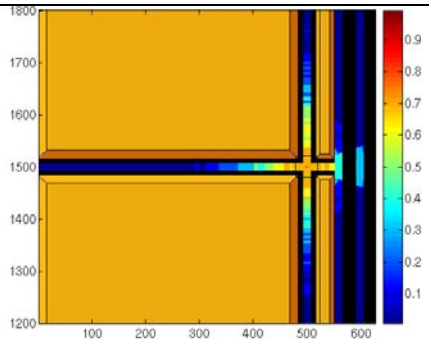
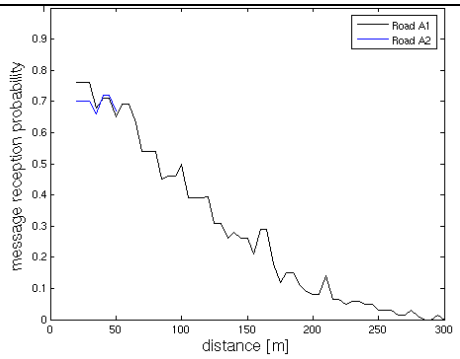
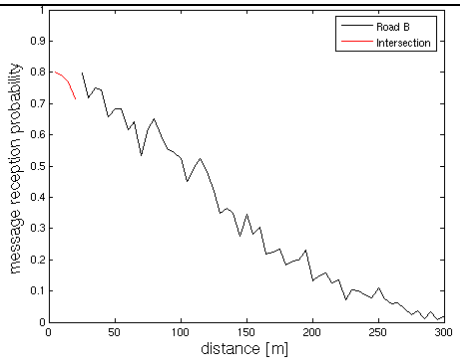
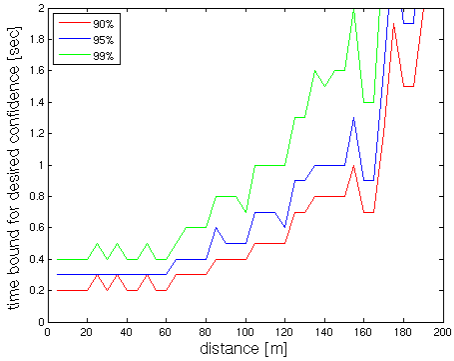
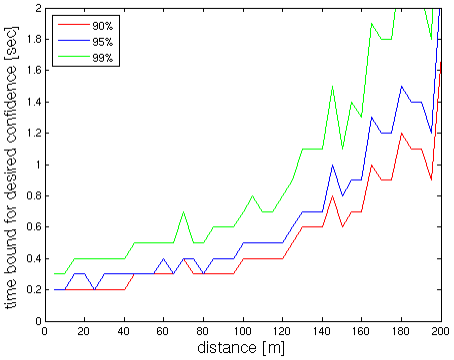


Figure 8-94: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

8.6.2 Time Bound for Emergency Messages

Number	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz, 250 byte	200m	

	Emergency Messages	
	Road A	Road B
Reception probability		
	Figure 8-95: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 8-96: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 8-97: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 8-98: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

8.6.3 Reception Probability of Routine Messages

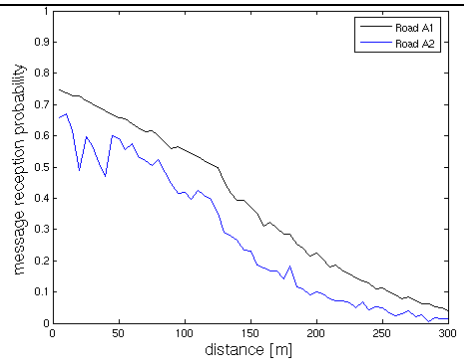


Figure 8-99: Reception Probability of Routine Messages on Road A, Scenario 11

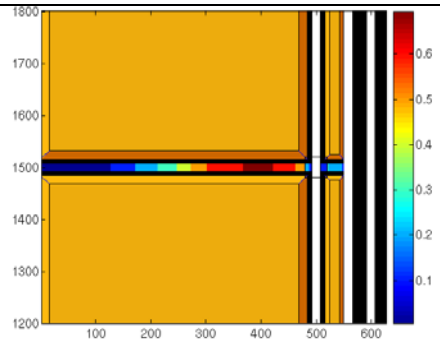


Figure 8-100: Reception Probability of Routine Messages on Road A, Scenario 11

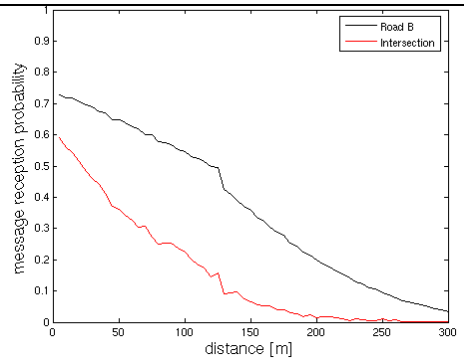


Figure 8-101: Reception Probability of Routine Messages on Road B, Scenario 11

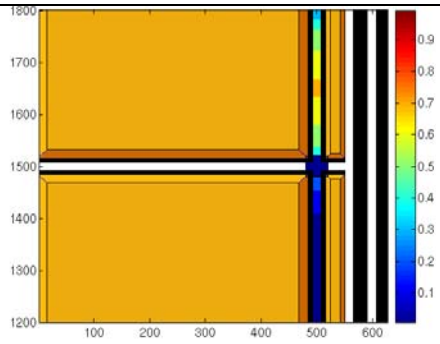


Figure 8-102: Reception Probability of Routine Messages on Road B, Scenario 11

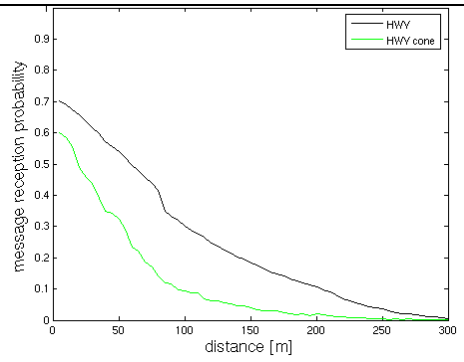


Figure 8-103: Reception Probability of Routine Messages on HWY, Scenario 11

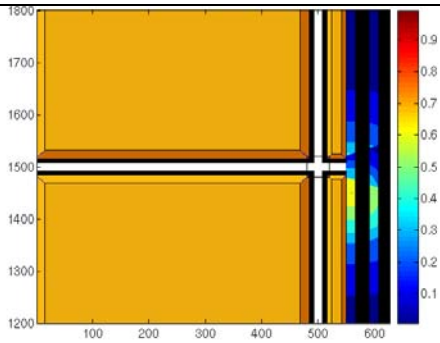
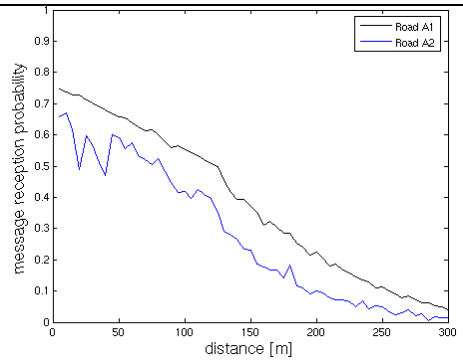
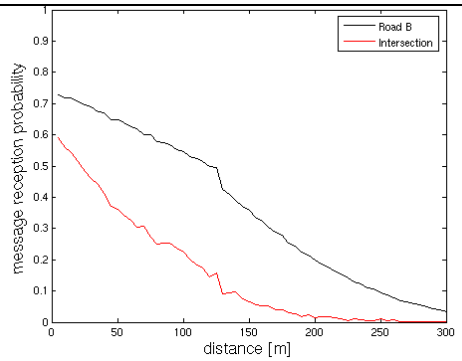
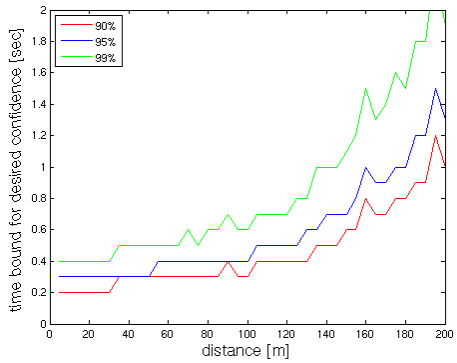
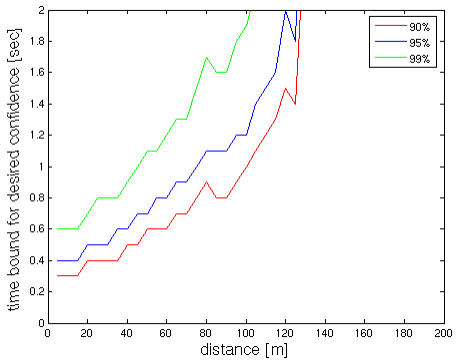


Figure 8-104: Reception Probability of Routine Messages on HWY, Scenario 11

8.6.4 Time Bound for Routine Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz, 250 byte	200m	

	Routine Messages	
	Road A	Road B
Reception probability	 **Figure 8-105: Reception Probability of Routine Messages on Road A, Scenario 11**	 **Figure 8-106: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence	 **Figure 8-107: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A**	 **Figure 8-108: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**

8.7 Routine Messages at 5 Hz, Routine Message Size – 300 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500 bytes/2Hz/200m
Routine Messages	300 byte /5Hz /200m

8.7.1 Reception Probability of Emergency Messages

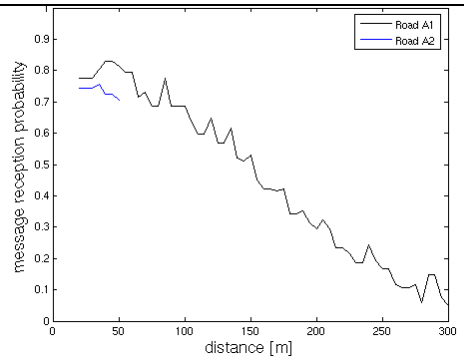


Figure 8-109: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

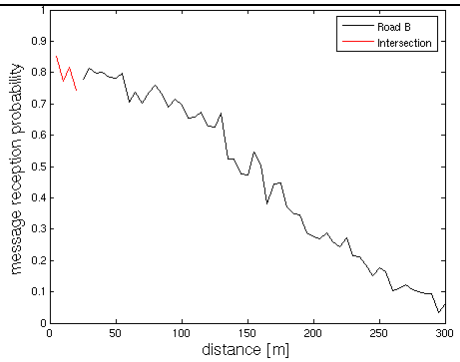


Figure 8-110: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

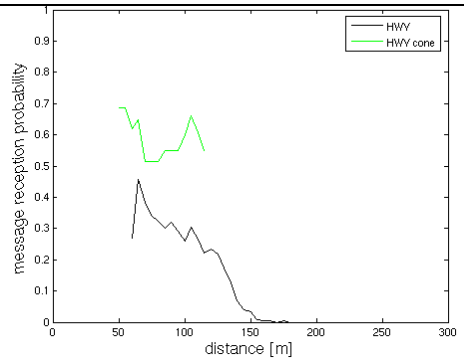


Figure 8-111: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

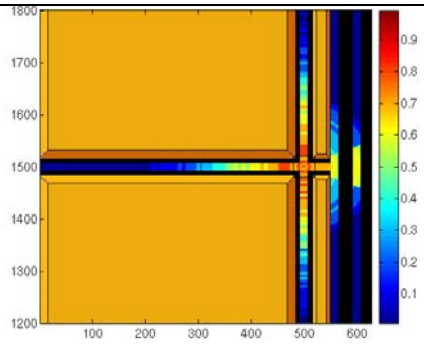
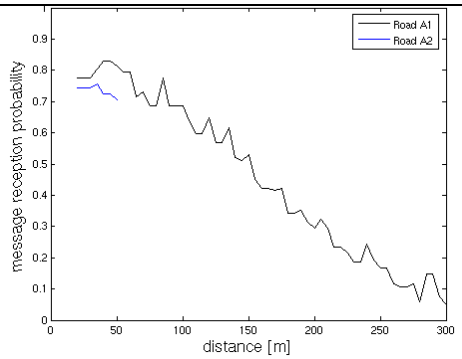
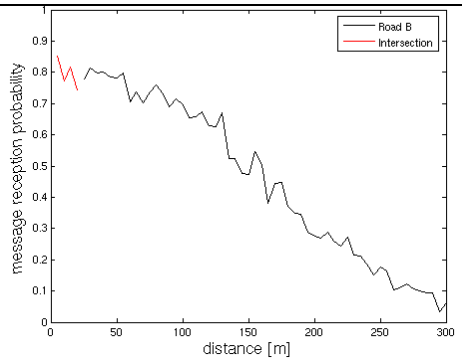
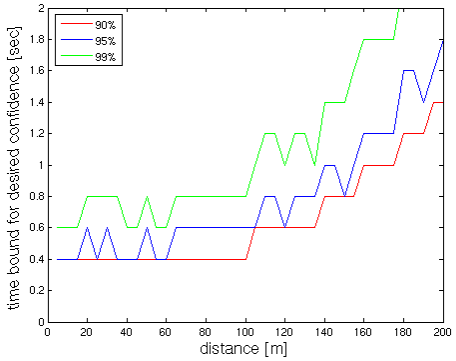
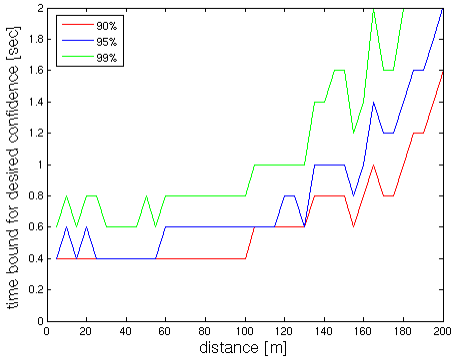


Figure 8-112: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

8.7.2 Time Bound for Emergency Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	5Hz, 300 byte	200m	

	Emergency Messages	
	Road A	Road B
Reception probability		
	Figure 8-113: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 8-114: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 8-115: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 8-116: Time Bound for Desired Confidence, Emergency Messages – Scenario 11, Road B, Sender RSU**

8.7.3 Reception Probability of Routine Messages

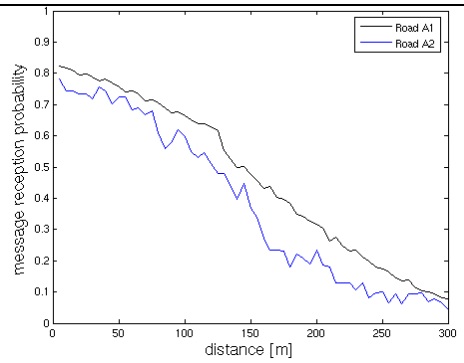


Figure 8-117: Reception Probability of Routine Messages on Road A, Scenario 11

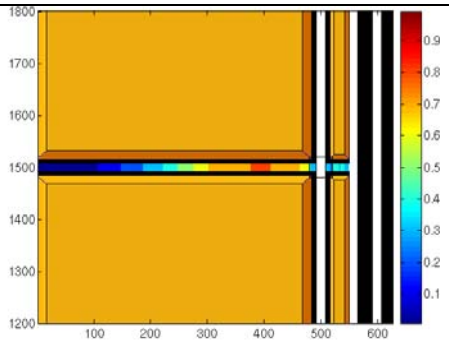


Figure 8-118: Reception Probability of Routine Messages on Road A, Scenario 11

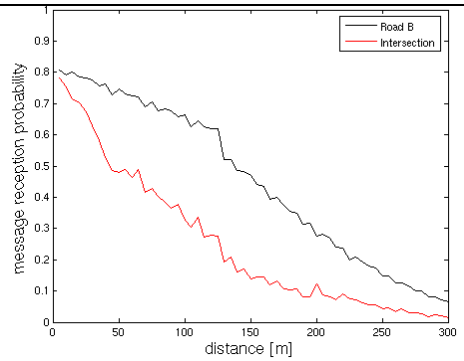


Figure 8-119: Reception Probability of Routine Messages on Road B, Scenario 11

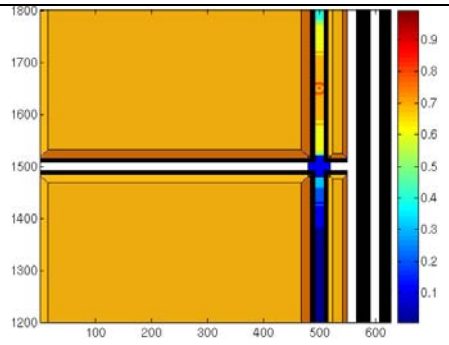


Figure 8-120: Reception Probability of Routine Messages on Road B, Scenario 11

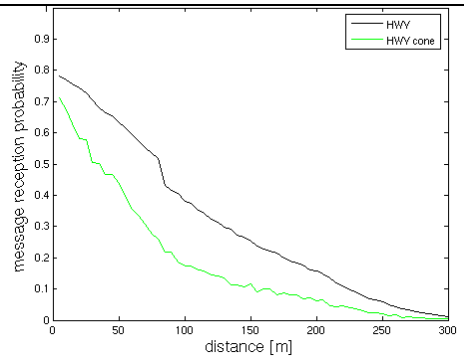


Figure 8-121: Reception Probability of Routine Messages on HWY, Scenario 11

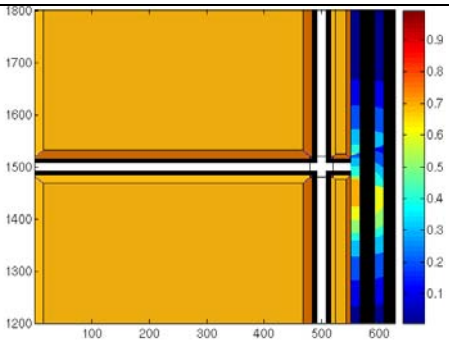
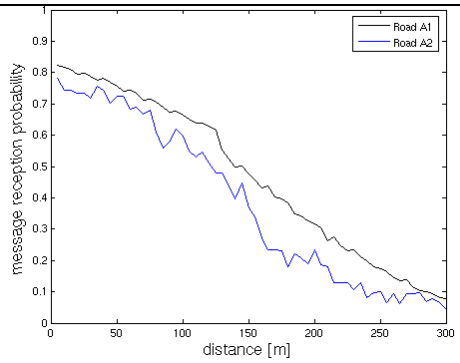
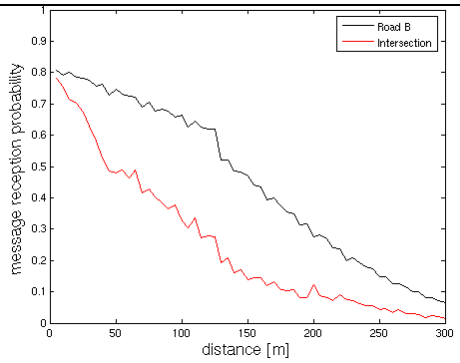
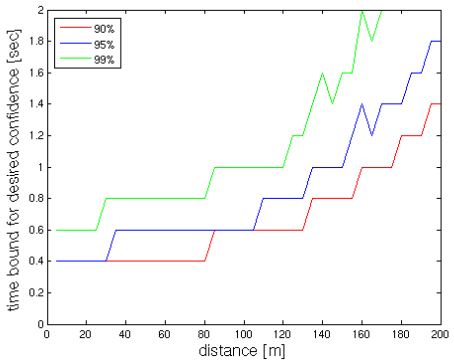
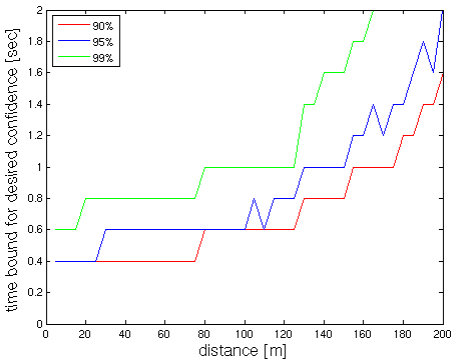


Figure 8-122: Reception Probability of Routine Messages on HWY, Scenario 11

8.7.4 Time Bound for Routine Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	5Hz, 300 byte	200m	

	Routine Messages	
	Road A	Road B
Reception probability		
	Figure 8-123: Reception Probability of Routine Messages on Road A, Scenario 11	**Figure 8-124: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence		
	Figure 8-125: Time Bound for desired Confidence, Routine Messages – Scenario 11, Road A	**Figure 8-126: Time Bound for desired Confidence, Routine Messages - Scenario 11, Road B**

8.8 Routine Messages at 10 Hz, Routine Message Size – 300 byte

Simulation Scenario Settings:

RF Model	Distributed
Emergency Message Sender	RSU, 500 bytes/ 10Hz/200m
Corner Model	Tall buildings
Commercial RSU	On, 500bytes/2Hz/200m
Routine Messages	300byte /10Hz /200m

8.8.1 Reception Probability of Emergency Messages

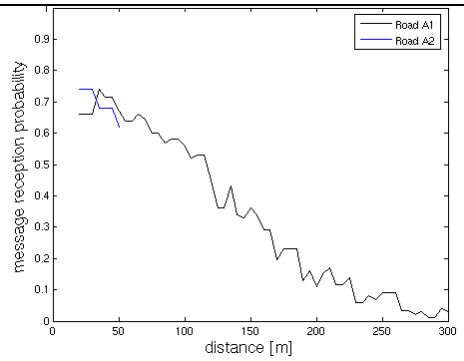


Figure 8-127: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU

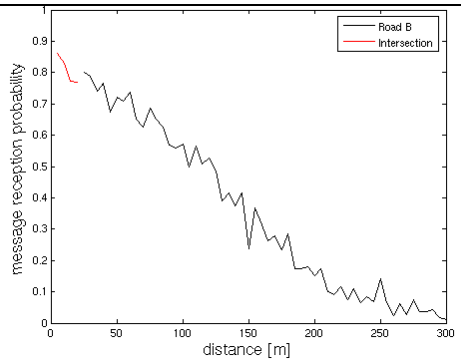


Figure 8-128: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU

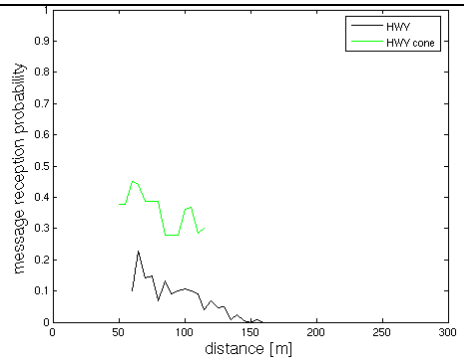


Figure 8-129: Reception Probability of Emergency Messages-Scenario 11, HWY, Sender RSU

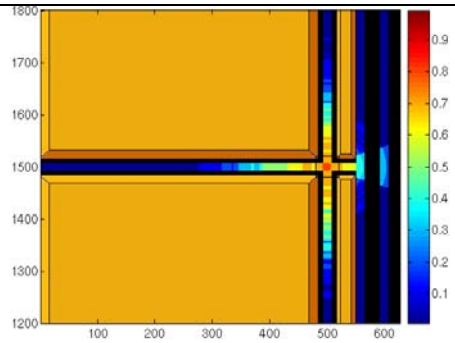
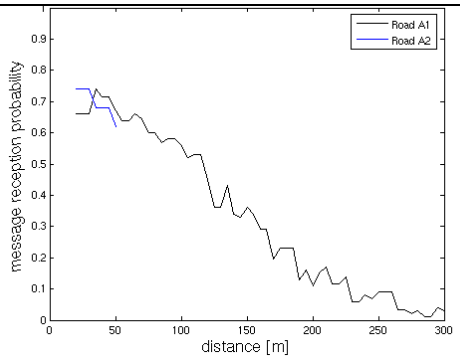
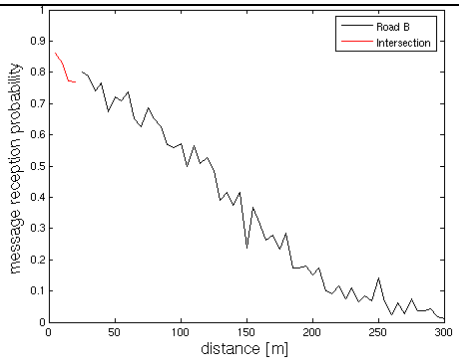
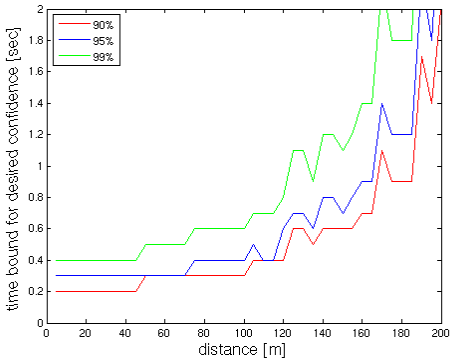
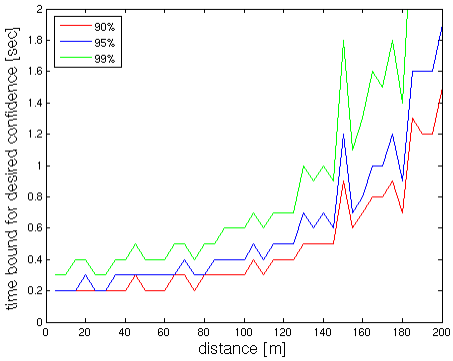


Figure 8-130: Reception Probability of Emergency Messages-Scenario 11, Sender RSU

8.8.2 Time Bound for Emergency Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz, 300 byte	200m	

	Emergency Messages	
	Road A	Road B
Reception probability		
	Figure 8-131: Reception Probability of Emergency Messages-Scenario 11, Road A, Sender RSU	**Figure 8-132: Reception Probability of Emergency Messages-Scenario 11, Road B, Sender RSU**
Time bound for needed confidence		
	Figure 8-133: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road A, Sender RSU	**Figure 8-134: Time Bound for Desired Confidence, Emergency Messages - Scenario 11, Road B, Sender RSU**

8.8.3 Reception Probability of Routine Messages

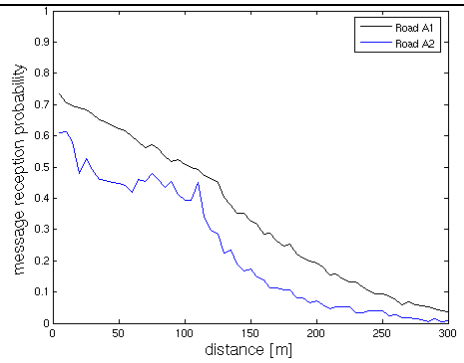


Figure 8-135: Reception Probability of Routine Messages on Road A, Scenario 11

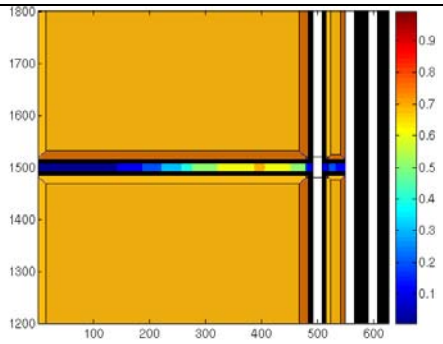


Figure 8-136: Reception Probability of Routine Messages on Road A, Scenario 11

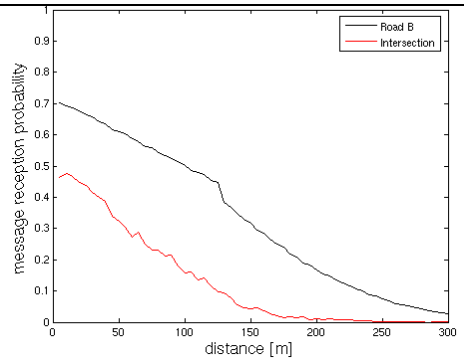


Figure 8-137: Reception Probability of Routine Messages on Road B, Scenario 11

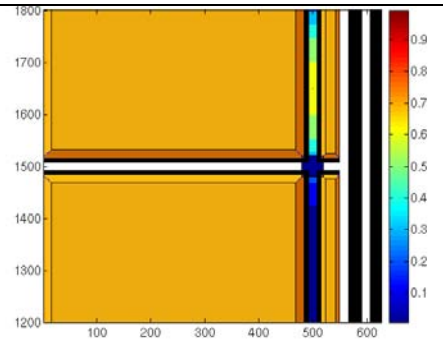


Figure 8-138: Reception Probability of Routine Messages on Road B, Scenario 11

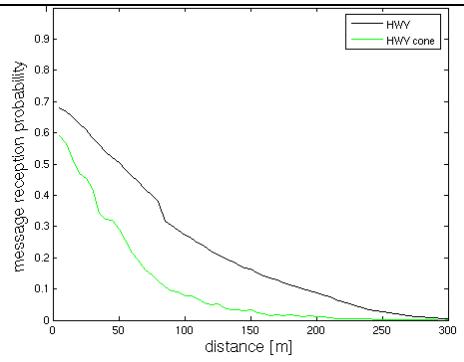


Figure 8-139: Reception Probability of Routine Messages on HWY, Scenario 11

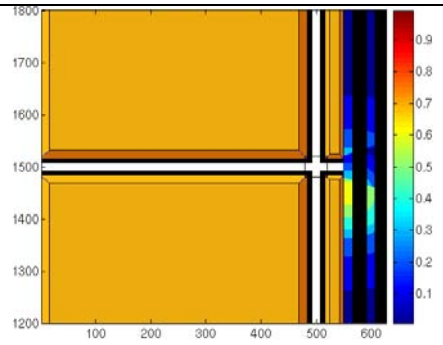
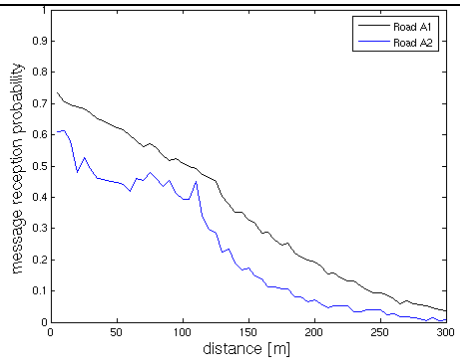
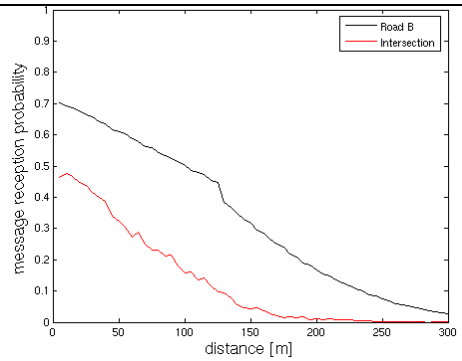
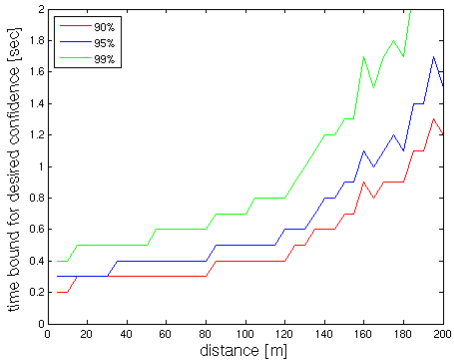
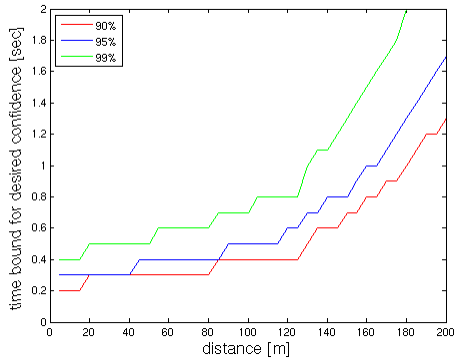


Figure 8-140: Reception Probability of Routine Messages on HWY, Scenario 11

8.8.4 Time Bound for Routine Messages

Number.	RF Model	Corner Model	Emergency Message Sender	Emergency Message Range	Commercial RSU	Routine Safety Message Frequency	Routine Safety Message Range	Emergency Message Cascading Protocol
11	Distributed	Building	RSU	200m	ON	10Hz, 300 byte	200m	

	Routine Messages	
	Road A	Road B
Reception probability		
	Figure 8-141: Reception Probability of Routine Messages on Road A, Scenario 11	**Figure 8-142: Reception Probability of Routine Messages on Road B, Scenario 11**
Time bound for needed confidence		
	Figure 8-143: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road A	**Figure 8-144: Time Bound for Desired Confidence, Routine Messages - Scenario 11, Road B**