HARRIS COUNTY METROPOLITAN TRANSIT AUTHORITY

Bar Signal Overrun System Final Report

Contract: RC0800012 **Work Authorization: 30**

11/15/11

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Bar Signal Overrun System
Final Performance Report

This report summarizes the performance of the Emtrac Bar Signal Overrun System over the test period beginning August 19, 2011, and ending November 10, 2011.

Background

Beginning July, 2007 METRO commenced a project to evaluate the use of a Global Positioning System (GPS) based system to detect and report when a Light Rail Vehicle (LRV) passed a stop indicator (horizontal bar signal). The system was based upon a transit priority system manufactured by Emtrac Systems of Mount Vernon, IL, and modified to monitor the aspect of bar signals while detecting the position of the LRVs, with a positional accuracy of +/-19 inches. With the conclusion of the evaluation project and its acceptance, METRO initiated a complete Bar Signal Overrun System on the Redline.

Test Locations

The test involved the installation of equipment onboard all 18 LRV's and all 64 signalized intersections on the alignment known as the Red Line and as shown in Table 1:

Int ID	Zone ID	Route St.	Crossing St.	Direction	Int ID	Zone ID	Route St.	Crossing St.	Direction
1	1	MAIN	COMMERCE	N	29	57	SAN JACINTO	WENTWORTH	N
1	2	MAIN	COMMERCE	S	30	58	FANNIN	WENTWORTH	S
2	3	MAIN	FRANKLIN	N	31	59	SAN JACINTO	ROSEDALE	N
2	4	MAIN	FRANKLIN	S	32	60	FANNIN	ROSEDALE	S
3	5	MAIN	CONGRESS	N	33	61	SAN JACINTO	WICHITA	N
3	6	MAIN	CONGRESS	S	34	62	FANNIN	WICHITA	S
4	7	MAIN	PRESTON	N	35	63	SAN JACINTO	SOUTHMORE	N
4	8	MAIN	PRESTON	S	36	64	FANNIN	SOUTHMORE	S
5	9	MAIN	PRAIRIE	N	38	66	FANNIN	OAKDALE	S
5	10	MAIN	PRAIRIE	S	39	67	SANJACINTO	BINZ	N
6	11	MAIN	TEXAS	N	40	68	FANNIN	BINZ	S
6	12	MAIN	TEXAS	S	41	69	SAN JACINTO	EWING	N
7	13	MAIN	CAPITOL	N	42	70	FANNIN	EWING	S
7	14	MAIN	CAPITOL	S	43	71	SANJACINTO	HERMANN	N
8	15	MAIN	RUSK	N	44	72	FANNIN	HERMANN	S
8	16	MAIN	RUSK	S	45	391	SAN JACINTO	HERMAN CIRCLE	N
9	17	MAIN	WALKER	N	45	392	FANNIN	HERMAN CIRCLE DR	S
9	18	MAIN	WALKER	S	46	73	FANNIN	SUNSET	N
10	19	MAIN	MCKINNEY	N	46	74	FANNIN	SUNSET	S
10	20	MAIN	MCKINNEY	S	47	77	FANNIN	CAMBRIDGE	N
11	21	MAIN	LAMAR	N	47	78	FANNIN	CAMBRIDGE	S
11	22	MAIN	LAMAR	S	48	75	FANNIN	HERMAN PED	N
12	23	MAIN	DALLAS	N	48	76	FANNIN	HERMAN PED	S
12	24	MAIN	DALLAS	S	49	79	FANNIN	ROSS STERLING	N
13	25	MAIN	POLK	N	49	80	FANNIN	ROSS STERLING	S
13	26	MAIN	POLK	S	50	81	FANNIN	JOHN FREEMAN	N
14	27	MAIN	CLAY	N	50	82	FANNIN	JOHN FREEMAN	S
14	28	MAIN	CLAY	S	51	83	FANNIN	UNIVERSITY BLVD	N
15	29	MAIN	BELL	N	51	84	FANNIN	UNIVERSITY BLVD	S
15	30	MAIN	BELL	S	52	85	FANNIN	DRYDEN	N
16	31	MAIN	LEELAND	N	52	86	FANNIN	DRYDEN	S
16	32	MAIN	LEELAND	S	53	87	FANNIN	BELLOWS TCH	N
17	33	MAIN	PEASE	N	53	88	FANNIN	BELLOWS TCH	S
17	34	MAIN	PEASE	S	54	89	FANNIN	PRESSLER	N
18	35	MAIN	JEFFERSON	N	54	90	FANNIN	PRESSLER	S
18	36	MAIN	JEFFERSON	S	55	352	BRAESWOOD	FANNIN	N
19	37	MAIN	ST JOSEPH	N	55	353	BRAESWOOD	FANNIN	S
19	38	MAIN	ST JOSEPH	S	56	354	GREENBRIAR	S BRAESWOOD	N
20	39	MAIN	PIERCE	N	56	355	GREENBRIAR	S BRAESWOOD	S
20	40	MAIN	PIERCE	S	57	91	GREENBRIAR	COLONNADE	N

21	41	MAIN	GRAY	N	57	92	GREENBRIAR	COLONNADE	S
21	42	MAIN	GRAY	S	58	93	GREENBRIAR	OLD SPANISH TRAIL	N
22	43	MAIN	WEBSTER	N	58	94	GREENBRIAR	OLD SPANISH TRAIL	S
22	44	MAIN	WEBSTER	S	59	305	FANIN	GREENBRIAR	N
23	45	MAIN	MCGOWEN	N	59	361	FANIN S	GREENBRIAR	S
23	46	MAIN	MCGOWEN	S	60	308	FANNIN	RELIANT PARK	N
24	47	MAIN	ELGIN	N	60	307	FANNIN	RELIANT PARK	S
24	48	MAIN	ELGIN	S	61	95	FANNIN	HOLLY HALL	N
25	49	MAIN	HOLMAN	N	61	96	FANNIN	HOLLY HALL	S
25	50	MAIN	HOLMAN	S	62	97	FANNIN	NAOMI	N
26	51	MAIN	ALABAMA	N	62	98	FANNIN	NAOMI	S
26	52	MAIN	ALABAMA	S	63	99	FANNIN	SOUTH LOOP	N
27	53	MAIN	RICHMOND AVE	N	63	100	FANNIN	SOUTH LOOP	S
27	54	MAIN	RICHMOND AVE	S	64	101	FANNIN	BELLFORT	N
28	55	FANNIN	BLODGETT	N	64	102	FANNIN	BELLFORT	S
28	56	FANNIN	BLODGETT	S					

Table 1: Intersection List including Zone Legend

Vehicle Equipment

The LRV Equipment consisted of a Vehicle Computer Unit (VCU) and a combination GPS/UHF antenna. The VCU was installed behind the drop-down panel located in the ceiling just behind the operator's chair, in both cabs of each test vehicle. Figure 1 depicts the LRV equipment. Figure 2 shows the location of the Combo GPS/UHF antenna mounted on the top of the LRV.

Emtrac ST-9142-S LRV Vehicle Computer Unit (Mounted inside LRV)
Emtrac ST-9157 LRV GPS-UHF Antenna

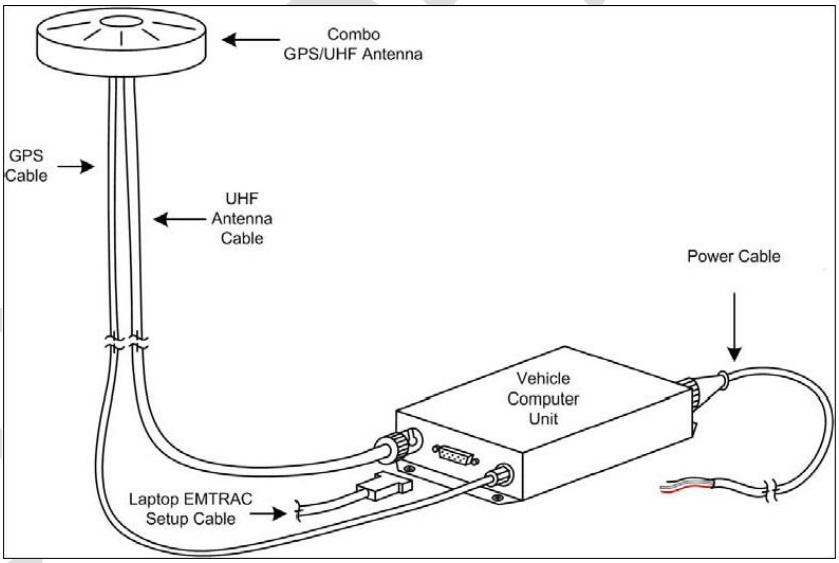


Figure 1: Vehicle Equipment

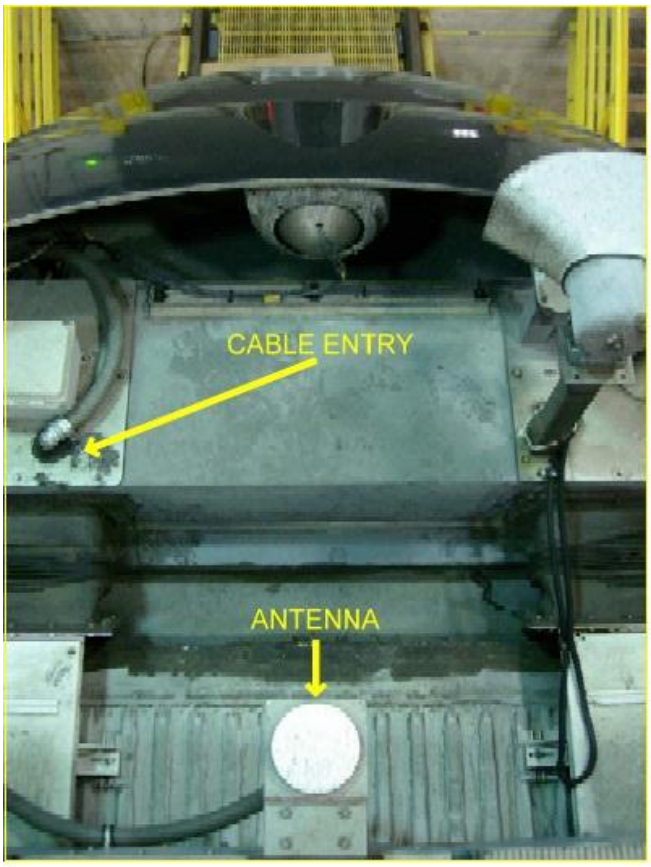


Figure 2: Antenna Location on Roof of LRV Cab

Wayside Equipment

The wayside equipment consisted of components mounted on traffic poles, and in the existing traffic signal control cabinets. The following components were installed:

Emtrac ST-9158 36	Rail Omni-directional Antenna with two mounting brackets (Pole Mounted)
Emtrac ST-9186 RG-8,	50-Ohm Coaxial Cable (Pole to Cabinet)
Emtrac ST-9183	Surge Protector for Omni-directional Antenna (Cabinet Mounted)
Emtrac ST-9141-O8	Rail Priority Detector (Cabinet Mounted)
Emtrac ST-9134	Standalone Case with side mounted L-bracket

Figure 3: Pole Mounted Equipment

Figure 3 shows the typical mounting of the pole mounted Antenna being banded to the pole.

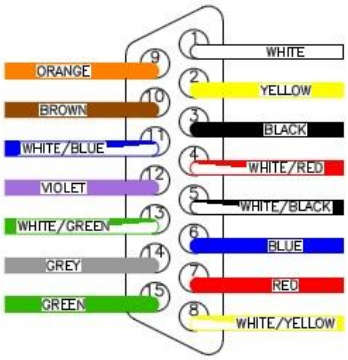
Figure 4: Pole Mounted Equipment, San Jacinto @ Wichita

Figure 4 is a photo of an actual installation on San Jacinto @ Wichita. The Antenna is normally mounted between 15 and 17 feet above curb level.

Input wires for the Emtrac Priority Detector were connected to the back panel of the Output File and the associated load switches controlling the bar signals.

15 PIN D–PLUG PIN#	WIRE COLOR	WIRE DESCRIPTION	CABINET CONNECTION
1	WHITE	120VAC NEUTRAL	120VAC NEUTRAL
2	YELLOW	LOGIC GND	NEMA LOGIC GND
3	BLACK	120VAC	120VAC (HOT)
4	WHITE/RED	AUX OUT #1	NC
5	WHITE/BLACK	AUX OUT #2	NC
6	BLUE	SIGNAL NORTH	NC
7	RED	SIGNAL EAST	NC
8	WHITE/YELLOW	AUX OUT #3	NC
9	ORANGE	SIGNAL SOUTH	NC
10	BROWN	SIGNAL WEST	NC
11	WHITE/BLUE	AUX IN #1	NORTH VERTICAL BAR SIG
12	VIOLET	AUX IN #2	NORTH HORIZONTAL BAR SIG
13	WHITE/GREEN	AUX IN #3	SOUTH VERTICAL BAR SIG
14	GREY	AUX IN #4	SOUTH HORIZONTAL BAR SIG
15	GREEN	CHASSIS GND	CHASSIS GND

NOTES:
ALL WIRES ARE 6 FEET LONG AND 22AWG.



BACK VIEW
15 POSITION
D–SUB HOUSING, STC P/N # EJ120
SOCKET PINS, STC P/N# EJ124
D–SUB PLUG SHELL, STC P/N# EJ126

Figure 5: Priority Detector Harness Diagram

Figure 5 shows a diagram of the 15 pin Priority Detector Harness, the pins, wire color and their function within the controller cabinet.

Wire Color	Cabinet Connection	Cabinet Location
White / Blue	N. Vertical Bar Signal	FT3 – Pin 5 or 6
Violet	N. Horizontal Bar Signal	FT3 – Pin 1 or 2
White / Green	S. Vertical Bar Signal	FT2 – Pin 5 or 6
Grey	S. Horizontal Bar Signal	FT2 – Pin 1 or 2

Table 2: Bar Signal Wiring details

Table 2 depicts Bar Signal Wiring details and their termination point within the associated cabinet location for a Model 332 Cabinet and Model 332D Cabinet.

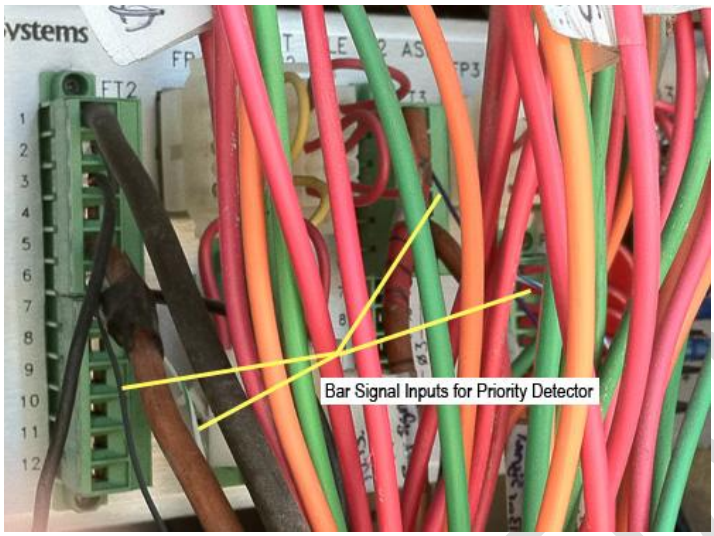


Figure 6: Emtrac Priority Detector input wires

Figure 6 shows input wires for the Emtrac Priority Detector connected to phoenix connectors on the back panel of the Output File of the bar signal load switch outputs.

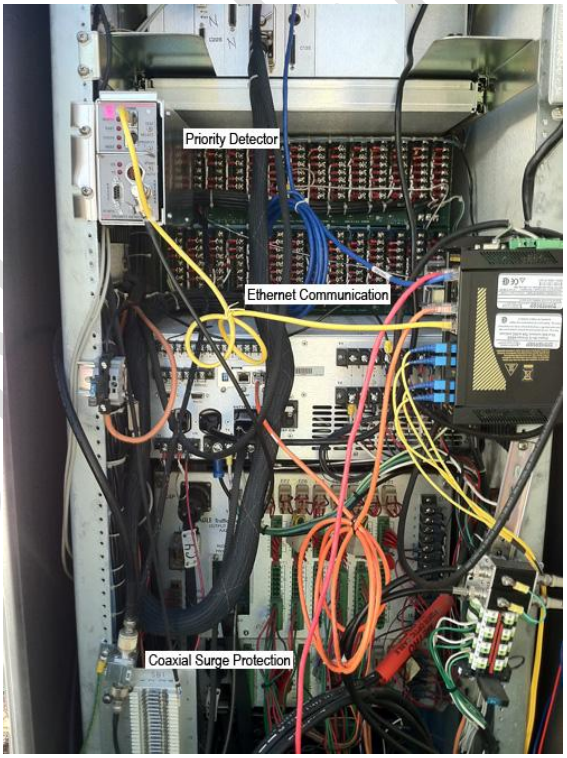


Figure 7: Wayside Equipment Mounted in a 332 Cabinet

Figure 7 shows the mounting location of the Emtrac Systems Standalone Case with mounting ears within a Model 332 Cabinet.

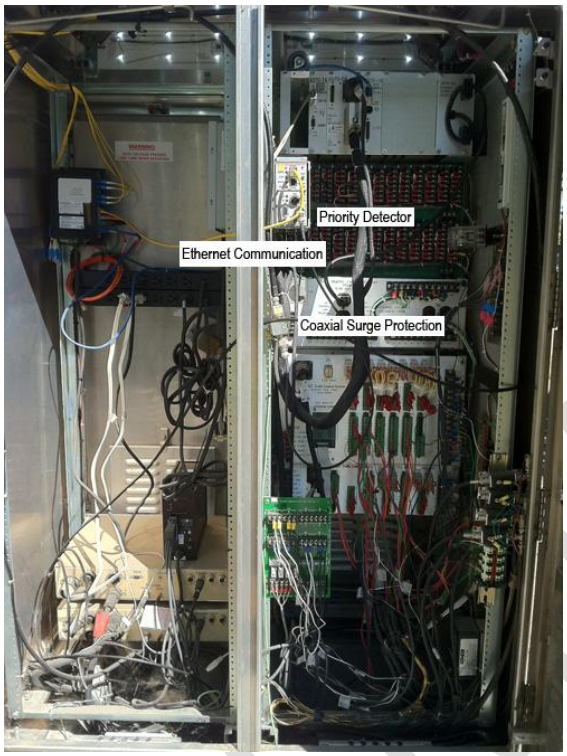


Figure 8: Wayside Equipment Mounted in a 332D Cabinet

Figure 8 shows the mounting location of the Emtrac Systems Standalone Case with mounting ears within a Model 332D Cabinet.

Testing

The original requirements called for a 90-day operational test period for evaluation, with Daily automated alarm reports and weekly samples of detection reports of at least 500 detections per train. However, limitations to VPN access caused a reduction in the testing period.

Test Results

The test results are based upon three sample periods reported previously in monthly accuracy verification meetings.

The sample periods are:
Period 1: August 19, 2011 through September 7, 2011
Period 2: September 8, 2011 through October 6, 2011
Period 3: October 12, 2011 through November 10, 2011

LRV Detections

	1st 30 Day Totals		2nd 30 Day Totals		3rd 30 Day Totals	
LRV	Actual Det.	Expected Det.	Actual Det.	Expected Det.	Actual Det.	Expected Det.
101	1064	1065	2136	2140	2181	2183
102	1074	1082	2200	2211	2180	2192
103	1078	1082	2199	2208	2178	2188
104	1067	1069	2200	2213	2150	2157
105	1076	1082	2200	2208	2145	2152
106	1085	1093	2199	2204	2151	2159
107	1079	1081	2198	2217	2185	2193
108	1074	1083	2193	2208	2194	2205
109	1079	1086	2189	2197	2155	2164
110	1072	1080	2199	2204	2191	2200
111	1082	1090	2200	2201	2198	2207
112	1077	1084	2198	2200	2179	2188
113	1070	1085	2198	2208	2181	2191
114	1074	1083	2197	2207	2197	2204
115	1076	1078	2200	2214	2199	2210
116	1077	1087	2161	2189	LRV Not Operational	
117	1076	1080	2152	2161	2180	2186
118	1076	1088	2146	2149	2168	2172
Total	**19356**	**19478**	**39365**	**39539**	**37012**	**37151**

Table 3: Cumulative Zone Detections per LRV

Table 3 shows the estimated and actual total number of times each LRV passed through all detection zones during the sample observation periods.

3rd 30 Day Zone Totals					
Zone	Detect	Miss	Zone	Detect	Miss
1	350	0	100	379	0
3	345	1	98	376	0
5	343	1	96	372	0
7	344	0	307	370	1
9	341	3	361	364	3
11	338	4	94	358	3
13	337	5	92	358	0
15	334	6	355	354	0
17	334	6	353	349	1
19	307	2	90	347	0
21	335	1	88	346	1
23	336	0	86	334	13
25	336	0	84	347	0
27	336	0	82	346	0
29	335	0	80	346	0
31	335	0	76	345	1
33	335	0	78	346	0
35	335	0	74	345	0
37	334	1	392	345	0
39	334	1	72	344	0
41	332	3	70	343	0
43	335	0	68	341	2
45	335	0	66	343	0
47	331	4	64	343	0
49	334	1	62	343	0
51	333	2	60	343	0
53	335	0	58	342	1
55	325	10	56	342	0
57	335	0	54	342	0
59	335	0	52	342	0
61	334	0	50	342	0
63	334	0	48	341	1
67	333	1	46	342	0
69	333	1	44	342	0

71	333	1	42	342	0
391	332	2	40	342	0
73	333	0	38	342	0
77	333	0	36	341	1
75	332	1	34	341	1
79	333	0	32	342	0
81	332	1	30	339	3
83	333	0	28	338	4
85	326	7	26	336	6
87	329	2	24	337	5
89	331	0	22	337	4
352	325	5	20	311	2
354	330	0	18	337	2
91	330	0	16	338	1
93	326	2	14	339	0
305	327	1	12	339	0
308	328	0	10	338	1
95	327	0	8	338	1
97	327	0	6	335	4
99	327	1	4	337	1
			2	336	0
			102	69	0
			101	14	0

Table 4: 3rd 30 day zone detections

Table 4 shows the last test periods ability to detect each detection zone. Northbound and Southbound detection zones are shown separately, for each intersection.

Bar Signal Overrun Alarms

Bar signal overrun alarms were detected and reported by e-mail nightly for each of the three test periods. These alarms were generated as a result of LRV operators passing a horizontal solid or horizontal flashing signal. The following morning METRO would pull DVR's from trains reporting unauthorized bypasses. Review of these DVR's would determine if unauthorized bypasses in the alarm reports were true or false.

1st 30 day Alarm Report by Vehicle				2nd 30 day Alarm Report by Vehicle				3rd 30 day Alarm Report by Vehicle			
LRV	TRUE	False	Indeterminate	LRV	TRUE	False	Indeterminate	LRV	TRUE	False	Indeterminate
101	9	0	0	101	51	0	0	101	29	2	0
102	15	0	0	102	59	0	1	102	39	0	0
103	35	0	0	103	87	0	0	103	41	0	0
104	69	0	0	104	42	0	0	104	37	0	0
105	39	0	0	105	30	0	1	105	54	0	0
106	20	2	0	106	41	0	0	106	45	0	0
107	16	0	0	107	39	0	0	107	45	0	0
108	62	0	0	108	47	2	0	108	37	0	0
109	28	0	0	109	41	0	0	109	35	0	0
110	31	0	0	110	117	0	0	110	29	0	0
111	35	1	0	111	52	1	0	111	43	0	0
112	27	2	0	112	55	0	0	112	40	1	0
113	33	1	0	113	56	0	0	113	39	1	0
114	21	0	0	114	37	0	0	114	39	1	0
115	14	1	0	115	53	0	0	115	42	2	0
116	22	2	0	116	32	2	0	116	0	0	0
117	25	0	0	117	51	0	0	117	46	0	0
118	68	0	2	118	60	4	0	118	30	0	0
Total	**569**	**9**	**2**	**Total**	**950**	**9**	**2**	**Total**	**670**	**7**	**0**

Table 5: Overrun Alarms by LRV

Table 5 shows the total number of overrun alarms that were generated by the system during each of the three periods per LRV.

1st 30 Day Zone Alarms				2nd 30 Day Zone Alarms				3rd 30 Day Zone Alarms			
Zone	TRUE	FALSE	Indeterminate	Zone	TRUE	FALSE	Indeterminate	Zone	TRUE	FALSE	Indeterminate
1	4	2	0	1	9	1	0	1	1	0	0
2	0	0	0	2	2	1	0	2	1	0	0
3	19	0	0	3	4	0	0	3	1	0	0
4	0	0	0	4	3	1	0	4	0	0	0
5	5	0	0	5	4	0	0	5	0	2	0
6	6	0	0	6	4	0	0	6	5	0	0
7	4	0	0	7	5	0	0	7	2	1	0
8	3	0	0	8	8	0	0	8	5	0	0
9	4	0	0	9	2	0	0	9	1	0	0
10	1	0	0	10	1	0	0	10	1	0	0
11	5	0	0	11	4	0	0	11	0	0	0
12	3	0	0	12	3	0	0	12	0	0	0
13	47	0	0	13	57	0	0	13	0	0	0
14	4	0	0	14	3	0	0	14	0	0	0
15	2	0	0	15	2	0	0	15	0	0	0
16	31	0	0	16	4	0	0	16	0	0	0
17	7	0	0	17	3	1	0	17	2	0	0
18	7	0	0	18	5	0	0	18	0	0	0
19	3	0	0	19	2	0	0	19	1	1	0
20	3	0	0	20	4	0	0	20	1	0	0
21	2	0	0	21	4	0	0	21	0	0	0
22	4	0	0	22	4	0	1	22	0	1	0
23	0	0	0	23	2	0	0	23	0	0	0
24	3	1	0	24	12	1	0	24	3	0	0
25	3	0	0	25	4	0	0	25	0	0	0
26	1	0	0	26	8	0	0	26	0	0	0
27	6	0	0	27	3	0	0	27	1	0	0
28	1	1	0	28	5	0	0	28	0	0	0
29	4	0	0	29	11	0	0	29	4	0	0
30	3	0	0	30	5	0	0	30	1	0	0
31	3	0	0	31	4	0	0	31	1	0	0
32	3	0	0	32	7	0	0	32	1	0	0
33	3	0	0	33	2	0	0	33	0	0	0
34	4	0	0	34	5	0	0	34	0	0	0
35	6	0	0	35	4	0	0	35	0	0	0
36	2	0	0	36	5	0	0	36	0	0	0
37	34	1	0	37	17	0	0	37	16	0	0
38	1	0	2	38	7	0	0	38	0	0	0
39	35	0	0	39	28	0	0	39	18	0	0
40	1	0	0	40	6	1	0	40	0	0	0
41	30	0	0	41	17	0	0	41	3	0	0
42	2	0	0	42	16	0	0	42	1	0	0
43	5	0	0	43	3	1	0	43	4	0	0
44	6	0	0	44	7	0	0	44	3	0	0
45	0	0	0	45	0	0	0	45	4	0	0
46	1	0	0	46	3	0	0	46	3	0	0
47	16	0	0	47	17	0	0	47	31	0	0
48	0	0	0	48	2	0	0	48	5	0	0
49	0	0	0	49	12	0	0	49	4	0	0
50	4	0	0	50	39	0	0	50	39	0	0
51	0	0	0	51	1	0	0	51	3	0	0
52	1	0	0	52	13	0	0	52	1	0	0
53	0	0	0	53	0	0	0	53	0	0	0
54	6	0	0	54	0	0	0	54	0	0	0
55	1	0	0	55	0	0	0	55	0	0	0
56	0	0	0	56	0	0	0	56	0	0	0
58	4	0	0	58	0	0	0	58	0	0	0
59	0	0	0	59	0	0	0	59	0	0	0
60	2	0	0	60	1	0	0	60	0	0	0
61	0	0	0	61	0	0	0	61	0	0	0
62	1	0	0	62	2	0	0	62	3	0	0
63	0	0	0	63	0	0	0	63	0	0	0
64	2	0	0	64	2	0	0	64	0	0	0

66	1	0	0	66	2	0	0	66	6	0	0
67	1	0	0	67	1	0	0	67	1	0	0
68	1	0	0	68	0	0	0	68	2	1	0
69	0	0	0	69	2	0	0	69	1	0	0
70	1	0	0	70	2	0	0	70	2	1	0
71	0	0	0	71	2	0	0	71	0	0	0
72	1	0	0	72	2	0	0	72	0	0	0
73	0	0	0	73	0	0	0	73	2	0	0
74	0	0	0	74	0	0	0	74	0	0	0
75	2	1	0	75	30	0	0	75	1	0	0
76	2	0	0	76	74	0	0	76	3	0	0
77	24	0	0	77	18	0	0	77	47	0	0
78	18	0	0	78	7	0	0	78	39	0	0
79	8	0	0	79	23	0	0	79	31	0	0
80	5	1	0	80	27	0	0	80	33	0	0
81	1	0	0	81	2	0	0	81	0	0	0
82	0	0	0	82	1	0	0	82	1	0	0
83	2	0	0	83	5	0	0	83	16	0	0
84	23	0	0	84	20	0	0	84	25	0	0
85	12	0	0	85	28	0	0	85	37	0	0
86	63	0	0	86	102	0	1	86	20	0	0
87	5	0	0	87	32	1	0	87	32	0	0
88	16	0	0	88	93	0	0	88	20	0	0
89	0	1	0	89	0	0	0	89	84	0	0
90	1	0	0	90	0	0	0	90	40	0	0
91	0	0	0	91	0	0	0	91	0	0	0
92	0	0	0	92	0	1	0	92	0	0	0
93	0	0	0	93	0	0	0	93	0	0	0
94	0	0	0	94	2	0	0	94	0	0	0
95	5	0	0	95	13	0	0	95	10	0	0
96	2	0	0	96	5	0	0	96	3	0	0
307	12	1	0	307	38	0	0	307	38	0	0
308	0	0	0	308	4	0	0	308	2	0	0
391	4	0	0	391	4	0	0	391	4	0	0
392	1	0	0	392	4	0	0	392	0	0	0
Total	**569**	**9**	**2**	**Total**	**950**	**9**	**2**	**Total**	**670**	**7**	**0**

Table 6: Overrun alarms by alarm detection zone

Table 6 shows the total number of overrun alarms that were generated by the system during each of the three periods per alarm detection zone.

Statistical Composite

Detection Accuracy

Vehicle detection accuracy measures the reliability of LRV detection at each zone. Since the path of the train is known, it can be expected to travel past test intersections in a certain sequence. By reviewing the logs in chronological order, missed detections are identified by missing zones in the sequence of the logs. All missing zones are counted, even though they may have resulted from any number of causes, such as a variation from normal operations, a power interruption at the intersection, or connecting two LRVs somewhere other than the Rail Operating Facility. Based upon these variances and the pattern of some missed detections, it is suspected that the true accuracy of detection is likely to be significantly greater than values reported.

Multiple detections are identified by multiple sequential listings of detection for a given zone. Multiple detections are fairly common, but they are normally filtered out by the system. Any multiple detections at intersection zones during the entire test period were removed from detection logs prior to accuracy calculation.

90 Day Detection Accuracy		
Actual Det.	Expected Det.	Accuracy
5381	5388	99.87%
5454	5485	99.43%
5455	5478	99.58%
5417	5439	99.60%
5421	5442	99.61%
5435	5456	99.62%
5462	5491	99.47%
5461	5496	99.36%
5423	5447	99.56%
5462	5484	99.60%
5480	5498	99.67%
5454	5472	99.67%
5449	5484	99.36%
5468	5494	99.53%
5475	5502	99.51%
3238	3276	98.84%
5408	5427	99.65%
5390	5409	99.65%
95733	**96168**	**99.55%**

Table 7: Vehicle Detection Accuracy

Table 7 is a summary of detection accuracy, by LRV, for all three observation periods. The calculated detection accuracy was 99.55%.

3rd 30 Day Zone Accuracy			
Zone	Accuracy	Zone	Accuracy
1	100.00%	100	100.00%
3	99.71%	98	100.00%
5	99.71%	96	100.00%
7	100.00%	307	99.73%
9	99.13%	361	99.18%
11	98.83%	94	99.17%
13	98.54%	92	100.00%
15	98.24%	355	100.00%
17	98.24%	353	99.71%
19	99.35%	90	100.00%
21	99.70%	88	99.71%
23	100.00%	86	96.25%
25	100.00%	84	100.00%
27	100.00%	82	100.00%
29	100.00%	80	100.00%
31	100.00%	76	99.71%
33	100.00%	78	100.00%
35	100.00%	74	100.00%
37	99.70%	392	100.00%
39	99.70%	72	100.00%
41	99.10%	70	100.00%
43	100.00%	68	99.42%
45	100.00%	66	100.00%
47	98.81%	64	100.00%
49	99.70%	62	100.00%
51	99.40%	60	100.00%
53	100.00%	58	99.71%
55	97.01%	56	100.00%
57	100.00%	54	100.00%
59	100.00%	52	100.00%
61	100.00%	50	100.00%

63	100.00%	48	99.71%
67	99.70%	46	100.00%
69	99.70%	44	100.00%
71	99.70%	42	100.00%
391	99.40%	40	100.00%
73	100.00%	38	100.00%
77	100.00%	36	99.71%
75	99.70%	34	99.71%
79	100.00%	32	100.00%
81	99.70%	30	99.12%
83	100.00%	28	98.83%
85	97.90%	26	98.25%
87	99.40%	24	98.54%
89	100.00%	22	98.83%
352	98.48%	20	99.36%
354	100.00%	18	99.41%
91	100.00%	16	99.71%
93	99.39%	14	100.00%
305	99.70%	12	100.00%
308	100.00%	10	99.71%
95	100.00%	8	99.71%
97	100.00%	6	98.82%
99	99.70%	4	99.70%
		2	100.00%
		102	100.00%
		101	100.00%
		Total	**99.63%**

Table 8: Vehicle Detection Accuracy By Zone

Table 8 is a summary of detection accuracy, by intersection zone, for both Northbound and Southbound zones of all Redline intersections for the last 30 day test period. The calculated detection accuracy was 99.63%.

Alarm Accuracy

Alarm accuracy determined below occurred over the entire test period.

90 day Alarm Report by Vehicle				
LRV	TRUE	False	Indeterminate	Vehicle Acc.
101	89	2	0	97.80%
102	113	0	1	100.00%
103	163	0	0	100.00%
104	148	0	0	100.00%
105	123	0	1	100.00%
106	106	2	0	98.15%
107	100	0	0	100.00%
108	146	2	0	98.65%
109	104	0	0	100.00%
110	177	0	0	100.00%
111	130	2	0	98.48%
112	122	3	0	97.60%
113	128	2	0	98.46%
114	97	1	0	98.98%
115	109	3	0	97.32%
116	54	4	0	93.10%
117	122	0	0	100.00%
118	158	4	2	97.53%
Total	**2189**	**25**	**4**	**98.87%**

Table 9: Cumulative alarm accuracy per LRV

Table 9 shows cumulative alarm accuracy per LRV.

90 Day Zone Alarms				
Zone	TRUE	FALSE	Indeterminate	Zone Acc.
1	14	3	0	82.35%
2	3	1	0	75.00%
3	24	0	0	100.00%
4	3	1	0	75.00%
5	9	2	0	81.82%
6	15	0	0	100.00%
7	11	1	0	91.67%
8	16	0	0	100.00%
9	7	0	0	100.00%
10	3	0	0	100.00%
11	9	0	0	100.00%
12	6	0	0	100.00%
13	104	0	0	100.00%
14	7	0	0	100.00%
15	4	0	0	100.00%
16	35	0	0	100.00%
17	12	1	0	92.31%
18	12	0	0	100.00%
19	6	1	0	85.71%
20	8	0	0	100.00%
21	6	0	0	100.00%
22	8	1	1	88.89%
23	2	0	0	100.00%
24	18	2	0	90.00%
25	7	0	0	100.00%
26	9	0	0	100.00%
27	10	0	0	100.00%
28	6	1	0	85.71%
29	19	0	0	100.00%
30	9	0	0	100.00%
31	8	0	0	100.00%
32	11	0	0	100.00%
33	5	0	0	100.00%
34	9	0	0	100.00%
35	10	0	0	100.00%
36	7	0	0	100.00%
37	67	1	0	98.53%
38	8	0	2	100.00%
39	81	0	0	100.00%
40	7	1	0	87.50%
41	50	0	0	100.00%
42	19	0	0	100.00%
43	12	1	0	92.31%
44	16	0	0	100.00%
45	4	0	0	100.00%
46	7	0	0	100.00%
47	64	0	0	100.00%
48	7	0	0	100.00%
49	16	0	0	100.00%
50	82	0	0	100.00%
51	4	0	0	100.00%
52	15	0	0	100.00%
53	0	0	0	-
54	6	0	0	100.00%
55	1	0	0	100.00%
56	0	0	0	-
58	4	0	0	100.00%
59	0	0	0	-
60	3	0	0	100.00%
61	0	0	0	-
62	6	0	0	100.00%
63	0	0	0	-
64	4	0	0	100.00%
66	9	0	0	100.00%
67	3	0	0	100.00%
68	3	1	0	75.00%
69	3	0	0	100.00%
70	5	1	0	83.33%
71	2	0	0	100.00%

72	3	0	0	100.00%
73	2	0	0	100.00%
74	0	0	0	-
75	33	1	0	97.06%
76	79	0	0	100.00%
77	89	0	0	100.00%
78	64	0	0	100.00%
79	62	0	0	100.00%
80	65	1	0	98.48%
81	3	0	0	100.00%
82	2	0	0	100.00%
83	23	0	0	100.00%
84	68	0	0	100.00%
85	77	0	0	100.00%
86	185	0	1	100.00%
87	69	1	0	98.57%
88	129	0	0	100.00%
89	84	1	0	98.82%
90	41	0	0	100.00%
91	0	0	0	-
92	0	1	0	0.00%
93	0	0	0	-
94	2	0	0	100.00%
95	28	0	0	100.00%
96	10	0	0	100.00%
307	88	1	0	98.88%
308	6	0	0	100.00%
391	12	0	0	100.00%
392	5	0	0	100.00%
Total	**2189**	**25**	**4**	**98.87%**

Table 10: Cumulative alarm accuracy per alarm detection zone

Table 10 shows cumulative alarm accuracy per alarm detection zone.

Conclusions

The system meets the minimum requirement of 98% average detection accuracy.
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