8. COMMUNICATION SYSTEMS PERFORMANCE – A CASE STUDY

This section presents an important thrust in the ITS Architecture development effort. The use of existing (i.e., commercially available) and emerging telecommunication infrastructures is integral to the ITS Architecture and corner stone to its feasibility. In this section detailed, in-depth analyses and simulations are performed to support this architecture development philosophy. Through the results of the simulations in a specific case study, it will be demonstrated that the ITS data loads, particularly for wide area communications, can be handled by existing, i.e., commercially deployed and available systems.

For wide area communications in particular, the ITS Architecture leverages the communication infrastructures put in place by the very broad telecommunication industry (see Sections 3 and 7 for the technologies applicable to the myriad ITS data flows). Correspondingly, the evaluation strategy in this section utilizes the expertise that has been developed in the telecommunications industry in planning, deploying and operating these infrastructures. More specifically, the evaluation uses and builds upon simulation tools that have been developed for real systems, i.e., which have been and continue to be deployed commercially. The simulation tools and various of their results have been validated over time by a cross-section of leading industry partners. These partners include GTE, AT&T/McCaw, Bell Atlantic, NYNEX, and others in the CDPD Forum for Cellular Digital Packet Data (CDPD), and Qualcomm, GTE, Nokia, and others in the CDMA Development Group (CDG) for CDMA. In addition to the established tools, the use of existing and emerging standards (e.g., CDPD in wireless communication) simplifies the evaluation process through a structured, well accepted, and reliable definition of the key simulation parameters. This, in turn, aids the Independent Verification and Validation (IV&V) process sought by the Government.

The ITS communication systems simulation is configured into two segments – wireless and wireline – reflecting the nature of the modern communication infrastructure. Although the wireless segment typically limits performance, the performance of both segments is required for a complete and thorough characterization of the communication layer of the ITS system architecture.

Significant resources were dedicated to analyzing, simulating, and evaluating a specific wireless infrastructure that can accommodate the wide area ITS services. For practical reasons, the wireless simulation effort had to be constrained to open, already standardized systems. Thus, given that Cellular Digital Packet Data (CDPD) is the only fully standardized, open-system for data communications over cellular (in the U.S. or abroad), with the advantage of being in an advanced deployment stage, CDPD is used as a case study to show the feasibility of a wide-area ITS cellular solution. This does not imply, however, any *a priori* commitment to CDPD as *the* ITS wide-area delivery platform. Rather, it serves to demonstrate the feasibility of the architecture in that commercially available wireless systems do indeed exist that can handle the ITS data load requirements into the foreseeable future.

Meanwhile, wireline simulation is not neglected, it is used to aid in designing a candidate backbone network to provide connectivity and access to the wireless assets and to tie together the fixed transportation entities.

End-to-end communication system performance will be obtained by integrating the simulation efforts in these two areas. Performance results for the overall communication system associated with given users and/or user services will be obtained. Naturally, the end-to-end communication system performance should be tied to the corresponding latencies identified in the *Mission Definition* document for the ITS services (whose offering involves both communication and transportation subsystems). The selection of the best communication architecture and technologies can then be pursued to meet the broad objectives of sufficiency, cost effectiveness, and risk mitigation through proper utilization of existing and emerging wireless and wireline technologies.

With the objective of promoting user acceptance for each medium, and especially for those that involve air-time charges (e.g., wireless data systems like CDPD), care is taken to utilize a message structure that minimizes user cost by reducing overhead (transmitting the required information, and not requiring unnecessary padding to fit fixed message sizes). Simultaneously, but secondarily, this approach optimizes system performance by increasing throughput for a given infrastructure, or improving performance for the same effective user load.

8.1 Wireless Systems Performance

The objective of this section is to determine whether the communications element or "layer" of the system architecture is both sufficient and efficient at all stages of deployment, especially for the 1997, 2002, and 2012 time frames.

The analysis of the 2012 time frame was performed at earlier stages of the National ITS Architecture Study (Phase I), and is reported herein, even though the loads date back to the Phase II IPR2 submission (Logical and Physical Architecture data flows of August 1995). The objective of presenting these results is to show system performance with the highest ITS only loads anticipated for that time frame.

The 2002 time frame was selected for complete evaluation upon discussions with the Government and the Technical Review Team. We will analyze the performance of the CDPD system for the cases of ITS only, ITS plus Non-ITS, and ITS plus Non-ITS in case of Incident. These simulations will use worst case loads for the most recent (January 1996) Logical and Physical Architecture data flows.

8.1.1 Scope of Performance Analysis

The peak period scenario to be analyzed is obtained from the actual cellular deployment for each Government chosen scenario (which we assume not to expand with time thereby implying worst case performance results). The peak voice load was computed for each sector from the Erlang-B formula for 2% blocking probability. For the ITS data load, proportionality to the voice load (i.e., to the number of cellular users) was assumed. The underlying implication is that there is a proportionality between the number of cellular voice users and the number of ITS users (i.e., the concept of a “wireless” use pattern is assumed for the lack of better information). Thus, the overall ITS data load was divided proportionally by the sectors as a function of their voice load.

CDPD performance was simulated for two of the three scenarios defined by the Government, namely Urbansville, and Thruville. Mountainville was analyzed from the point of view of cellular coverage, but CDPD was not exercised because it is very unlikely that CDPD will be deployed in Lincoln County, MT at that time, given the small population density, and the foreseeable loads. That, however, does not mean that users in those regions would be left out of data coverage. Indeed, through Circuit-Switched CDPD, everyone could piggyback on that infrastructure to exchange data wherever cellular coverage reaches.

8.1.1.1 Urbansville 2002 and 2012

In Phase I, we analyzed the case of one reserved CDPD channel plus another one dynamically assigned as a function of availability and demand. In Phase II, we considered the case of one reserved CDPD channel without any additional dynamically assigned channels, as well as a totally dynamic solution for the CDPD problem, with no reserved channels.

8.1.1.1.1 Cellular Deployment in the Detroit MSA

The CDPD deployment under consideration will be analyzed as an overlay onto the real cellular infrastructure deployed in the Detroit area (up-to-date as of November 1993). The definition of this realistic deployment required the compilation of a very large set of detailed infrastructure parameters from the FCC filings of the Detroit Cellular Telephone Company (DCTC).

The DCTC FCC filing information is summarized in Table 8.1-1. An example of base station (BS) characterization thus obtained is provided in Table 8.1-2 for DCTC Site #25. Each antenna was characterized based, whenever possible, on manufacturer provided information, and otherwise by reading from polar plots filed with the site authorization requests. An example is shown in Table 8.1-3.

The area analyzed in this case study corresponds to the total area of the three counties that make up Urbansville. In Figure 8.1-1, we schematically present the distribution of the BSs read from the FCC filings. Note that it was not possible to include the boundaries of Urbansville since they were not provided by the Government to the Teams. Figure 8.1-2 (obtained using GRANET) presents the best server map for the three counties encompassing Urbansville (in the Detroit area). The ragged boundaries of the cells reflect actual propagation conditions, thus showing how topography, topology, and land use affect conditions.

In this realistic test case, the uniformity assumption that had been used early in Phase I has been removed (the number of channels in a given sector varies from 8 to 37). The peak voice was computed for each sector from the Erlang-B formula for 2% blocking probability. For the IVHS data load, the same assumption was made of proportionality to the voice load (i.e., to the number of cellular users). Thus, the overall Urbansville IVHS data load was divided proportionally by the sectors.

Table 8.1-1 Summary of DCTC FCC Filings (Nov. 1993)

DCTC Location Number	Location Code Name	N Latitude	W Longitude	Sector Number	Number of Channels	Antenna Type	ERP (W)
3	Proud Lake	42-33-40	83-34-20	1	16	DB874H83	100
3	Proud Lake	42-33-40	83-34-20	2	24	DB874H83	20
3	Proud Lake	42-33-40	83-34-20	3	15	DB874H83	100
4	Novi	42-28-47	83-27-40	1	20	ALP8013-N	35
4	Novi	42-28-47	83-27-40	2	28	ALP8013-N	36
4	Novi	42-28-47	83-27-40	3	31	ALP8013-N	50
7	Mt. Clemens	42-32-26	82-53-25	1	20	ALP8013-N	75
7	Mt. Clemens	42-32-26	82-53-25	2	16	ALP8013-N	25
7	Mt. Clemens	42-32-26	82-53-25	3	31	ALP8013-N	27
8	Anchorville	42-45-25	82-44-25	1	12	ALP11011-N	86
8	Anchorville	42-45-25	82-44-25	2	19	ALP11011-N	60
8	Anchorville	42-45-25	82-44-25	3	12	ALP11011-N	89
9	Holly	42-47-02	83-32-05	1	16	PD-1136	83.2
9	Holly	42-47-02	83-32-05	2	15	PD-1136	83.2
12	WDIV Tower	42-28-58	83-12-19	1	16	ALP8010	12.5
12	WDIV Tower	42-28-58	83-12-19	2	24	ALP8010	50
12	WDIV Tower	42-28-58	83-12-19	3	24	ALP8010	50
14	Lake Angelous	42-41-25	83-17-50	1	24	DB-564	75
14	Lake Angelous	42-41-25	83-17-50	2	16	ALP8013-N	25
14	Lake Angelous	42-41-25	83-17-50	3	20	ALP8013-N	50
15	Rochester	42-40-42	83-07-27	1	24	DB-564	75
15	Rochester	42-40-42	83-07-27	2	22	DB-834	40
15	Rochester	42-40-42	83-07-27	3	28	DB874H83	75
16	Livonia	42-19-35	83-25-42	1	16	ALP8010	50
16	Livonia	42-19-35	83-25-42	2	19	ALP8010	75
16	Livonia	42-19-35	83-25-42	3	35	DB874H83	50
17	Walled Lake	42-34-09	83-26-30	1	20	DB874H83	50
17	Walled Lake	42-34-09	83-26-30	2	16	DB874H83	25
17	Walled Lake	42-34-09	83-26-30	3	19	DB874H83	50
18	Warren	42-36-27	83-02-33	1	28	DB874H83	100
18	Warren	42-36-27	83-02-33	2	24	DB874H83	50
18	Warren	42-36-27	83-02-33	3	19	DB874H83	25
19	Dearborn	42-18-52	83-09-07	1	16	ALP8013-N	73
19	Dearborn	42-18-52	83-09-07	2	24	DB882H60	64
19	Dearborn	42-18-52	83-09-07	3	27	DB874H83	64
21	Bloomfield Hills	42-36-32	83-17-35	1	20	DB872H83	25
21	Bloomfield Hills	42-36-32	83-17-35	2	28	ALP8013-N	30
21	Bloomfield Hills	42-36-32	83-17-35	3	26	DB874H83	25
22	Franklin	42-30-07	83-18-33	1	20	ALP8013-N	10
22	Franklin	42-30-07	83-18-33	2	32	ALP8013-N	6

22	Franklin	42-30-07	83-18-33	3	36	ALP8013-N	27
23	Redford	42-24-07	83-16-29	1	16	DB882H60	25
23	Redford	42-24-07	83-16-29	2	20	DB872H83	43
23	Redford	42-24-07	83-16-29	3	20	ALP8013-N	50
24	Strohs	42-20-12	83-01-03	1	20	DB883H60	75
24	Strohs	42-20-12	83-01-03	2	16	PD-1132	50
25	Detroit West	42-23-13	83-10-50	1	16	ALP8010-N	57
25	Detroit West	42-23-13	83-10-50	2	16	ALP8010-N	50
25	Detroit West	42-23-13	83-10-50	3	23	ALP8010-N	30
26	Detroit Baltimore	42-22-13	83-04-06	1	24	DB872H83	20
26	Detroit Baltimore	42-22-13	83-04-06	2	24	DB882H60	20
26	Detroit Baltimore	42-22-13	83-04-06	3	23	DB872H83	18
27	Grosse Pointe	42-24-11	82-58-08	1	20	ALP8010	50
27	Grosse Pointe	42-24-11	82-58-08	2	16	ALP8010	50
27	Grosse Pointe	42-24-11	82-58-08	3	19	ALP8010	50
28	Dearborn West	42-19-51	83-13-13	1	16	DB-834	100
28	Dearborn West	42-19-51	83-13-13	2	16	DB-834	100
28	Dearborn West	42-19-51	83-13-13	3	15	DB-834	100
29	East Detroit	42-29-28	83-02-32	1	16	DB-564S	100
29	East Detroit	42-29-28	83-02-32	2	16	DB-564S	100
29	East Detroit	42-29-28	83-02-32	3	15	DB-564S	100
30	Clawson	42-32-29	83-07-58	1	24	DB874H83	50
30	Clawson	42-32-29	83-07-58	2	24	DB874H83	50
30	Clawson	42-32-29	83-07-58	3	20	DB874H83	50
31	Bloomfield Hills	42-32-26	83-17-03	1	18	DB-834	100
31	Bloomfield Hills	42-32-26	83-17-03	2	15	DB-834	66
31	Bloomfield Hills	42-32-26	83-17-03	3	12	DB-834	66
32	Inkster	42-17-43	83-17-42	1	24	ALP8013-N	12.5
32	Inkster	42-17-43	83-17-42	2	24	ALP8013-N	50
32	Inkster	42-17-43	83-17-42	3	16	ALP8013-N	50
33	Hazel Park	42-27-55	83-05-01	1	16	DB-834	100
33	Hazel Park	42-27-55	83-05-01	2	16	DB-834	100
33	Hazel Park	42-27-55	83-05-01	3	16	DB-834	100
34	Pleasant Ridge	42-28-53	83-08-22	1	16	DB-834	50
34	Pleasant Ridge	42-28-53	83-08-22	2	24	DB874H83	50
34	Pleasant Ridge	42-28-53	83-08-22	3	23	ALP8007-N	12.5
35	Birmingham	42-32-43	83-11-37	1	24	ALP8010	50
35	Birmingham	42-32-43	83-11-37	2	16	ALP8010	25
35	Birmingham	42-32-43	83-11-37	3	19	ALP8010	50
36	Northville	42-23-50	83-26-11	1	20	ALP8010-N	35
36	Northville	42-23-50	83-26-11	2	24	ALP8010-N	67
36	Northville	42-23-50	83-26-11	3	16	ALP8013-N	100
37	Farmington Hills	42-29-52	83-22-45	1	12	LPD-7907	58
37	Farmington Hills	42-29-52	83-22-45	2	16	LPD-7907	58
37	Farmington Hills	42-29-52	83-22-45	3	13	LPD-7907	58
38	Auburn Hills	42-38-03	83-12-58	1	14	DB874H83	100

38	Auburn Hills	42-38-03	83-12-58	2	12	DB874H83	50
38	Auburn Hills	42-38-03	83-12-58	3	19	DB874H83	75
39	Sterling Heights	42-33-01	83-00-03	1	14	DB-834	80
39	Sterling Heights	42-33-01	83-00-03	2	12	DB-834	80
39	Sterling Heights	42-33-01	83-00-03	3	16	DB-834	80
40	Southfield	42-27-00	83-16-57	1	16	DB-834	75
40	Southfield	42-27-00	83-16-57	2	16	DB-834	75
40	Southfield	42-27-00	83-16-57	3	15	DB-834	75
42	Detroit N.	42-27-18	83-00-28	1	16	DB-834	100
42	Detroit N.	42-27-18	83-00-28	2	16	DB-834	100
42	Detroit N.	42-27-18	83-00-28	3	16	DB-834	100
43	Big Beaver	42-34-35	83-07-37	1	16	DB-834	100
43	Big Beaver	42-34-35	83-07-37	2	16	DB-834	100
43	Big Beaver	42-34-35	83-07-37	3	16	DB-834	100
44	Highland Park	42-24-07	83-07-29	1	16	DB-834	100
44	Highland Park	42-24-07	83-07-29	2	16	DB-834	100
44	Highland Park	42-24-07	83-07-29	3	15	DB-834	100
45	Oak Park	42-26-20	83-11-41	1	16	DB-834	100
45	Oak Park	42-26-20	83-11-41	2	16	DB-834	100
45	Oak Park	42-26-20	83-11-41	3	15	DB-834	100
46	Taylor	42-13-34	83-14-08	1	16	DB-834	100
46	Taylor	42-13-34	83-14-08	2	16	DB-834	100
46	Taylor	42-13-34	83-14-08	3	16	DB-834	100
47	Farmington	42-26-26	83-21-52	1	20	DB-834	30
47	Farmington	42-26-26	83-21-52	2	11	DB874H83	50
47	Farmington	42-26-26	83-21-52	3	16	DB-834	63
48	East Livonia	42-22-24	83-22-13	1	20	ALP8010-N	67
48	East Livonia	42-22-24	83-22-13	2	16	ALP8013-N	30
48	East Livonia	42-22-24	83-22-13	3	14	ALP8013-N	13
49	Minnow Lake	42-34-44	83-16-54	1	19	ALP8013-N	100
49	Minnow Lake	42-34-44	83-16-54	2	16	ALP8013-N	50
49	Minnow Lake	42-34-44	83-16-54	3	16	ALP8013-N	100
50	Lathrup	42-29-12	83-16-10	1	20	ALP8010	80
50	Lathrup	42-29-12	83-16-10	2	20	ALP8010	40
50	Lathrup	42-29-12	83-16-10	3	15	ALP8010	25
51	Harper Woods	42-28-05	82-55-14	1	20	ALP8013-N	79
51	Harper Woods	42-28-05	82-55-14	2	20	ALP8010-N	30
51	Harper Woods	42-28-05	82-55-14	3	14	ALP8013-N	79
52	Orchard Lake	42-33-35	83-22-20	1	19	ALP8010-N	25
52	Orchard Lake	42-33-35	83-22-20	2	20	ALP8010-N	25
52	Orchard Lake	42-33-35	83-22-20	3	10	ALP8013-N	100
53	Troy	42-36-13	83-10-05	1	16	DB-834	100
53	Troy	42-36-13	83-10-05	2	16	DB-834	100
53	Troy	42-36-13	83-10-05	3	16	DB-834	100
54	Elizabeth Lake	42-38-21	83-22-52	1	16	DB-834	100
54	Elizabeth Lake	42-38-21	83-22-52	2	16	DB-834	100

54	Elizabeth Lake	42-38-21	83-22-52	3	16	DB-834	100
55	Knollwood	42-32-39	83-19-46	1	16	DB-834	100
55	Knollwood	42-32-39	83-19-46	2	16	DB-834	100
55	Knollwood	42-32-39	83-19-46	3	16	DB-834	100
56	Cranbrook	42-35-05	83-14-44	1	10	LPD7907	100
56	Cranbrook	42-35-05	83-14-44	2	12	LPD7907	100
56	Cranbrook	42-35-05	83-14-44	3	8	LPD7907	100
57	Tally Hall	42-31-41	83-21-34	1	20	DB882H60	50
57	Tally Hall	42-31-41	83-21-34	2	24	DB882H60	50
57	Tally Hall	42-31-41	83-21-34	3	19	DB872H83	100
58	Airport	42-13-25	83-23-28	1	32	DB874H83	67.6
58	Airport	42-13-25	83-23-28	2	16	DB874H83	100
58	Airport	42-13-25	83-23-28	3	20	DB874H83	200
59	Mt. Clemens North	42-36-47	82-52-57	1	24	DB-834	100
59	Mt. Clemens North	42-36-47	82-52-57	2	20	DB-834	61
59	Mt. Clemens North	42-36-47	82-52-57	3	16	DB-834	40
60	Royal Oak	42-30-54	83-11-03	1	20	DB882H60	50
60	Royal Oak	42-30-54	83-11-03	2	20	DB882H60	50
60	Royal Oak	42-30-54	83-11-03	3	19	DB882H60	50
61	Madisson Heights	42-30-51	83-05-08	1	16	DB-834	100
61	Madisson Heights	42-30-51	83-05-08	2	16	DB-834	100
61	Madisson Heights	42-30-51	83-05-08	3	15	DB-834	100
62	Beverly Hills	42-30-51	83-13-28	1	16	ALP8010	50
62	Beverly Hills	42-30-51	83-13-28	2	16	ALP8010	50
62	Beverly Hills	42-30-51	83-13-28	3	16	ALP8010	50
64	Hamtramck	42-24-34	83-02-18	1	16	DB-834	75
64	Hamtramck	42-24-34	83-02-18	2	16	DB-834	55
64	Hamtramck	42-24-34	83-02-18	3	16	DB-834	75
67	Murray Lake	42-38-17	83-39-25	1	8	DB872H83	100
67	Murray Lake	42-38-17	83-39-25	2	8	DB872H83	50
67	Murray Lake	42-38-17	83-39-25	3	12	DB872H83	100
68	Oakwood	42-47-14	83-18-20	1	16	DB-560	100
69	Romeo	42-50-03	83-00-44	1	16	DB-560	100
72	Tiger Stadium	42-20-08	83-05-55	1	16	DB-834	67
72	Tiger Stadium	42-20-08	83-05-55	2	16	DB-834	30
72	Tiger Stadium	42-20-08	83-05-55	3	12	DB-834	67
73	Roseville	42-29-28	82-58-53	1	16	DB872H83	50
73	Roseville	42-29-28	82-58-53	2	16	DB872H83	50
73	Roseville	42-29-28	82-58-53	3	16	DB872H83	50
75	Orion Township	42-43-07	83-14-09	1	16	ALP8013-N	100
75	Orion Township	42-43-07	83-14-09	2	16	ALP8013-N	75
75	Orion Township	42-43-07	83-14-09	3	11	ALP8013-N	12.5
76	Ferndale	42-26-19	83-06-25	1	20	DB874H83	50
76	Ferndale	42-26-19	83-06-25	2	20	DB874H83	50
76	Ferndale	42-26-19	83-06-25	3	19	DB874H83	50
77	Northville North	42-26-27	83-26-17	1	12	DB882H60	50

77	Northville North	42-26-27	83-26-17	2	12	DB882H60	25
77	Northville North	42-26-27	83-26-17	3	8	DB872H83	100
79	Clarkston	42-43-54	83-22-28	1	16	DB874H83	100
79	Clarkston	42-43-54	83-22-28	2	16	DB874H83	100
79	Clarkston	42-43-54	83-22-28	3	16	DB874H83	100
83	Pontiac South	42-38-53	83-16-09	1	16	DB874H83	50
83	Pontiac South	42-38-53	83-16-09	2	16	DB874H83	50
83	Pontiac South	42-38-53	83-16-09	3	16	DB874H83	50
84	Downtown Detroit	42-19-37	83-02-44	1	16	DB882H60	50
84	Downtown Detroit	42-19-37	83-02-44	2	15	DB874H83	50
85	Mound	42-33-09	83-02-42	1	16	DB874H83	25
85	Mound	42-33-09	83-02-42	2	12	DB874H83	50
85	Mound	42-33-09	83-02-42	3	12	DB874H83	50
86	Canton	42-16-38	83-27-04	1	16	DB874H83	50
86	Canton	42-16-38	83-27-04	2	16	DB874H83	50
86	Canton	42-16-38	83-27-04	3	16	DB874H83	100
87	Detroit West II	42-24-07	83-13-13	1	12	DB874H83	50
87	Detroit West II	42-24-07	83-13-13	2	12	DB874H83	50
87	Detroit West II	42-24-07	83-13-13	3	12	DB874H83	50
89	Livonia Mall	42-24-49	83-20-11	1	12	DB874H83	50
89	Livonia Mall	42-24-49	83-20-11	2	12	DB874H83	50
89	Livonia Mall	42-24-49	83-20-11	3	12	DB874H83	50
90	Northwestern Hwy	42-27-56	83-14-00	1	16	DB874H83	14
90	Northwestern Hwy	42-27-56	83-14-00	2	16	DB874H83	50
90	Northwestern Hwy	42-27-56	83-14-00	3	16	DB874H83	25
92	Rochester South	42-39-26	83-09-19	1	12	ALP8013-N	50
92	Rochester South	42-39-26	83-09-19	2	12	ALP8013-N	50
92	Rochester South	42-39-26	83-09-19	3	12	ALP8013-N	50
94	Grosse Pointe Park	42-22-16	82-57-06	1	12	ALP4014-N	100
94	Grosse Pointe Park	42-22-16	82-57-06	2	12	ALP6011-N	50
95	Airport North	42-14-44	83-18-25	1	12	ALP8010	50
95	Airport North	42-14-44	83-18-25	2	12	ALP8010	50
95	Airport North	42-14-44	83-18-25	3	16	ALP8010	100
96	Dearborn Heights	42-20-59	83-16-32	1	16	DB874H83	50
96	Dearborn Heights	42-20-59	83-16-32	2	16	DB874H83	25
96	Dearborn Heights	42-20-59	83-16-32	3	16	DB874H83	50
99	Grosse Pointe Yacht Club	42-26-04	82-52-21	1	8	LPD-7907	5
99	Grosse Pointe Yacht Club	42-26-04	82-52-21	2	8	LPD-7907	100
114	White Lake	42-39-29	83-32-45	1	8	ALP8013-N	50
114	White Lake	42-39-29	83-32-45	2	8	ALP8013-N	50
114	White Lake	42-39-29	83-32-45	3	12	ALP8013-N	50
115	Keego Harbor	42-36-42	83-19-47	1	16	ALP8010	25
115	Keego Harbor	42-36-42	83-19-47	2	12	ALP8010	25
115	Keego Harbor	42-36-42	83-19-47	3	12	ALP8010	25
116	Garfield	42-36-22	82-57-04	1	16	ALP8010	100
116	Garfield	42-36-22	82-57-04	2	12	ALP8010	50

116	Garfield	42-36-22	82-57-04	3	16	ALP8010	50
120	Halstead	42-29-35	83-25-18	1	16	DB874H83	25
120	Halstead	42-29-35	83-25-18	2	16	DB874H83	25
120	Halstead	42-29-35	83-25-18	3	16	DB874H83	50
124	Stephenson Hwy	42-30-37	83-06-58	1	16	ALP8010	50
124	Stephenson Hwy	42-30-37	83-06-58	2	16	ALP8010	25
124	Stephenson Hwy	42-30-37	83-06-58	3	12	ALP8010	23.3
132	Troy South	42-33-47	83-09-03	1	16	DB874H83	25
132	Troy South	42-33-47	83-09-03	2	16	DB874H83	25
132	Troy South	42-33-47	83-09-03	3	16	DB874H83	25
133	Birmingham Downtown	42-32-44	83-12-51	1	20	DB872H83	100
133	Birmingham Downtown	42-32-44	83-12-51	2	20	DB872H83	50
133	Birmingham Downtown	42-32-44	83-12-51	3	20	DB872H83	50
150	Allen Park	42-16-19	83-12-04	1	16	DB874H83	25
150	Allen Park	42-16-19	83-12-04	2	16	DB874H83	50
150	Allen Park	42-16-19	83-12-04	3	16	DB874H83	25
155	Haggerty x 14 Mile Road	42-31-42	83-26-28	1	16	ALP8010	50
155	Haggerty x 14 Mile Road	42-31-42	83-26-28	2	16	ALP8010	50
155	Haggerty x 14 Mile Road	42-31-42	83-26-28	3	16	ALP8010	100

Table 8.1-2 Characterization of the DCTC Site #25

SITE_NAME	Detroit West
SITE_ID	DCTC-025
LATITUDE	42 23 13 N
LONGITUDE	83 10 50 E
FREQUENCY	860 MHz
VOICE_CHANNEL_DATA	
NUMBER_OF_SECTORS	3
FOR_SECTOR	1
ANTENNA_HEIGHT	159 FT
ANTENNA_MODEL_NUMBER	ALP8010-N
ANTENNA_MAIN_LOBE	30 degrees
ERP	57 W
NUMBER_OF_CHANNELS	16
CONTROL _CHANNEL	333
VOICE_CHANNELS 270 250 228 207 186 165 144 123 102 81 60 39 18	
FOR_SECTOR	2
ANTENNA_HEIGHT	159 FT
ANTENNA_MODEL_NUMBER	ALP8010-N
ANTENNA_MAIN_LOBE	150 degrees
ERP	50 W
NUMBER_OF_CHANNELS	16
CONTROL _CHANNEL	321
VOICE_CHANNELS 258 237 216 195 174 153 132 111 90 69 48 27 6	
FOR_SECTOR	3
ANTENNA_HEIGHT	159 FT
ANTENNA_MODEL_NUMBER	ALP8010-N
ANTENNA_MAIN_LOBE	270 degrees
ERP	30 W
NUMBER_OF_CHANNELS	23
CONTROL _CHANNEL	316
VOICE_CHANNELS 708 690 687 669 666 295 274 253 232 211 190 169 148 127 106 85 64 43 22 1	

Table 8.1-3 Manufacturer-Provided Pattern for DB874H83 Antenna

Gain (dB)	11.8					(Continued)	
Manufacturer	Decibel Products					Angle	dBi
Sectored						-9.1	7.6
						-7.9	8.9
Horizontal Pattern						-5.4	10.5
Symmetric						-2.6	11.4
Equally Spaced						-0.3	11.8
From/To/Step	0	180	5			0	11.8
11.8	11.7	11.5	11.3	11.1		1	11.6
10.8	10.4	9.1	8.7	8		1.8	11.5
7.4	6.5	5.7	4.9	4.1		3.3	11.1
1.9	0.8	-0.4	-1.3	-2.1		4.9	10.4
-3.3	-4.3	-7.6	-9.3	-10.9		6.2	9.5
-12.2	-13.1	-12.1	-10.9	-8.5		6.8	9.1
						8.3	7.8
Vertical Pattern						9.9	6.1
Asymmetric						10.4	5.2
Unequally Spaced						11	4
Angle	dBi					12.5	2
-83.1	-21.7					13.2	0.7
-74.3	-17.4					13.7	-0.7
-71.8	-17.1					14.1	-4.3
-67.2	-18.9					14.6	-5.4
-66.7	-17.6					14.9	-12.4
-57.1	-14.2					15.2	-11.9
-56.7	-19.3					15.7	-14
-56.3	-20.4					17.4	-14
-55.9	-12.9					18.8	-6.9
-52.9	-9.3					19	-8.6
-46.4	-6.9					19.1	-9.7
-43.3	-7.5					19.4	-5.2
-41.3	-8.2					20.8	-2.3
-39.6	-11.1					22.8	-0.8
-38.4	-13.9					24.6	-0.2
-35.4	-16					29.5	-1.7
-34.5	-15.8					32.5	-5.1
-33.3	-13.9					34.1	-9.9
-32.7	-10.8					34.6	-14.6
-31.1	-7.4					37.9	-16.6
-28.5	-4.8					41	-13.7
-24.5	-3.4					42.3	-10.6
-22.9	-4.2					44.5	-8.5
-21.6	-5.7					46.5	-7.3
-21.3	-7.3					51.5	-7.8
-20.3	-8.8					55	-10.8
-19.6	-9.5					57.9	-15.2
-18.7	-10.5					60.5	-17.7
-17.2	-8.2					62.2	-17.8
-16.5	-6.1					66.3	-15.7
-16.4	-4.2					72.8	-12.5
-14.9	-2					78	-12.3
-14.4	0.2					83.9	-14.9
-13.4	2.2					87	-16
-12.2	4					89.2	-16.9
-10.9	5.6					90	-21.7

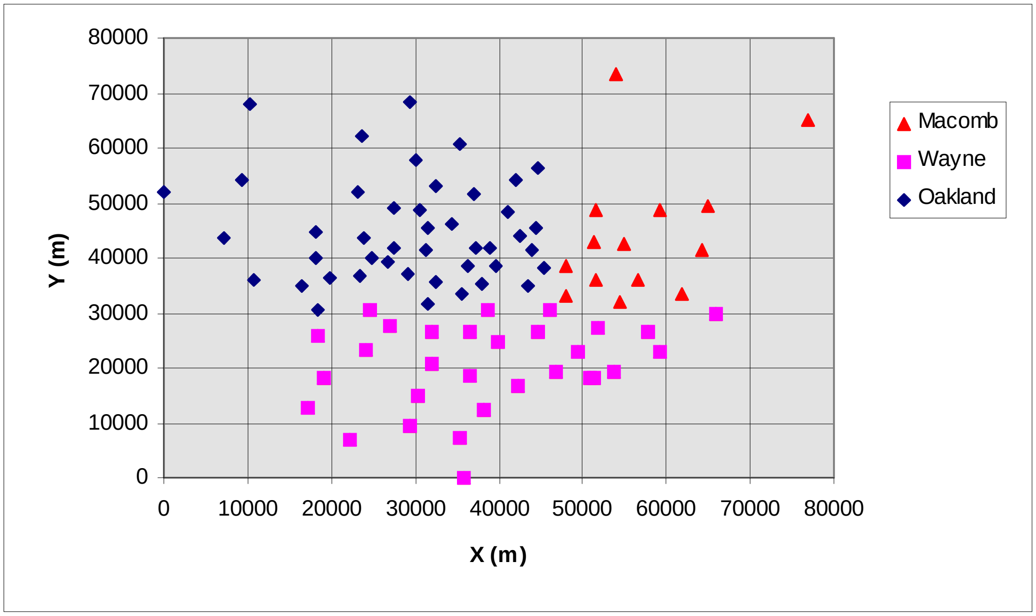

Figure 8.1-1 Base Station Locations in the Detroit Area

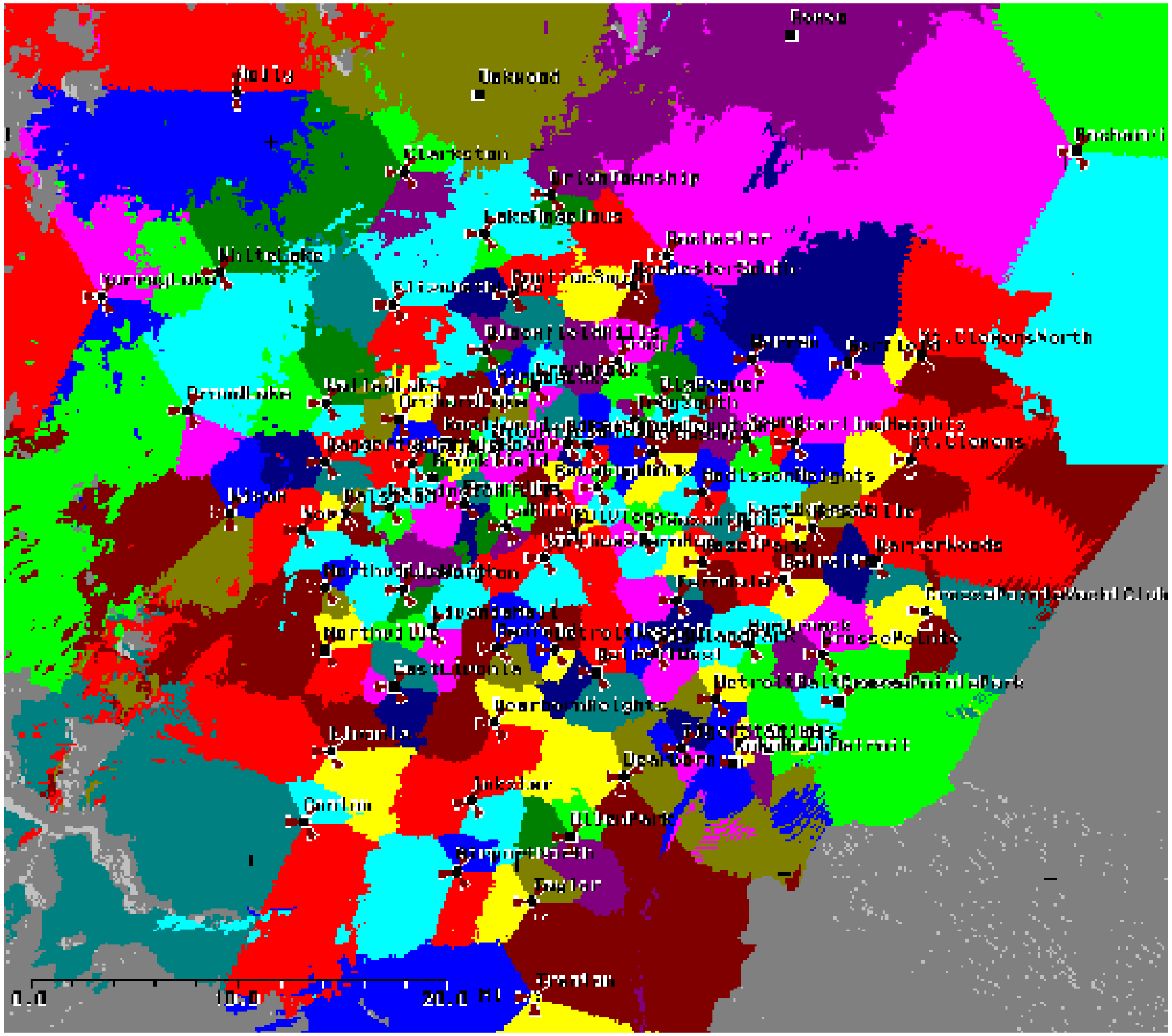

Figure 8.1-2 Best Server Map of the Detroit Area obtained using GRANET

8.1.1.1.2 2012 (Phase I) Data Loads

The performance study of a CDPD system began in Phase I by establishing the capacity of what was called a minimal CDPD deployment, which was one reserved CDPD channel per sector.

The analysis performed in Phase I for the data loads anticipated for 2012 was for one reserved CDPD channel plus one dynamically assigned channel. This analysis is reported herein, even though the loads have since changed. The purpose of this is to illustrate system performance when the data loads are much higher then those considered in the 2002 time frame.

8.1.1.1.3 2002 (Phase II) Data Loads

Three case studies of CDPD overlaid on cellular AMPS voice will be presented for Urbansville for the 2002 time frame. A minimal CDPD deployment (defined as one CDPD channel per sector) was initially considered, with the channel reserved for exclusive use of CDPD and no additional dynamically assigned channel. Later, a totally dynamic solution was also considered with three dynamically assigned CDPD channels but with no channels reserved for CDPD. The results from both cases will be reported in detail in the sections that will follow.

8.1.1.1.3.1 Deployment 1: One Reserved CDPD Channel (No Dynamic)

MOSS, the GTE Laboratories (GTEL) proprietary mobile radio simulation package (see Appendix I), was exercised first to determine the performance of a mix of voice and data from ITS users only for that minimal CDPD deployment, based upon coverage information obtained with another GTEL’s proprietary package, GRANET. The same system was also simulated for the case of a mix of voice and data from ITS and Non-ITS users. Finally, an incident was considered, based upon information obtained from MITRE (February 1, 1996) taken from their vehicular traffic simulations, on top of the above mix of voice and data from ITS and non-ITS users.

8.1.1.1.3.2 Deployment 2: Three Dynamically Assigned CDPD Channels (No Reserved)

Given that CDPD was in fact designed to operate in a dynamic mode (making use of the idle periods between calls) another solution was also analyzed. Three CDPD channels are dynamically assigned to CDPD traffic as a function of availability and demand. That number corresponds to an optimal use of the available idle moments during the peak period. A fourth one would provide minimal improvement (diminishing returns). The data loads considered here correspond to the mix of voice and data from ITS and non-ITS users.

8.1.1.2 Thruville 2002

In the case of Thruville, based upon the Philadelphia-Trenton Corridor, getting cellular deployment information was much more difficult. The information obtained from the FCC filings was of much poorer quality than that of Detroit, with only incomplete information available for many cells. The reasons for this shortcoming are two fold: 1) the filing rules give some latitude to the cellular companies as to the detail of what is reported, and 2) the rules have been changed in the interim, reducing the requirements for information (presently only information concerning the sites that affect surrounding markets needs to be provided).

As a consequence, some radio planning had to be performed to complete the information obtained from the FCC. The quality of the complete deployment, especially in terms of interference, had to be tested to guarantee acceptable performance before CDPD simulations could begin.

Two scenarios were simulated for the case of one reserved CDPD channel and no additional dynamically assigned channel: ITS only, and ITS plus non-ITS. The case of ITS plus non-ITS with Incident, could not be analyzed in time (priority was given to simulating the n-dynamic CDPD channels deployment). The incident data was obtained from MITRE, taken from their vehicular traffic simulations using Integration. The fact that the simulated roadway links, represented by link numbers, had no obvious correspondence to actual roadway segments made the mapping extremely difficult.

8.1.1.3 Mountainville

The cellular deployment information for Mountainville was not much better than that of Philadelphia. However, having decided that CDPD would not be exercised for the scenario for the 2002 time frame, the task became much simpler. The only concern became the coverage provided by the present cellular deployment, rather than its frequency plan.

GRANET was used to calculate the coverage for the hilly terrain of Lincoln County, Montana. Only this coverage result is provided for this scenario.

8.1.2 Simulation Strategy

The relationship between the communication simulation, traffic simulation and other architecture development tasks is shown in Figure 8.1-3. Teletraffic information is derived by the Teletraffic Generator from the traffic simulation packages (Integration and THOREAU), and from demographic data, independently obtained, on the government-selected scenarios. Market penetration plays a key role.

The market penetration drives the teletraffic figures, and through that strongly impacts the configuration and technology selection for the communication architecture. It is, therefore, critical to arrive at realistic projections. It is also obvious that the Phase I definition by MITRE of “market penetration” as route guidance penetration left out most of the services and, as is shown in great detail in the Data Loading analysis, most of the teletraffic as well.

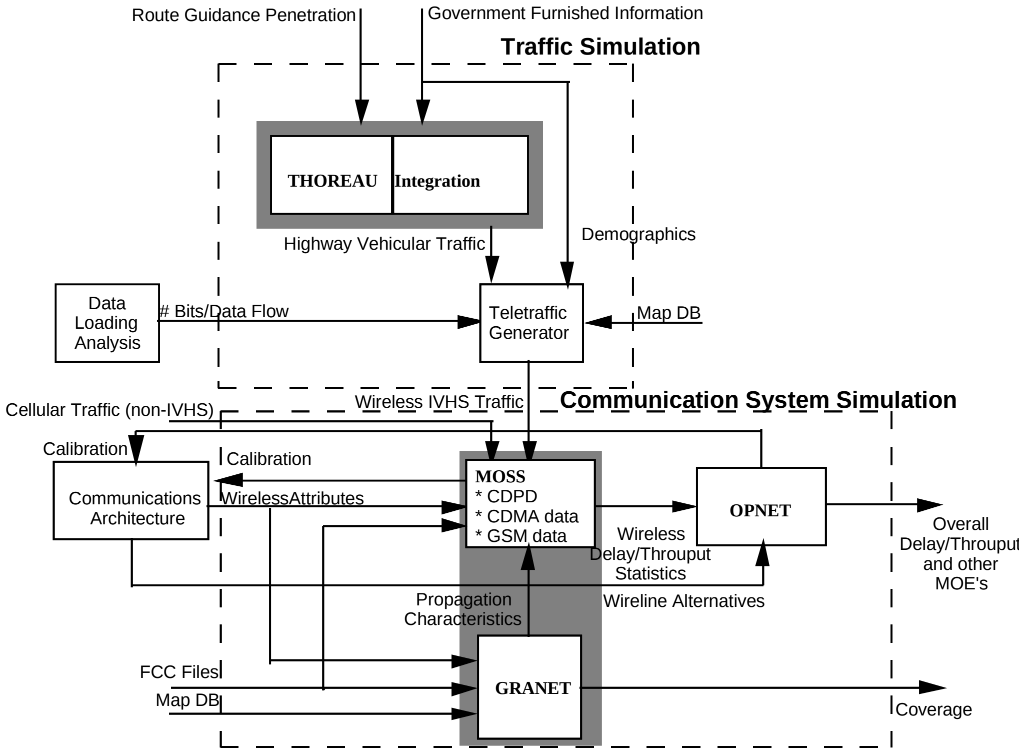

Figure 8.1-3 Communication System Simulation/Evaluation Methodology

Preliminary market studies indicate that market penetration will vary significantly by type of service, as it will vary within a type of service by application or group of applications. The penetration is anticipated to be high for Commercial Vehicle Operation (CVO), Advanced Public Transit Systems (APTS), and Emergency Vehicle Management (EVM), but significantly smaller for ATIS, even in the 20 year time frame. This information is covered extensively in the Data Loading section (Section 5), and is summarized for the reader's convenience in Table 8.1-4 for the 2002 time frame. The ranges shown correspond to the penetrations for the different applications within a type of service and/or group of users.

Table 8.1-4 Market Penetration Figures Derived from Preliminary Market Studies

2002	Penetration
Personal Information Access	7 - 10%
Transit Vehicles	10 - 100%
Traffic Management	100%
Private Vehicle	7 - 100%
Emergency Vehicles	100%
CVO Local	7 - 50%
CVO Long Haul	7 - 100%

MOSS was used extensively to simulate CDPD systems using actual cellular deployment information obtained from FCC filings. At least one CDPD channel per sector was assumed in the urban scenario (i.e., "fully deployed", in a regional, geographic sense). Note that there is no incompatibility between the use of the term “minimal deployment” (channel-wise) for the case of one reserved CDPD channel per sector, and the full geographic deployment nomenclature above.

MOSS uses the ITS teletraffic information from the Teletraffic Generator, as well as cellular non-ITS traffic information (initially voice only, later also non-ITS data), in combination with the wireless attributes from the Communication Architecture to compute, using the propagation characteristics obtained from GRANET, delay/throughput statistics for the wireless portion of the communication system.

Besides propagation information, GRANET also provides coverage, C/I, and best server information based upon deployment information. This information includes characteristics of the base stations, their locations, and the underlying terrain topography, morphology, and land-use/land-cover (partially derived from the latest commercially available GIS data bases).

The reverse link delay characterization obtained from MOSS is then fed into the OPNET protocol simulation, and also into the wireline simulations. OPNET was already used in Phase I to simulate the wireline network (in fact, the fixed, point-to-point network, since it can also analyze the microwave links between any two nodes), and to perform the comparison of a few technological and topological wireline alternatives.

To conclude, the outputs of the Communication System Simulation (Figure 8.1-4) are, among others, the quantitative technical MOE’s – Coverage, Delay, Throughput, and information on a link by link level about utilization and bandwidth efficiency.

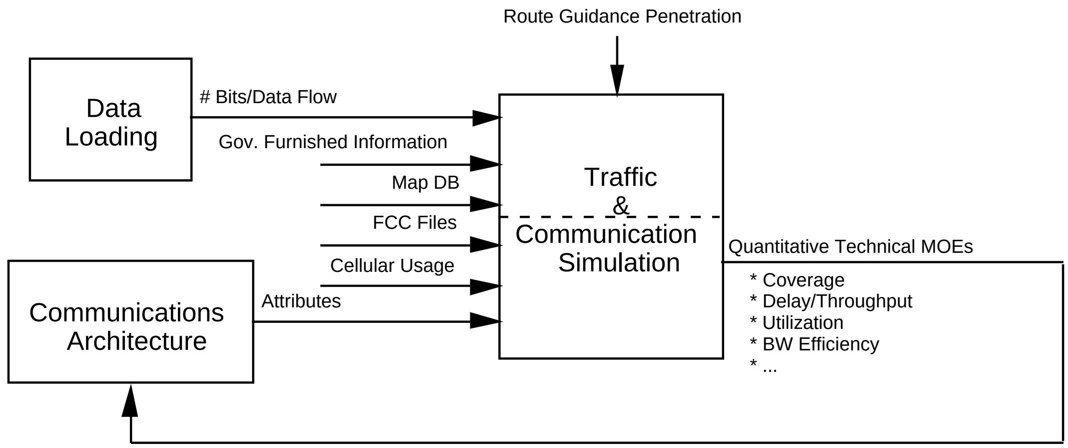

Figure 8.1-4 Quantitative Technical MOE's

As in Phase I, system performance is studied during the peak period, and in the case of an incident. For the latter, the same approach of analyzing the worst-case incident during the rush hour is followed, now in with the incident locations chosen by the Government Team. Information on the effect of the incidents was recently obtained from MITRE (February 1, 1996).

8.1.3 CDPD Protocol Overhead

For convenience, Figure 8.1-5 reproduces the CDPD protocol stack[1], since it will enable us to identify all the steps that introduce overhead. We can begin from the top. Even if outside of the picture, we have the layers of the protocol above IP, namely TCP (or, better, the transport family of protocols, including in particular UDP), and the remaining upper layers that we conveniently group as the Application layer. Here we do not account for Application overhead, since it can be included in the message that is passed to the Transport layer (TCP or UDP) which is considered below. In practice, the applications' developer will have to address all the details of their overhead to arrive at a successful product.

At the Transport layer, TCP will add 20 bytes of overhead. Note that the TCP payload has to be an integer number of bytes long – this is the first level that must be quantified, although most applications, especially those generating textual data, already do that. UDP, the other Transport protocol alternative would only add 8 bytes. Its behavior, however, is quite different from that of TCP. TCP guarantees delivery of the messages to the destination, UDP doesn't.

The reason to maintain TCP here is two-fold: (1) it is our observation that, at the infancy of any service, developers tend to seek the advantage of an application that works as soon as possible – only later, with experience, will they worry about making it "slick and slim"; (2) by using the larger overhead we are "stretching" as much as possible the communication system under analysis, to obtain conservative assessments.

[1] *TCP/IP Illustrated* - Vol. I: *The Protocols*, W. Richard Stevens, Addison-Wesley, 1994.

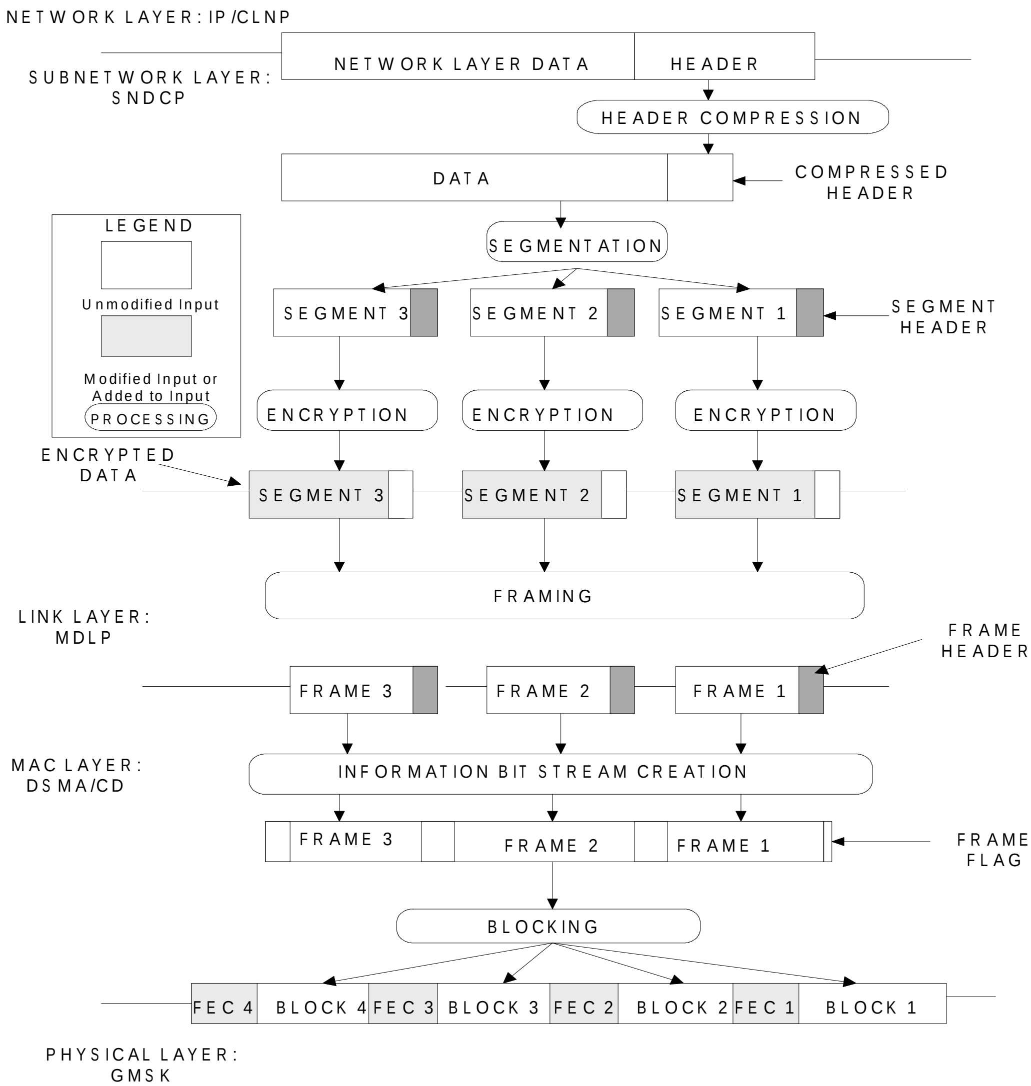

Figure 8.1-5 CDPD Protocol Stack (Cellular Digital Packet Data System Specification, Release 1.0)

At the Network layer, IP adds another 20 bytes of overhead. Then, at the sub-network layer, SNDCP performs TCP/IP header compression[2]. If more than one packet is required in a given transaction, significant header compression gain can be achieved (from 40 to 3 on average). In the case of the wide area ITS applications, almost all the transactions identified thus far require only one packet in each direction. No significant gain is thus to be expected from that step.

Next we have the Segmentation and Framing steps. One or two (1-2) additional bytes are added at segmentation time, and two to six (2-6) additional bytes are added at MDLP framing. Due to system settings, 2 bytes are added during segmentation (for non-guaranteed delivery), and we opted to average the number of bytes added by MDLP. Hence, we have added a total of 6 bytes during Segmentation and Framing.

[2] "Compressing TCP/IP Headers for Low-Speed Serial Links", V. Jacobson, Network Working Group Request for Comments 1144, Feb. 1990

Finally, at the MAC layer, during the process of bit stream creation, additional zeros have to be intercalated in the approximately random (due to the previous encryption step) stream of framed data bits to avoid the accidental occurrence of the Flag or Abort sequence [01111110]. No more than five consecutive 1's can thus be allowed, which implies that zeros have to be padded as soon as five consecutive 1's are detected.

The number of zeros thus added to the frame is a random number with a mean that is close to 1.6% of the length of the message[3], although its distribution has a considerable positive tail that can have some impact, as we will see. It is easy to see that a simple zero added at the wrong time can make it necessary to use an additional RS-block to carry the message.

When the zero padded bit stream is finally available, different color coding is added for each link (see Figure 8.1-6), and the bits are prepared to be sent over the mobile link by using a 63/47 Reed-Solomon (RS) error correcting code. The CDPD specification establishes the Reed-Solomon (RS)-block as the "quantum of information" transmitted over the CDPD wireless channel. All messages are carried in an integer number of RS-blocks, even if they do not fill the "envelope". This final quantization step has the most significance, since it determines the characteristics of the CDPD traffic (in terms of the proportion of messages being transmitted in a given number of RS-blocks).

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[3] "The Effects of Zero Padding on the CDPD Wide-Area IVHS Data Load", Jorge M. Pereira, Personal, Indoors, and Mobile Communications Conference, PIMRC '95, Toronto, Canada, September 26-29, 1995.

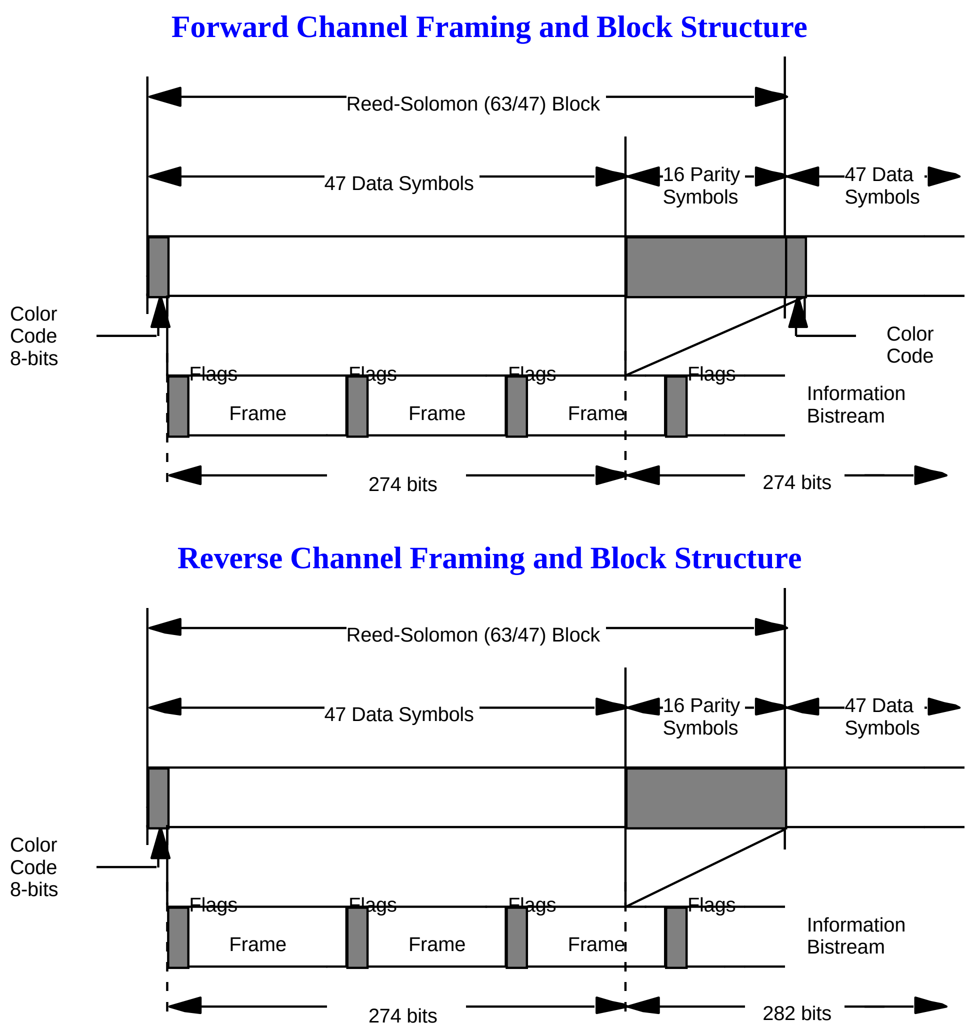


Figure 8.1-6 Framing and Block Structure Showing the Color Code

It is important to point out that from a service and billing perspective, the customer pays per byte and is not responsible for any network overhead at the IP (network) layer or below. Whatever takes place in the process of segmentation, framing, zero padding, or blocking, is completely transparent to the user and has no impact on the cost of the service. Also, any re-transmissions at any of these lower layers are not the responsibility of the customer. (These overheads have, nevertheless, an impact on network performance, and that is why they are analyzed here.) The lower layers of the protocol guarantee the error-free delivery of the message to the MDBS or the M-ES. If that is not possible due to congestion, or repeated occurrence of errors during the transmission (39 unsuccessful lower-layer re-transmissions are tried before the system quits and warns the upper-layers), then the user does not pay for the undelivered (but later) delivered bytes.

However, any re-transmissions generated at the higher layers of the protocol, namely by TCP (due to time-outs and lost packets elsewhere in the network), will be of the responsibility of the user, i.e., the user will have to pay again for the transmitted bytes.

For the purpose of computing and characterizing the CDPD traffic resulting from the wide area wireless ITS data loading, all the above overhead, and mainly the quantization steps were taken into account. The results are presented in the following sections for the two scenarios analyzed for the 2002 time frame.

8.1.4 Non-ITS Applications CDPD Data Loads

In Section 7.3, we concluded that, as a result of the decision to share deployed infrastructure with other users, the traffic generated by non-ITS users will have an impact on ITS performance. In that section, we analyzed in detail the different types of non-ITS traffic to be expected, and came to the conclusion that E-mail and Internet access, the latter dominated by WWW access, would clearly dominate the non-ITS traffic.

The message sizes associated with those two applications were studied in detail, and are reproduced here for the reader's convenience. Figure 8.1-7 shows the message distribution for Wireless E-mail Access. E-mail, even if wireless, is a two-way application, so the same distribution applies both in the forward and in the reverse directions. Figure 8.1-8 shows, lacking any more detailed information, the average file transfer size in bytes, as a function of the time of the day, from a typical WWW server to the user, i.e., in the forward direction. The reverse direction traffic for Internet access is much smaller, consisting mainly of transmission of URL's. Any other traffic is mainly of the E-mail type, especially since e-mail messages can be sent from the most popular WWW browsers.

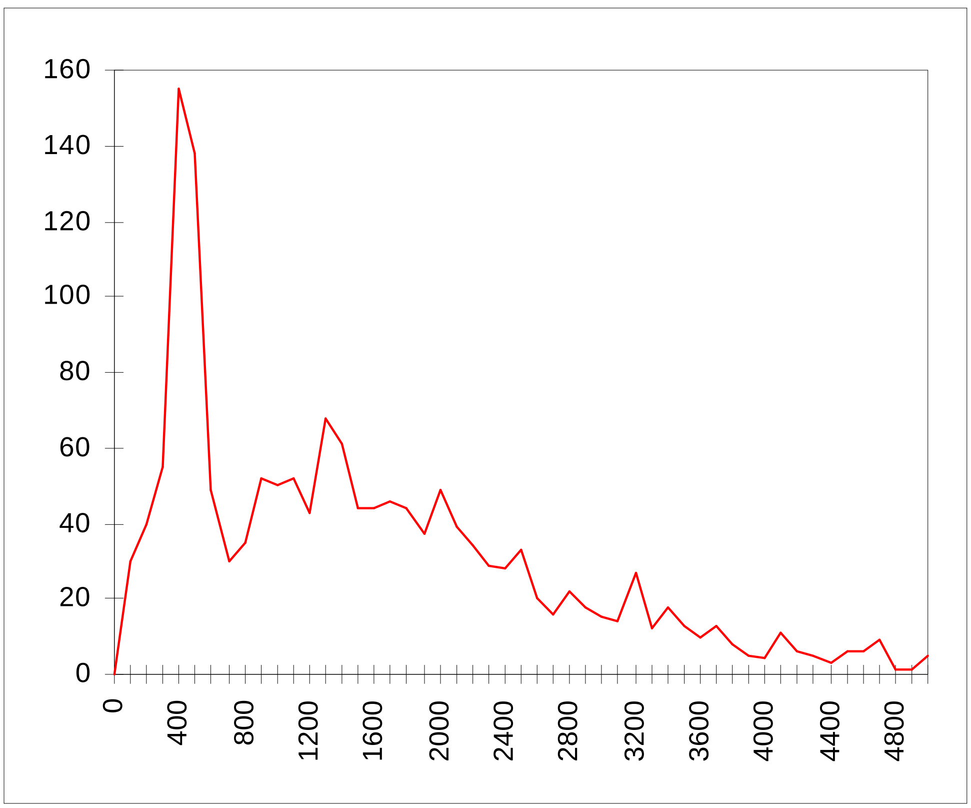


Figure 8.1-7 Histogram of Wireless E-mail Message Sizes (up to 5 kbytes)

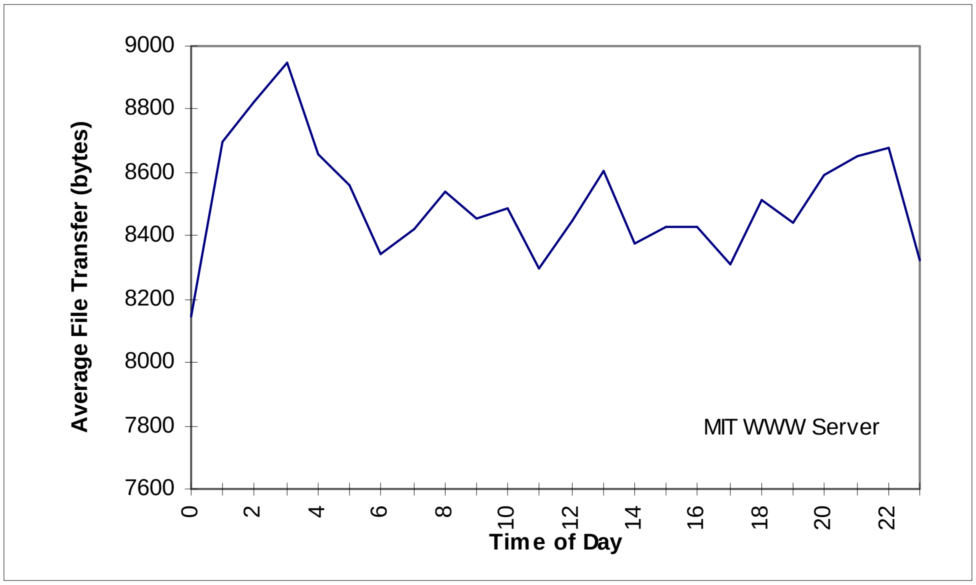


Figure 8.1-8 Average File Transfer Size for the MIT WWW Server (All day Average: 8490 bytes)

In order to approximate the non-ITS traffic, we used the above information to compute the distribution of the CDPD packet lengths (in RS-blocks) for the corresponding CDPD traffic. This distribution is irrespective of the total volume, since it relates only to the message sizes involved.

The resulting distribution is shown in Table 8.1-5, independent of the direction.

Table 8.1-5 CDPD Packet Length Distribution for Non-ITS Data

Packet Length (RS-blocks)	1	2	3	4	5
Distribution	58.848%	19.616%	13.077%	5.517%	2.942%

We must note here that whereas the distribution may be the same, the actual traffic (volume) in each direction will not be. This will be discussed in detail for each scenario under consideration.

8.1.5 CDPD Data Loads

8.1.5.1 Urbansville

8.1.5.1.1 2012 Time Frame, ITS Only, Phase I Data Loads

As discussed in Section 8.1.3, the CDPD specification establishes the Reed-Solomon (RS)-block as the quantum of information transmitted in the radio channel. Thus, for the purposes of network performance simulation, the transaction lengths determined during the Data Loading analysis in Phase I had to be converted to the corresponding number of RS-blocks, taking into account the total CDPD protocol overhead.

Tables 8.1-6 through 8.1-13 summarize the data load figures for the 2012 time frame, documenting the required number of RS-blocks per message. The ITS load thus obtained takes into account demographic information on Detroit, Michigan DoT information and GTE Mobilnet market analysis. Note that in Table 8.1-9, corresponding to the ITS traffic associated with emergency vehicles, messages with length greater than 6 blocks were split into packets of at most 4 blocks, the industry consensus for optimum (in terms of delay/throughput performance) number of blocks per packet.

From Table 8.1-13, it is clear that most of the data load is generated by Local Fleet Commercial Vehicles, Private Vehicles, and Probe Vehicles. As expected, the forward link has a somewhat larger data load than the reverse link. Note that on the forward link, where there is no contention for channel access, there is no problem in accommodating the data load – the average channel occupancy is only 34.8%, i.e., the forward channel will operate far below capacity. This fact allows for reducing, as a first-cut, the delay in the forward link to queuing delay. As for the reverse channel, due to the inherent contention mechanism, only simulation can provide the necessary delay/throughput information.

It is noteworthy that the penetration values used in Tables 8.1-6 through 8.1-13 are different (i.e., higher) than those defined in the *Market Bundles/Packages Description* Blue Book. These “optimistic” values result obviously in upper-bound, worst case data loads relative to what is realistic to expect. However, this margin can compensate both for the anticipated inclusion of additional messages resulting from the refinement of the services definition, and any unanticipated acceptance “take-off” for the 20-year time frame.

Table 8.1-6 Private Vehicles Data Load for the Year 2012—Projected Penetration

Private Vehicles - Peak period, 20 year time frame													
Number of potential users:	575654	Peak Period: 6-9am & 4-7pm											
Penetration:	20%	21600	Forward	Reverse				Forward Link			Reverse Link		
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**2**	**3**	**4**
Estimate Absolute Position	80	16	2	2	1.4	2.8	2.8	2.8	0	0	2.8	0	0
Provide Current Position	112	48	2	2	0.0038	0.0076	0.0076	0.0076	0	0	0.0076	0	0
Generate Route Plan	144	112	2	2	1.4	2.8	2.8	2.8	0	0	2.8	0	0
Generate Route Plan	260	80	3	2	1.4	4.2	2.8	0	4.2	0	2.8	0	0
Generate Route Plan	354		3	2	1.4	4.2	2.8	0	4.2	0	2.8	0	0
Generate Route Plan	454	48	3	2	0.2	0.6	0.4	0	0.6	0	0.4	0	0
Generate Route Plan		128	2	2	1.4	2.8	2.8	2.8	0	0	2.8	0	0
Generate Route Plan		146	2	2	0.2	0.4	0.4	0.4	0	0	0.4	0	0
Generate Route Plan	392		3	2	1.4	4.2	2.8	0	4.2	0	2.8	0	0
Generate Route Plan	392		3	2	1.4	4.2	2.8	0	4.2	0	2.8	0	0
Generate Route Plan	368		3	2	1.4	4.2	2.8	0	4.2	0	2.8	0	0
Generate Route Plan		212	2	2	1.4	2.8	2.8	2.8	0	0	2.8	0	0
Select Potential Routes	656	128	4	2	0.2	0.8	0.4	0	0	0.8	0.4	0	0
Access Congestion Data and A	392		3	2	2	6	4	0	6	0	4	0	0
Log Route Plan		390	2	3	0.6	1.2	1.8	1.2	0	0	0	1.8	0
Log Route Plan	312		3	2	0.6	1.8	1.2	0	1.8	0	1.2	0	0
Service Driver Requests		144	2	2	4	8	8	8	0	0	8	0	0
Service Driver Requests	160		2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	240		3	2	2	6	4	0	6	0	4	0	0
Service Driver Requests	88		2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	122	128	2	2	0.2	0.4	0.4	0.4	0	0	0.4	0	0
Service Driver Requests	160	208	2	2	0.2	0.4	0.4	0.4	0	0	0.4	0	0
Service Driver Requests	656	128	4	2	0.2	0.8	0.4	0	0	0.8	0.4	0	0
Service Driver Requests	146	112	2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	392	112	3	2	2	6	4	0	6	0	4	0	0
Service Driver Requests	464	146	3	2	0.2	0.6	0.4	0	0.6	0	0.4	0	0
Improve Driver Roadway Perce	80		2	2	4	8	8	8	0	0	8	0	0
Collect Roadway Conditions	48	48	2	2	4	8	8	8	0	0	8	0	0
Perform Vehicle Check In		576	2	4	2	4	8	4	0	0	0	0	8
Support Manually Initiated Assistance Req		294	2	3	0.0057	0.0114	0.0171	0.0114	0	0	0	0.0171	0
Formulate MAYDAY Message		216	2	2	0.00285	0.0057	0.0057	0.0057	0	0	0.0057	0	0
Generate Toll Billing Request	56	48	2	2	0.0038	0.0076	0.0076	0.0076	0	0	0.0076	0	0
Generate Parking Billing Reque	52	48	2	2	0.2	0.4	0.4	0.4	0	0	0.4	0	0
Generate Parking Billing Request		256	2	3	0.2	0.4	0.6	0.4	0	0	0	0.6	0
		Total # Blocks/User during Peak Period				98.0323	88.038	54.4323	42	1.6	77.6209	2.4171	8
		Total # Blocks during Peak Period				11286537	10135885	6266834	4835494	184209.3	8936556	278282.7	921046.4
		Total # Blocks/s during Peak Period				522.5249	469.254	290.1312	223.8654	8.528207	413.7295	12.88346	42.64104

Table 8.1-7 Long-Haul Freight and Fleet Vehicles Data Load for the Year 2012

Commercial Vehicle - Long Haul, peak period, 20 year time frame													
Number of potential users:	7802	Peak Period: 6am-6pm											
Penetration:	100%	43200	Forward	Reverse				Forward Link			Reverse Link		
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**2**	**3**	**4**
Disseminate On Board Safety Status		544	2	4	1	2	4	2	0	0	0	0	4
Disseminate On Board Safety Status		240	2	3	0.668	1.336	2.004	1.336	0	0	0	2.004	0
Disseminate On Board Safety Status		146	2	2	36	72	72	72	0	0	72	0	0
Disseminate On Board Safety Status		322	2	3	0.268	0.536	0.804	0.536	0	0	0	0.804	0
Disseminate On Board Safety Status		146	2	2	0.167	0.334	0.334	0.334	0	0	0.334	0	0
Detect Border Crossing	48		2	2	4	8	8	8	0	0	8	0	0
Automatically Log Mileage and Fuel Use		96	2	2	4	8	8	8	0	0	8	0	0
Estimate Absolute Position	80	16	2	2	12	24	24	24	0	0	24	0	0
Provide Current Position	112	48	2	2	4	8	8	8	0	0	8	0	0
Generate Route Plan	144	112	2	2	1.8	3.6	3.6	3.6	0	0	3.6	0	0
Generate Route Plan	260	80	3	2	1.8	5.4	3.6	0	5.4	0	3.6	0	0
Generate Route Plan	354		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Generate Route Plan		128	2	2	4.2	8.4	8.4	8.4	0	0	8.4	0	0
Generate Route Plan	352		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Generate Route Plan	392		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Generate Route Plan	392		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Generate Route Plan	368		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Select Potential Routes		216	2	2	4.2	8.4	8.4	8.4	0	0	8.4	0	0
Select Potential Routes	656	128	4	2	0.15	0.6	0.3	0	0	0.6	0.3	0	0
Access Congestion Data and A	392		3	2	3	9	6	0	9	0	6	0	0
Log Route Plan		390	2	3	0.9	1.8	2.7	1.8	0	0	0	2.7	0
Log Route Plan	312		3	2	0.9	2.7	1.8	0	2.7	0	1.8	0	0
Formulate Route Guidance	392		3	2	3	9	6	0	9	0	6	0	0
Service Driver Requests		144	2	2	16	32	32	32	0	0	32	0	0
Service Driver Requests	160		2	2	6	12	12	12	0	0	12	0	0
Service Driver Requests	392		3	2	2.1	6.3	4.2	0	6.3	0	4.2	0	0
Service Driver Requests	88		2	2	12	24	24	24	0	0	24	0	0
Service Driver Requests	160	208	2	2	3	6	6	6	0	0	6	0	0
Service Driver Requests	146	112	2	2	4	8	8	8	0	0	8	0	0
Service Driver Requests	392	112	3	2	6	18	12	0	18	0	12	0	0
Service Driver Requests		128	2	2	0.9	1.8	1.8	1.8	0	0	1.8	0	0
Disseminate On Board Safety Status		240	2	3	0.668	1.336	2.004	1.336	0	0	0	2.004	0
Improve Driver Roadway Perce	80		2	2	6	12	12	12	0	0	12	0	0
Collect Roadway Conditions	48	48	2	2	6	12	12	12	0	0	12	0	0
Support Manually Initiated Assistance Req		294	2	3	0.045	0.09	0.135	0.09	0	0	0	0.135	0
Formulate MAYDAY Message		216	2	2	0.023	0.046	0.046	0.046	0	0	0.046	0	0
Generate Toll Billing Request	56	48	2	2	1	2	2	2	0	0	2	0	0
		Total # Blocks/User during Peak Period				369.542	335.946	255.542	113.4	0.6	324.434	7.512	4
		Total # Blocks during Peak Period				2883167	2621051	1993739	884746.8	4681.2	2531234	58608.62	31208
		Total # Blocks/s during Peak Period				66.73997	60.67247	46.15136	20.48025	0.108361	58.59338	1.356681	0.722407

Table 8.1-8 Local Freight and Fleet Vehicles Data Load for the Year 2012

Commercial Vehicle - Local, peak period, 20 year time frame													
Number of potential users:	109182	Peak Period: 6am-6pm											
Penetration:	60%	43200	Forward	Reverse				Forward Link			Reverse Link		
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**2**	**3**	**4**
Disseminate On Board Safety Status		544	2	4	1	2	4	2	0	0	0	0	4
Disseminate On Board Safety Status		240	2	3	0.668	1.336	2.004	1.336	0	0	0	2.004	0
Disseminate On Board Safety Status		146	2	2	36	72	72	72	0	0	72	0	0
Disseminate On Board Safety Status		322	2	3	0.268	0.536	0.804	0.536	0	0	0	0.804	0
Disseminate On Board Safety Status		146	2	2	0.167	0.334	0.334	0.334	0	0	0.334	0	0
Detect Border Crossing	48		2	2	1	2	2	2	0	0	2	0	0
Automatically Log Mileage and Fuel Use		96	2	2	1	2	2	2	0	0	2	0	0
Estimate Absolute Position	80	16	2	2	12	24	24	24	0	0	24	0	0
Provide Current Position	112	48	2	2	0.804	1.608	1.608	1.608	0	0	1.608	0	0
Generate Route Plan	144	112	2	2	3.6	7.2	7.2	7.2	0	0	7.2	0	0
Generate Route Plan	260	80	3	2	3.6	10.8	7.2	0	10.8	0	7.2	0	0
Generate Route Plan	354		3	2	8.4	25.2	16.8	0	25.2	0	16.8	0	0
Generate Route Plan		128	2	2	8.4	16.8	16.8	16.8	0	0	16.8	0	0
Generate Route Plan	352		3	2	8.4	25.2	16.8	0	25.2	0	16.8	0	0
Generate Route Plan	392		3	2	8.4	25.2	16.8	0	25.2	0	16.8	0	0
Generate Route Plan	392		3	2	8.4	25.2	16.8	0	25.2	0	16.8	0	0
Generate Route Plan	368		3	2	8.4	25.2	16.8	0	25.2	0	16.8	0	0
Select Potential Routes		216	2	2	8.4	16.8	16.8	16.8	0	0	16.8	0	0
Select Potential Routes	656	128	4	2	0.3	1.2	0.6	0	0	1.2	0.6	0	0
Access Congestion Data and A	392		3	2	6	18	12	0	18	0	12	0	0
Log Route Plan		390	2	3	3.6	7.2	10.8	7.2	0	0	0	10.8	0
Log Route Plan	312		3	2	3.6	10.8	7.2	0	10.8	0	7.2	0	0
Service Driver Requests		144	2	2	39	78	78	78	0	0	78	0	0
Service Driver Requests	160		2	2	12	24	24	24	0	0	24	0	0
Service Driver Requests	392		3	2	4.2	12.6	8.4	0	12.6	0	8.4	0	0
Service Driver Requests	88		2	2	12	24	24	24	0	0	24	0	0
Service Driver Requests	122	128	2	2	1	2	2	2	0	0	2	0	0
Service Driver Requests	160	208	2	2	6	12	12	12	0	0	12	0	0
Service Driver Requests	656	128	4	2	1	4	2	0	0	4	2	0	0
Service Driver Requests	146	112	2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	392	112	3	2	12	36	24	0	36	0	24	0	0
Service Driver Requests		128	2	2	6	12	12	12	0	0	12	0	0
Disseminate On Board Safety Status		240	2	3	2.4	4.8	7.2	4.8	0	0	0	7.2	0
Improve Driver Roadway Perce	80		2	2	4	8	8	8	0	0	8	0	0
Collect Roadway Conditions	48	48	2	2	6	12	12	12	0	0	12	0	0
Support Manually Initiated Assistance Req		294	2	3	0.045	0.09	0.135	0.09	0	0	0	0.135	0
Formulate MAYDAY Message		216	2	2	0.023	0.046	0.046	0.046	0	0	0.046	0	0
Generate Toll Billing Request	56	48	2	2	0.0038	0.0076	0.0076	0.0076	0	0	0.0076	0	0
Generate Parking Billing Reque	52	48	2	2	0.1	0.2	0.2	0.2	0	0	0.2	0	0
Generate Parking Billing Request		256	2	3	0.2	0.4	0.6	0.4	0	0	0	0.6	0
		Total # Blocks/User during Peak Period				542.014	476.95	322.614	214.2	5.2	452.142	20.808	4
		Total # Blocks during Peak Period				35506904	31244613	21134185	14032071	340647.8	29619461	1363115	262036.8
		Total # Blocks/s during Peak Period				821.9191	723.2549	489.2172	324.8165	7.885367	685.6357	31.5536	6.065667

Table 8.1-9 Emergency Vehicles Data Load for the Year 2012

Emergency Vehicle, peak period, 20 year time frame													
Number of potential users:	3305	Peak Period: 6am-7pm											
Penetration:	100%	46800	Forward	Reverse				Forward Link			Reverse Link		
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**2**	**3**	**4**
Present Dispatch Instructions T	2708		12	2	26		52				52	0	0
			4		78	312		0	0	312			
Estimate Absolute Position	80	16	2	2	13	26	26	26	0	0	26	0	0
Generate Route Plan	160	112	2	2	2	4	4	4	0	0	4	0	0
Generate Route Plan	260	80	3	2	2	6	4	0	6	0	4	0	0
Select Potential Routes	656	128	4	2	0.045	0.18	0.09	0	0	0.18	0.09	0	0
Access Congestion Data and A	392		3	2	2	6	4	0	6	0	4	0	0
Log Route Plan	312		3	2	2	6	4	0	6	0	4	0	0
Service Driver Requests		144	2	2	6.2	12.4	12.4	12.4	0	0	12.4	0	0
Service Driver Requests	160		2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	88		2	2	12	24	24	24	0	0	24	0	0
Service Driver Requests	160	208	2	2	0.2	0.4	0.4	0.4	0	0	0.4	0	0
Service Driver Requests	146	112	2	2	2	4	4	4	0	0	4	0	0
Service Driver Requests	392	112	3	2	2	6	4	0	6	0	4	0	0
Disseminate Vehicle and Driver Safety Sta		112	2	2	4	8	8	8	0	0	8	0	0
Improve Driver Roadway Perce	80	40	2	2	4	8	8	8	0	0	8	0	0
Support Manually Initiated Assistance Req		294	2	3	0.0019	0.0038	0.0057	0.0038	0	0	0	0.0057	0
Formulate MAYDAY Message		216	2	2	0.0019	0.0038	0.0038	0.0038	0	0	0.0038	0	0
Communicate Emergency Status		374	2	3	52	104	156	104	0	0	0	156	0
Maintain Emergency Vehicle Status		208	2	2	2	4	4	4	0	0	4	0	0
Maintain Emergency Vehicle Status		274	2	3	26	52	78	52	0	0	0	78	0
Maintain Emergency Vehicle Status		216	2	2	52	104	104	104	0	0	104	0	0
Determine Best Vehicle Routes		392	2	3	13	26	39	26	0	0	0	39	0
Monitor Emergency Status		1376	2	7	7	14		14	0	0	0	0	0
				4	7		28				0	0	28
				3	7		21				0	21	0
Manage Vehicle Dispatch		2708	2	12	6	12		12	0	0	0	0	0
				4	18		72	0	0	0	0	0	72
		Total # Blocks/User during Peak Period				742.9876	660.8995	406.8076	24	312.18	266.8938	294.0057	100
		Total # Blocks during Peak Period				2455574	2184273	1344499	79320	1031755	882084	971688.8	330500
		Total # Blocks/s during Peak Period				52.46953	46.6725	28.72861	1.694872	22.04604	18.84795	20.76258	7.061966

Table 8.1-10 Public Transportation Services Data Load for the Year 2012

Transit Vehicle, peak period, 20 year time frame														
Number of potential users:	1789	Peak Period: 6am-7pm												
Penetration:	100%	46800	Forward	Reverse				Forward Link				Reverse Link		
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**5**	**2**	**3**	**4**
Real Time Information Dissemi	656		4	2	26	104	52	0	0	104	0	52	0	0
Real Time Information Dissemi	200		2	2	52	104	104	104	0	0	0	104	0	0
Real Time Information Dissemi	392		3	2	52	156	104	0	156	0	0	104	0	0
Real Time Information Dissemi	656		4	2	52	208	104	0	0	208	0	104	0	0
Real Time Information Dissemi	144		2	2	13	26	26	26	0	0	0	26	0	0
Report Traffic Information	392		3	2	13	39	26	0	39	0	0	26	0	0
Report Traffic Information		272	2	3	13	26	39	26	0	0	0	0	39	0
Report Traffic Information	1000		5	2	7	35	14	0	0	0	35	14	0	0
Report Vehicle Position Information		48	2	2	78	156	156	156	0	0	0	156	0	0
Report Transit Request Information		160	2	2	13	26	26	26	0	0	0	26	0	0
Report Transit Request Informa	122		2	2	13	26	26	26	0	0	0	26	0	0
Report Transit Request Informa	160		2	2	13	26	26	26	0	0	0	26	0	0
Monitor Transit Schedule Adhe	24		2	2	13	26	26	26	0	0	0	26	0	0
Assess Driver Performance		528	2	4	2	4	8	4	0	0	0	0	0	8
Monitor Transit Vehicle Condition		400	2	3	6.24	12.48	18.72	12.48	0	0	0	0	18.72	0
Monitor Transit Vehicle Condition		48	2	2	6.24	12.48	12.48	12.48	0	0	0	12.48	0	0
Report Passenger Information		160	2	2	26	52	52	52	0	0	0	52	0	0
Report Passenger Information	1016		5	2	26	130	52	0	0	0	130	52	0	0
Generate Passenger Fare And Loading Sta		160	2	2	78	156	156	156	0	0	0	156	0	0
Generate Transit Fare Billing Request		176	2	2	13	26	26	26	0	0	0	26	0	0
Generate Transit Fare Billing Request		260	2	3	100	200	300	200	0	0	0	0	300	0
Control Passenger Access	88		2	2	100	200	200	200	0	0	0	200	0	0
Log Route Plan	312		3	2	26	78	52	0	78	0	0	52	0	0
Service Driver Requests		146	2	2	65	130	130	130	0	0	0	130	0	0
Service Driver Requests	336		3	2	52	156	104	0	156	0	0	104	0	0
Service Driver Requests	88		2	2	13	26	26	26	0	0	0	26	0	0
Service Driver Requests	122	128	2	2	13	26	26	26	0	0	0	26	0	0
Service Driver Requests	160	208	2	2	13	26	26	26	0	0	0	26	0	0
Service Driver Requests		176	2	2	2	4	4	4	0	0	0	4	0	0
Improve Driver Roadway Perce	80		2	2	4	8	8	8	0	0	0	8	0	0
Determine Longitudinal Collisio	48		2	2	2	4	4	4	0	0	0	4	0	0
Collect Roadway Conditions	48	48	2	2	4	8	8	8	0	0	0	8	0	0
Regulate Lateral Vehicle Contr	18	20	2	2	4	8	8	8	0	0	0	8	0	0
Support Manually Initiated Assistance Req		294	2	3	0.2	0.4	0.6	0.4	0	0	0	0	0.6	0
Formulate MAYDAY Message		216	2	2	0.1	0.2	0.2	0.2	0	0	0	0.2	0	0
Generate Toll Billing Request	56	48	2	2	0.0038	0.0076	0.0076	0.0076	0	0	0	0.0076	0	0
		Total # Blocks/User during Peak Period				2225.568	1951.008	1319.568	429	312	165	1584.688	358.32	8
		Total # Blocks during Peak Period				3981540	3490353	2360706	767481	558168	295185	2835006	641034.5	14312
		Total # Blocks/s during Peak Period				85.07565	74.58018	50.44245	16.39917	11.92667	6.307372	60.57705	13.69732	0.305812

Table 8.1-11 Traveler Information Services Data Load for the Year 2012

Traveler Information, peak period, 20 year time frame												
Number of potential users:	57858	Peak Period: 6-9am &4-7pm										
Penetration:	20%	21600	Forward	Reverse				Forward Link			Reverse Link	
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**3**	**4**	**2**	**3**
Reconcile Estimated Position w	24		2	2	0.045	0.09	0.09	0.09	0	0	0.09	0
Reconcile Estimated Position w	48		2	2	0.045	0.09	0.09	0.09	0	0	0.09	0
Select Potential Routes		216	2	2	2.2	4.4	4.4	4.4	0	0	4.4	0
Select Potential Routes	656		4	2	2	8	4	0	0	8	4	0
Select Potential Routes	352		3	2	0.2	0.6	0.4	0	0.6	0	0.4	0
Access Congestion Data and A	392		3	2	1	3	2	0	3	0	2	0
Access Congestion Data and A	160		2	2	2	4	4	4	0	0	4	0
Access Congestion Data and A	240		3	2	1	3	2	0	3	0	2	0
Access Congestion Data and A	392		3	2	0.1	0.3	0.2	0	0.3	0	0.2	0
Access Congestion Data and A	392		3	2	0.2	0.6	0.4	0	0.6	0	0.4	0
Format Traveler Information Request		228	2	2	4.3	8.6	8.6	8.6	0	0	8.6	0
Support Manually Initiated Assistance Requ		296	2	3	0.0057	0.0114	0.0171	0.0114	0	0	0	0.0171
Transmit MAYDAY Message		216	2	2	0.0057	0.0114	0.0114	0.0114	0	0	0.0114	0
		Total # Blocks/User during Peak Period				32.7028	26.2085	17.2028	7.5	8	26.1914	0.0171
		Total # Blocks during Peak Period				378423.7	303274.3	199063.9	86787	92572.8	303076.4	197.8744
		Total # Blocks/s during Peak Period				17.51962	14.04048	9.215922	4.017917	4.285778	14.03132	0.009161

Table 8.1-12 Probe Vehicles Data Load for the Year 2012

Traffic Management: Probes, peak period, 20 year time frame										
Number of potential users:	7704	Peak Period: 6-9am &4-7pm								
Penetration:	100%	21600	Forward	Reverse				Forward	Reverse	
name	**fbits**	**rbits**	**# blocks**	**# blocks**	**freq**	Forward	Reverse	**2**	**2**	**3**
Probe Trip Notice		464	2	3	2	4	6	4	0	6
Probe Trip Accept	64		2	2	2	4	4	4	4	0
Probe Report		106	2	2	360	720	720	720	720	0
		Total # Blocks/User during Peak Period				728	730	728	724	6
		Total # Blocks during Peak Period				5608512	5623920	5608512	5577696	46224
		Total # Blocks/s during Peak Period				259.6533	260.3667	259.6533	258.2267	2.14

Table 8.1-13 Overall ITS Data Load Summary for the Year 2012

Peak period, 20 year time frame			Forward Link				Reverse Link		
Services/Users Groupings	Forward	Reverse	**2**	**3**	**4**	**5**	**2**	**3**	**4**
Transit Vehicles	85.08	74.58	50.44	16.40	11.93	6.31	60.58	13.70	0.31
Traveler Information	17.52	14.04	9.22	4.02	4.29		14.03	0.01	
Traffic Management: Probes	259.65	260.37	259.65				258.23	2.14	
Private Vehicles	522.52	469.25	290.13	223.87	8.53		413.73	12.88	42.64
Emergency Vehicles	52.47	46.67	28.73	1.69	22.05		18.85	20.76	7.06
Commercial Vehicles - Long Haul	66.74	60.67	46.15	20.48	0.11		58.59	1.36	0.72
Commercial Vehicles - Local	821.92	723.25	489.22	324.82	7.89		685.64	31.55	6.07
TOTAL # Blocks/s	1825.90	1648.84	1173.54	591.27	54.78	6.31	1509.64	82.40	56.80
TOTAL # Blocks/s/sector	16.01668	14.46352							
Channel Utilization	34.8%	31.4%							
Packet Length Distribution			64.3%	32.4%	3.0%	0.3%	91.6%	5.0%	3.4%

8.1.5.1.2 2002 Time Frame, Phase II Data Loads

8.1.5.1.2.1 ITS Only

Table 8.1-14 through Table 8.1-21 summarize the data load figures for the 2002 time frame, and document the required number of RS-blocks per message.

Two facts should be noted. First, the penetration values used in Table 8.1-14 through Table 8.1-21 are those defined in the *Evaluatory Design* document. However, in order to upper-bound, and thus get a worst case CDPD traffic, we assumed that even if there is a competing technology to carry a given message, all the load would be carried over CDPD. As an example, for the traffic between the PIAS and the ISP, which can either be wireless or wireline, as a worst case assumption, we assumed all of it going over CDPD. Again, we think this margin is necessary to compensate both for the anticipated inclusion of additional messages resulting from the refinement of the services definition, and any unanticipated acceptance “take-off.”

Second, in spite of the use of worst case traffic, the overall data loads shown in summary Table 8.1-21 are still lower than the ones of Phase I, corresponding to Urbansville 2012. This reflects not only a more conservative approach to ITS service acceptance and adoption rates, but mainly the fact that we are now looking at the 2002 time frame instead, where the penetration figures are naturally lower.

		Table 8.1-14 Private Vehicles CDPD Traffic for the Year 2002											**Table 8.1-14 Private Vehicles CDPD Traffic f**			
Private Vehicle																
Number of users:		828,947														
Peak Period: 6-9am &4-7pm			21600	seconds												
				Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.1	6146	0	771	0	24	0	0.1	2.4	0	0	0	0	0
ISP	VS							<34333+22222>						1	1.2	0.4
ISP	VS	10%	0.01	10802	0	1353	0	41	0	0.01	0.41	0	0	0	0	0
ISP	VS							<2*34333+4332>						0.02	0.3	0.12
LocData	VS	7%	0.007	146	0	21	0	2	0	0.007	0.014	0	0	0.014	0	0
PayInstr	VS	10%	0.0001	178	0	25	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
PayInstr	VS	100%	0.0001	178	0	25	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
VS	EM	10%	0.0001	0	282	0	38	0	3	0.0001	0	0.0003	0	0	0	0
VS	EM	10%	0.0001	0	3354	0	422	0	14	0.0001	0	0.0014	0	0	0	0
VS	EM								<333222>							
VS	ISP	10%	0.0001	0	632.4	0	82	0	4	0.0001	0	0.0004	0	0	0	0
VS	ISP	10%	0.0001	0	642	0	83	0	4	0.0001	0	0.0004	0	0	0	0
VS	ISP	10%	0.1	0	290	0	39	0	3	0.1	0	0.3	0	0	0	0
VS	ISP	7%	0.14	0	34	0	7	0	2	0.035	0	0.07	0	0	0	0
VS	ISP	10%	0.01	0	674	0	87	0	4	0.01	0	0.04	0	0	0	0
VS	PayInstr	10%	0.0001	0	50	0	9	0	2	0.0001	0	0.0002	0	0	0	0
VS	PMS	10%	0.00005	0	514	0	67	0	4	0.0001	0	0.0004	0	0	0	0
VS	PMS	10%	0.00005	0	26	0	6	0	2	0.0001	0	0.0002	0	0	0	0
												Total # blocks/User during peak period	0	1.0344	1.5012	0.52
												*Population	0	857463	1244416	431052.6
												/peak period duration	0	39.69736	57.61183	19.95614
												/per sector	0	0.172597	0.250486	0.086766
										packets/s	44.042	5.611	0.00000	19.84868	19.20394	4.98903
													0.0%	45.1%	43.6%	11.3%

Table 8.1-14 Private Vehicles CDPD Traffic for the Year 2002

		Table 8.1-15 Long-Haul Freight and Fleet Vehicles CDPD Traffic for the Year 2002											**Table 8.1-15 Long-Haul Freight and Fleet Ve**			
CVO Long Haul																
Number of users:		6,397														
Peak Period: 6am-6pm		43200	seconds													
				Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
CVAS	CVCS	50%	5E-05	482	0	63	0	4	0	0.0005	0.002	0	0	0	0	0.002
CVAS	CVCS	50%	0.005	410	0	54	0	3	0	0.05	0.15	0	0	0	0.15	0
CVAS	CVCS	100%	0.001	410	0	54	0	3	0	0.01	0.03	0	0	0	0.03	0
CVAS	CVCS	100%	0.001	410	0	54	0	3	0	0.01	0.03	0	0	0	0.03	0
CVAS	FMS	50%	0.05	26	0	6	0	2	0	0.5	1	0	0	1	0	0
CVAS	FMS	50%	0.025	3818	0	480	0	16	0	0.25	4	0	0	0	0	0
CVAS	FMS							<34333+2>						0.5	3	1
CVAS	FMS	50%	0.05	170	0	24	0	3	0	0.5	1.5	0	0	0	1.5	0
CVAS	FMS	50%	0.025	3818	0	480	0	16	0	0.25	4	0	0	0	0	0
CVAS	FMS							<34333+2>						0.5	3	1
CVAS	FMS	50%	0.05	346	0	46	0	3	0	0.5	1.5	0	0	0	1.5	0
CVCS	CVAS	50%	0.005	0	554	0	72	0	4	0.05	0	0.2	0	0	0	0
CVCS	CVAS	50%	0.0005	0	3362	0	423	0	14	0.005	0	0.07	0	0	0	0
CVCS	CVAS								<333222>							
CVCS	CVAS	100%	0.01	0	554	0	72	0	4	0.1	0	0.4	0	0	0	0
CVCS	CVAS	100%	0.001	0	538	0	70	0	4	0.01	0	0.04	0	0	0	0
CVS	FMS	50%	0.5	0	154	0	22	0	2	0.5	0	1	0	0	0	0
CVS	FMS	50%	0.5	0	330	0	44	0	3	0.5	0	1.5	0	0	0	0
CVS	FMS	50%	0.5	0	98	0	15	0	2	0.5	0	1	0	0	0	0
CVS	FMS	50%	1	0	1234	0	157	0	6	1	0	6	0	0	0	0
CVS	FMS								<22111>							
CVS	FMS	50%	0.05	0	26	0	6	0	2	0.05	0	0.1	0	0	0	0
CVS	FMS	50%	1	0	2066	0	261	0	9	1	0	9	0	0	0	0
CVS	FMS								<22222>							
EM	FMS	10%	1E-05	146	0	21	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
FMS	CVAS	50%	0.05	0	402	0	53	0	3	0.5	0	1.5	0	0	0	0
FMS	CVAS	50%	0.05	0	414	0	54	0	3	0.5	0	1.5	0	0	0	0
FMS	CVAS	50%	0.05	0	3498	0	440	0	15	0.5	0	7.5	0	0	0	0
FMS	CVAS								<4443>							
FMS	CVAS	50%	0.05	0	414	0	54	0	3	0.5	0	1.5	0	0	0	0
FMS	CVAS	50%	0.05	0	3498	0	440	0	15	0.5	0	7.5	0	0	0	0
FMS	CVAS								<4443>							
FMS	CVS	50%	0.5	5082	0	638	0	20	0	0.5	10	0	0	0	0	0
FMS	CVS							<34333+2211>					1	2	6	2
FMS	CVS	50%	0.25	82	0	13	0	2	0	0.25	0.5	0	0	0.5	0	0
FMS	CVS	50%	0.5	346	0	46	0	3	0	0.5	1.5	0	0	0	1.5	0
FMS	CVS	50%	1	3042	0	383	0	13	0	1	13	0	0	0	0	0
FMS	CVS							<1/2* 355+1/2*522221>					0.5	4	1.5	
FMS	CVS	50%	1	1226	0	156	0	6	0	1	6	0	0	0	0	0
FMS	CVS							<1/2*33+1/2*22111>					1.5	2	3	
FMS	EM	10%	1E-05	0	3754	0	472	0	16	0.0001	0	0.0016	0	0	0	0
FMS	EM								<34333+2>							
FMS	EM	10%	1E-05	0	242	0	33	0	3	0.0001	0	0.0003	0	0	0	0
FMS	ImFrghtD	50%	0.005	0	530	0	69	0	4	0.05	0	0.2	0	0	0	0
FMS	ImFrghtS	50%	0.005	0	530	0	69	0	4	0.05	0	0.2	0	0	0	0
FMS	ISP	50%	0.05	0	1234	0	157	0	6	0.5	0	3	0	0	0	0
FMS	ISP								<22111>							
FMS	ISP	50%	0.1	0	1354	0	172	0	7	1	0	7	0	0	0	0
FMS	ISP								<421>							
FMS	PayInstr	50%	0.05	0	50	0	9	0	2	0.5	0	1	0	0	0	0
ImFrghtD	FMS	50%	0.005	530	0	69	0	4	0	0.05	0.2	0	0	0	0	0.2
ImFrghtS	FMS	50%	0.005	530	0	69	0	4	0	0.05	0.2	0	0	0	0	0.2
ISP	FMS	50%	0.05	3034	0	382	0	13	0	0.5	6.5	0	0	0	0	0
ISP	FMS							<522221>					0.5	4		
ISP	FMS	50%	0.1	3154	0	397	0	13	0	1	13	0	0	0	0	0
ISP	FMS							<43322>						4	6	4
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.1	6146	0	771	0	24	0	0.1	2.4	0	0	0	0	0
ISP	VS							<34333+22222>						1	1.2	0.4
ISP	VS	10%	0.01	10802	0	1353	0	41	0	0.01	0.41	0	0	0	0	0
ISP	VS							<2*34333+1/2*5322+1/2*4332>						0.03	0.285	0.1
LocData	VS	7%	0.007	146	0	21	0	2	0	0.007	0.014	0	0	0.014	0	0
PayInstr	FMS	50%	0.05	114	0	17	0	2	0	0.5	1	0	0	1	0	0
PayInstr	VS	10%	0.0001	178	0	25	0	3	0	0.0001	0.0003	0	0	0	0.0003	0

Table 8.1-15 Long-Haul Freight and Fleet Vehicles CDPD Traffic for the Year 2002

		Table 8.1-16 Local Freight and Fleet Vehicles CDPD Traffic for the Year 2002											**Table 8.1-16 Local Freight and Fleet Vehicle**			
CVO Local																
Number of users:		89,565														
Peak Period: 6am-6pm		43200	seconds													
				Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
CVS	FMS	50%	1	0	154	0	22	0	2	1	0	2	0	0	0	0
CVS	FMS	50%	2	0	1234	0	157	0	6	1.5	0	9	0	0	0	0
CVS	FMS								<22111>							
CVS	FMS	50%	0.05	0	26	0	6	0	2	0.05	0	0.1	0	0	0	0
CVS	FMS	50%	2	0	2066	0	261	0	9	2	0	18	0	0	0	0
CVS	FMS								<22222>							
EM	FMS	10%	1E-05	146	0	21	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
EM	VS	10%	0.0001	26	0	6	0	2	0	0.0001	0.0002	0	0	0.0002	0	0
FMS	CVS	50%	1	5082	0	638	0	20	0	1	20	0	0	0	0	0
FMS	CVS							<34333+2211>					2	4	12	4
FMS	CVS	50%	2	3042	0	383	0	13	0	2	26	0	0	0	0	0
FMS	CVS							<355>							6	
FMS	CVS	50%	2	1226	0	156	0	6	0	2	12	0	0	0	0	0
FMS	CVS							<22111>					6	8		
FMS	EM	10%	1E-05	0	3754	0	472	0	16	0.0001	0	0.0016	0	0	0	0
FMS	EM								<34333+2>							
FMS	EM	10%	1E-05	0	242	0	33	0	3	0.0001	0	0.0003	0	0	0	0
FMS	ImFrghtD	50%	0.005	0	530	0	69	0	4	0.05	0	0.2	0	0	0	0
FMS	ImFrghtS	50%	0.005	0	530	0	69	0	4	0.05	0	0.2	0	0	0	0
FMS	ISP	50%	0.1	0	1234	0	157	0	6	1	0	6	0	0	0	0
FMS	ISP								<22111>							
FMS	ISP	50%	0.2	0	1354	0	172	0	7	2	0	14	0	0	0	0
FMS	ISP								<421>							
ImFrghtD	FMS	50%	0.005	530	0	69	0	4	0	0.05	0.2	0	0	0	0	0.2
ImFrghtS	FMS	50%	0.005	530	0	69	0	4	0	0.05	0.2	0	0	0	0	0.2
ISP	FMS	50%	0.1	3034	0	382	0	13	0	1	13	0	0	0	0	0
ISP	FMS							<522221>					1	8		
ISP	FMS	50%	0.2	3154	0	397	0	13	0	2	26	0	0	0	0	0
ISP	FMS							<1/2*43322+1/2*24422>						10	6	12
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.0001	234	0	32	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
ISP	VS	10%	0.2	6146	0	771	0	24	0	0.2	4.8	0	0	0	0	0
ISP	VS							<34333+22222>						2	2.4	0.8
ISP	VS	10%	0.01	10802	0	1353	0	41	0	0.01	0.41	0	0	0	0	0
ISP	VS							<2*34333+5322>						0.04	0.27	0.08
LocData	VS	7%	0.007	146	0	21	0	2	0	0.007	0.014	0	0	0.014	0	0
PayInstr	VS	10%	0.0001	178	0	25	0	3	0	0.0001	0.0003	0	0	0	0.0003	0
VS	EM	10%	0.0001	0	282	0	38	0	3	0.0001	0	0.0003	0	0	0	0
VS	EM	10%	0.0001	0	3354	0	422	0	14	0.0001	0	0.0014	0	0	0	0
VS	EM								<333222>							
VS	ISP	10%	0.0001	0	632.4	0	82	0	4	0.0001	0	0.0004	0	0	0	0
VS	ISP	10%	0.0001	0	642	0	83	0	4	0.0001	0	0.0004	0	0	0	0
VS	ISP	10%	0.2	0	290	0	39	0	3	0.2	0	0.6	0	0	0	0
VS	ISP	10%	0.01	0	674	0	87	0	4	0.01	0	0.04	0	0	0	0
VS	PayInstr	10%	0.0001	0	50	0	9	0	2	0.0001	0	0.0002	0	0	0	0
VS	PMS	10%	0.00005	0	514	0	67	0	4	0.0001	0	0.0004	0	0	0	0
VS	PMS	10%	0.00005	0	26	0	6	0	2	0.0001	0	0.0002	0	0	0	0
												Total # blocks/User during peak period	9	32.0546	26.6709	17.28
												*Population	806084.1749	2870967	2388777	1547682
												/peak period duration	18.6593559	66.45758	55.29576	35.82596
												/per sector	0.081127634	0.288946	0.240416	0.155765
										packets/s	89.664	61.912	18.65936	33.22879	18.43192	8.95649
													20.8%	37.1%	20.6%	10.0%

Table 8.1-16 Local Freight and Fleet Vehicles CDPD Traffic for the Year 2002

		Table 8.1-17 Emergency Vehicles CDPD Traffic for the Year 2002											**Table 8.1-17 Emergency Vehicles CDPD Traf**			
Emergency Vehicle																
Number of users:		4,850														
Peak Period: 6am-7pm		46800	seconds													
				Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
EM	EVS	100%	13	1042	0	133	0	6	0	13	78	0	0	0	0	0
EM	EVS							<411>					26			52
EVS	EM	100%	26	0	26	0	6	0	2	26	0	52	0	0	0	0
EVS	EM	100%	26	0	146	0	21	0	2	26	0	52	0	0	0	0
EVS	EM	100%	13	0	530	0	69	0	4	13	0	52	0	0	0	0
												Total # blocks/User during peak period	26	0	0	52
												*Population	126093.5221	0	0	252187
												/peak period duration	2.694306027	0	0	5.388612
												/per sector	0.011714374	0	0	0.023429
										packets/s	4.041	6.736	2.69431	0.00000	0.00000	1.34715
													66.7%	0.0%	0.0%	33.3%

Table 8.1-17 Emergency Vehicles CDPD Traffic for the Year 2002

		Table 8.1-18 Transit Vehicles CDPD Traffic for the Year 2002											**Table 8.1-18 Transit Vehicles CDPD Traffic f**			
Transit Vehicles																
Public_Transit_Vehicles		1466	Peak Period: 6am-7pm		46800	seconds										
ParaTransit_Vehicles		367														
Transit Customers		47,440		Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
ISP	RTS	10%	0.00032	426	0	56	0	3	0	0.003236016	0.00971	0	0	0	0.009708	0
ISP	RTS	10%	0.00032	666	0	86	0	4	0	0.003236016	0.01294	0	0	0	0	0.012944
ISP	RTS	10%	0.00032	498	0	65	0	4	0	0.003236016	0.01294	0	0	0	0	0.012944
ISP	RTS	10%	0.00032	987.68	0	126	0	5	0	0.003236016	0.01618	0	0	0	0	0
PayInstr	RTS	10%	0.064	26	0	6	0	2	0	0.647203274	1.29441	0	0	1.294407	0	0
PayInstr	RTS	10%	0.00032	178	0	25	0	3	0	0.003236016	0.00971	0	0	0	0.009708	0
PayInstr	RTS	10%	0.00032	178	0	25	0	3	0	0.003236016	0.00971	0	0	0	0.009708	0
PayInstr	RTS	10%	0.00032	178	0	25	0	3	0	0.003236016	0.00971	0	0	0	0.009708	0
PayInstr	TRVS	100%	32	26	0	6	0	2	0	32.36016371	64.7203	0	0	64.72033	0	0
PayInstr	TRVS	100%	0.032	178	0	25	0	3	0	0.032360164	0.09708	0	0	0	0.09708	0
RTS	EM	100%	0.0032	0	370	0	49	0	3	0.032360164	0	0.09708	0	0	0	0
RTS	ISP	10%	0.00032	0	738	0	95	0	5	0.003236016	0	0.01618	0	0	0	0
RTS	ISP	10%	0.320000005	0	98	0	15	0	2	3.236016371	0	6.47203	0	0	0	0
RTS	ISP	10%	0.064000001	0	66	0	11	0	2	0.647203274	0	1.29441	0	0	0	0
RTS	ISP	10%	0.320000005	0	58	0	10	0	2	3.236016371	0	6.47203	0	0	0	0
RTS	ISP	10%	0.00032	0	978	0	125	0	5	0.003236016	0	0.01618	0	0	0	0
RTS	ISP	10%	0.00032	0	402	0	53	0	3	0.003236016	0	0.00971	0	0	0	0
RTS	ISP	10%	0.00032	0	858	0	110	0	5	0.003236016	0	0.01618	0	0	0	0
RTS	ISP	10%	0.00032	0	1434	0	182	0	7	0.003236016	0	0.02265	0	0	0	0
RTS	ISP								<34>							
RTS	ISP	10%	0.00032	0	26	0	6	0	2	0.003236016	0	0.00647	0	0	0	0
RTS	PayInstr	10%	0.064000001	0	50	0	9	0	2	0.647203274	0	1.29441	0	0	0	0
RTS	PayInstr	10%	0.032	0	50	0	9	0	2	0.323601637	0	0.6472	0	0	0	0
RTS	PayInstr	10%	0.00032	0	50	0	9	0	2	0.003236016	0	0.00647	0	0	0	0
RTS	PayInstr	10%	0.00032	0	34	0	7	0	2	0.003236016	0	0.00647	0	0	0	0
TRMS	TRVS	100%	0.1	8210	0	1029	0	32	0	0.1	3.2	0	0	0	0	0
TRMS	TRVS							<2*34333+2>						0.2	2.4	0.8
TRMS	TRVS	100%	32	26	0	6	0	2	0	32.36016371	64.7203	0	0	64.72033	0	0
TRMS	TRVS	10%	0.0032	2418	0	305	0	11	0	0.003236016	0.0356	0	0	0	0	0
TRMS	TRVS							<3332>						0.006472	0.029124	
TRMS	TRVS	100%	13	1042	0	133	0	6	0	13.01773533	78.1064	0	0	0	0	0
TRMS	TRVS							<411>					26.03547067			52.07094
TRMS	TRVS	100%	0.032	82	0	13	0	2	0	0.032360164	0.06472	0	0	0.06472	0	0
TRMS	TRVS	100%	0.032	34	0	7	0	2	0	0.032360164	0.06472	0	0	0.06472	0	0
TRMS	TRVS	100%	13	17260	0	2160	0	65	0	13	845	0	0	0	0	0
TRMS	TRVS							<4*34333+5>							624.00	208.00
TRMS	TRVS	100%	52	7786	0	976	0	30	0	52	1560	0	0	0	0	0
TRMS	TRVS							<34333+43333>							1248	416
TRMS	TRVS	100%	1	16826	0	2106	0	63	0	0.541666667	34.125	0	0	0	0	0
TRMS	TRVS							<4*34333+5>							26.00	8.67
TRMS	TRVS	100%	0.032	554	0	72	0	4	0	0.032360164	0.12944	0	0	0	0	0.129441
TRMS	TRVS	100%	1	922	0	118	0	5	0	1	5	0	0	0	0	0
TRMS	TRVS	100%	32	26	0	6	0	2	0	32.36016371	64.7203	0	0	64.72033	0	0
TRMS	TRVS	100%	32	34	0	7	0	2	0	32.36016371	64.7203	0	0	64.72033	0	0
TRVS	PayInstr	100%	32	0	50	0	9	0	2	32.36016371	0	64.7203	0	0	0	0
TRVS	PayInstr	100%	32	0	34	0	7	0	2	32.36016371	0	64.7203	0	0	0	0
TRVS	TRMS	10%	0.0032	0	2418	0	305	0	11	0.003236016	0	0.0356	0	0	0	0
TRVS	TRMS								<3332>							
TRVS	TRMS	100%	13	0	26	0	6	0	2	52	0	104	0	0	0	0
TRVS	TRMS	100%	32	0	466	0	61	0	4	32.36016371	0	129.441	0	0	0	0
TRVS	TRMS	100%	0.1	0	34	0	7	0	2	0.1	0	0.2	0	0	0	0
TRVS	TRMS	100%	0.0032	0	282	0	38	0	3	0.003236016	0	0.00971	0	0	0	0
TRVS	TRMS	100%	0.0032	0	282	0	38	0	3	0.003236016	0	0.00971	0	0	0	0
TRVS	TRMS	100%	0.0032	0	1042	0	133	0	6	0.003236016	0	0.01942	0	0	0	0
TRVS	TRMS								<411>							
TRVS	TRMS	100%	3.2	0	186	0	26	0	3	3.236016371	0	9.70805	0	0	0	0
TRVS	TRMS	100%	0.011	0	73746	0	9221	0	271	0.013642565	0	3.69714	0	0	0	0
TRVS	TRMS								<18*34333+3>							
TRVS	TRMS	10%	0.0032	0	1450	0	184	0	7	0.003236016	0	0.02265	0	0	0	0
TRVS	TRMS								<34>							
TRVS	TRMS	100%	13	0	1042	0	133	0	6	13	0	78	0	0	0	0
TRVS	TRMS								<411>							
TRVS	TRMS	100%	13	0	1826	0	231	0	9	13	0	117	0	0	0	0
TRVS	TRMS								<4221>							
TRVS	TRMS	100%	52	0	274	0	37	0	3	52	0	156	0	0	0	0
TRVS	TRMS	100%	156	0	234	0	32	0	3	156	0	468	0	0	0	0
TRVS	TRMS	100%	32	0	26	0	6	0	2	32.36016371	0	64.7203	0	0	0	0

Table 8.1-18 Transit Vehicles CDPD Traffic for the Year 2002

		Table 8.1-19 Personal Information Access CDPD Traffic for the Year 2002											Table 8.1-19 Personal Information Access C			
Personal Information Access			Peak Period: 6-9am & 4-7pm			21600	seconds									
	Universe	876,390		Remote Access Users		87,639										
Mobile (Profissional) Penetration			**10%**	Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
EM	PIAS	10%	0.000025	26	0	6	0	2	0	0.00005	0.0001	0	0	0.0001	0	0
ISP	PIAS	10%	0.00025	3578	0	450	0	15	0	0.005	0.075	0	0	0	0	0
ISP	PIAS										<532222>			0.04	0.015	
ISP	PIAS	7%	0.0035	18306	0	2291	0	69	0	0.07	4.83	0	0	0	0	0
ISP	PIAS										<4x43333 + 45>				3.36	1.4
ISP	PIAS	10%	0.005	818	0	105	0	5	0	0.01	0.05	0	0	0	0	0
ISP	PIAS	10%	0.005	650	0	84	0	4	0	0.01	0.04	0	0	0	0	0.04
ISP	PIAS	10%	0.05	1139.7	0	145	0	6	0	0.1	0.6	0	0	0	0	0
ISP	PIAS										<51>		0.1			
LocData	PIAS	7%	0.007	146	0	21	0	2	0	0.007	0.014	0	0	0.014	0	0
PayInstr	PIAS	10%	0.005	178	0	25	0	3	0	0.01	0.03	0	0	0	0.03	0
PIAS	EM	10%	0.000025	0	370	0	49	0	3	0.00005	0	0.00015	0	0	0	0
PIAS	ISP	10%	0.05	0	250	0	34	0	3	0.1	0	0.3	0	0	0	0
PIAS	ISP	10%	0.0025	0	250	0	34	0	3	0.005	0	0.015	0	0	0	0
PIAS	ISP	10%	0.05	0	210	0	29	0	3	0.1	0	0.3	0	0	0	0
PIAS	ISP	10%	0.005	0	1130	0	144	0	6	0.01	0	0.06	0	0	0	0
PIAS	ISP											<51>				
PIAS	ISP	10%	0.005	0	402	0	53	0	3	0.01	0	0.03	0	0	0	0
PIAS	ISP	10%	0.05	0	26	0	6	0	2	0.1	0	0.2	0	0	0	0
PIAS	PayInstr	10%	0.005	0	50	0	9	0	2	0.01	0	0.02	0	0	0	0
PIAS	TRMS	10%	0.005	0	466	0	61	0	4	0.01	0	0.04	0	0	0	0
TRMS	PIAS	10%	0.00165	2530	0	319	0	11	0	0.005	0.055	0	0	0	0	0
TRMS	PIAS										<222222>			0.06		
												Total # blocks/User during peak period	0.1	0.1141	3.405	1.44
												*Population	8763.9	9999.61	298410.8	126200.2
												/peak period duration	0.405736111	0.462945	13.81531	5.8426
												/per sector	0.00176407	0.002013	0.060067	0.025403
										packets/s	7.454	1.441	0.40574	0.23147	4.60510	1.46065
													5.4%	3.1%	61.8%	19.6%

Table 8.1-19 Personal Information Access CDPD Traffic for the Year 2002

		Table 8.1-20 Probe Vehicles CDPD Traffic for the Year 2002											**Table 8.1-20 Probe Vehicles CDPD Traffic fo**			
Trafic Management = Probes																
Number of users:		7,704														
Peak Period: 6-9am & 4-7pm			21600	seconds												
				Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link			
PA Source	PA Sink	Penetration	Frequency	bits	bits	bytes	bytes	**# blocks**	**# blocks**	Penetration	**blocks**	**blocks**	**1**	**2**	**3**	**4**
VS	ISP	100%	12	0	314	0	42	0	3	12	0	36		0	0	0
										Total # blocks/User during peak period				0	0	0
												*Population		0	0	0
											/peak period duration			0	0	0
												/per sector		0	0	0
										packets/s	0.000	4.280	0.00000	0.00000	0.00000	0.00000

Table 8.1-20 Probe Vehicles CDPD Traffic for the Year 2002, Urbansville

Table 8.1-21 ITS CDPD Traffic Summary for the Year 2002

(a) ITS CDPD Traffic

	Forward	1	2	3	4	5
Traveller Information	24.27965	0.405736	0.462945	13.81531	5.8426	3.753059
Transit	92.26808	0.815556	8.160471	59.53479	21.47918	2.27808
Probe Vehicles	0	0	0	0	0	0
Private Vehicles	117.2653	0	39.69736	57.61183	19.95614	0
Emergency Vehicles	8.082918	2.694306	0	0	5.388612	0
CVO Local	228.1739	18.65936	66.45758	55.29576	35.82596	51.93521
CVO Long	10.61325	0.518315	3.042452	4.249579	1.318298	1.484604
RS-Blocks/s		23.09327	117.8208	190.5073	89.8108	59.45095
	Packets/s	23.09327	58.9104	63.50243	22.4527	11.89019
Packets/s per Sector		0.100406	0.256132	0.276098	0.09762	0.051696

Total Forward Link CDPD Traffic: 0.295 Erlang

	Reverse	1	2	3	4	5
Traveller Information	3.915962	0.040574	0.892619	2.617607	0.162294	0.202868
Transit	63.49485	1.221869	11.48263	42.91129	7.877541	0.001521
Probe Vehicles	12.84	0	0	12.84	0	0
Private Vehicles	15.86513	0	2.72478	11.55921	1.58114	0
Emergency Vehicles	16.16584	0	10.77722	0	5.388612	0
CVO Local	113.2944	19.69599	74.84724	1.249555	17.50165	0
CVO Long	7.943628	0.814496	3.170787	1.428729	2.529616	0
RS-Blocks/s		21.77293	103.8953	72.60639	35.04085	0.204389
	Packets/s	21.77293	51.94764	24.20213	8.760213	0.040878
Packets/s per Sector		0.094665	0.225859	0.105227	0.038088	0.000178

Total Reverse Link CDPD Traffic: 0.265 Erlang

(b) CDPD Traffic Packet Distribution

Distribution	1	2	3	4	5
Forward	12.840%	32.755%	35.309%	12.484%	6.611%
Reverse	20.401%	48.675%	22.677%	8.208%	0.038%

It is clear from Table 8.1-21 that most of the traffic is generated by and directed to CVO Local, and Private Vehicles, although Transit Vehicles receive a lot of traffic.

The forward channel operates obviously far below capacity. This fact allows for reducing, as a first-cut, the delay in the forward link to queuing delay. As for the reverse channel, due to the inherent contention mechanism, only simulation can provide the necessary delay/throughput information.

8.1.5.1.2.2 Non-ITS Data Load

Trying to conservatively estimate the Non-ITS data loads, we projected that the non-ITS data load would be **2.5** times that of ITS in the reverse direction (from the user to the F-ES's), and that it would be 4 times higher than that (i.e., **10** times the ITS traffic in the reverse direction) in the forward direction. The reason for this different treatment is that, as we have already discussed, the reverse direction traffic is mostly due to E-mail, while the forward traffic consists mainly of E-mail and WWW Access, with its associated downloads, and is therefore expected to be much larger.

The resulting traffic for Urbansville 2002 is, therefore, as shown in Table 8.1-22.

Table 8.1-22 Non-ITS CDPD Traffic

Non-ITS Traffic	Forward	1	2	3	4	5
RS-Blocks/s per Sector		3.3724	2.248267	2.248267	1.26465	0.8431
Packets/s per Sector		3.3724	1.124133	0.749422	0.316163	0.16862
	Reverse	1	2	3	4	5
RS-Blocks/s per Sector		0.8431	0.562067	0.562067	0.316163	0.210775
Packets/s per Sector		0.8431	0.281033	0.187356	0.079041	0.042155

The distribution, as was discussed before, is taken to be the same in both directions. The resulting overall traffic follows in Table 8.1-23.

Table 8.1-23 Overall ITS plus Non-ITS CDPD Traffic

Total Traffic	Forward	1	2	3	4	5
RS-Blocks/s per Sector		3.472806	2.760531	3.076559	1.655132	1.101582
Packets/s per Sector		3.472806	1.380266	1.02552	0.413783	0.220316
Distribution		53.324%	21.193%	15.746%	6.353%	3.383%
	Reverse	1	2	3	4	5
RS-Blocks/s per Sector		0.937765	1.013785	0.877747	0.468514	0.211664
Packets/s per Sector		0.937765	0.506893	0.292582	0.117129	0.042333
Distribution		49.442%	26.725%	15.426%	6.175%	2.232%

8.1.5.1.2.3 Incident Case

The incident case for Urbansville was defined by MITRE. Unfortunately, at the time when the information was requested, all the simulation files obtained from Integration had already been erased. Given time constraints, it was not possible to re-run Integration for the Urbansville scenario, and the information provided to the Joint Team (February 1, 1996) was the following:

1. Incident occurring at the intersection of Ford and Lodge freeways in downtown Detroit, in the direction E-W, affecting approximately 2.5 miles of freeway. This information was used to conclude that two sectors would be affected by the incident, namely Tiger Stadium #1, and Baltimore #3. Furthermore, most of the congestion occurs within the Tiger Stadium #1 sector.

    a) Number of vehicles in the most affected sector under normal peak period traffic conditions: 4905.

    b) Number of vehicles in the most affected sector immediately before the incident began to clear: 7256.

In order to analyze a worst case scenario, we assumed that all the vehicles identified as being in the most affected sector were in the affected link of freeway. Furthermore, we assumed that all those vehicles, independent of their direction, would be affected. (In reality, assuming equilibrium during the peak period, only approximately 4800 [~ 7256-(4905/2)] vehicles are affected by the incident). As such, we have maximized the CDPD traffic increase due to the incident, i.e., its impact on CDPD performance (see Figure 8.1-9).

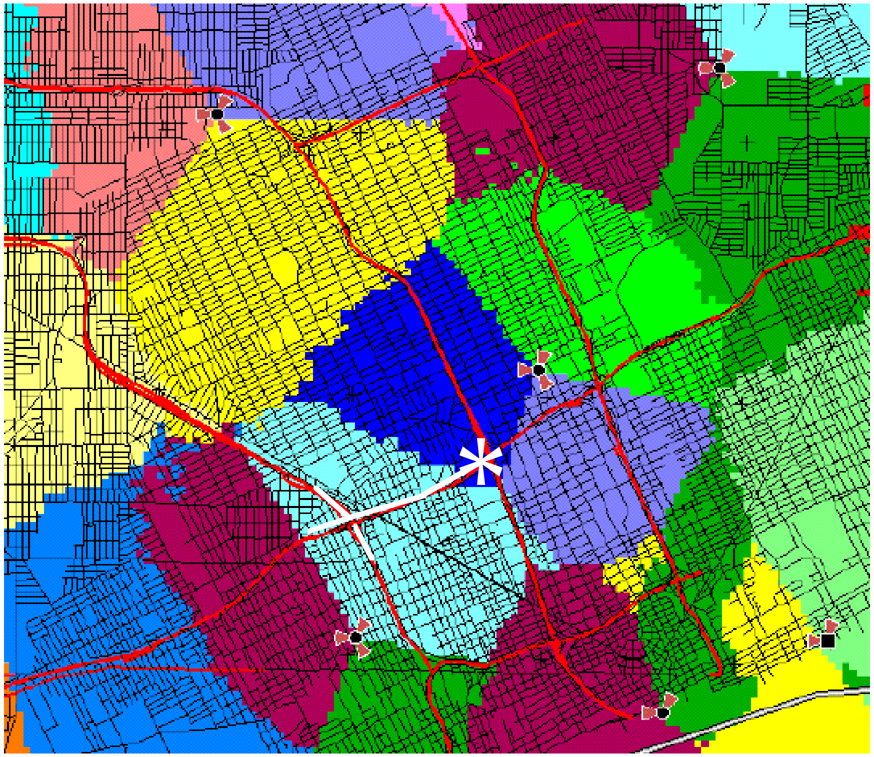


Figure 8.1-9 Location of the Incident showing the Sectors Involved, as well as the Sectors and Roadway Segments Affected by the Incident

8.1.5.2 Thruville 2002

It should be noted that the Data Loading analysis in this document, as well as the *Evaluatory Design* document, looked at only the New Jersey side of Thruville. Given that our cellular deployment extended into the Pennsylvania side, where Philadelphia is located, we had to extend the population figures considered therein to account for the whole scenario.

In any case, as it is very easy to observe, the ITS traffic considered for Thruville is quite different from that analyzed for Urbansville. This stems, as explained in the *Evaluatory Design* document, from the different set of ITS services scheduled for deployment in this inter-urban scenario.

8.1.5.2.1 ITS only

Table 8.1-24 through Table 8.1-31 summarize the data load for the 2002 time frame for Thruville (Philadelphia-Trenton corridor). As shown In Table 8.1-31, the data loads are now significantly smaller then those in Detroit, given that a smaller set of ITS services will be deployed at that time.

Table 8.1-24 Private Vehicles CDPD Traffic for the Year 2002

Private Vehicle — 1.086276259 Factor due to through traffic

Number of users: 3,202,686

Peak Period: 6-9am/4-7pm

21600 s

Penetration: 7%, 100%

PA Source	PA Sink	Physical Data Flow	Penetration	(DL Freq) * Penetration	1/(DL Freq)	Explanation	Number
EM	VS	emergency_request_driver_acknowledge	10%	0.0001	1000	one emergency per 1000 vehicles	1000
EM	VS	emergency_request_vehicle_acknowledge	10%	0.0001	1000	one emergency per 1000 vehicles	1000
LocData	VS	From_Location_Data_Source	7%	0.007	10	one in 10 vs	10
PayInstr	VS	fpi_transit_user_vehicle_input_credit_identity	100%	0.0001	10000	one in 10000 vehicles this flow	10000
VS	EM	emergency_request_driver_details	10%	0.0001	1000	one emergency per 1000 vehicles	1000
VS	EM	emergency_request_vehicle_details	10%	0.0001	1000	one emergency per 1000 vehicles	1000
VS	ISP	advisory_data_request	10%	0.1	1	one request per vehicle	1
VS	ISP	vehicle_guidance_route_accepted	7%	0.14	1/2	two acceptances	1/2

W.C. Factor	Forward bits	Reverse bits	Forward bytes	Reverse bytes	Forward # blocks	Reverse # blocks	Frequency Penetration	Forward blocks	Reverse blocks	Forward Link 1	2	3	4	5	Reverse Link 1	2	3
1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0
1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0
1	146	0	21	0	2	0	0.007	0.014	0		0.014	0	0	0		0	0
1	178	0	25	0	3	0	0.0001	0.0003	0		0	0.0003	0	0		0	0
1	0	282	0	38	0	3	0.0001	0	0.0003		0	0	0	0		0	0.0003
1	0	3354	0	422	0	14	0.0001	0	0.0014		0	0	0	0		0	0
						<53322>										0.0004	0.0006
1	0	290	0	39	0	3	0.1	0	0.3		0	0	0	0		0	0.3
1	0	34	0	7	0	2	0.14	0	0.28		0	0	0	0		0.28	0
								Total # blocks/User		0	0.0144	0.0003	0	0	0	0.2804	0.3009
								*Population		0	50097.63	1043.701	0	0	0	975512.1	1046832
								/peak period duration		0	2.319335	0.048319	0	0	0	45.1626	48.46443
								/per sector		0	0.010084	0.00021	0	0	0	0.196359	0.210715

Table 8.1-25 Long-Haul Freight and Fleet Vehicles CDPD Traffic for the Year 2002

Table 8.1-25 Long-Haul Freight and Fleet Vehicles CDPD Traffic for the Year 2002

CVO Long Haul			1.0862763	Factor due to through traffic																							
Number of users:		24,717	Penetration	50%	of LH Trucks operating in a Metro Area																						
Peak Period:		43200	7%																								
6am-6pm		(12 hours)	100%	(DL Freq) *				W.C.	Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency*	Forward	Reverse	Forward Link					Reverse Link				
PA Source	PA Sink	Physical Data Flow	Penetration	Penetration	1/(DL Freq)	Explanation	Number	Factor	bits	bits	bytes	bytes	# blocks	# blocks	Penetration	blocks	blocks	1	2	3	4	5	1	2	3	4	5
CVAS	CVCS	cv_credentials_database_update	50%	0.00005	10000	1 out of 1000 vehicles	1000	10	482	0	63	0	4	0	0.0005	0.002	0		0	0	0.002	0		0	0	0	0
CVAS	CVCS	cv_credentials_information_response	50%	0.005	100	1 out of 10 vehicles	10	10	410	0	54	0	3	0	0.05	0.15	0		0	0.15	0	0		0	0	0	0
CVAS	CVCS	cv_safety_database_update	100%	0.001	1000	1 out of 100 vehicles	100	10	410	0	54	0	3	0	0.01	0.03	0		0	0.03	0	0		0	0	0	0
CVAS	CVCS	cv_safety_information_response	100%	0.001	1000	1 out of 100 vehicles are transmitted	100	10	410	0	54	0	3	0	0.01	0.03	0		0	0.03	0	0		0	0	0	0
CVAS	FMS	cf_clearance_enrollment_confirm	50%	0.05	10	1 per vehicle	1	10	26	0	6	0	2	0	0.5	1	0		1	0	0	0		0	0	0	0
CVAS	FMS	cf_enrollment_information	50%	0.025	20	1 out of 2 vehicles require info.	2	10	3818	0	480	0	16	0	0.25	4	0		0	0	0	0		0	0	0	0
													<5443+2>						0.5	0.75	2	1.25					
CVAS	FMS	cf_enrollment_payment_confirmation	50%	0.05	10	1 per vehicle	1	10	170	0	24	0	3	0	0.5	1.5	0		0	1.5	0	0		0	0	0	0
CVAS	FMS	cv_enrollment_information	50%	0.025	20	1 out of 2 vehicles require info.	2	10	3818	0	480	0	16	0	0.25	4	0		0	0	0	0		0	0	0	0
													<5443+2>						0.5	0.75	2	1.25					
CVAS	FMS	cv_enrollment_payment_confirmation	50%	0.05	10	1 per vehicle	1	10	346	0	46	0	3	0	0.5	1.5	0		0	1.5	0	0		0	0	0	0
CVCS	CVAS	cv_credentials_information_request	50%	0.005	100	request info on 1 in 10 vehicles	10	10	0	554	0	72	0	4	0.05	0	0.2		0	0	0	0		0	0	0.2	0
CVCS	CVAS	cv_roadside_daily_log	50%	0.0005	1000	1 report per 100 vehicles	100	10	0	3362	0	423	0	14	0.005	0	0.07		0	0	0	0		0	0	0	0
														<333222>										0.03	0.045		
CVCS	CVAS	cv_safety_information_request	100%	0.01	100	request info on 1 in 10 vehicles	10	10	0	554	0	72	0	4	0.1	0	0.4		0	0	0	0		0	0	0.4	0
CVCS	CVAS	cv_update_safety_problems_list	100%	0.001	1000	1 out of 100 vehicles are on the list	100	10	0	538	0	70	0	4	0.01	0	0.04		0	0	0	0		0	0	0.04	0
CVS	FMS	cf_driver_route_instructions_request	50%	0.5	1	average fleet vehicle requests 1 route	1	1	0	154	0	22	0	2	0.5	0	1		0	0	0	0		1	0	0	0
CVS	FMS	cv_driver_enrollment_payment_request	50%	0.5	1	1 per vehicle	1	1	0	330	0	44	0	3	0.5	0	1.5		0	0	0	0		0	1.5	0	0
CVS	FMS	cv_driver_enrollment_request	50%	0.5	1	1 per vehicle	1	1	0	98	0	15	0	2	0.5	0	1		0	0	0	0		1	0	0	0
CVS	FMS	cv_driver_route_request	50%	1	1/2	average vehicle requests 2 routes	1/2	1	0	1234	0	157	0	6	1	0	6		0	0	0	0		0	0	0	0
														<4111>									3			4	
CVS	FMS	cv_driver_storage_request	50%	0.05	10	1 in 10 vehicles	10	1	0	26	0	6	0	2	0.05	0	0.1		0	0	0	0		0.1	0	0	0
CVS	FMS	cv_static_route_data	50%	1	1/2	2 routes per vehicle	1/2	1	0	2066	0	261	0	9	1	0	9		0	0	0	0		0	0	0	0
														<5221>									1	4			5
EM	FMS	cf_hazmat_request	10%	0.00001	10000	1 per 1000 vehicles	1000	10	146	0	21	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
EM	VS	emergency_request_driver_acknowledge	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
EM	VS	emergency_request_vehicle_acknowledge	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
FMS	CVAS	cf_enroll_clearance_data	50%	0.05	10	1 per vehicle	1	10	0	402	0	53	0	3	0.5	0	1.5		0	0	0	0		0	1.5	0	0
FMS	CVAS	cf_enrollment_payment_request	50%	0.05	10	1 per vehicle	1	10	0	414	0	54	0	3	0.5	0	1.5		0	0	0	0		0	1.5	0	0
FMS	CVAS	cf_enrollment_request	50%	0.05	10	1 per vehicle	1	10	0	3498	0	440	0	15	0.5	0	7.5		0	0	0	0		0	0	0	0
														<4443>											1.5	6	
FMS	CVAS	cv_enrollment_payment_request	50%	0.05	10	1 per vehicle	1	10	0	414	0	54	0	3	0.5	0	1.5		0	0	0	0		0	1.5	0	0
FMS	CVAS	cv_enrollment_request	50%	0.05	10	1 per vehicle	1	10	0	3498	0	440	0	15	0.5	0	7.5		0	0	0	0		0	0	0	0
														<4443>											1.5	6	
FMS	CVS	cf_driver_route_instructions	50%	0.5	1	1 per vehicle	1	1	5082	0	638	0	20	0	0.5	10	0		0	0	0	0		0	0	0	0
													<5443+2211>					1	2	1.5	4	2.5					
FMS	CVS	cv_driver_enrollment_information	50%	0.25	2	1 out of 2 vehicles require info.	2	1	82	0	13	0	2	0	0.25	0.5	0		0.5	0	0	0		0	0	0	0
FMS	CVS	cv_driver_enrollment_payment_confirmation	50%	0.5	1	1 per vehicle	1	1	346	0	46	0	3	0	0.5	1.5	0		0	1.5	0	0		0	0	0	0
FMS	CVS	cv_driver_route_data	50%	1	1/2	average vehicle requests 2 routes	1/2	1	3042	0	383	0	13	0	1	13	0		0	0	0	0		0	0	0	0
													<355>							3		10					
FMS	CVS	cv_static_route_request	50%	1	1/2	average vehicle requests 2 routes	1/2	1	1226	0	156	0	6	0	1	6	0		0	0	0	0		0	0	0	0
													<22111>					3	4								
FMS	EM	cf_hazmat_route_information	10%	0.00001	10000	1 per 1000 vehicles	1000	10	0	3754	0	472	0	16	0.0001	0	0.0016		0	0	0	0		0	0	0	0
														<5443>											0.0003	0.0008	0.0005
FMS	EM	cf_hazmat_vehicle_information	10%	0.00001	10000	1 per 1000 vehicles	1000	10	0	242	0	33	0	3	0.0001	0	0.0003		0	0	0	0		0	0.0003	0	0
FMS	ImFrghtD	To_Intermodal_Freight_Depot	50%	0.005	100	1 in 10 vehicles interacts 1 with an intermodal carrier	10	10	0	530	0	69	0	4	0.05	0	0.2		0	0	0	0		0	0	0.2	0
FMS	ImFrghtS	To_Intermodal_Freight_Shipper	50%	0.005	100	1 in 10 vehicles interacts 1 with an intermodal carrier	10	10	0	530	0	69	0	4	0.05	0	0.2		0	0	0	0		0	0	0.2	0
FMS	ISP	cf_route_request	50%	0.05	10	1 per vehicle	1	10	0	1234	0	157	0	6	0.5	0	3		0	0	0	0		0	0	0	0
														<4111>									1.5			2	
FMS	ISP	cv_route_request	50%	0.1	5	twice per vehicle	1/2	10	0	1354	0	172	0	7	1	0	7		0	0	0	0		0	0	0	0
														<421>									1	2		4	
FMS	PayInstr	tpi_debited_commercial_manager_payment	50%	0.05	10	1 per enrollment	1	10	0	50	0	9	0	2	0.5	0	1		0	0	0	0		1	0	0	0
ImFrghtD	FMS	From_Intermodal_Freight_Depot	50%	0.005	100	1 in 10 vehicles interacts 1 with an intermodal carrier	10	10	530	0	69	0	4	0	0.05	0.2	0		0	0	0.2	0		0	0	0	0
ImFrghtS	FMS	From_Intermodal_Freight_Shipper	50%	0.005	100	1 in 10 vehicles interacts 1 with an intermodal carrier	10	10	530	0	69	0	4	0	0.05	0.2	0		0	0	0.2	0		0	0	0	0
ISP	FMS	cf_route	50%	0.05	10	1 per vehicle	1	10	3034	0	382	0	13	0	0.5	6.5	0		0	0	0	0		0	0	0	0
													<355>							1.5		5					
ISP	FMS	cv_route	50%	0.1	5	twice per vehicle	1/2	10	3154	0	397	0	13	0	1	13	0		0	0	0	0		0	0	0	0
													<24422>						6		8						
LocData	VS	From_Location_Data_Source	7%	0.007	10	1 in 10 vehicles 1	10	1	146	0	21	0	2	0	0.007	0.014	0		0.014	0	0	0		0	0	0	0
PayInstr	FMS	fpi_commercial_manager_input_credit_identity	50%	0.05	10	1 per enrollment = 1 per cv	1	10	114	0	17	0	2	0	0.5	1	0		1	0	0	0		0	0	0	0
VS	EM	emergency_request_driver_details	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	0	282	0	38	0	3	0.0001	0	0.0003		0	0	0	0		0	0.0003	0	0
VS	EM	emergency_request_vehicle_details	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	0	3354	0	422	0	14	0.0001	0	0.0014		0	0	0	0		0	0	0	0
														<333222>										0.0006	0.0009		
VS	ISP	advisory_data_request	10%	0.2	1/2	2 requests per vehicle	1/2	1	0	290	0	39	0	3	0.2	0	0.6		0	0	0	0		0	0.6	0	0
VS	ISP	vehicle_guidance_route_accepted	7%	0.14	1/2	2 acceptances	1/2	1	0	34	0	7	0	2	0.14	0	0.28		0	0	0	0		0.28	0	0	0
																	Total # blocks/User	4	15.5146	12.21	16.402	20	6.5	9.4106	9.6468	23.0408	5.0005
																	*Population	53698.98	208279.6	163916.1	220192.7	268494.9	87260.84	126334.9	129505.8	309316.9	67130.44
																	/peak period duration	1.243032	4.821286	3.794355	5.097053	6.21516	2.019927	2.924419	2.99782	7.160113	1.553945
																	/per sector	0.003733	0.014478	0.011394	0.015306	0.018664	0.006066	0.008782	0.009002	0.021502	0.004667

Table 8.1-26 Local Freight and Fleet Vehicles CDPD Traffic for the Year 2002

Table 8.1-26 Local Freight and Fleet Vehicles CDPD Traffic for the Year 2002

CVO Local

Number of users: 346,039

Peak Period: 6am-6pm

43200 s

			Penetration																								
			7%																								
			50%	(DL Freq) *				W.C.	Forward	Reverse	Forward	Reverse	Forward	Reverse	Frequency	Forward	Reverse	Forward Link					Reverse Link				
PA Source	PA Sink	Physical Data Flow	Penetration	Penetration	1/(DL Freq)	Explanation	Number	Factor	bits	bits	bytes	bytes	# blocks	# blocks	Penetration	blocks	blocks	1	2	3	4	5	1	2	3	4	5
CVS	FMS	cf_driver_route_instructions_request	50%	1	1/2	average fleet vehicle requests 2 routes	1/2	1	0	154	0	22	0	2	1	0	2		0	0	0	0		2	0	0	0
CVS	FMS	cv_driver_route_request	50%	2	1/4	average vehicle requests 4 routes	1/4	1	0	1234	0	157	0	6	2	0	12		0	0	0	0		0	0	0	0
														<22111>									6	8			
CVS	FMS	cv_driver_storage_request	50%	0.05	10	1 in 10 vehicles	10	1	0	26	0	6	0	2	0.05	0	0.1		0	0	0	0		0.1	0	0	0
CVS	FMS	cv_static_route_data	50%	2	1/4	4 routes per vehicle	1/4	1	0	2066	0	261	0	9	2	0	18		0	0	0	0		0	0	0	0
														<5221>									2	8			10
EM	FMS	cf_hazmat_request	10%	0.00001	10000	1 per 1000 vehicles	1000	10	146	0	21	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
EM	VS	emergency_request_driver_acknowledge	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
EM	VS	emergency_request_vehicle_acknowledge	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	26	0	6	0	2	0	0.0001	0.0002	0		0.0002	0	0	0		0	0	0	0
FMS	CVS	cf_driver_route_instructions	50%	1	1/2	twice per vehicle	1/2	1	5082	0	638	0	20	0	1	20	0		0	0	0	0		0	0	0	0
													<2211+5443>					2	4	3	8	5					
FMS	CVS	cv_driver_route_data	50%	2	1/4	average vehicle requests 4 routes	1/4	1	3042	0	383	0	13	0	2	26	0		0	0	0	0		0	0	0	0
													<355>							6		20					
FMS	CVS	cv_static_route_request	50%	2	1/4	average vehicle requests 4 routes	1/4	1	1226	0	156	0	6	0	2	12	0		0	0	0	0		0	0	0	0
													<22111>					6	8								
FMS	EM	cf_hazmat_route_information	10%	0.00001	10000	1 per 1000 vehicles	1000	10	0	3754	0	472	0	16	0.0001	0	0.0016		0	0	0	0		0	0	0	0
														<5443>											0.0003	0.0008	0.0005
FMS	EM	cf_hazmat_vehicle_information	10%	0.00001	10000	1 per 1000 vehicles	1000	10	0	242	0	33	0	3	0.0001	0	0.0003		0	0	0	0		0	0.0003	0	0
FMS	ImFrghtD	To_Intermodal_Freight_Depot	50%	0.005	100	1 in 10 of vehicles interact 1 with an intermodal carrier	10	10	0	530	0	69	0	4	0.05	0	0.2		0	0	0	0		0	0	0.2	0
FMS	ImFrghtS	To_Intermodal_Freight_Shipper	50%	0.005	100	1 in 10 of vehicles interact 1 with an intermodal carrier	10	10	0	530	0	69	0	4	0.05	0	0.2		0	0	0	0		0	0	0.2	0
FMS	ISP	cf_route_request	50%	0.1	5	twice per vehicle	1/2	10	0	1234	0	157	0	6	1	0	6		0	0	0	0		0	0	0	0
														<22111>									3	4			
FMS	ISP	cv_route_request	50%	0.2	2 1/2	4 times per vehicle	1/4	10	0	1354	0	172	0	7	2	0	14		0	0	0	0		0	0	0	0
														<421>									2	4		8	
ImFrghtD	FMS	From_Intermodal_Freight_Depot	50%	0.005	100	1 in 10 of vehicles interact 1 with an intermodal carrier	10	10	530	0	69	0	4	0	0.05	0.2	0		0	0	0.2	0		0	0	0	0
ImFrghtS	FMS	From_Intermodal_Freight_Shipper	50%	0.005	100	1 in 10 of vehicles interact 1 with an intermodal carrier	10	10	530	0	69	0	4	0	0.05	0.2	0		0	0	0.2	0		0	0	0	0
ISP	FMS	cf_route	50%	0.1	5	twice per vehicle	1/2	10	3034	0	382	0	13	0	1	13	0		0	0	0	0		0	0	0	0
													<355>							3		10					
ISP	FMS	cv_route	50%	0.2	2 1/2	4 times per vehicle	1/4	10	3154	0	397	0	13	0	2	26	0		0	0	0	0		0	0	0	0
													<33332>						4	24							
LocData	VS	From_Location_Data_Source	7%	0.007	10	1 in 10 vehicles 1	10	1	146	0	21	0	2	0	0.007	0.014	0		0.014	0	0	0		0	0	0	0
VS	EM	emergency_request_driver_details	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	0	282	0	38	0	3	0.0001	0	0.0003		0	0	0	0		0	0.0003	0	0
VS	EM	emergency_request_vehicle_details	10%	0.0001	1000	1 emergency per 1000 vehicles	1000	1	0	3354	0	422	0	14	0.0001	0	0.0014		0	0	0	0		0	0	0	0
														<333222>										0.0006	0.0009		
VS	ISP	advisory_data_request	10%	0.2	1/2	2 requests per vehicle	1/2	1	0	290	0	39	0	3	0.2	0	0.6		0	0	0	0		0	0.6	0	0
																	Total # blocks/User	8	16.0146	36	8.4	35	13	26.1006	0.6018	8.4008	10.0005
																	*Population	2768312	5541676	12457404	2906728	12111365	4498507	9031826	208246.3	2907004	3460563
																	/peak period duration	64.0813	128.2795	288.3658	67.28536	280.3557	104.1321	209.07	4.820516	67.29177	80.10563
																	/per sector	0.192436	0.385224	0.865963	0.202058	0.841909	0.312709	0.627838	0.014476	0.202077	0.240557

Table 8.1-27 Emergency Vehicles CDPD Traffic for the Year 2002

Emergency Vehicle

Number of users: 18,737

Peak Period 6am-7pm (13 hours)

46800 s

Penetration 100%

PA Source	PA Sink	Physical Data Flow	Penetration	(DL Freq) * Penetration	1/(DL Freq)	Explanation	Number	W.C. Factor	Forward bits	Reverse bits	Forward bytes	Reverse bytes	Forward # blocks	Reverse # blocks	Frequency* Penetration	Forward blocks	Reverse blocks	Forward Link 1	2	3	4	5	Reverse Link 1	2	3	4	5
EM	EVS	emergency_vehicle_driver_outputs	100%	13	1/13	average one driver output per vehicle per hour	1/13	1	1042	0	133	0	6	0	13	78	0		0	0	0	0		0	0	0	0
													<51>					13				65					
EVS	EM	emergency_driver_dispatch_acknowledge	100%	26	1/26	average one dispatch acknowledge per vehicle per 1/2 hour	1/26	1	0	26	0	6	0	2	26	0	52		0	0	0	0		52	0	0	0
EVS	EM	emergency_driver_status_update	100%	26	1/26	average one status update per vehicle per 1/2 hour	1/26	1	0	146	0	21	0	2	26	0	52		0	0	0	0		52	0	0	0
EVS	EM	emergency_vehicle_driver_inputs	100%	13	1/13	average one driver input per vehicle per hour	1/13	1	0	530	0	69	0	4	13	0	52		0	0	0	0		0	0	52	0
																	Total # blocks/User	13	0	0	0	65	0	104	0	52	0
																	*Population	243581	0	0	0	1217905	0	1948648	0	974324	0
																	/peak period duration	5.204722	0	0	0	26.02361	0	41.63778	0	20.81889	0
																	/per sector	0.01563	0	0	0	0.078149	0	0.125038	0	0.062519	0

Table 8.1-27 Emergency Vehicles CDPD Traffic for the Year 2002

Table 8.1-28 Transit Vehicles CDPD Traffic for the Year 2002

Transit Management

Public_Transit_Vehicles	1,925	Penetration	Peak Period	6am-7pm
ParaTransit_Vehicles	481	10%	46800	s
Transit Customers	62,281	100%		

PA Source	PA Sink	Physical Data Flow	Penetration	(DL Freq) * Penetration	1/(DL Freq)	Explanation	Frequency	W.C. Factor
PayInstr	TRVS	fpi_confirm_fare_payment_on_transit_vehicle	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
PayInstr	TRVS	fpi_transit_vehicle_tag_data	100%	0.032	1/31	one data set for 1000 users = 0.032 per transit vehicle	1/31	1.011
RTS	ISP	traffic_data_kiosk_request	10%	0.32	3 1/5	1 per transit user = 32 per transit vehicle	32 23/65	10.111
RTS	ISP	transit_deviation_kiosk_request	10%	0.064	16/25	one in five transit users = 6.4 per transit vehicle	6 8/17	10.111
RTS	ISP	traveler_current_condition_request	10%	0.32	3 1/5	1 per transit user = 32 per transit vehicle	32 23/65	10.111
TRMS	TRVS	approved_corrective_plan	100%	0.1	1/10	one corrective message per ten vehicles	1/10	1
TRMS	TRVS	confirm_vehicle_fare_payment	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRMS	TRVS	paratransit_transit_driver_instructions	100%	13	13	dispatch message every 15 min. /4 (ratio of paratr/tr veh)	13	1
TRMS	TRVS	request_transit_user_image	100%	0.032	1/31	one image for 1000 users = 0.032 per transit vehicle	1/31	1.011
TRMS	TRVS	transit_services_for_corrections	100%	13	13	one correction per hour	13	1
TRMS	TRVS	transit_services_for_eta	100%	52	52	update every 15 minutes	52	1
TRMS	TRVS	transit_services_for_vehicle_fares	100%	1	1	update daily	1	1
TRMS	TRVS	transit_vehicle_advanced_payment_response	100%	0.032	1/31	one data set for 1000 users = 0.032 per transit vehicle	1/31	1.011
TRMS	TRVS	transit_vehicle_fare_data	100%	1	1	updated once per transit vehicle	1	1
TRMS	TRVS	transit_vehicle_fare_payment_debited	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRMS	TRVS	transit_vehicle_fare_payment_request	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRVS	PayInstr	tpi_debited_payment_on_transit_vehicle	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRVS	PayInstr	tpi_request_fare_payment_on_transit_vehicle	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRVS	TRMS	paratransit_transit_vehicle_availability	100%	13	13	avail. message every 15 min./4 (ratio of paratr/tr veh)	13	1
TRVS	TRMS	request_vehicle_fare_payment	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRVS	TRMS	transit_conditions_request	100%	0.1	1/10	one corrective message per ten vehicles	1/10	1
TRVS	TRMS	transit_services_for_eta_request	100%	3.2	3 1/5	1 per 10 transit users = 3.2 per transit vehicle	3 4/17	1.011
TRVS	TRMS	transit_user_vehicle_image	100%	0.0104	1/96	20 images per metro area	1/96	1
TRVS	TRMS	transit_vehicle_arrival_conditions	100%	13	13	updated every 60 minutes	13	1
TRVS	TRMS	transit_vehicle_collected_trip_data	100%	13	13	every hour for each transit vehicle	13	1
TRVS	TRMS	transit_vehicle_deviations_from_schedule	100%	52	52	update every 15 minutes	52	1
TRVS	TRMS	transit_vehicle_eta	100%	156	156	updated every 5 minutes	156	1
TRVS	TRMS	transit_vehicle_fare_payment_confirmation	100%	32	32	1 per transit user = 32 per transit vehicle	32 23/65	1.011
TRVS	TRMS	transit_vehicle_location	100%	52	52	updated every 15 minutes	52	1
TRVS	TRMS	transit_vehicle_location_for_deviation	100%	52	52	updated every 15 minutes	52	1
TRVS	TRMS	transit_vehicle_location_for_store	100%	13	13	updated every 60 minutes	13	1
TRVS	TRMS	transit_vehicle_passenger_data	100%	52	52	update every 15 minutes	52	1
TRVS	TRMS	transit_vehicle_schedule_deviation	100%	52	52	updated every 15 minutes	52	1

Table 8.1-28 Transit Vehicles CDPD Traffic for the Year 2002

Physical Data Flow	Forward bits	Reverse bits	Forward bytes	Reverse bytes	Forward # blocks	Reverse # blocks	Frequency* Penetration	Forward blocks	Reverse blocks	Forward Link 1	2	3	4	5	Reverse Link 1	2	3	4	5
fpi_confirm_fare_payment_on_transit_vehicle	26	0	6	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
fpi_transit_vehicle_tag_data	178	0	25	0	3		0.032	0.097061	0		0	0.097061	0	0		0	0	0	0
traffic_data_kiosk_request	0	98	0	15		2	3.235	0	6.470753		0	0	0	0		6.470753	0	0	0
transit_deviation_kiosk_request	0	66	0	11		2	0.647	0	1.294151		0	0	0	0		1.294151	0	0	0
traveler_current_condition_request	0	58	0	10		2	3.235	0	6.470753		0	0	0	0		6.470753	0	0	0
approved_corrective_plan	8210	0	1029	0	32		0.1	3.2	0		0	0	0	0		0	0	0	0
					<2+2x5443>						0.2	0.6	1.6	1					
confirm_vehicle_fare_payment	26	0	6	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
paratransit_transit_driver_instructions	1042	0	133	0	6		13	78	0		0	0	0	0		0	0	0	0
request_transit_user_image	82	0	13	0	2		0.032	0.064708	0		0.064708	0	0	0		0	0	0	0
transit_services_for_corrections	17260	0	2160	0	65		13	845	0		0	0	0	0		0	0	0	0
					<2211+4x5443>					26	52	156	416	260					
transit_services_for_eta	7786	0	976	0	30		52	1560	0		0	0	0	0		0	0	0	0
					<34333+5443>							780	624	260					
transit_services_for_vehicle_fares	16826	0	2106	0	63		1	63	0		0	0	0	0		0	0	0	0
					<22+4x5443>						4	12	32	20					
transit_vehicle_advanced_payment_response	554	0	72	0	4		0.032	0.129415	0		0	0	0.129415	0		0	0	0	0
transit_vehicle_fare_data	922	0	118	0	5		1	5	0		0	0	0	5		0	0	0	0
transit_vehicle_fare_payment_debited	26	0	6	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
transit_vehicle_fare_payment_request	34	0	7	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
tpi_debited_payment_on_transit_vehicle	50	0	9	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
tpi_request_fare_payment_on_transit_vehicle	34	0	7	0	2		32.354	64.70753	0		64.70753	0	0	0		0	0	0	0
paratransit_transit_vehicle_availability	0	26	0	6		2	12.993	0	25.98649		0	0	0	0		25.98649	0	0	0
request_vehicle_fare_payment	0	466	0	61		4	32.354	0	129.4151		0	0	0	0		0	0	129.4151	0
transit_conditions_request	0	34	0	7		2	0.1	0	0.2		0	0	0	0		0.2	0	0	0
transit_services_for_eta_request	0	186	0	26		3	3.235	0	9.70613		0	0	0	0		0	9.70613	0	0
transit_user_vehicle_image	0	73746	0	9221		271	0.010	0	2.815584		0	0	0	0		0	0	0	0
						<22+18x5443>										0.041558	0.561039	1.496104	0.935065
transit_vehicle_arrival_conditions	0	1042	0	133		6	13	0	78		0	0	0	0		0	0	0	0
						<411>									26			52	
transit_vehicle_collected_trip_data	0	1826	0	231		9	13	0	117		0	0	0	0		0	0	0	0
						<4221>									13	52		52	
transit_vehicle_deviations_from_schedule	0	274	0	37		3	52	0	156		0	0	0	0		0	156	0	0
transit_vehicle_eta	0	234	0	32		3	156	0	468		0	0	0	0		0	468	0	0
transit_vehicle_fare_payment_confirmation	0	26	0	6		2	32.354	0	64.70753		0	0	0	0		64.70753	0	0	0
transit_vehicle_location	0	250	0	34		3	52	0	156		0	0	0	0		0	156	0	0
transit_vehicle_location_for_deviation	0	250	0	34		3	52	0	156		0	0	0	0		0	156	0	0
transit_vehicle_location_for_store	0	250	0	34		3	13	0	39		0	0	0	0		0	39	0	0
transit_vehicle_passenger_data	0	242	0	33		3	52	0	156		0	0	0	0		0	156	0	0
transit_vehicle_schedule_deviation	0	274	0	37		3	52	0	156		0	0	0	0		0	156	0	0
									Total # blocks/User	26	444.5099	948.6971	1073.729	546	39	157.1712	1297.267	234.9112	0.935065
									*Population	50050	855681.6	1826242	2066929	1051050	75075	302554.6	2497239	452204	1800
									/peak period duration	1.069444	18.28379	39.02226	44.16515	22.45833	1.604167	6.464843	53.35981	9.662479	0.038462
									/per sector	0.003212	0.054906	0.117184	0.132628	0.067442	0.004817	0.019414	0.16024	0.029016	0.000116

Table 8.1-29 Personal Information Access CDPD Traffic for the Year 2002

Table 8.1-29 Personal Information Access CDPD Traffic for the Year 2002

Personal Information Access

Peak Period: 6-9am &4-7pm

Travel Information Users 3,385,984 | Penetration | 21600 s

Number of users: 87,639 | 7%

rofessional) Penetration 10% | 10%

PA Source	PA Sink	Physical Data Flow	Penetration	(DL Freq) * Penetration	1/(DL Freq)	Explanation	Number	W.C. Factor	Forward bits	Reverse bits	Forward bytes	Reverse bytes	Forward # blocks	Reverse # blocks	Frequency* Penetration	Forward blocks	Reverse blocks	Forward Link 1	2	3	4	5	Reverse Link 1	2	3	4	5
EM	PIAS	emergency_request_personal_traveler_acknowledg	10%	0.000025	4000	one emergency per 2000 users in peak period	2000	2	26	0	6	0	2	0	0.00005	0.0001	0		0.0001	0	0	0		0	0	0	0
ISP	PIAS	transit_deviations_for_portables	10%	0.00025	400	one request per 20 pias	20	20	3578	0	450	0	15	0	0.005	0.075	0		0	0	0	0		0	0	0	0
													<532222>						0.04	0.015		0.025					
ISP	PIAS	traveler_guidance_route	7%	0.0035	20	one route per day per pias	1	20	18306	0	2291	0	69	0	0.07	4.83	0		0	0	0	0		0	0	0	0
													<42211+4x5443>					0.14	0.28	0.84	2.52	1.4					
LocData	PIAS	From_Location_Data_Source	7%	0.007	10	one in 10 pias	10	1	146	0	21	0	2	0	0.007	0.014	0		0.014	0	0	0		0	0	0	0
PIAS	EM	emergency_request_personal_traveler_details	10%	0.000025	4000	one emergency per 2000 users in peak period	2000	2	0	370	0	49	0	3	0.00005	0	0.00015		0	0	0	0		0	0.00015	0	0
PIAS	ISP	traffic_data_portables_request	10%	0.05	2	one request per pias	1	2	0	250	0	34	0	3	0.1	0	0.3		0	0	0	0		0	0.3	0	0
PIAS	ISP	transit_deviations_portables_request	10%	0.0025	40	one request per 20 pias	20	2	0	250	21	0	2	0	0.005	0.028	0		0.028	0	0	0		0	0	0	0
																	Total # blocks/User	0.14	0.3621	0.855	2.52	1.425	0	0	0.30015	0	0
																	*Population	12269.46	31734.08	74931.35	220850.3	124885.6	0	0	26304.85	0	0
																	/peak period duration	0.568031	1.46917	3.469044	10.22455	5.78174	0	0	1.217817	0	0
																	/per sector	0.001706	0.004412	0.010418	0.030704	0.017363	0	0	0.003657	0	0

Table 8.1-30 Probe Vehicles CDPD Traffic for the Year 2002

Table 8.1-30 Probe Vehicles CDPD Traffic for the Year 2002

Traffic Management = Probes 1.086276 Factor due to through traffic

Number of users: 29,765

Peak Period: 6-9am/4-7pm

21600 s

PA Source	PA Sink	Physical Data Flow	Penetration	(DL Freq) * Penetration	1/(DL Freq)	Explanation	Number	W.C. Factor	Forward bits	Reverse bits	Forward bytes	Reverse bytes	Forward # blocks	Reverse # blocks	Frequency* Penetration	Forward blocks	Reverse blocks	Forward Link 1	2	3	4	5	Reverse Link 1	2	3	4	5
VS	ISP	vehicle_guidance_probe_data	100%	0.24	6/25	average of 12 probe reports per vehicle	1/12	2.88	0	314	0	42	0	3	12	0	36		0	0	0	0		0	36	0	0
																	Total # blocks/User	0	0	0	0	0	0	0	36	0	0
																	*Population	0	0	0	0	0	0	0	1163988	0	0
																	/peak period duration	0	0	0	0	0	0	0	53.88835	0	0
																	/per sector	0	0	0	0	0	0	0	0.161827	0	0

Table 8.1-31 ITS CDPD Traffic Summary for Thruville 2002

(a) ITS CDPD Traffic

	Forward	1	2	3	4	5
Traveller Information	21.5125	0.5680	1.4692	3.4690	10.2246	5.7817
Transit Vehicles	124.9990	1.0694	18.2838	39.0223	44.1652	22.4583
Probe Vehicles	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Private Vehicles	2.3677	0.0000	2.3193	0.0483	0.0000	0.0000
Emergency Vehicles	31.2283	5.2047	0.0000	0.0000	0.0000	26.0236
CVO Local	828.3677	64.0813	128.2795	288.3658	67.2854	280.3557
CVO Long	21.1709	1.2430	4.8213	3.7944	5.0971	6.2152
	RS-Blocks/s	72.1665	155.1731	334.6998	126.7721	340.8345
	Packets/s	72.1665	77.5866	111.5666	31.6930	68.1669
	Packets/s per Sector	0.2167	0.2330	0.3350	0.0952	0.2047

Total Forward Link CDPD Traffic: 0.0744 Erlang

	Reverse	1	2	3	4	5
Traveller Information	1.2178	0.0000	0.0000	1.2178	0.0000	0.0000
Transit Vehicles	71.1298	1.6042	6.4648	53.3598	9.6625	0.0385
Probe Vehicles	53.8884	0.0000	0.0000	53.8884	0.0000	0.0000
Private Vehicles	93.7076	0.0000	45.1626	48.4644	0.0000	0.0805
Emergency Vehicles	62.4567	0.0000	41.6378	0.0000	20.8189	0.0000
CVO Local	465.4201	104.1321	209.0700	4.8205	67.2918	80.1056
CVO Long	16.6562	2.0199	2.9244	2.9978	7.1601	1.5539
	RS-Blocks/s	107.7562	305.2597	164.7487	104.9332	81.7786
	Packets/s	107.7562	152.6298	54.9162	26.2333	16.3557
	Packets/s per Sector	0.3236	0.4583	0.1649	0.0788	0.0491

Total Reverse Link CDPD Traffic: 0.0569 Erlang

(b) CDPD Traffic Packet Distribution

Distribution	1	2	3	4	5
Forward	19.981%	21.481%	30.890%	8.775%	18.873%
Reverse	30.109%	42.647%	15.344%	7.330%	4.570%

8.1.5.2.2 Non-ITS Data Load

The non-ITS data load requires in this scenario a more detailed analysis. The Thruville scenario emcompasses, as the Government has repeated stressed, an urban scenario including the city of Philadelphia, PA, and an inter-urban corridor in the New Jersey side.

The approach addopted here was to maintain the same assumptions as for Urbansville for the urban portion of the scenario, corresponding to Pensilvania, but to take a more conservative approach for the New Jersey portion. So, the factors 2.5 times and 10 times reverse link ITS loads were used for the urban (PA) portion for the reverse link and forward link non-ITS loads, repectively. Those factors were reduced to 2.5 times and 5 times reverse link ITS loads for the interurban (NJ) portion. We decided to keep the same factor for the reverse link as a worst case situation, although we think it should be smaller in the NJ side.

The resulting trafic for Thruville 2002 is, therefore, as shown in Table 8.1-32.

Table 8.1-32 Non-ITS CDPD Traffic for Thruville 2002

Forward	1	2	3	4	5
RS-Blocks/s	2318.482	1545.654	1545.654	869.431	579.620
Packets/s	2318.482	772.827	515.218	217.358	115.924
Packets/s per Sector	6.962407	2.320802	1.547202	0.652726	0.34812
Reverse	1	2	3	4	5
RS-Blocks/s	646.036	430.691	430.691	242.264	161.509
Packets/s	646.036	215.345	143.564	60.566	32.302
Packets/s per Sector	1.940049	0.646683	0.431122	0.18188	0.097002

The distribution, as it was discussed before, is taken to be the same in both directions. The resulting overall traffic follows in Table 8.1-33.

Table 8.1-33 Overall ITS plus Non-ITS CDPD Traffic for Thruville 2002

Forward	1	2	3	4	5
RS-Blocks/s	2390.648	1700.828	1880.354	996.203	920.455
Packets/s	2390.648	850.414	626.785	249.051	184.091
Packets/s per Sector	7.179123	2.553795	1.882236	0.7479	0.552826
Distribution	55.584%	19.773%	14.573%	5.791%	4.280%
Reverse	1	2	3	4	5
RS-Blocks/s	753.793	735.951	595.440	347.197	243.288
Packets/s	753.793	367.975	198.480	86.799	48.658
Packets/s per Sector	2.263642	1.105031	0.596036	0.260658	0.146119
Distribution	51.782%	25.278%	13.635%	5.963%	3.343%

8.1.5.2.3 Incident Case

MITRE provided extensive information on an incident occurring at the intersection of an interstate highway and a state highway. All the sectors affected by the resulting increase in traffic were identified (see Figure 8.1-10).

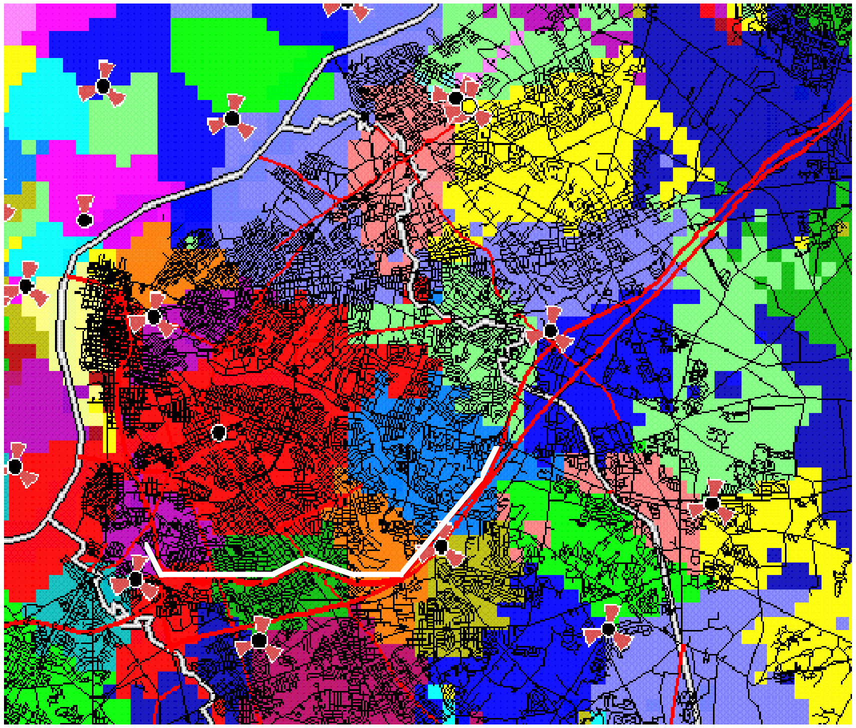


Figure 8.1-10 Extension of the Queues induced by the Incident immediately before its Dissipation, showing the Affected Sectors

It must be understood that the above queues built up during a long interval. As a result, when the last vehicles were added to the queue, 20 minutes had already passed. The implication is that all the vehicles stuck had all that time to try to arrange for a solution (although, obviously, none was available).

8.2 CDPD Simulation Results

8.2.1 Urbansville 2002 and 2012

The actual cellular deployment in Detroit (as of November 1993) used in Phase I, was used again in Phase II to analyze the three time frames (and their loads). We begin by showing in Figure 8.2-1 the coverage for Detroit as provided by GRANET.

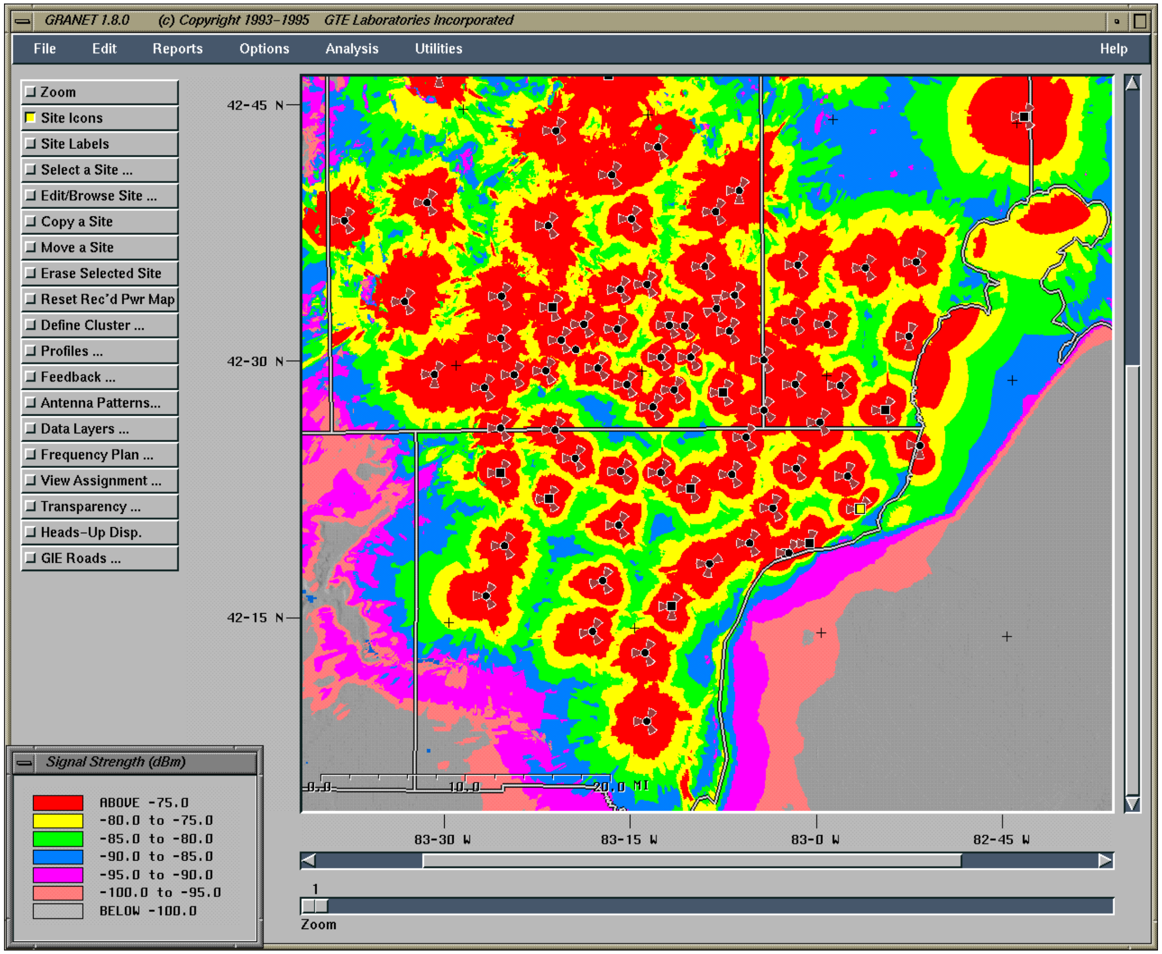


Figure 8.2-1 Detroit (Urbansville) Coverage

8.2.1.1 Capacity Comparison of One Reserved CDPD Channel versus One Reserved Plus One Dynamically Assigned CDPD Channels

We see in Figure 8.2-2 that the CDPD channel capacity, assuming the channel is reserved, is slightly higher than 0.7 Erlang for an idealized deployment with 11.5 Erlang voice activity and 19 voice channels per sector (see Phase I Document). That capacity corresponds to an effective throughput higher than 0.7 x 19.2 x 47/63 kbps ≅ 10 kbps including the TCP/IP overhead (i.e., the net effective throughput is smaller).

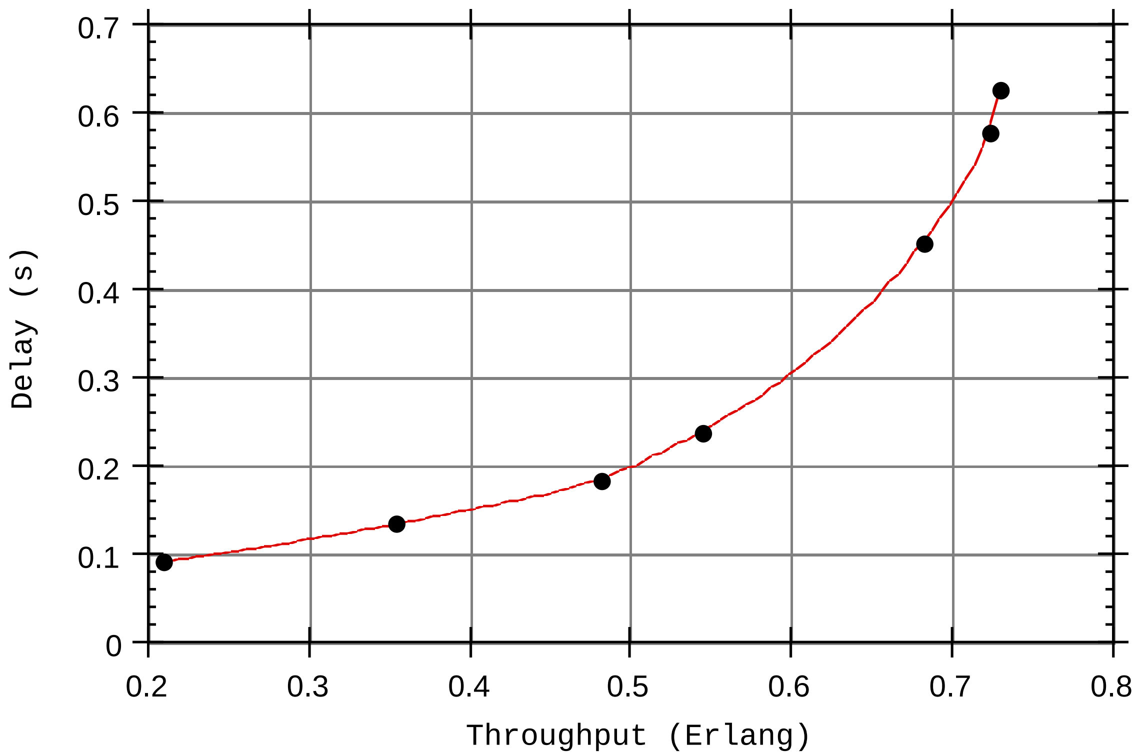


Figure 8.2-2 Capacity of a Reserved CDPD Channel

It is now interesting to compute the capacity for the case where a second CDPD channel is dynamically assigned when voice does not require all voice channels.

The following assumptions were made for the use of a dynamically assigned channel:

1. If a second channel is available and assigned to CDPD, the traffic is evenly split between the two channels.
2. When the dynamically assigned channel is called away for voice usage, all users on that channel will crowd onto the fixed CDPD channel:
   a. Any swapped “call” in transmission (TX) mode will enter the BACK-OFF state;
   b. All swapped “calls” waiting for a TRANSMIT-DONE flag stop waiting and enter the BACK-OFF state;
   c. All swapped “calls” in BACK-OFF remain in BACK-OFF.

3. Once a voice channel frees up again and is assigned to CDPD:
   a. The "calls" in IDLE mode, as well as those in WAITING-TO-TX mode, will be evenly split between the two channels;
   b. All "calls" already in TX or waiting for a TRANSMIT-DONE flag will remain on the fixed channel;
   c. All "calls" in BACK-OFF remain on the fixed channel.

Figure 8.2-3 shows that the capacity of the new "channel" is higher than 1.3 Erlang, not much less than twice that of the single, reserved CDPD channel.The dynamic use of only one additional channel is responsible for the small difference referring to twice the capacity of one reserved CDPD channel.

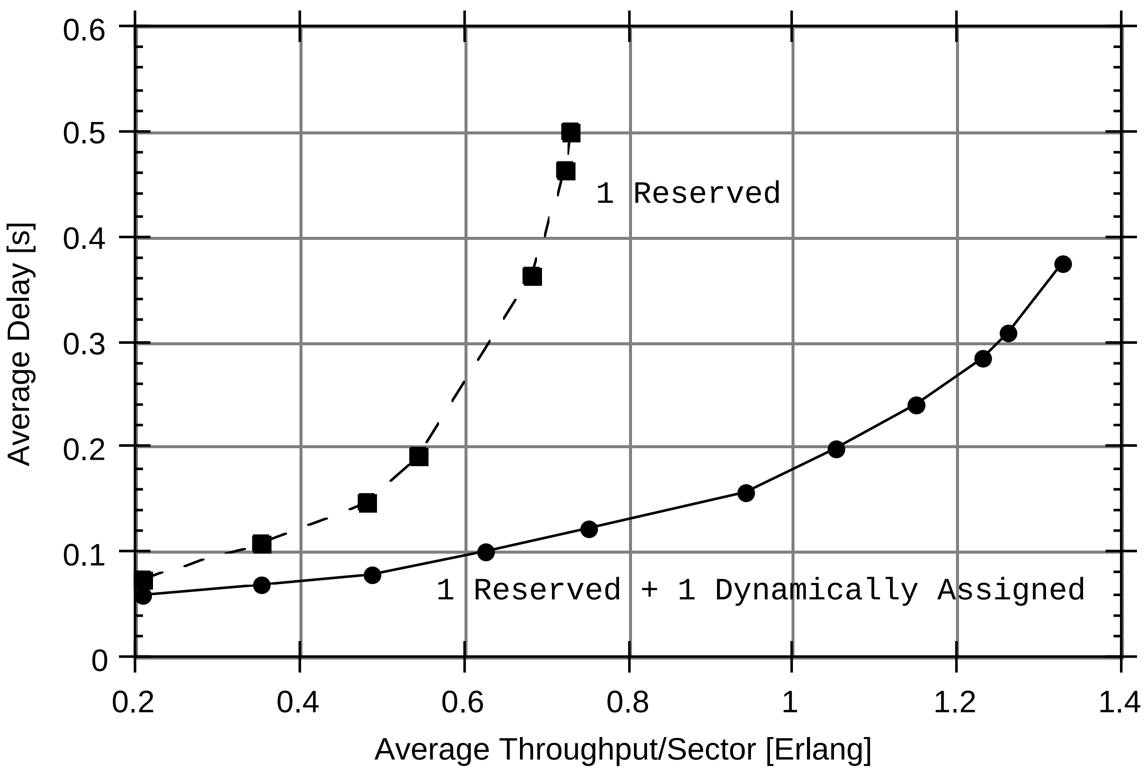


Figure 8.2-3 Capacity of One Reserved plus One Dynamically Assigned CDPD Channels

8.2.1.2 Urbansville 2012 -- One Reserved CDPD Channel

Figure 8.2-4 shows the delay/throughput pairs corresponding to all sectors in the Detroit MSA. Although the general behavior closely matches the delay/throughput curves obtained in the previous section, we observe quite a few sectors with inferior performance. The reason for this phenomenon is the fact that the present day cellular infrastructure has been designed for voice, which is more tolerant of noise and interference than data. Consequently, for a few sectors the available C/I, although appropriate for voice, was low for data.

Figure 8.2-5 is a color-coded map of the Detroit area showing the average delay in each sector. We easily identify in this map the sectors which would require some sort of re-engineering in order to improve CDPD performance. Note, however, that the average delay, for the worst sectors, does not exceed 0.5 s.

Although network re-engineering will happen quite frequently over a ten or twenty year period to accommodate network usage and other changes (in practice this is done every few weeks), we will not try to re-engineer any sector to make it perform better.

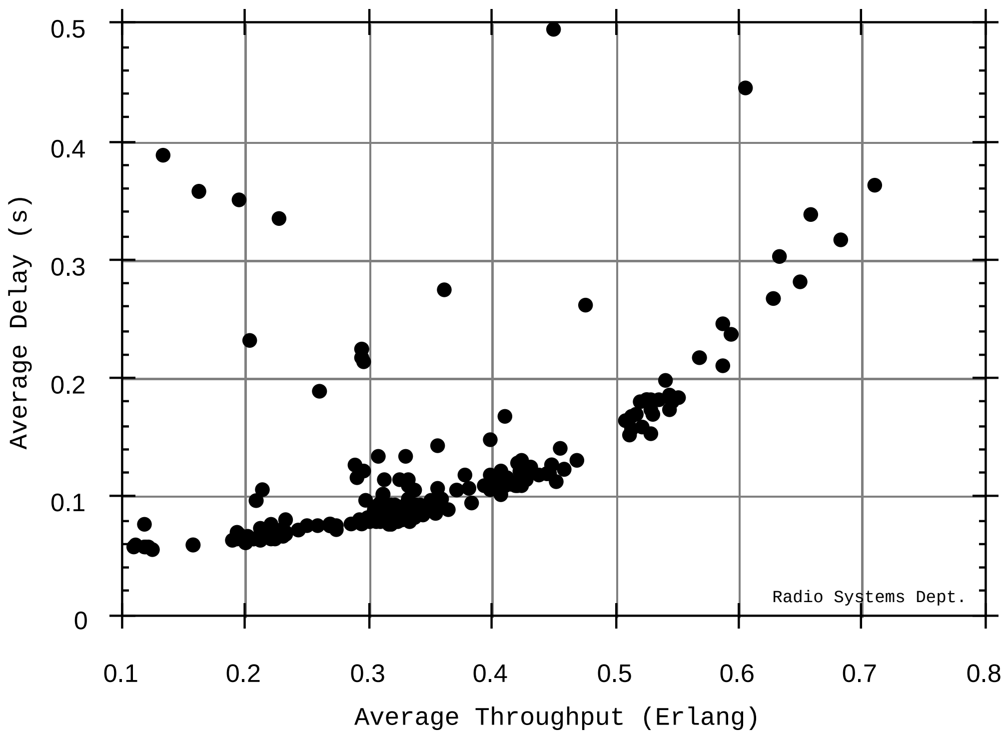


Figure 8.2-4 Delay/Throughput Pairs for the Actual Cellular Deployment in Detroit

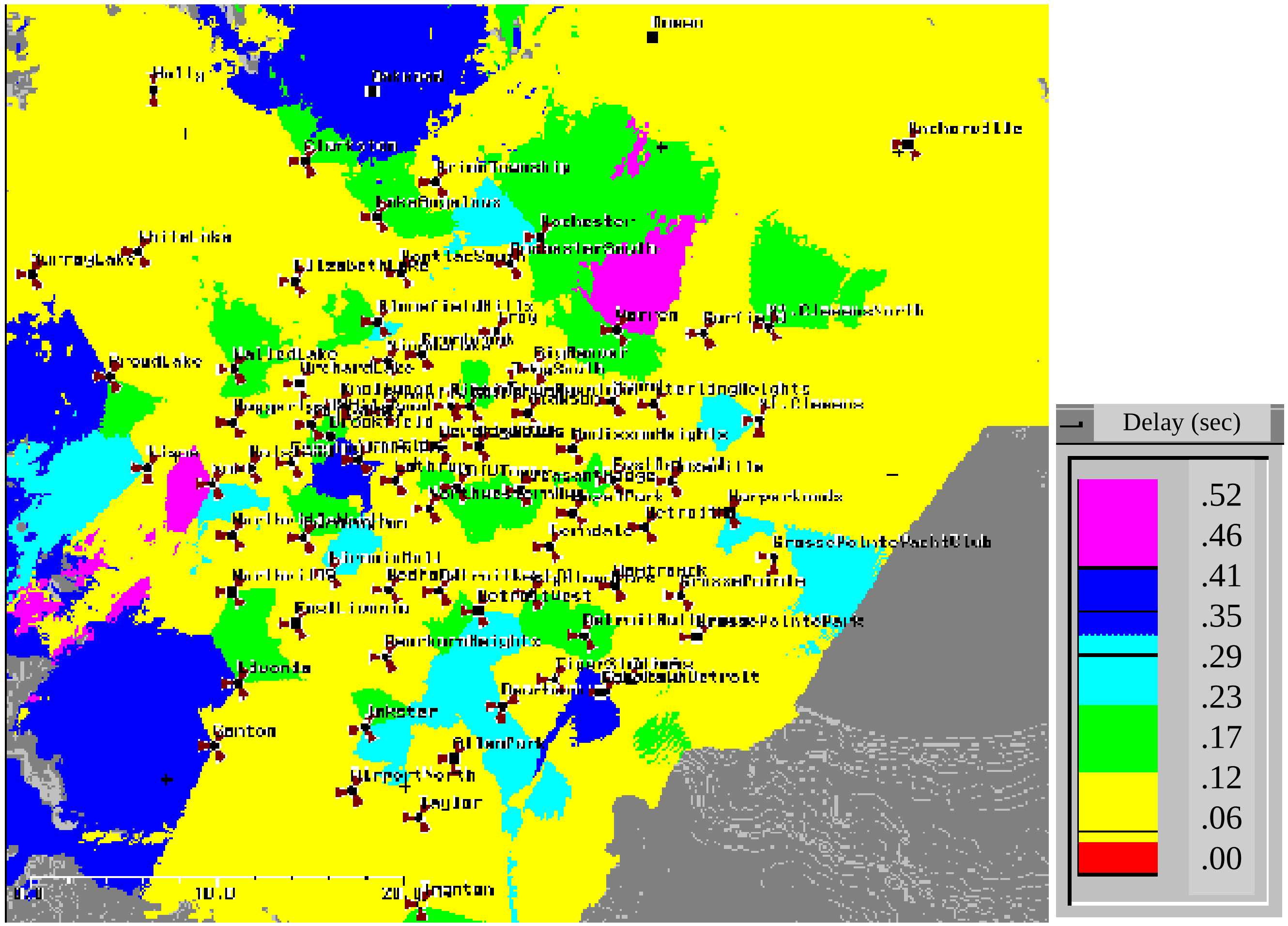


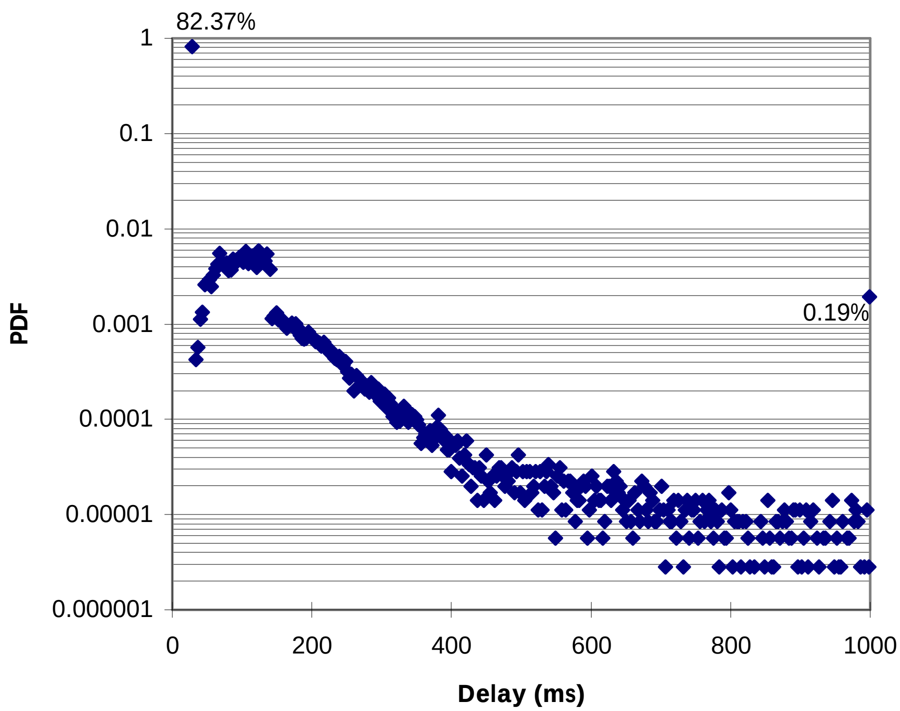
Figure 8.2-5: Delay Map for Urbansville 2012 (Phase 1 Data Loads) for an Actual Cellular Deployment in Detroit

8.2.1.3 Urbansville 2002 -- One Reserved CDPD Channel

8.2.1.3.1 Peak-Period ITS only

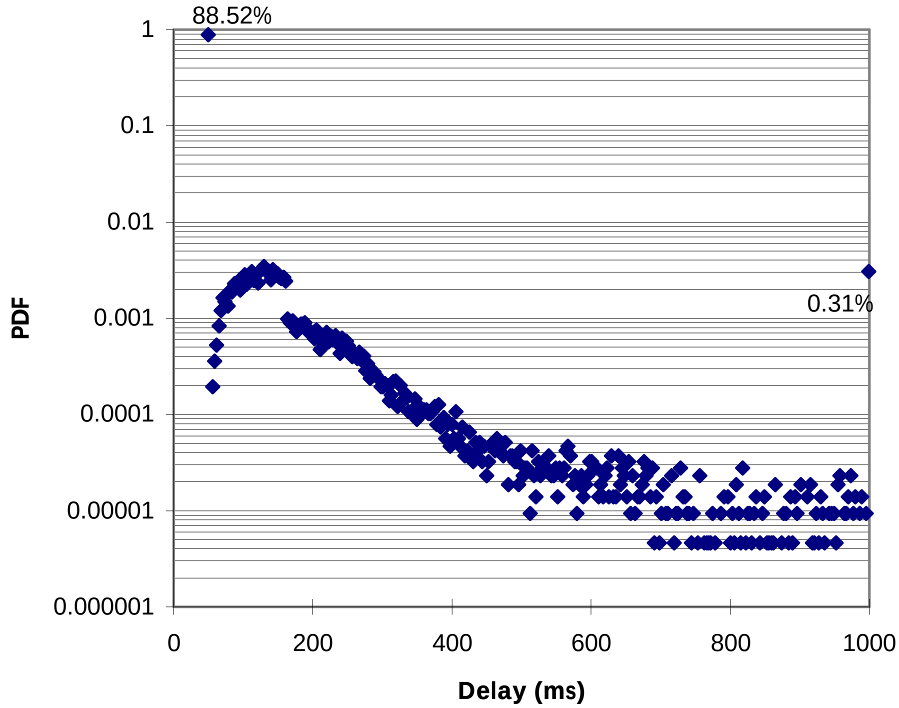
A new, detailed characterization of the CDPD Reverse Link delay is shown in Figure 8.2-6. The delay histograms are presented in logarithmic form to emphasize the all important tail. A few observations can be made. First, one concludes that there is an underlying continuous probability density function for the delay accompanied with discrete peaks at 29, 50, 71, 93, 124 ms, for 1, 2, 3, 4, and 5 RS-blocks long packets, respectively. Those specific delays correspond to the unimpeded transmission of 1, 2, 3, 4, and 5 RS-blocks long packets, respectively, which happens quite often (61 to 88% of the mass of probability concentrated there) since the CDPD channel is lightly loaded and coverage is in general good. All the remaining points correspond to the occurrence of extra delays due to contention and/or channel impairments.

Referring to the tail of the distribution, we represented the probability of occurrence of delays bigger than one second in the "outlier" at the extreme right. Note that the probability of getting such delays is very small (0.2 to 0.9% of the cases).

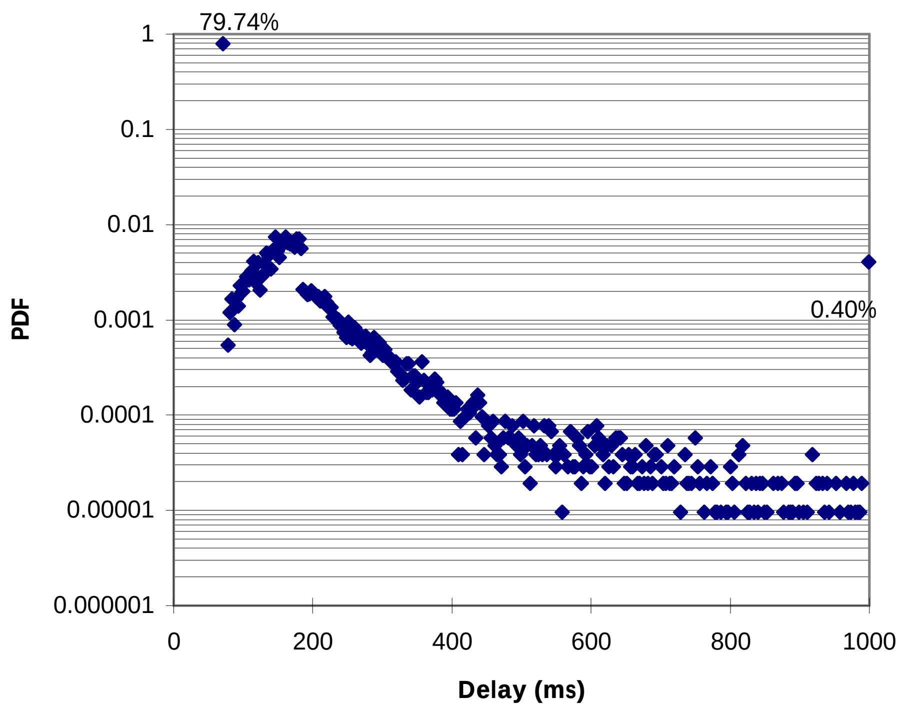


1 RS-block Long Packets

Figure 8.2-6 Reverse Link CDPD Delay Histograms on a Logarithmic Scale

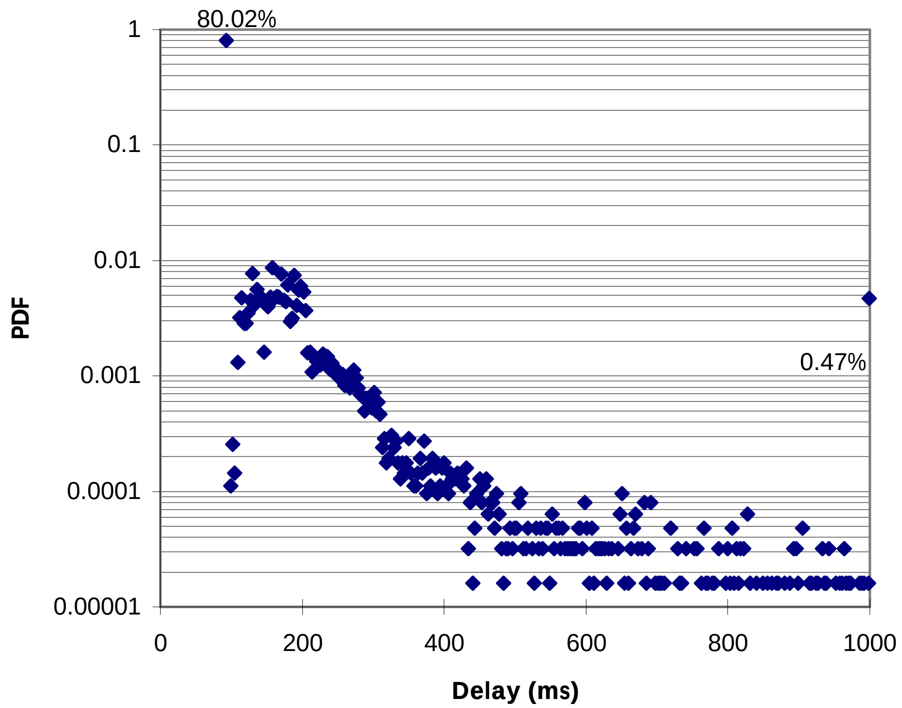


2 RS-blocks Long Packets

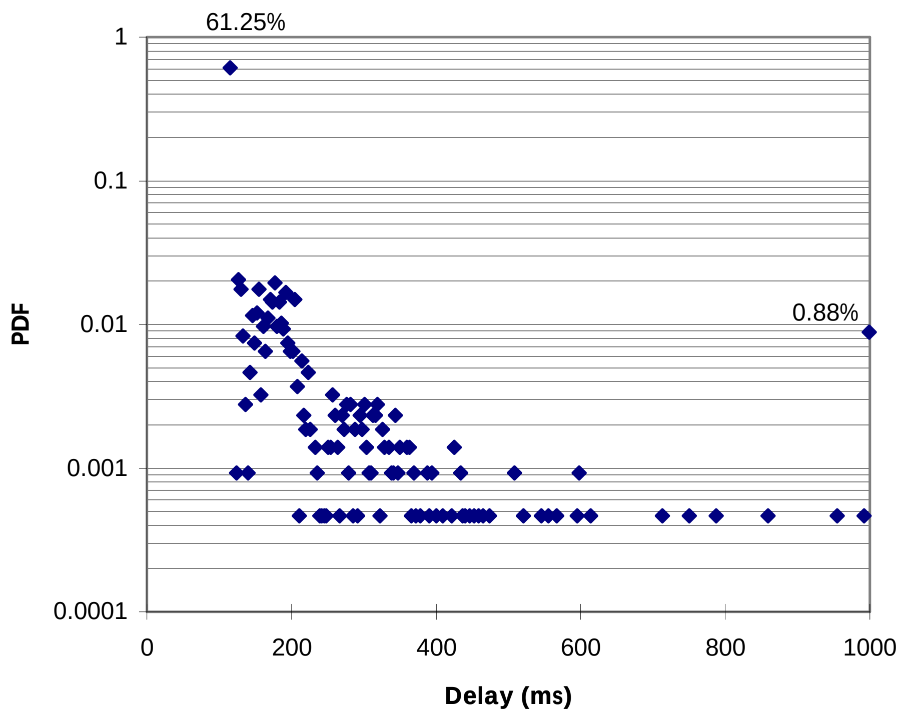


3 RS-blocks Long Packets

Figure 8.2-6 (Cont.) Reverse Link CDPD Delay Histograms on a Logarithmic Scale



4 RS-blocks Long Packets



5 RS-blocks Long Packets

Figure 8.2-6 (Con't.) Reverse Link CDPD Delay Histograms on a Logarithmic Scale

The distributions arrived at in the previous figures result in the Average and Standard Deviations in Figure 8.2-7. We observe that, as expected, the longer the packet, the longer the delay – in fact, we observe an almost linear relation. The explanation is obvious, in that it takes longer to transmit longer packets over a fixed rate channel like the Reverse CDPD channel. The observed standard deviation, or better still, the standard deviation normalized by the average delay, decreases with increasing packet length.

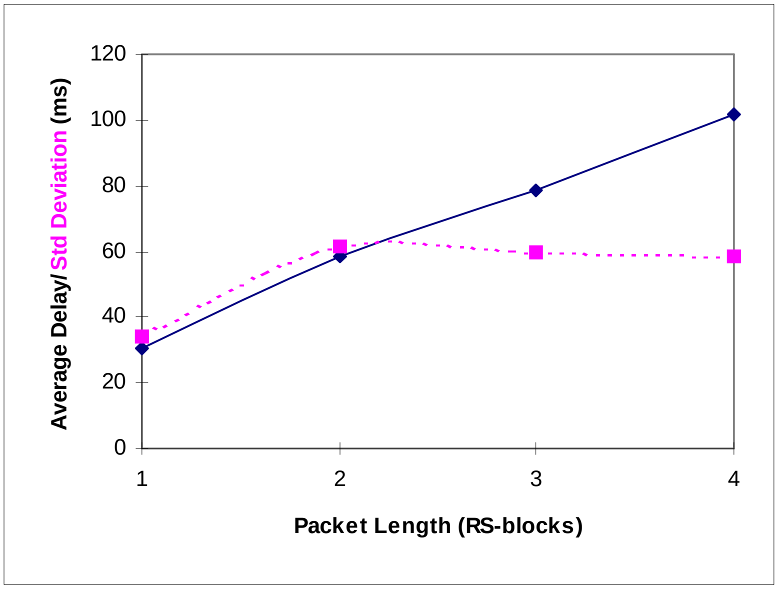


Figure 8.2-7 Average Delay and Standard Deviation as a function of Packet Length

As in Phase I, we obtained the average delay for all sectors in the Detroit area. Since no step has yet been taken to correct the radio engineering issues detected in Phase I, we still observe in Figure 8.2-8 a few "ill-behaved" sectors with somewhat higher delays.

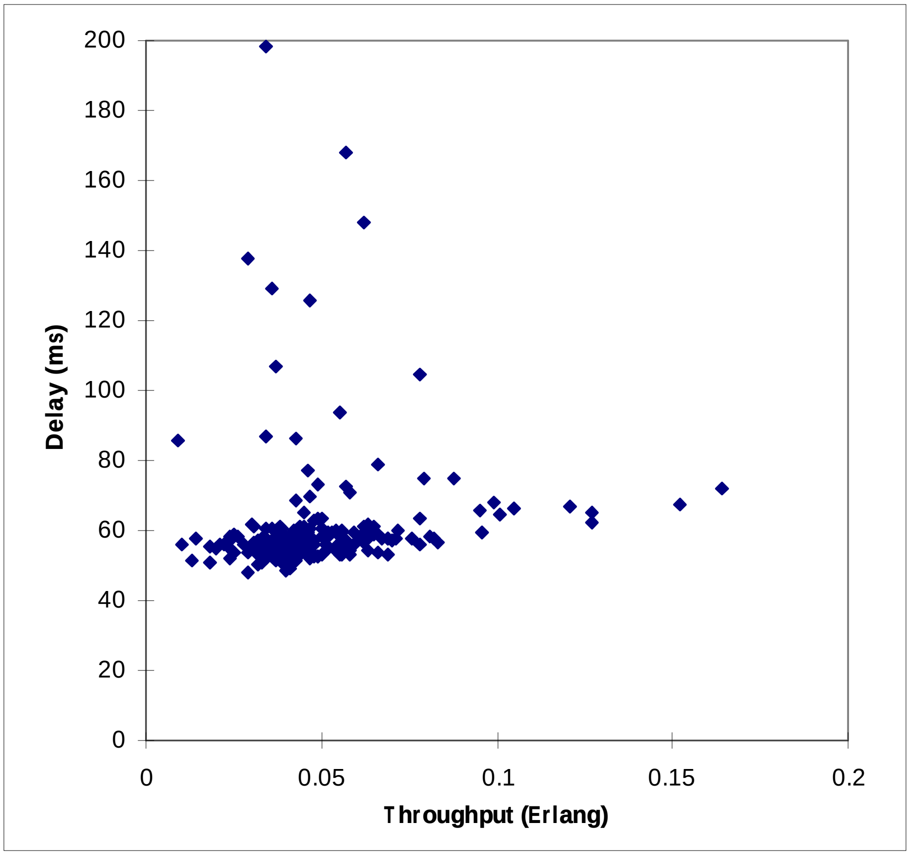


Figure 8.2-8 Delay-Throughput Pairs for all the Sectors in Detroit 2002

In any case, only two out of 230 sectors have average delays above 150 ms. All these results are obviously better than those in Phase I since the traffic is now significantly smaller (because of lower penetrations in 2002 than in 2012). Figure 8.2-9 presents a color-coded delay map of Detroit for the case of ITS loads only.

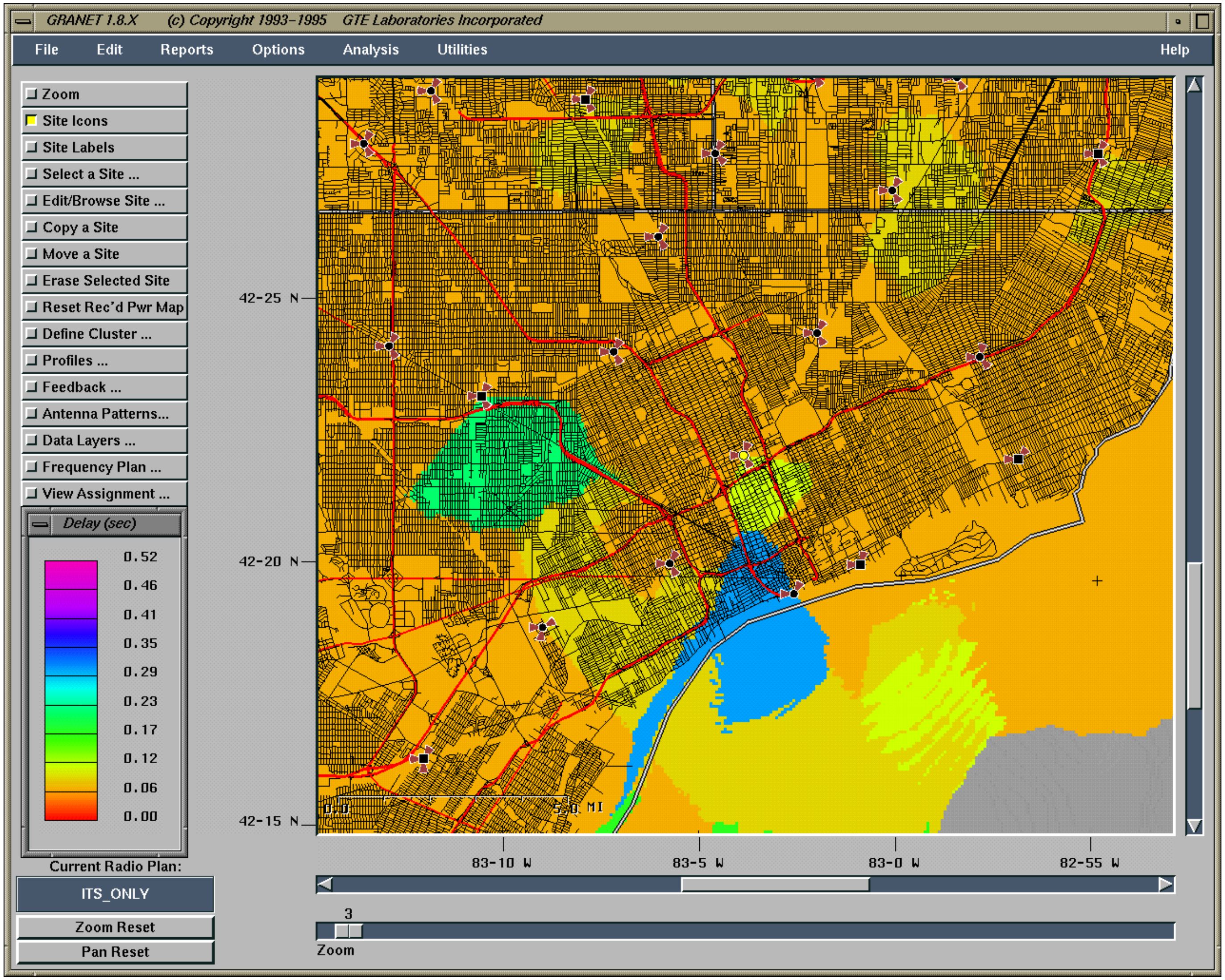


Figure 8.2-9 ITS only CDPD Reverse Link Delay for Urbansville 2002

8.2.1.3.2 Peak-Period ITS plus Non-ITS

Simulating now the ITS plus non-ITS data loads, we increase the load substantially, but we still remain at almost half of the load assessed in Phase I for the 2012 time frame. Looking first at the Average Delay and Standard Deviation as a function of packet length in Figure 8.2-10, we observe the same behavior identified above – almost linear increase of average delay with packet length, and decreasing normalized standard deviation.

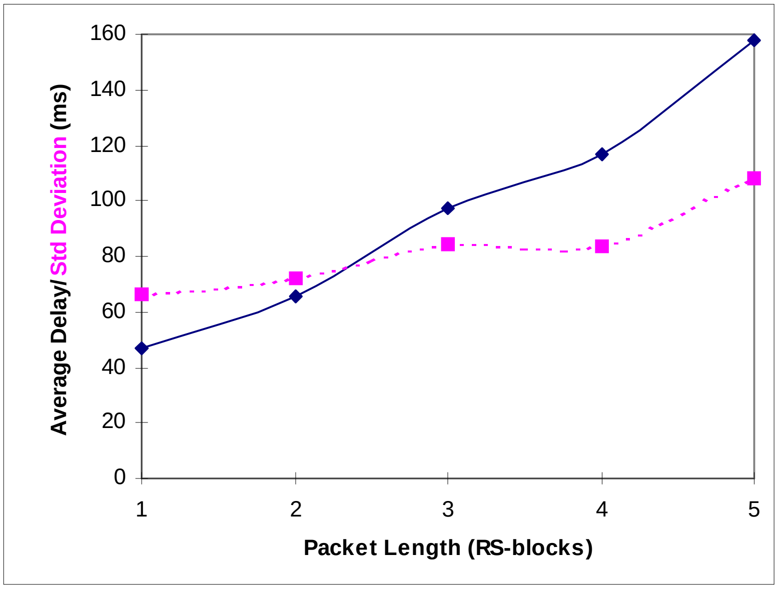


Figure 8.2-10 Average Delay and Standard Deviation as a Function of Packet Length

The delay observed in Figure 8.2-11 is obviously somewhat higher than before, given that the reverse link load increased by a factor of 3.5, but not by much. We are still in the almost constant delay portion of the Delay-Throughput "curve" identified in Section 8.2.1.1. Now, 10 out of the 230 sectors have delays above 150 ms.

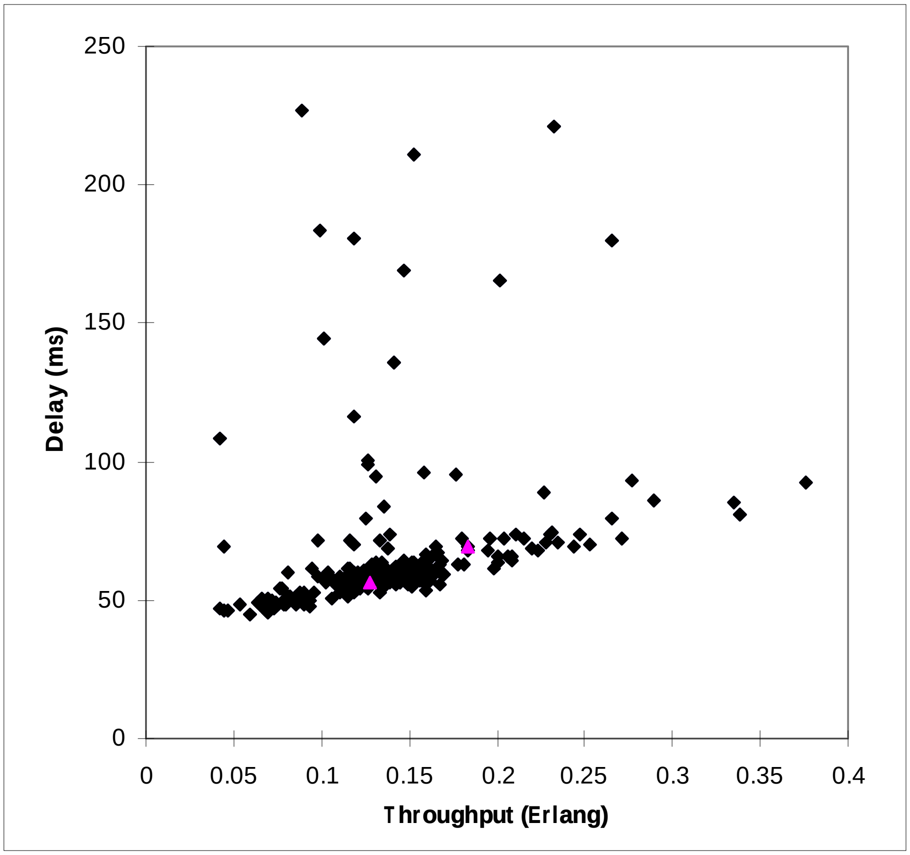


Figure 8.2-11 Delay-Throughput Pairs for Detroit 2002 for ITS plus Non-ITS

Figure 8.2-12 presents a color-coded delay map of Detroit for the case of ITS plus non-ITS loads.

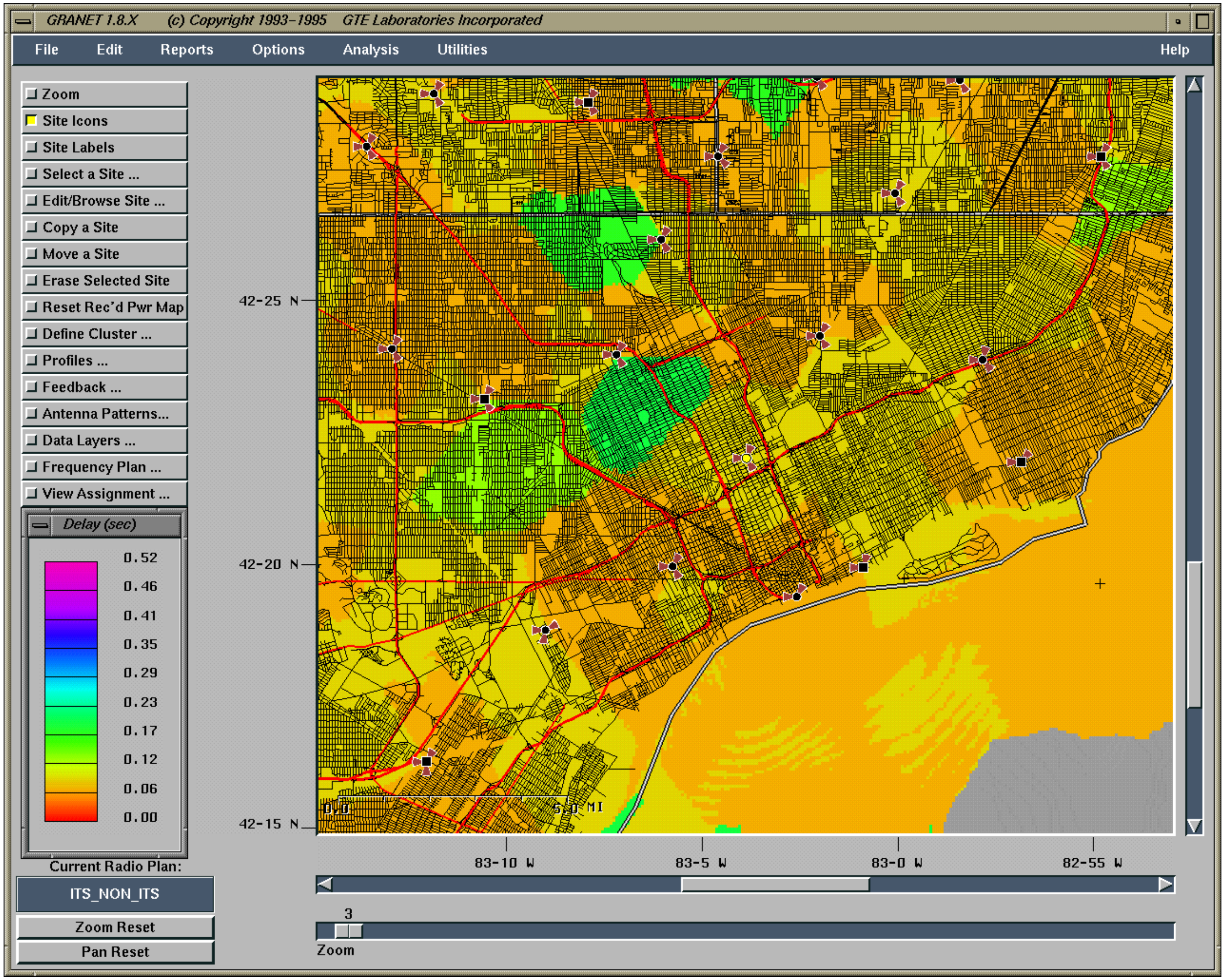


Figure 8.2-12 ITS plus Non-ITS CDPD Reverse Link Delay for Urbansville 2002

8.2.1.3.3 Peak-Period ITS plus Non-ITS with Incident

In Phase I, a worst case type incident was modeled but not specifically for Detroit. In Phase II, an accident occurring in the CBD of the Detroit scenario was simulated with “incident loads” obtained from MITRE from their vehicular traffic simulations.

We now analyze the impact of an incident on the CDPD performance. The average delay in the affected sectors and in those in the immediate vicinity will be compared with those in absence of the incident. For convenience, the two sectors affected by the incident have been signaled in Figure 8.2-13 (gray instead of black) to make it easier to compare with the results in Figure 8.2-13 for the case of incident.

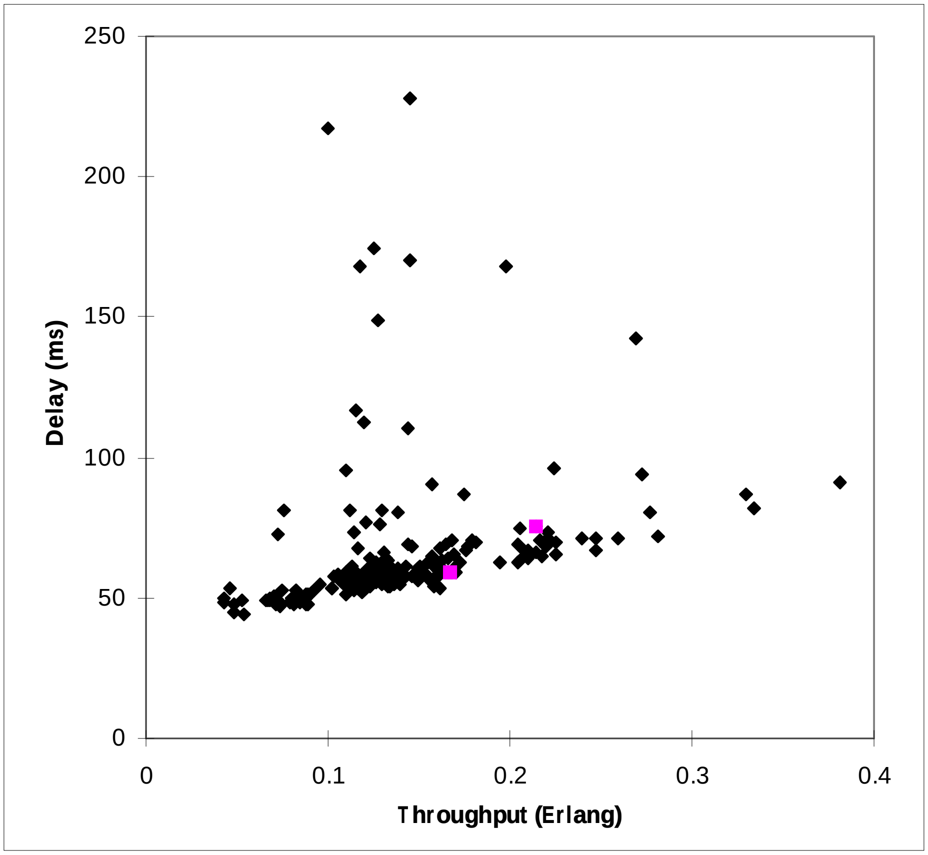


Figure 8.2-13 Delay-Throughput Pairs for Detroit 2002 for ITS plus Non-ITS in case of Incident

In the two sectors affected by the incident, the delay increased by a factor of 3.9% in the Tiger Stadium #1 sector, and by a factor of 7.95% in the Baltimore #3 sector. On the other hand, comparing the above result with the one in absence of incident, we notice considerable fluctuation of the observed pairs, due to a natural statistical variation of the observed traffic from one simulation run to another. That fluctuation makes the delay increase in the affected sectors almost meaningless (statistically insignificant). Again, the fact that we are in the “flat” portion of the curve makes the increase in delay due to the increase in load very small, and thus is buried in the statistical fluctuation.

Figure 8.2-14 presents a color-coded delay map of Detroit for the case of ITS plus non-ITS loads with incident affecting two of the downtown sectors.

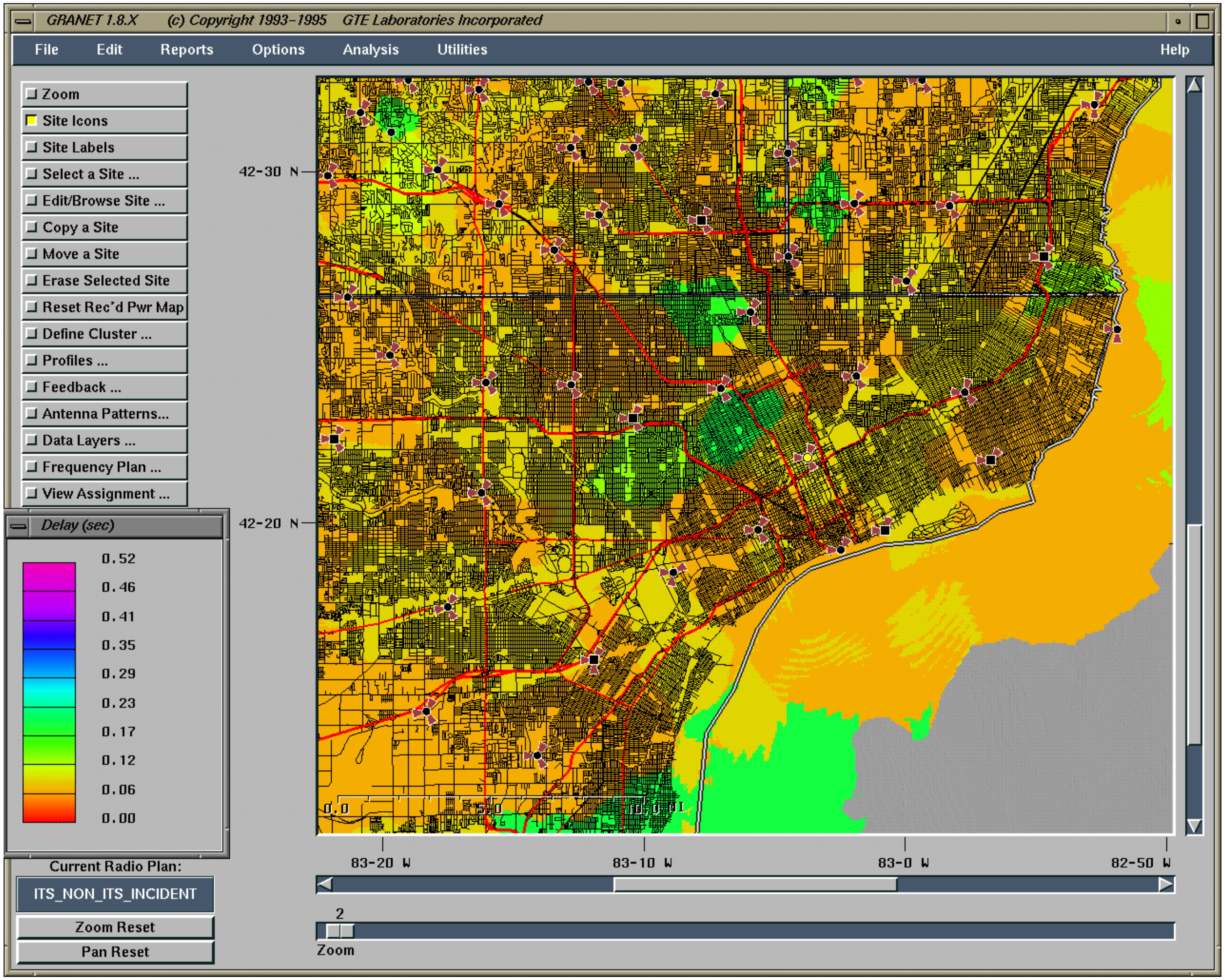


Figure 8.2-14 ITS plus Non-ITS with Incident CDPD Reverse Link Delay for Urbansville 2002

8.2.1.4 Urbansville 2002 -- Dynamic Assignment of CDPD Channels (No Reserved Channel)

When the CDPD was initially conceived, the idea was to make exclusive use of the idle periods between voice calls. In order to be able to do that, the MD-BS either has a connection to the Mobile Switching Office (the AMPS switch), or has to implement “sniffing”, which is forward-sensing the channels that are momentarily not in use.

A simpler method would be to reserve a channel for CDPD exclusive use, either by adding a new channel to the existing grouping, or by subtracting one from voice. The latter alternative is in general only temporary, since all cellular providers keep checking blocking probability, and adding channels whenever it begins to approach the dreaded 2%.

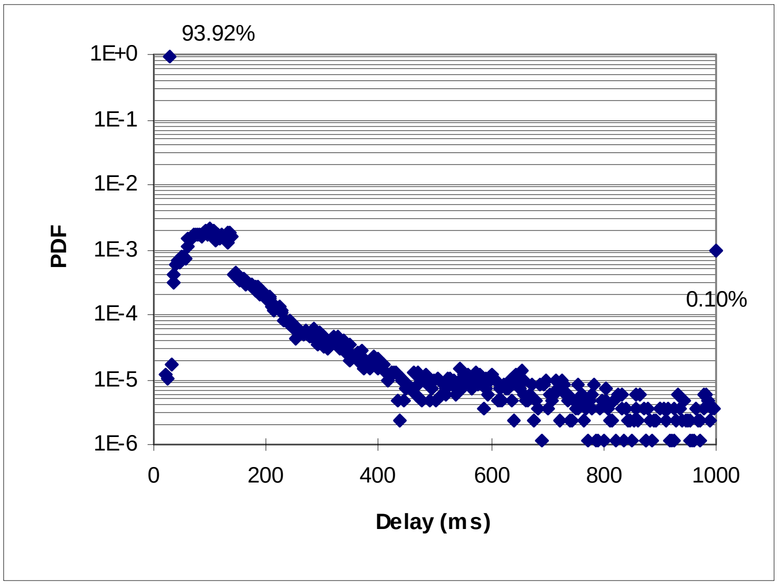
The previous section looked into the performance of a system with a reserved CDPD channel in each sector, the so called minimal CDPD deployment. Here we are going to analyze the case where no channel is reserved for CDPD, and only the idle periods are used.

Well established queuing theory results indicate that for a properly designed cellular network with a reasonable number of channels per sector, which is always the case for urban environments, three CDPD channels can capture, during the peak period, almost all the idle periods in the voice channels, and a fourth would have minimal impact (very quickly diminishing returns). It should be noted that the cost of three CDPD channels per sector is considerably less than adding a new voice channel to each sector.

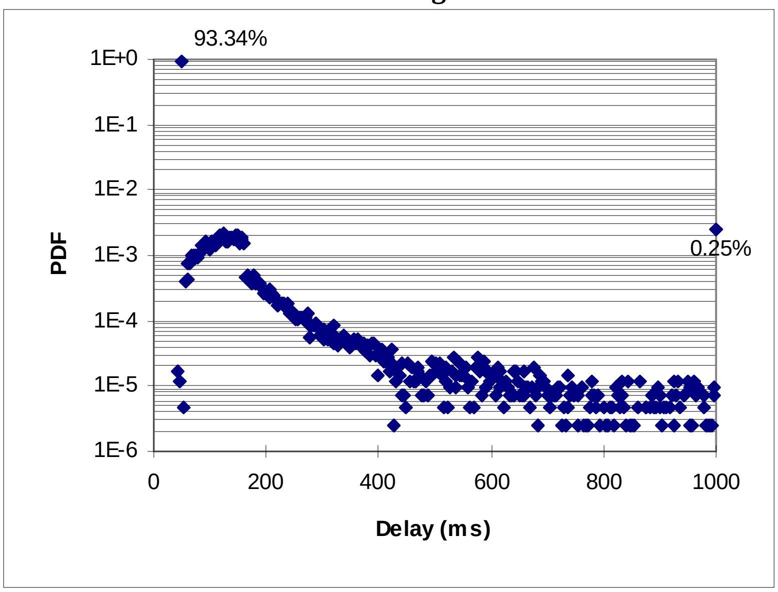
The performance of a 3-Dynamic CDPD channels (No Reserved) deployment will be assessed for the ITS plus non-ITS data Loads for the Detroit scenario. The resulting system performance is slightly better than that of the One Reserved CDPD channel minimal deployment.

8.2.1.4.1 System Performance for 3-Dynamically Assigned CDPD Channels

Figure 8.2-15 shows the delay PDF’s obtained for a totally dynamic deployment. The observed PDF’s are quite different from those obtained for one reserved CDPD channel. It is quite apparent the smaller standard deviation of the delay that results from the availability of in general more than one channel for re-transmission in case of back-off due to collision or in case of packet error (remaining traffic has alternative channels for delivery, and simultaneously is less likely to interfere with the re-trials).

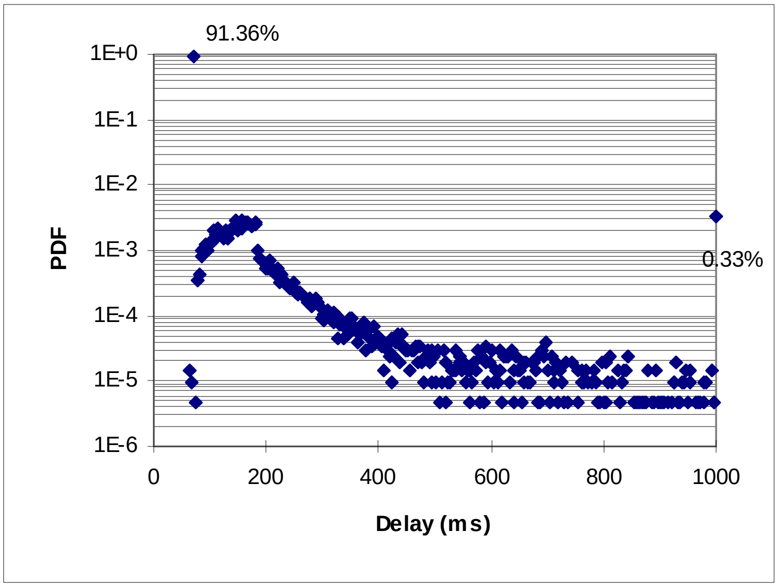


1 RS-block Long Packets

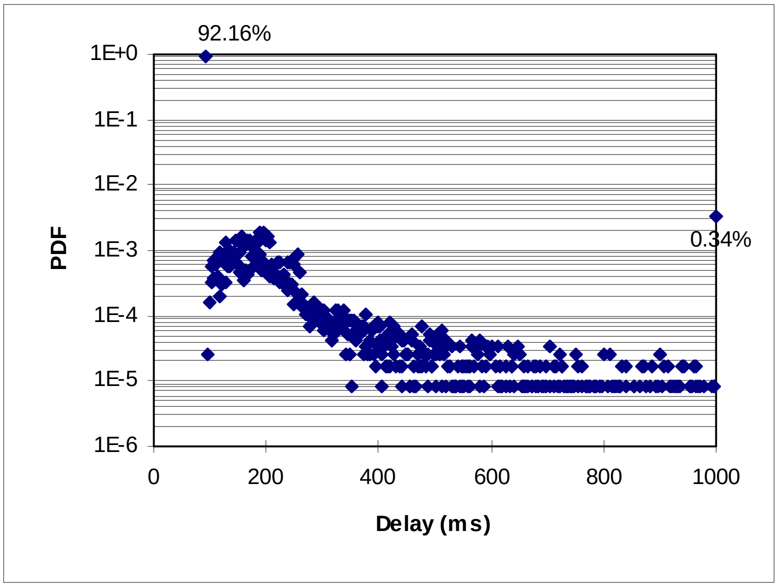


2 RS-block Long Packets

Figure 8.2-15 Delay PDF's as a Function of the Packet Length in RS-blocks, for 3-Dynamically Assigned CDPD Channels (No Reserved) for ITS+Non-ITS Data Loads

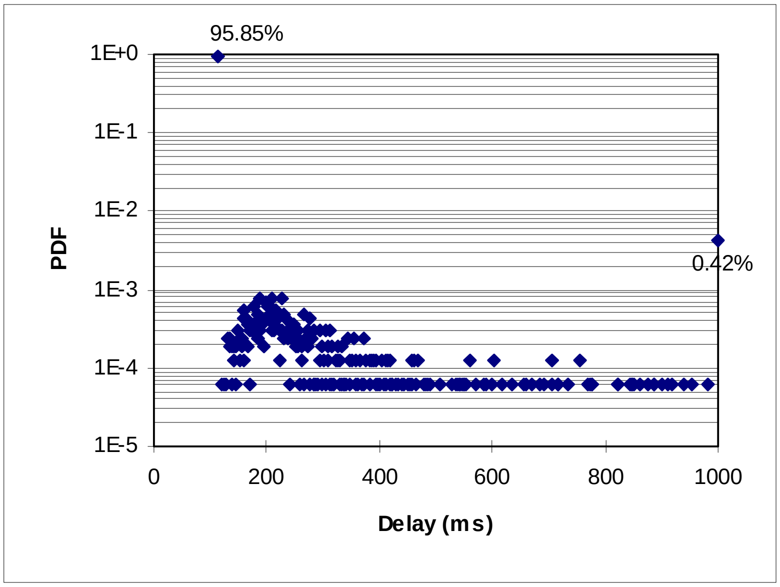


3 RS-block Long Packets



4 RS-block Long Packets

Figure 8.2-15 (Con't) Delay PDF's as a Function of the Packet Length in RS-blocks, for 3-Dynamically Assigned CDPD Channels (No Reserved) for ITS+Non-ITS Data Loads



5 RS-block Long Packets

Figure 8.2-15 (Con't) Delay PDF's as a Function of the Packet Length in RS-blocks, for 3-Dynamically Assigned CDPD Channels (No Reserved) for ITS+Non-ITS Data Loads

Figure 8.2-16 shows the behavior we came to expect. Also note the nearly perfect linear relation of Average Delay to Packet Length (driven by the channels fixed data rate).

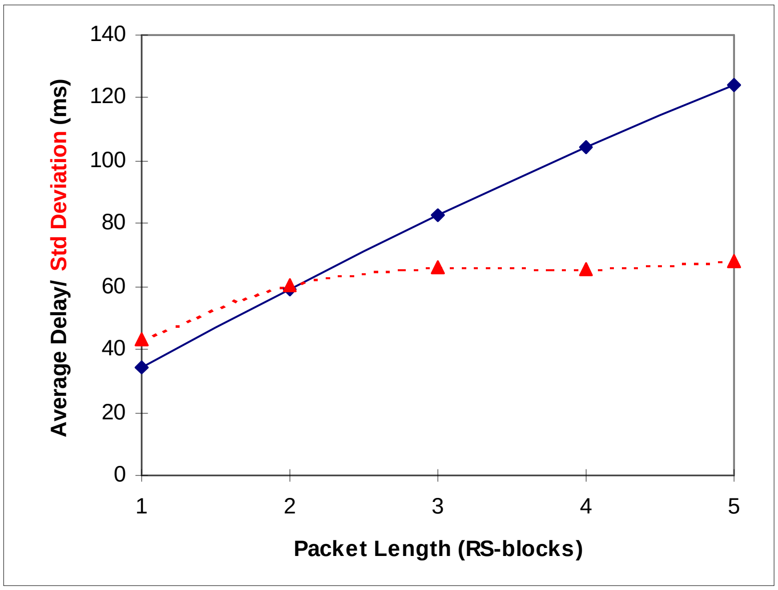


Figure 8.2-16 Average Delay and Standard Deviation for 3-Dynamically Assigned CDPD Channels

Figure 8.2-17 shows the Delay-Throughput pairs for this totally dynamic deployment. The delay is obviously much smaller than in the case of One Reserved CDPD Channel, and the "curve" is now even flatter.

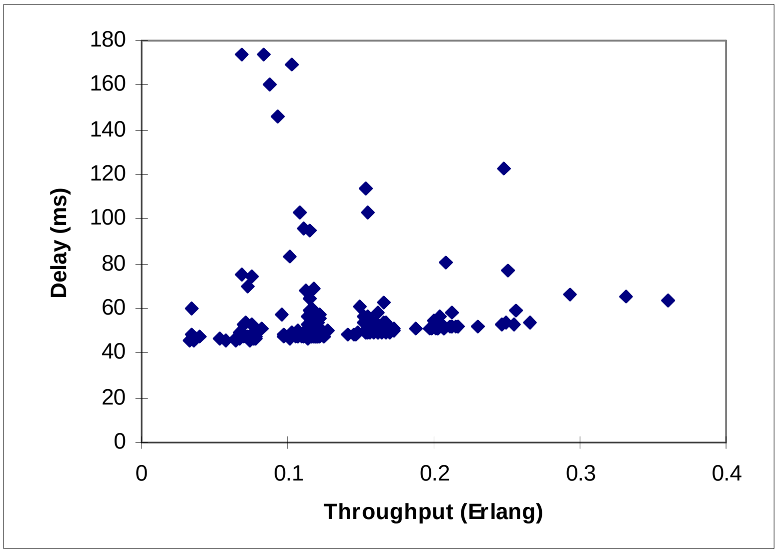


Figure 8.2-17 Delay-Throughput for 3-Dynamically Assigned CDPD Channels (No Reserved) for ITS+Non-ITS Data Loads

Since we had noticed fluctuations in the case of One Reserved channel, we looked at three distinct runs of the Dynamic Deployment for the Detroit scenario. The statistical fluctuations are here smaller (Figure 8.2-18), reflecting the increased number of channels available on average for transmission.

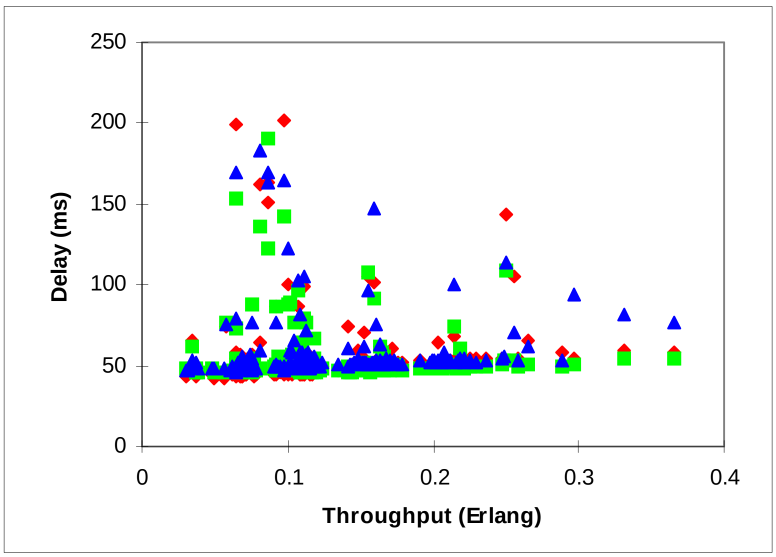


Figure 8.2-18 Delay-Throughput Pairs Observed in Three Different Simulation Runs for 3-Dynamically Assigned CDPD Channels (No Reserved) for ITS+Non-ITS Data Loads

Figure 8.2-19 shows a color-coded delay map of Detroit for the case of ITS plus non-ITS loads for this dynamic deployment.

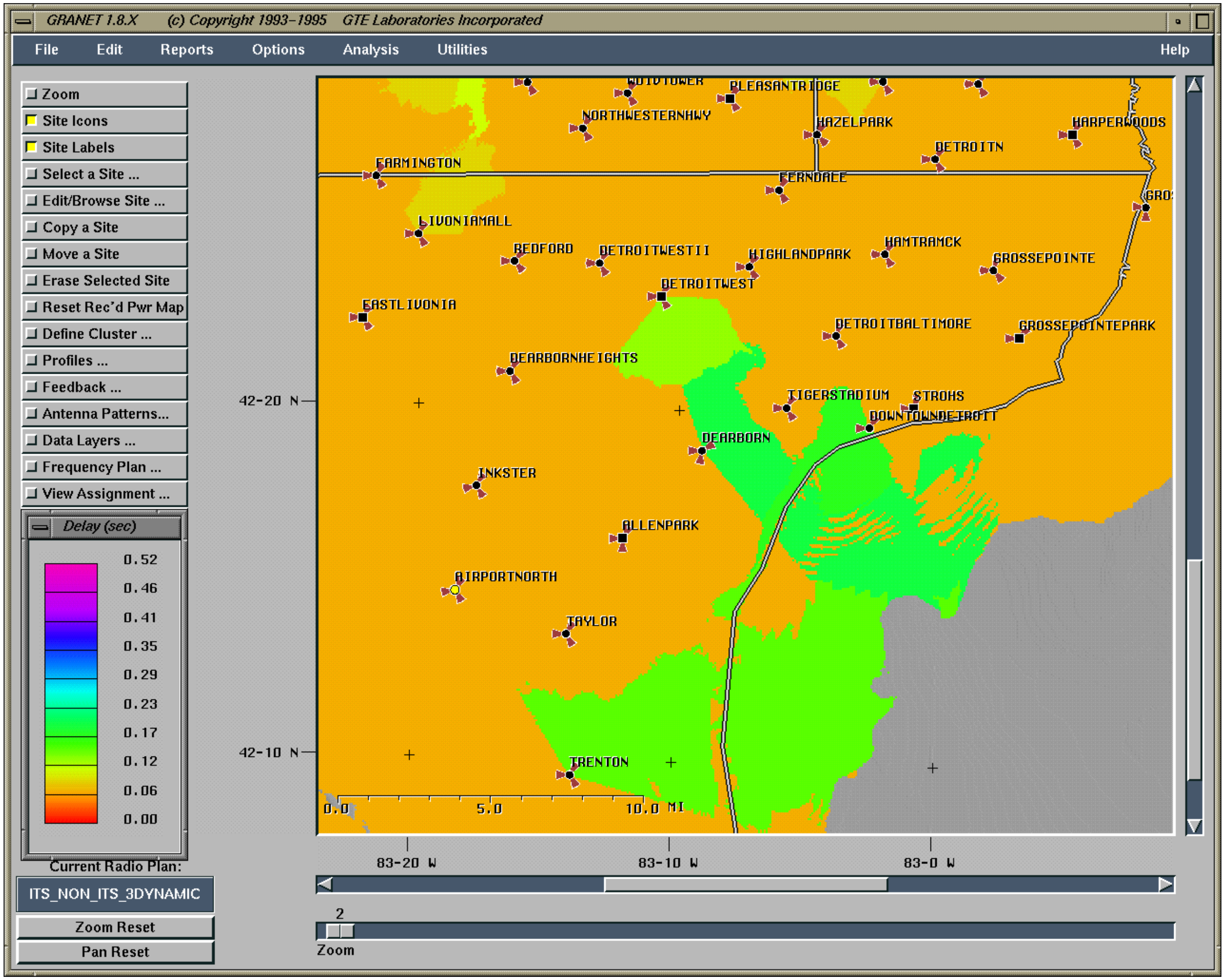


Figure 8.2-19 CDPD Reverse Link Delay for ITS plus Non-ITS Data Loads and 3-Dynamically Assigned CDPD Channels

8.2.2 Thruville 2002

Coverage for the present cellular deployment, as well as best server information, (obtained using GRANET), is shown in Figure 8.2-20.

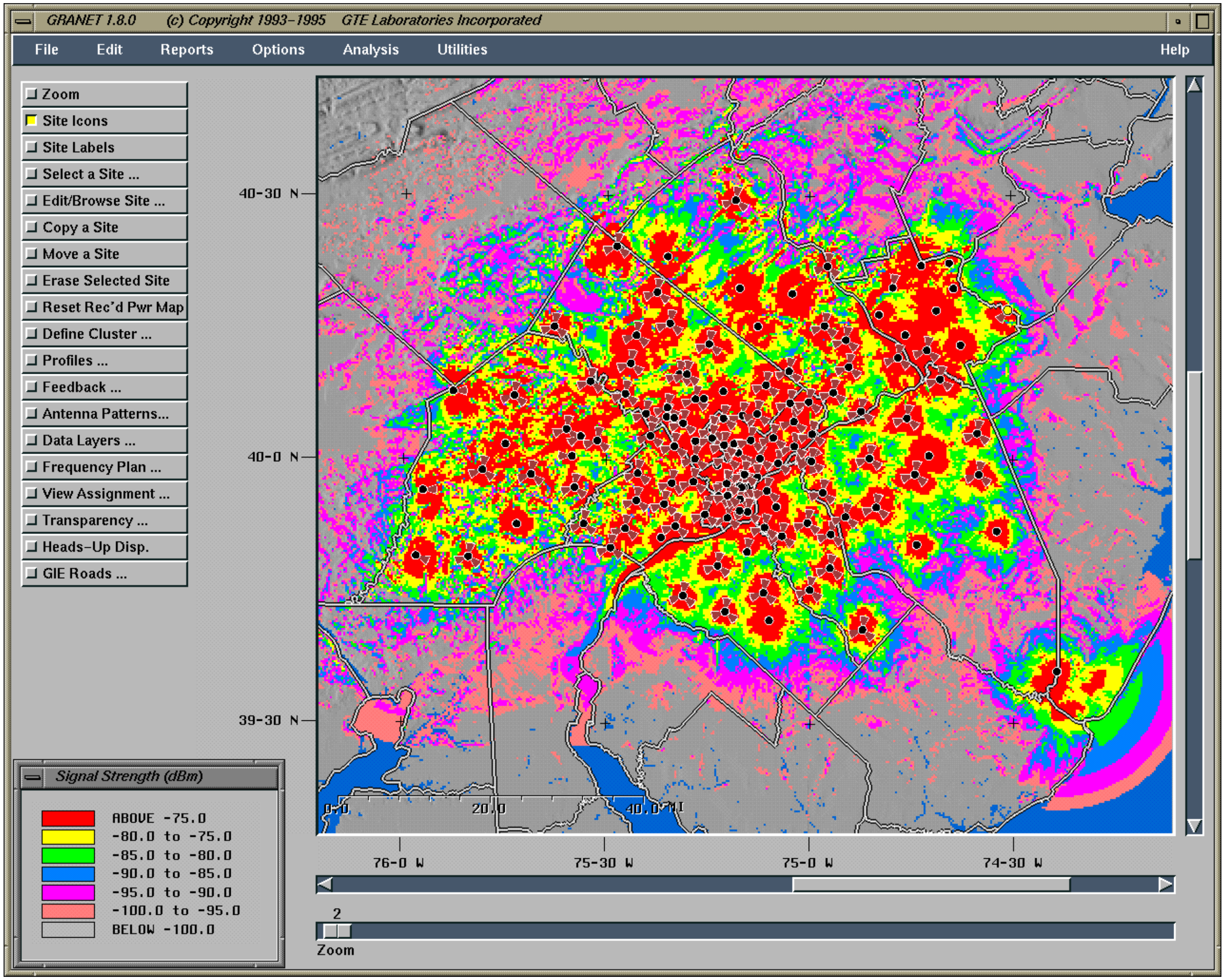


Figure 8.2-20 Philadelphia-Trenton Corridor (Thruville) Coverage

For the data loads identified in Section 8.1.5, performance information was obtained for the cases of ITS Only, and ITS plus non-ITS. As in the previous cases for the Detroit cellular scenario, we observe for the Philadelphia-Trenton cellular deployment, updated in March 1995, a few sectors that deviate from the expected Delay-Throughput curve.

Figure 8.2-21 shows that, for the small loads associated with ITS only, almost all sectors fall in the "linear", almost flat portion of the Delay-Throughput curve. Out of the 333 sectors in the scenario, only 13 have delays above 200 ms.

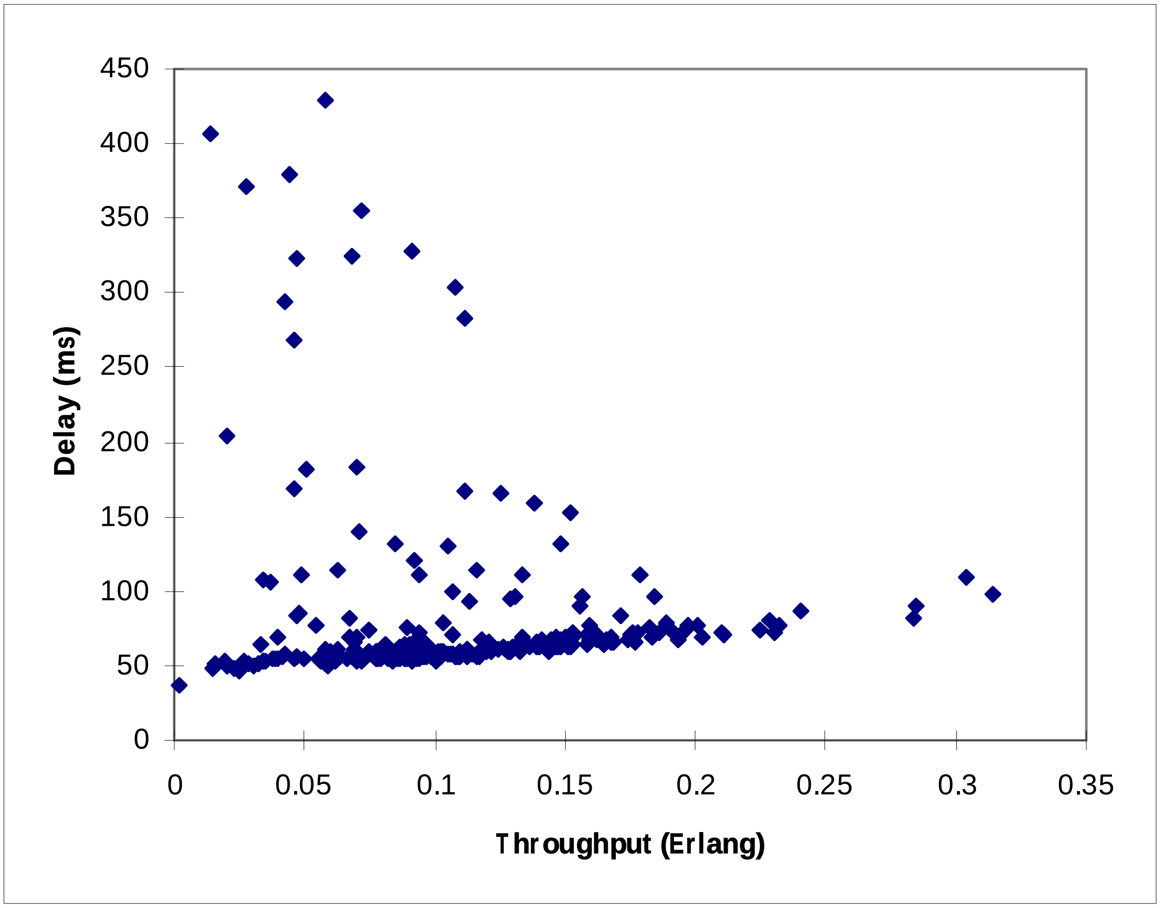


Figure 8.2-21 Delay-Throughput Pairs for ITS Only Data Loads for Thruville 2002

Figure 8.2-22 shows the performance of the system for ITS plus non-ITS Data Loads. We observe that almost all the Delay-Throughput curve is now filled. Exactly the same number of sectors, 13, is now above 400 ms (two times 200 ms), when the reverse link load increased by a factor of 3.5.

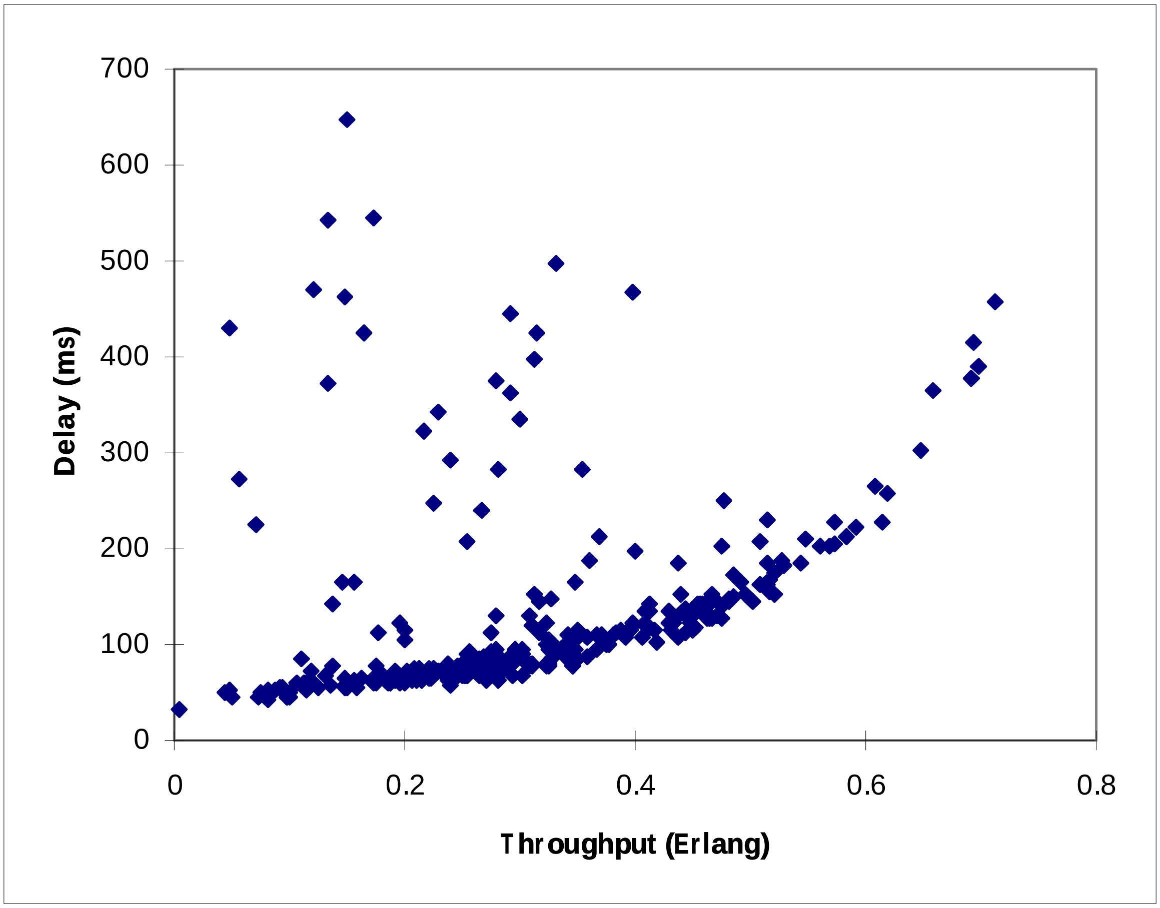


Figure 8.2-22 Delay-Throughput Pairs for ITS plus Non-ITS Data Loads for Thruville 2002

As stated before, we had no opportunity to explore the effects of the incident "created" by the Government. However, comparing the Thruville incident scenario with that of Urbansville, we can expect that the increase in data load due to the incident be, per cent-wise, even smaller in this case. This is in part because the incident expands over a much bigger region, and therefore it takes that much longer to build the queues that were observed in MITRE's simulation just before the incident began to clear. As a result, the increase in delay due to the (small) increase in load will, in all likelihood, be masked in the statistical fluctuation of the simulation.

8.2.3 Mountainville

Information on the cellular coverage in the Lincoln County, Montana area was used to compute the associated cellular coverage. *A priori*, full coverage of the area under consideration was not expected – the relief and the low population density are such that only the major highways and population concentrations have been targeted for coverage. However, looking at the obtained coverage information, we see that only a few deep valleys are not covered. The coverage for Mountainville is shown in Figure 8.2-23.

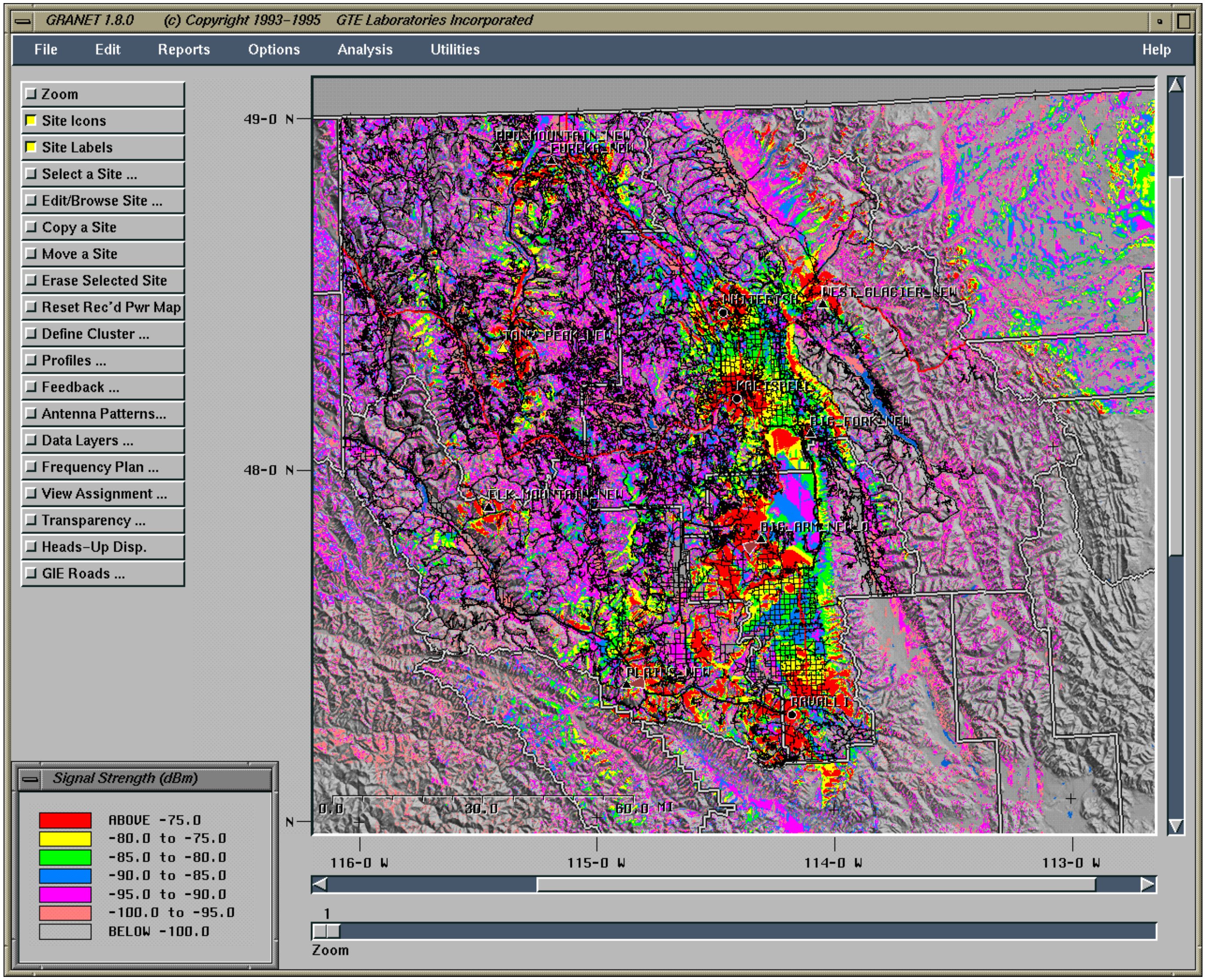


Figure 8.2-23 Lincoln County, Montana (Mountainville) Coverage

8.3 Wireline System Performance

Simulations of wireline networks were performed in Phase I (see Phase I Document: *Analysis of Data Loading Requirements*). The results showed that for communication among ITS subsystems the delay of a reasonably designed network, with readily available technology, is extremely small (microseconds) and insignificant. Consequently, in Phase II the wireline simulation focused on the wireline component of the CDPD network in order to obtain end-to-end system performance, including the effect of the higher layers of the protocol stack.

8.3.1 Traffic Over the Wireline Portion of the CDPD Network

Figure 8.3-1 shows the network to be simulated to assess the true end-to-end performance of the CDPD network. It takes into account all the CDPD traffic in the Urbansville area. It is based on the cellular deployment information already collected (230 sectors in 80 sites), and essentially follows the Rockwell Team's Evaluatory design of Phase I: three jurisdictions; two MD-IS's approximately splitting the control of the sites; two TMS's; and three (or possibly only two) ISP's. One of the TMS's, as well as one of the ISP's see higher concentration of traffic since they cover the CBD of Detroit. Those will be therefore selected for the worst-case end-to-end performance study.

In order to simplify the analysis, all users of a given type (of one of the groups identified above) will be treated as a composite source with the equivalent traffic. We will then identify the traffic that originates and terminates at each mobile user group destined to and arriving from each of the F-ES's of interest. In addition to the ISP, we have to consider the FMS, TRMS, EM, CVAS, PMS, and a few externals, like Pay Instrument, Location Data, and Intermodal Freight Depot/Shipper.

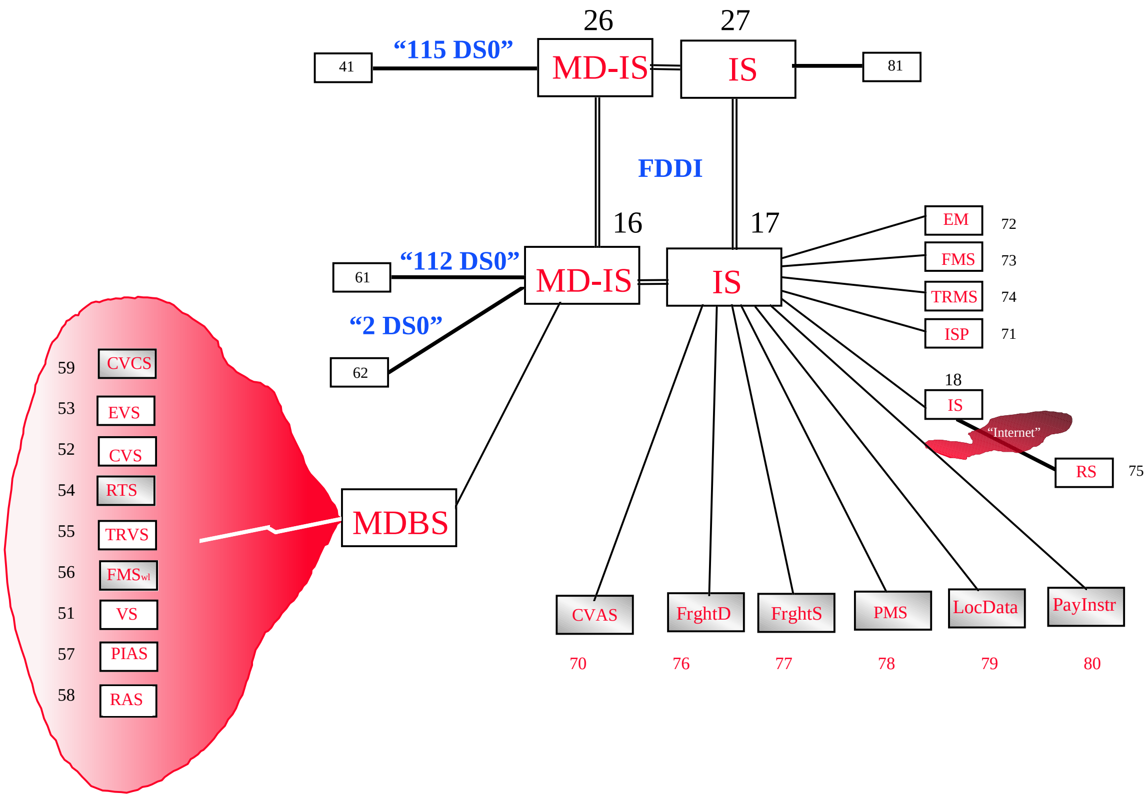


Figure 8.3-1 Network to be Simulated to Assess End-to-End Performance

Figure 8.3-2 shows the M-ES/F-ES Origin-Destination pairs of interest which will be simulated. Included are the non-ITS users (Remote Access - RAS) that also use the CDPD network to remotely access their home systems, mainly for the purpose of retrieving e-mail messages.

Figure 8.3-2 M-ES/F-ES Origin-Destination Pairs

Table 8.3-1 describes the traffic between ITS pairs, thus enabling an accurate simulation of the CDPD network performance in the Urbansville area.

Table 8.3-1 ITS Origin-Destination Pairs Traffic (RS-blocks/s/Sector)

		<<<<Forward	F1	F2	F3	F4	F5	Reverse>>>>	R1	R2	R3	R4	R5
CVCS	CVAS	0.000			0.000	0.000		0.000		0.000	0.000	0.000	
FMS	CVAS	0.003		0.001	0.002	0.000		0.004			0.002	0.002	
FMS	EM	0.000		0.000				0.000		0.000	0.000	0.000	
FMS	ImFrghtD	0.000				0.000		0.000				0.000	
FMS	ImFrghtS	0.000				0.000		0.000				0.000	
FMS	ISP	0.149	0.009	0.084	0.019	0.028	0.009	0.103	0.047	0.037		0.019	
FMS	PayInstr	0.000		0.000				0.000		0.000			
PIAS	EM	0.000		0.000				0.000			0.000		
PIAS	ISP	0.032	0.002	0.000	0.020	0.006	0.003	0.006	0.000	0.002	0.004		0.000
PIAS	LocData	0.000		0.000									
PIAS	PayInstr	0.000			0.000			0.000		0.000			
PIAS	TRMS	0.001		0.001				0.000				0.000	
RTS	EM							0.000			0.000		
RTS	ISP	0.000			0.000	0.000	0.000	0.001		0.001	0.000	0.000	0.000
RTS	PayInstr	0.000		0.000	0.000			0.000		0.000			
CVS	FMS	0.234	0.074	0.057	0.057	0.009	0.037	0.175	0.042	0.132	0.000		
EVS	EM	0.018	0.012			0.006		0.029		0.023		0.006	
TRVS	PayInstr	0.004		0.004	0.000			0.009		0.009			
TRVS	TRMS	0.128	0.004	0.013	0.086	0.023	0.002	0.091	0.005	0.015	0.062	0.009	
VS	EM	0.000		0.000				0.000		0.000	0.000		
VS	ISP	0.210		0.095	0.092	0.024	0.000	0.045		0.006	0.037	0.002	
VS	LocData	0.001		0.001									
VS	PayInstr	0.000			0.000			0.000		0.000	0.000		
VS	PMS							0.000		0.000		0.000	
RAS	RS	6.513	3.473	1.380	1.026	0.414	0.220	1.897	0.938	0.507	0.293	0.117	0.042

8.4 End-to-End System Performance

8.4.1 Scope of Performance Analysis

The cellular simulation capabilities of GTE Laboratories (GTEL) are combined with Loral's protocol simulation capabilities to provide the end-to-end performance. GTEL's MOSS accurately characterizes the lower layers of the CDPD protocol (MAC and Physical in Figure 8.4-1) in the reverse direction by using accurate propagation information obtained from GRANET and by taking into account all the interference effects arising from both voice and data. Loral's OPNET model of the CDPD protocol is used to model the higher layers, and the forward link, given that it operates in a broadcast mode (i.e., no contention).

Figure 8.4-1 shows the protocol stack to be simulated. The first observation is that for most applications, the Session, Presentation and Application layers are merged together. Thus, end-to-end performance will be measured from the moment information is delivered to the Transport layer at the Mobile or Fixed End Systems (M-ES/F-ES) till the moment it is delivered by the Transport layer at the other end (F-ES/M-ES).

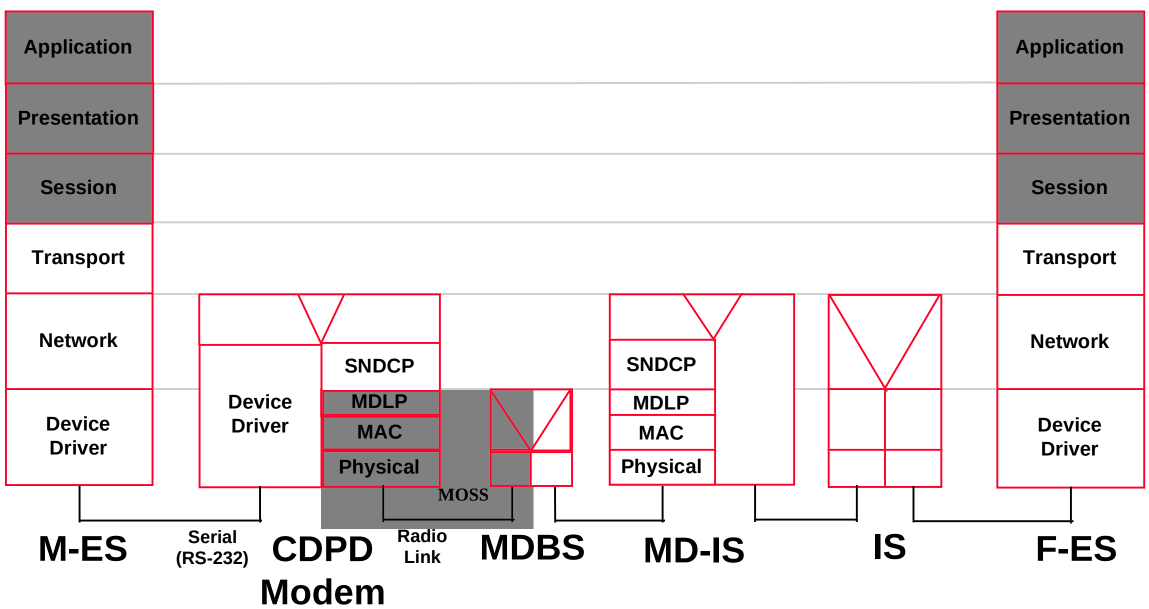


Figure 8.4-1 CDPD Protocol Stack for End-to-End Performance Evaluation (Shows the Portion to be Replaced by MOSS' CDPD Traffic Characterization in Terms of Delay)

The scope of MOSS (and GRANET) is clearly identified in Figure 8.4-1. The delay characterization of the CDPD reverse link will be used to account for the over-the-air delay. As a matter of fact, the lower layers of the CDPD protocol guarantee delivery of information from the M-ES to the MD-BS. MOSS does in fact "listen" to the forward channel to make sure it accounts for contention and other channel impairments as detected at the MD-BS.

With this integrated model (OPNET using the CDPD reverse channel characterization obtained from MOSS and GRANET), the Joint Team obtained end-to-end (application to application) CDPD delay information, thus answering some of the questions raised at the conclusion of Phase I. The performance of the CDPD networks deployed in Urbansville (based upon actual cellular deployment in the areas that inspired those scenarios) during the peak period was used for arriving at the end-to-end delay.

8.4.2 Results

Simulation results are obtained for the important segments of the overall CDPD network – emphasizing non-ITS users, and the effect of the overall traffic in the CDPD network. See Figure 8.4-2.

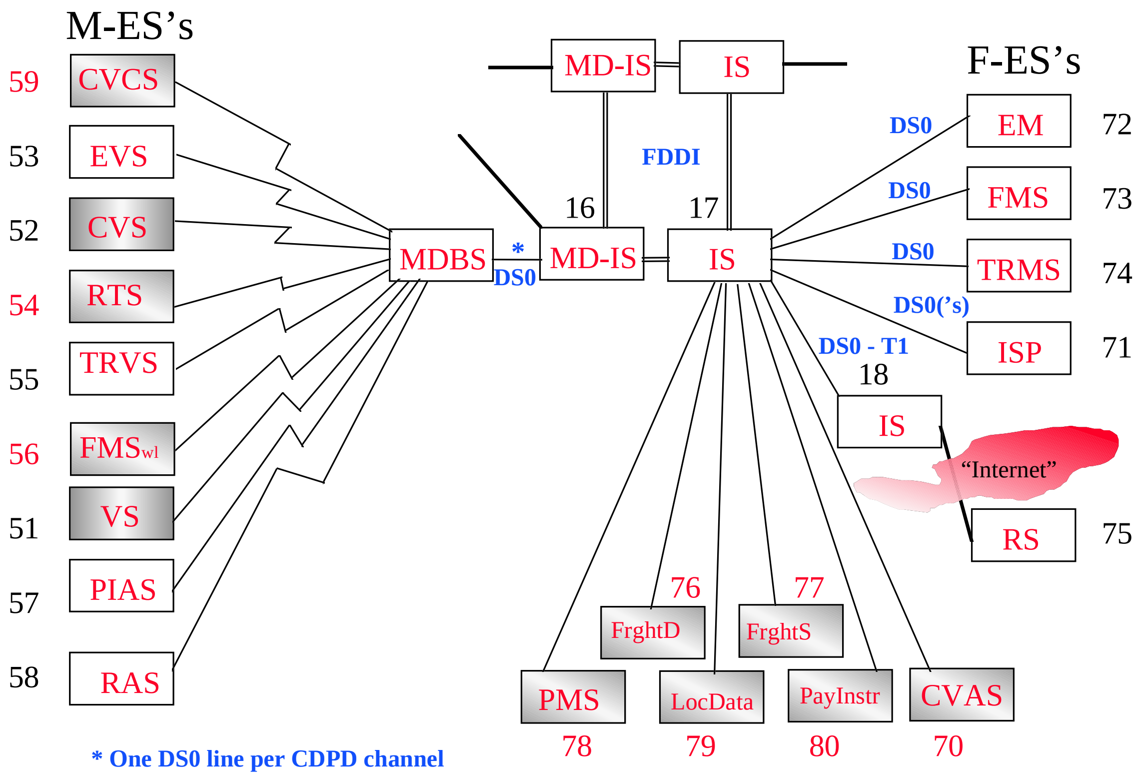


Figure 8.4-2 Portion of the CDPD Network that has been Simulated (Corresponding to One Sector of the Cellular Deployment)

The choice of specific links in the simulation (DS0 and T1) is determined by the expected traffic to and from the aggregated F-ES's for the various service groupings.

Table 8.4-1 presents the cumulative traffic to and from the F-ES's. It can be seen that, except for the Emergency Management and Transit Management subsystems, which can do with a DS0 line (56 kbps capacity), all others need to have a higher capacity connection. In most cases, this higher capacity will be achieved by leasing a few DS0 lines, allowing for flexibility in adding more, whenever needed while paying only for the required throughput, instead of going directly to fractional T1 or even T1 lines.

Table 8.4-1 Total Traffic Departing from/Arriving at the F-ES's

1 Sector													
Origin	Dest	<<<<Forward	F1	F2	F3	F4	F5	Reverse>>>>	R1	R2	R3	R4	R5
	CVAS	0.003		0.001	0.002	0.000		0.004		0.000	0.002	0.002	
	EM	0.018	0.012	0.000		0.006		0.029		0.023	0.000	0.006	
	FMS	0.234	0.074	0.057	0.057	0.009	0.037	0.175	0.042	0.132	0.000		
	ImFrghtD	0.000				0.000		0.000				0.000	
	ImFrghtS	0.000				0.000		0.000				0.000	
	ISP	0.391	0.011	0.179	0.131	0.058	0.013	0.155	0.047	0.046	0.041	0.020	0.000
	LocData	0.001		0.001									
	PayInstr	0.005		0.005	0.000			0.009		0.009	0.000		
	PMS							0.000		0.000		0.000	
	RS	6.513	3.473	1.380	1.026	0.414	0.220	1.897	0.938	0.507	0.293	0.117	0.042
	TRMS	0.129	0.004	0.014	0.086	0.023	0.002	0.091	0.005	0.015	0.062	0.009	
2 Sector Load													
		<<<<Forward	F1	F2	F3	F4	F5	Reverse>>>>	R1	R2	R3	R4	R5
#62	CVAS	0.006		0.001	0.004	0.001		0.007		0.000	0.003	0.004	
#62	EM	0.035	0.023	0.000		0.012		0.059		0.047	0.000	0.012	
#62	FMS	0.468	0.148	0.114	0.113	0.019	0.074	0.349	0.085	0.264	0.001		
#62	ImFrghtD	0.001				0.001		0.001				0.001	
#62	ImFrghtS	0.001				0.001		0.001				0.001	
#62	ISP	0.782	0.022	0.357	0.262	0.116	0.025	0.309	0.094	0.092	0.082	0.041	0.000
#62	LocData	0.003		0.003									
#62	PayInstr	0.010		0.010	0.000			0.019		0.019	0.000		
#62	PMS							0.000		0.000		0.000	
#62	RS	13.025	6.946	2.761	2.051	0.828	0.441	3.793	1.876	1.014	0.585	0.234	0.085
#62	TRMS	0.258	0.007	0.028	0.173	0.047	0.004	0.183	0.011	0.030	0.124	0.017	
112 Sector Load													
		<<<<Forward	F1	F2	F3	F4	F5	Reverse>>>>	R1	R2	R3	R4	R5
#61	CVAS	0.330		0.072	0.221	0.036		0.410		0.001	0.181	0.228	
#61	EM	1.972	1.312	0.004		0.656		3.295		2.630	0.009	0.656	
#61	FMS	26.195	8.293	6.364	6.346	1.046	4.147	19.561	4.759	14.765	0.036		
#61	ImFrghtD	0.054				0.054		0.054				0.054	
#61	ImFrghtS	0.054				0.054		0.054				0.054	
#61	ISP	43.818	1.243	20.012	14.668	6.473	1.422	17.308	5.248	5.153	4.594	2.293	0.020
#61	LocData	0.152		0.152									
#61	PayInstr	0.564		0.540	0.024			1.060		1.060	0.000		
#61	PMS							0.004		0.002		0.002	
#61	RS	729.421	388.954	154.590	114.858	46.344	24.675	212.431	105.030	56.772	32.769	13.118	4.741
#61	TRMS	14.439	0.397	1.543	9.663	2.615	0.222	10.223	0.595	1.685	6.965	0.979	
115 Sector Load					20%	goes to the F-ES's of the other region							
		<<<<Forward	F1	F2	F3	F4	F5	Reverse>>>>	R1	R2	R3	R4	R5
#41	CVAS	0.068		0.015	0.045	0.007		0.084		0.000	0.037	0.047	
#41	EM	0.405	0.269	0.001		0.135		0.677		0.540	0.002	0.135	
#41	FMS	5.379	1.703	1.307	1.303	0.215	0.852	4.017	0.977	3.032	0.007		
#41	ImFrghtD	0.011				0.011		0.011				0.011	
#41	ImFrghtS	0.011				0.011		0.011				0.011	
#41	ISP	8.998	0.255	4.110	3.012	1.329	0.292	3.554	1.078	1.058	0.943	0.471	0.004
#41	LocData	0.031		0.031									
#41	PayInstr	0.116		0.111	0.005			0.218		0.218	0.000		
#41	PMS							0.001		0.000		0.000	
#41	RS	149.792	79.875	31.746	23.587	9.517	5.067	43.624	21.569	11.659	6.729	2.694	0.974
#41	TRMS	2.965	0.082	0.317	1.984	0.537	0.046	2.099	0.122	0.346	1.430	0.201	
#41	#81	671.107	328.735	150.549	119.749	47.049	25.025	217.186	94.984	67.413	36.598	14.280	3.911

Preliminary simulation results are available and they are presented below for some of the O-D pairs previously identified. We account separately for the traffic in both directions. The main justification for this approach, besides the resulting simplification of the simulation effort, is that as stated at the outset, we are only taking into account the communication delay, and not the ITS Subsystems performance. The overall end-to-end delay can thus be approximated by adding to the independent delays in both directions, and then providing a margin for the expected processing and information access times at the F-ES's.

Figures 8.4-3 to 8.4-7 show the delay in both directions for the most relevant M-ES/F-ES O-D pairs: Private Vehicle-ISP, CVO Local-FMS, and RAS-RS, **assuming an initial period of 100 s with no packet loss followed by 40 s of 10% packet loss and then 60 s again with no packet loss**. Lost packets will eventually be retransmitted, as soon as the TCP timers at either end expire. This implies necessarily an increase in the overall CDPD traffic. As a first approximation, we can assume that there is a resulting 10% increase in the traffic in both directions between RAS and RS. Due to time and resource constraints, it was not possible to recompute the reverse link CDPD delay for this higher traffic, so the same CDPD delay distribution was used over the whole observation period. From all the analysis in Section 8.1 and 8.2, we are confident that the increase in delay due to this additional traffic would be minimal, since we are operating in a lightly loaded network.

Figure 8.4-3 shows the delay for the link directly affected by the packet loss. The increase in delay due to retransmission is obvious. However, the effect of the increase in traffic shows up on the other links: Figures 8.4-4 to 8.4-7 not only show a slight increase in delay, but hint at a slow recovery of the network.

In any case, the reverse link (including the CDPD Reverse Link) has higher delays, as expected, due to the contention mechanism involved.

In all cases, the delay is still quite small, less than 2 seconds, which is well within the delay requirements of the various ITS services employing wide area wireless/wireline information exchange.

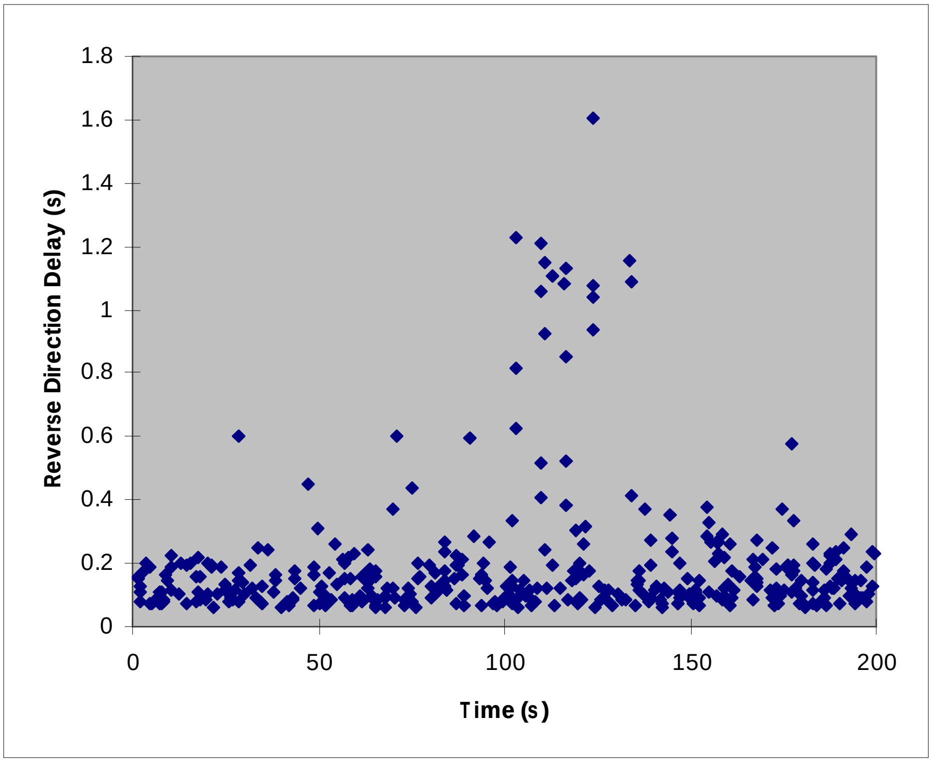


Figure 8.4-3 RAS -> RS (Reverse Link) Assuming 100 s with No Packet Loss followed by 40 s with 10% Packet Loss, and then 60 s with No Packet Loss

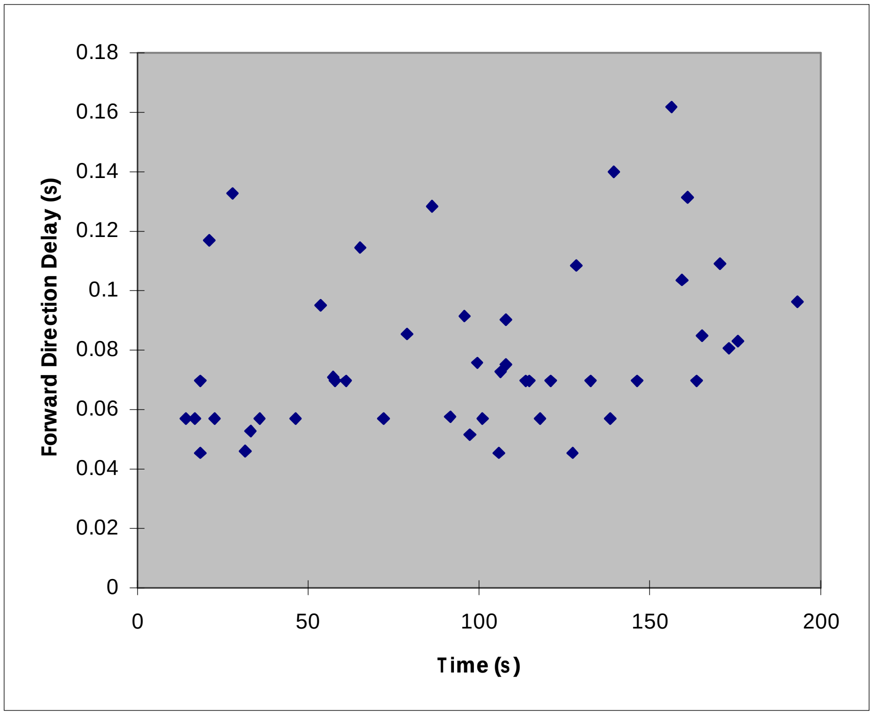


Figure 8.4-4 FMS -> CVO Local (Forward Link)

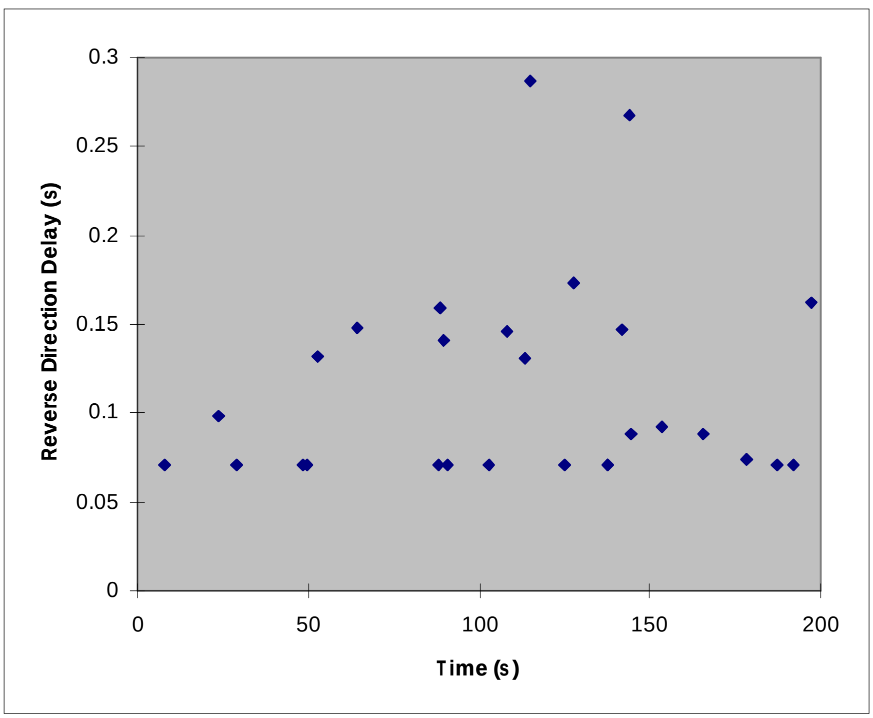


Figure 8.4-5 CVO Local -> FMS (Reverse Link)

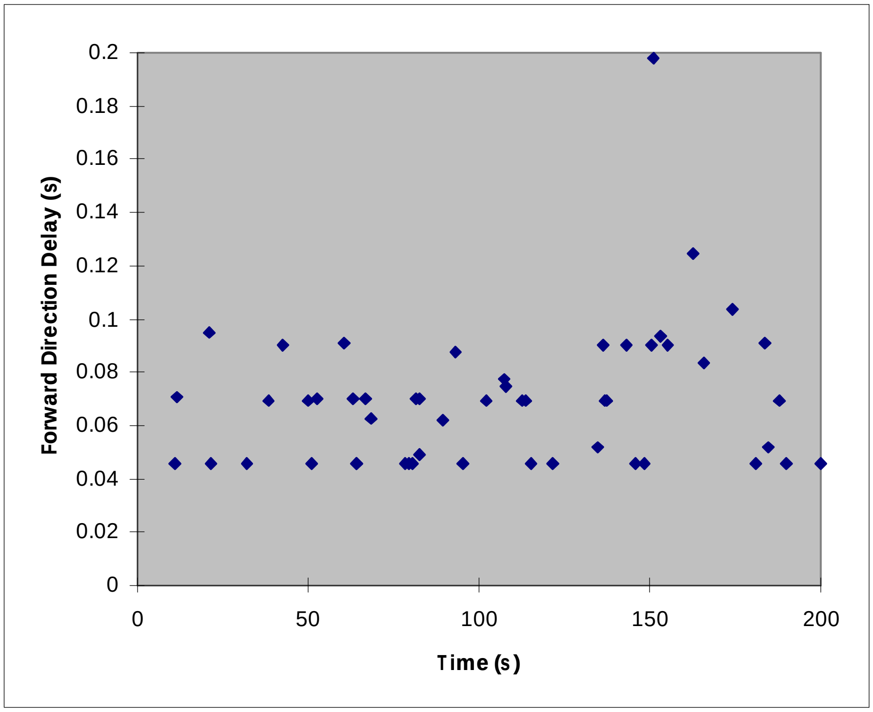


Figure 8.4-6 ISP -> Private Vehicle (Forward Link)

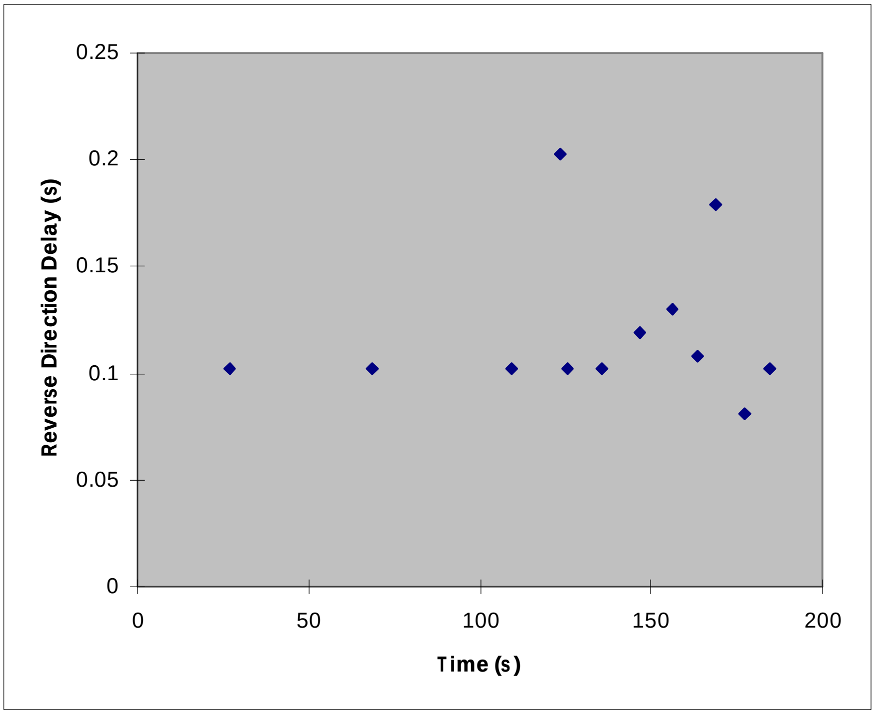


Figure 8.4-7 Private Vehicle -> ISP (Reverse Link)