Using Archived Intelligent Transportation Systems (ITS) Data for Transit Operations, Planning and Scheduling: The Tri-Met Experience.

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Tri-Met System Information

- 105 Bus Lines
- 2 Light Rail Lines
- 825 Vehicles
- 9,000 Bus Stops
- 50 Light Rail Stops
- 270,000 Weekday Boardings

Tri-Met Bus Dispatch System (BDS)

- Activated October, 1996
- Smart "Magic" Buses
  - Automatic Vehicle Location (AVL)
    - GPS-based locational referencing system
    - Fleet 100% AVL equipped
  - Automatic Passenger Counter (APC)
    - Fleet 50% APC equipped
  - On-Board Interface Unit (OBIU)
    - Schedule deviation
    - Pre-coded messages to dispatch
  - 2 Way Radio Communication
- Computer Aided Dispatch (CAD)
  - Dispatch consoles

Stop Records

- Route
- Direction
- Trip
- Date
- Vehicle ID
- Operator ID
- Stop Location
- Actual Arrive Time
- Actual Leave Time
- Scheduled Leave Time

- Ons (Boardings)
- Offs (Alightings)
- Passenger Load
- Door Opening
- Lift Operation
- Dwell Time
- Maximum Speed
- Latitude
- Longitude

Recorded at every bus stop or door opening (automatic collection)
500,000 daily stop records generated

Event Records

- Pass Up / Overload
- Traffic Delay
- Bridge / Train Delay
- Deadhead Delay
- Route Blocked
- Silent Alarm
- Accident
- Medical Emergency
- Fare Evasion
- Securement Refused
- Bill/Coin Jam
- Mechanical: Blocking/Danger
- Mechanical: Lift Problem
- Restroom break
- Operator Ill
- Etc.

Recorded at various locations (operator-initiated collection)
25,000 daily event records generated

CardRep - Notepad

File Edit Search Help

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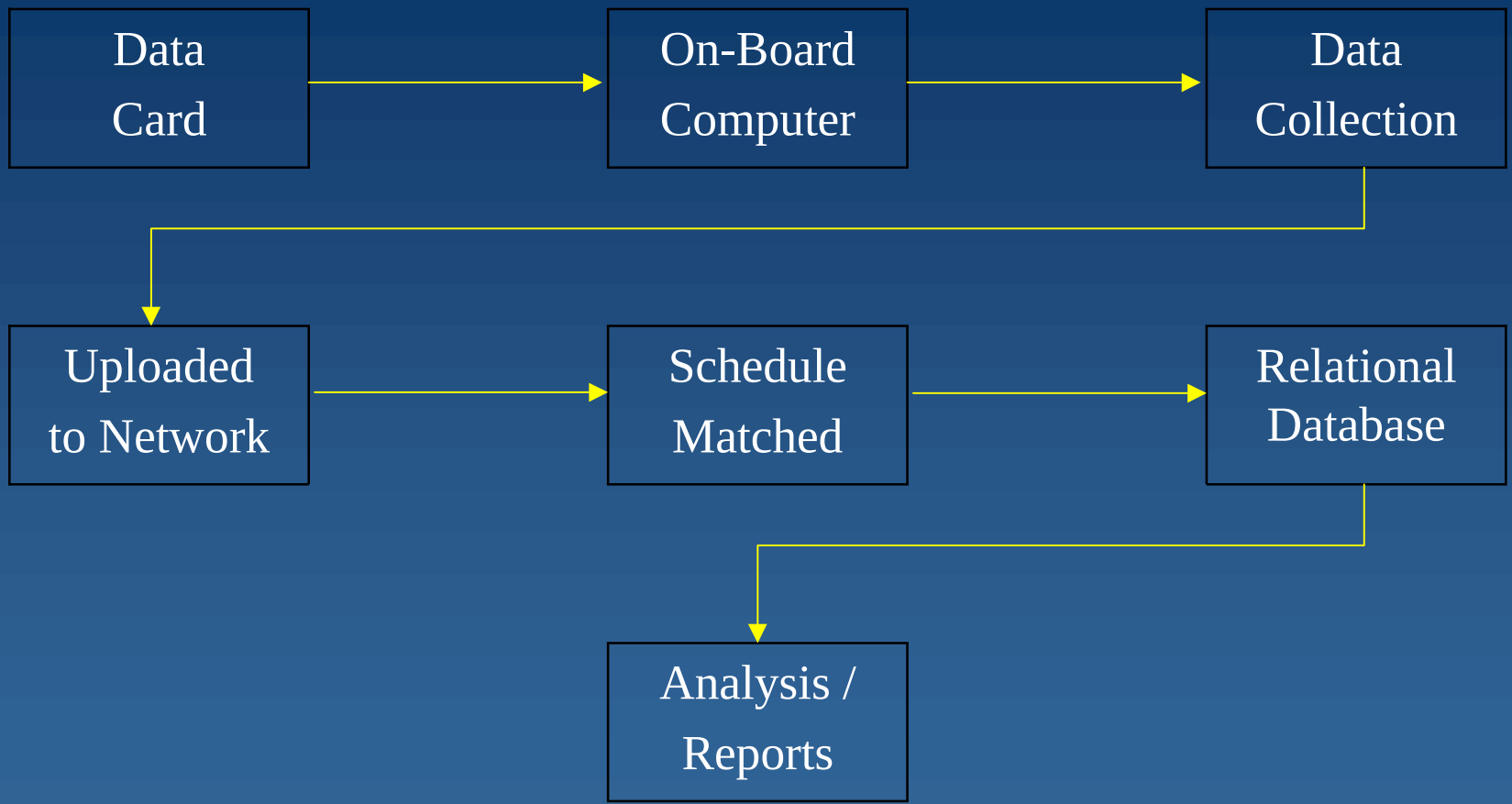
■BUS= 2134  TRAIN=  1401  DATE=20000313

STOP ID  STOP NAME                    ARRIVE    LEAVE ON OFF MI FT N  FT E D L DWEL SPD LOD

 9302 5TH & HOYT              (OP) 16:25:02 16:25:04  0   0  0                0 0      17   2
    0 unscheduled stop             16:25:06 16:25:08  0   0  0  -868     28 1 0    1  3   2
 9222 5TH & EVERETT           (NS) 16:25:08 16:25:52  2   0  1                0 0      18   4
 9303 5TH & COUCH             (NS) 16:26:04 16:26:40  8   0  1   -10      6 1 0   21 20  12
 7631 5TH & PINE              (OP) 16:27:14 16:28:28  4   1  1     2      5 1 0   45 19  15
       Scheduled times -------->   16:28:00 16:28:00
 7635 5TH & STARK             (FS) 16:28:30 16:29:52  3   0  1   -42      2 1 0   17 17  18
 7585 5TH & ALDER             (FS) 16:29:58 16:31:26  6   2  2     8     14 1 0   24 16  22
 7645 5TH & YAMHILL           (FS) 16:31:28 16:31:46  0   0  0                0 0      15  22
 7633 5TH & SALMON            (FS) 16:31:50 16:33:24 15   2  1   143     80 1 0   34 20  35
       Scheduled times -------->   16:33:00 16:33:00
 3639 MADISON & 4TH           (FS) 16:33:46 16:35:24  8   0  2   -14     59 1 0   22 15  43
       time=16:36:02; Fare Evasion.
 3635 MADISON & 1ST           (NS) 16:36:10 16:36:16  0   0  2                0 0      24  48
 2641 HAWTHORNE BRIDGE & EAST (AT) 16:37:16 16:37:38  0   2  4    28     60 1 0    7 30  46
    0 unscheduled stop             16:38:50 16:39:02  0   1  2    47   1119 1 0    5 29  45
 2594 HAWTHORNE & 6TH         (NS) 16:39:02 16:39:08  0   0  0                0 0      15  45
 2597 HAWTHORNE & 9TH         (NS) 16:40:04 16:40:28  1   1  2    10     23 1 0    6 24  45
 2599 HAWTHORNE & 12TH        (NS) 16:41:28 16:42:04  3   5  2    -2      8 1 0   18 23  43
       Scheduled times -------->   16:39:00 16:39:00
 2595 HAWTHORNE & MAPLE       (FS) 16:42:10 16:42:16  0   0  1                0 0      31  43
 2603 HAWTHORNE & 16TH        (FS) 16:42:22 16:42:56  0   5  1     8    -12 1 0    9 29  38
 2596 HAWTHORNE & POPLAR      (NS) 16:42:58 16:43:24  0   1  1    23   -100 1 0    4 21  37
 2607 HAWTHORNE & 20TH        (FS) 16:43:50 16:44:10  0   1  1                0 0      22  36
 2608 HAWTHORNE & 23RD        (NS) 16:44:20 16:44:26  0   0  1                0 0      31  36
 2612 HAWTHORNE & 25TH        (FS) 16:44:30 16:44:56  0   2  1     6     31 1 0    5 32  34
 2614 HAWTHORNE & 28TH        (OP) 16:45:12 16:45:44  1   3  2    12     29 1 0   15 21  32
 2615 HAWTHORNE & 30TH        (NS) 16:45:54 16:46:00  0   0  1                0 0      28  32
 2617 HAWTHORNE & 32ND PL     (FS) 16:46:16 16:46:44  0   3  2     1     -3 1 0    6 29  29
 2620 HAWTHORNE & 34TH        (FS) 16:46:50 16:47:28  1   3  1     2     32 1 0   11 19  27
 2623 HAWTHORNE & 37TH        (FS) 16:48:00 16:48:24  0   2  2     1    -85 1 0    5 26  25
 2625 HAWTHORNE & 39TH        (NS) 16:49:16 16:50:38  1   9  1    11    -80 1 0   12 22  17
```

Data Collection and Archiving Process



Agency Uses of BDS Data

- Real-Time Data
  - Operations
  - Dispatch
  - Security
- Archived Data
  - Performance Monitoring
  - Scheduling
  - Service Planning
  - Field Supervision
  - Project Development
  - Maintenance
  - Customer Service
  - Legal
  - Training

Scheduling

- *Concerned with implementing the service design- assignment of revenue vehicles and development of individual work schedules (runs)*
- Key inputs related to run times and passenger loads
- Schedule efficiency down approx. 3% since 1982 due to more variable operating conditions

Definitions

- Run time- amount of time taken for a bus to traverse between 2 points
- Headway- relative spacing between buses passing a single point
- On-time- bus departure between 1 minute early and 5 minutes late (discreet)
- Departure delay- actual departure time minus scheduled departure time (continuous)
- Trip- single bus run from route origin to route destination
- Tripper- bus brought on line during peak periods to complete 1 trip

APRIL 2000 SIGNUP - Run Time Data

Includes Analysis of Locations Where Operators are Killing Time

March 6, 2000 to April 12, 2000

Current Scheduled Run Times

Median Trip Level Run Times (mm:ss)

Actual Run Time By Date

Median vs. Sched. Run Times

mm:ss

Difference Between Killing Time and Non Killing Time

Average Run Time - Median Run Time

Average Trip Level Run Times (mm:ss)

Average vs. Sched. Run Times

mm:ss

View Run Time Graph

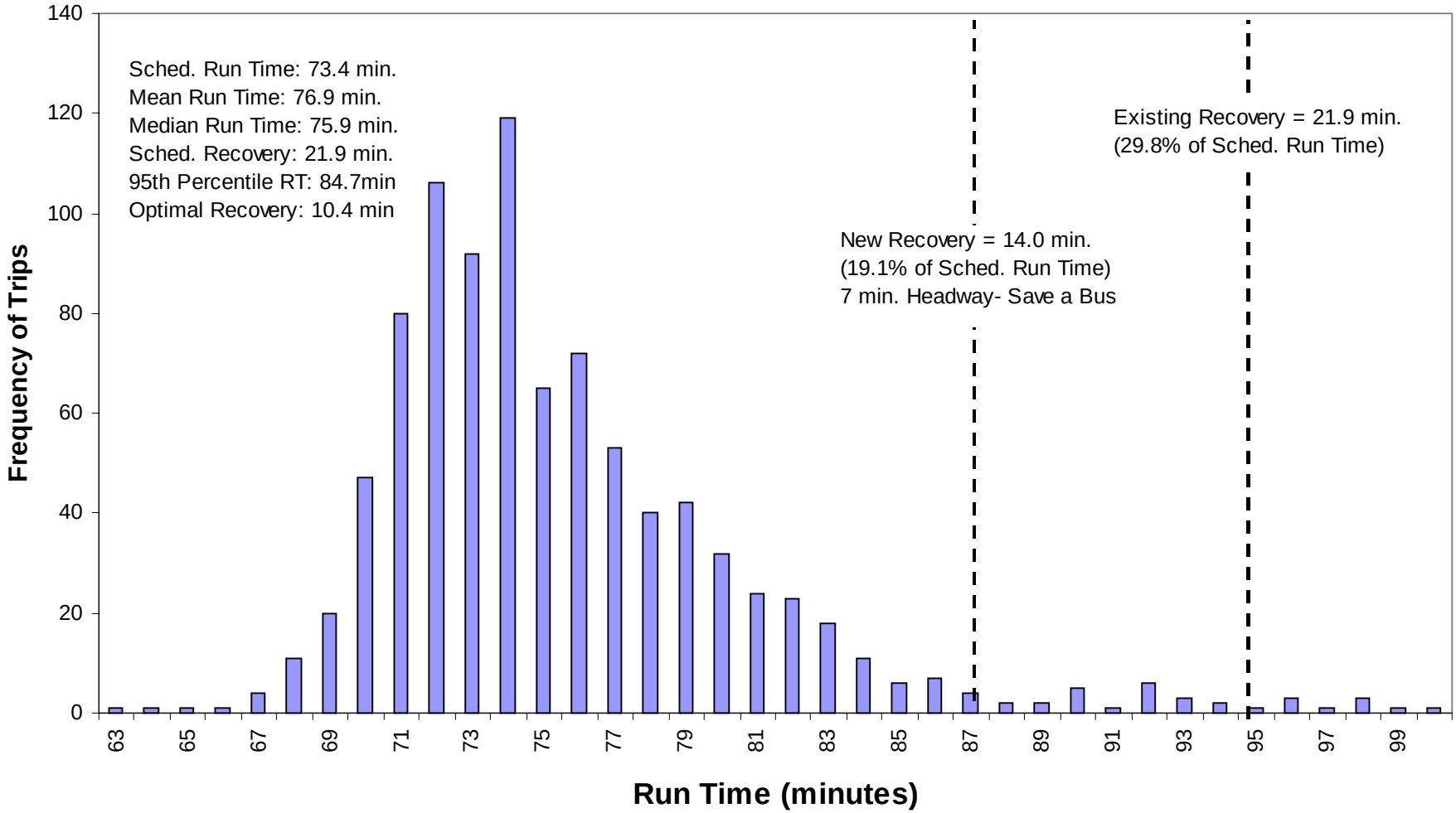
Exit SWAP Database

STOP

Running Time Analysis Report
[Example Trip]

	_Seg. 1	_Seg. 2	_Seg. 3	_Seg. 4	_Seg.5	_Total
Sched.	10:00	12:00	5:00	9:00	6:00	42:00
Mean RT	13:05	9:38	5:39	8:12	7:18	42:52
Median RT	12:44	9:20	5:34	7:41	6:49	42:18
Std Dev.	2:38	1:38	0:48	2:58	2:09	5:12
Avg. Mph	28	49	37	52	33	52
Max. Load	43	45	31	15	18	43

Run Time Distribution: PM Peak
[72] Killingsworth - 82nd Ave: East/South



Operators Leaving the End of the Line Late by More than 3 Minutes after an Adequate Layover (Sorted by Operator and District)

May 15, 2000 - May 26, 2000

Supervisor District: 6 PM Shift

Badge and Operator	Line/Train	Beginning of Line Location	Direction	Sched. Time	% of Time Late	Min. Late*
128 Operator Name	3107	NORTH TERMINAL / NOT A STOP	Out	7:09 PM	33%	04:29
162	5411	NORTH TERMINAL / NOT A STOP	Out	7:35 PM	38%	03:37
162	5411	NORTH TERMINAL / NOT A STOP	Out	9:35 PM	50%	03:48
162	5411	NORTH TERMINAL / NOT A STOP	Out	12:35 AM	38%	04:09
233	5412	NORTH TERMINAL / NOT A STOP	Out	11:35 PM	29%	04:19
355	3205	NORTH TERMINAL / NOT A STOP	Out	5:28 PM	50%	05:23
483	1409	NORTH TERMINAL / NOT A STOP	Out	6:43 PM	60%	04:27
483	1409	NORTH TERMINAL / NOT A STOP	Out	8:29 PM	40%	07:00
483	1409	NORTH TERMINAL / NOT A STOP	Out	10:16 PM	60%	06:27
633	1414	NORTH TERMINAL / NOT A STOP	Out	6:20 PM	33%	07:29
633	1414	NORTH TERMINAL / NOT A STOP	Out	8:14 PM	100%	05:11
633	1414	NORTH TERMINAL / NOT A STOP	Out	10:01 PM	100%	09:25
633	1414	NORTH TERMINAL / NOT A STOP	Out	11:46 PM	83%	07:22
696	1407	NORTH TERMINAL / NOT A STOP	Out	5:02 PM	67%	04:16
696	1407	NORTH TERMINAL / NOT A STOP	Out	6:58 PM	83%	04:56
696	1407	NORTH TERMINAL / NOT A STOP	Out	8:44 PM	67%	05:38
696	1407	NORTH TERMINAL / NOT A STOP	Out	10:31 PM	83%	06:00
697	1404	NORTH TERMINAL / NOT A STOP	Out	9:00 PM	40%	05:45
887	5402	NORTH TERMINAL / NOT A STOP	Out	8:05 PM	38%	06:08
1090	5406	NORTH TERMINAL / NOT A STOP	Out	3:09 PM	40%	03:52
1168	3106	NORTH TERMINAL / NOT A STOP	Out	3:09 PM	100%	03:55
1693	3501	NORTH TERMINAL / NOT A STOP	Out	3:54 PM	50%	03:34
1736	1401	NORTH TERMINAL / NOT A STOP	Out	4:23 PM	33%	03:38

Current Research: Run Time

- **Run Time Variation Analysis (in process)**
  - Study focuses on determinants of run time variation
  - Route-level analysis, variance generated over multiple trips
  - Run time variation= f(sched. headway, route char., passenger activity, delay events, route type, direction, time period

- **Operator Behavior Study (in process)**
  - Want to determine whether operator behavior influences run times
  - Fixed-effects model- dummy variable for each operator
  - Trip-level analysis, min. 10 trips per operator
  - Actual run time = f(sched. headway, route char., passenger activity, operator char., delay events, route typology, direction, time period
    - Operator char. = badge #, length of service, operator type, depart late from terminal

Operations Planning

- *Concerned with matching ridership to service levels subject to policy and budget constraints*
- Key inputs related to passenger loads, bus performance, bus productivity
- Route performance reports generated at route and trip-level on quarterly basis
- Passenger census generated at route, trip, and time point-level
  - Passenger census used to be undertaken every 5 years measuring a single trip, now conducted on quarterly basis using numerous trips

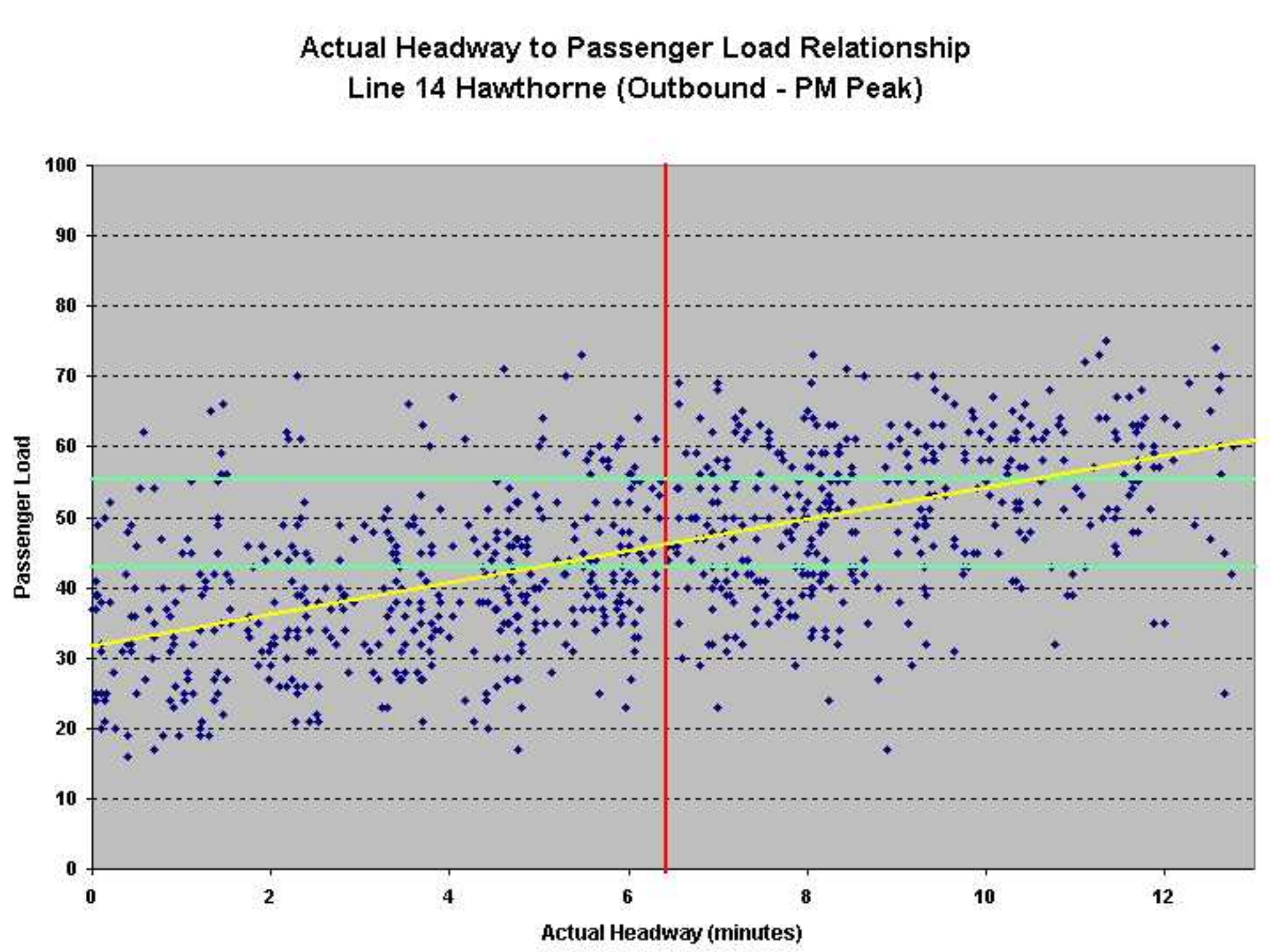
Route: 014 - Hawthorne **Weekdays** **December 5, 1999 to March 4, 2000**

Direction: Outbound to Foster & 94th

Start Time	Train	Start Location	Boarding Rides	Max Load	Max Load Factor	Percent Over Capacity	# of Pass Ups	APC Obs.	Sched. Run Time h:mm:ss	Median Run Time h:mm:ss	Run Time Ratio	Run Time CV	Median Speed mph	Sched. Recovery mm:ss	Median Recovery mm:ss	On Time	Early	Late
5:13 PM	1404	NW 5th & Hoyt	47	36	85%	10%	1	62	0:43:00	0:47:09	110%	10%	10.5	25:00	19:34	55%	3%	42%
5:19 PM	1411	NW 5th & Hoyt	55	37	86%	11%		19	0:43:00	0:47:22	110%	8%	10.5			61%	2%	37%
5:25 PM	1406	NW 5th & Hoyt	67	46	108%	17%	9	63	0:43:00	0:53:04	123%	12%	9.4			61%	1%	38%
5:31 PM	1405	NW 5th & Hoyt	64	49	114%	35%	6	62	0:43:00	0:46:14	108%	10%	10.7	22:00	16:56	58%	1%	41%
5:40 PM	1402	NW 5th & Hoyt	72	53	124%	56%	1	62	0:43:00	0:47:18	110%	8%	10.5	28:00	22:10	62%	0%	38%
5:50 PM	1412	NW 5th & Hoyt	70	45	104%	35%	8	17	0:43:00	0:47:07	110%	10%	10.5			61%	2%	37%
6:00 PM	1408	NW 5th & Hoyt	67	52	120%	42%	1	60	0:43:00	0:45:26	106%	9%	10.9	23:00	18:12	70%	1%	29%
6:10 PM	1410	NW 5th & Hoyt	61	37	85%	0%	1	14	0:40:00	0:42:24	106%	10%	11.7			65%	4%	31%
6:20 PM	1414	NW 5th & Hoyt	63	45	105%	22%	4	54	0:40:00	0:44:48	112%	8%	11.1	21:00	14:56	54%	1%	45%
6:30 PM	1415	NW 5th & Hoyt	45	31	71%	0%		17	0:38:00	0:40:50	107%	9%	12.2			64%	1%	35%
6:43 PM	1409	NW 5th & Hoyt	59	43	99%	3%		59	0:38:00	0:41:28	109%	10%	12.0	15:00	09:10	64%	1%	35%
6:58 PM	1407	NW 5th & Hoyt	58	41	96%	7%		60	0:38:00	0:42:41	112%	10%	11.6	15:00	07:58	48%	1%	52%
7:13 PM	1404	NW 5th & Hoyt	50	36	83%	3%		62	0:38:00	0:37:16	98%	13%	13.3	15:00	14:56	56%	5%	38%
7:28 PM	1405	NW 5th & Hoyt	44	34	78%	0%		61	0:38:00	0:41:02	108%	8%	12.1	17:00	12:24	78%	2%	21%
7:44 PM	1402	NW 5th & Hoyt	43	30	70%	0%		62	0:35:00	0:38:04	109%	10%	13.1	19:00	14:54	75%	0%	25%
7:59 PM	1408	NW 5th & Hoyt	43	31	73%	0%		60	0:35:00	0:38:30	110%	11%	12.9	19:00	13:27	53%	0%	47%
8:14 PM	1414	NW 5th & Hoyt	41	28	66%	0%		53	0:35:00	0:40:13	115%	11%	12.4	19:00	13:02	47%	0%	53%
8:29 PM	1409	NW 5th & Hoyt	32	24	55%	0%		59	0:35:00	0:37:49	108%	11%	13.1	19:00	14:58	69%	1%	31%
8:44 PM	1407	NW 5th & Hoyt	38	25	59%	0%		58	0:35:00	0:37:26	107%	12%	13.3	19:00	13:20	49%	1%	50%
9:00 PM	1404	NW 5th & Hoyt	41	27	64%	0%		62	0:35:00	0:36:28	104%	11%	13.6	18:00	13:42	51%	3%	45%
9:16 PM	1405	NW 5th & Hoyt	47	34	78%	2%		62	0:35:00	0:38:00	109%	8%	13.1	17:00	13:28	68%	0%	32%
9:31 PM	1402	NW 5th & Hoyt	39	28	64%	0%		62	0:35:00	0:37:10	106%	7%	13.4	17:00	14:44	82%	0%	17%
9:46 PM	1408	NW 5th & Hoyt	42	32	73%	0%		60	0:35:00	0:37:13	106%	7%	13.4	17:00	13:49	78%	0%	22%

Sorted by Total Excess Wait Time by Trip (Weighted by Boarding Rides)

	Trips	Boarding Rides	Rides/ Rev.Hr	Max Load	Load Factor	% Over Capacity	# of Passups	On Time	Early	Late	Sched. Headway hours/min	Headway CV	Excess Wait Time min/sec	Wait Time Per Trip hours/min
075 - 39th Avenue-Lombard (Outbound) - PM Peak	10	750	52.3	28	72%	0%	2	69%	6%	25%	0:11	43%	00:59	1:13
075 - 39th Avenue-Lombard (Inbound) - PM Peak	10	771	56.6	28	71%	0%	1	74%	7%	20%	0:11	42%	00:55	1:10
072 - Killingsworth-82nd Ave (Inbound) - PM Peak	15	1,256	68.4	31	81%	1%	9	77%	10%	13%	0:08	50%	00:50	1:09
012 - Barbur Blvd (Outbound) - PM Peak	18	771	45.7	33	76%	4%	8	71%	7%	22%	0:07	82%	01:29	1:03
119 - Woodstock (Outbound) - PM Peak	9	381	46.0	37	89%	4%	14	52%	8%	40%	0:13	51%	01:26	1:00
071 - 60th-122nd Ave (Outbound) - PM Peak	9	624	49.8	23	53%	0%	0	78%	6%	17%	0:14	35%	00:49	0:56
057 - TV Hwy / Forest Grove (Outbound) - PM Peak	8	498	60.0	30	70%	0%	1	70%	17%	12%	0:14	36%	00:53	0:55
117 - Holgate (Outbound) - PM Peak	10	461	51.1	36	83%	2%	2	47%	7%	47%	0:12	46%	01:08	0:52
072 - Killingsworth-82nd Ave (Inbound) - AM Peak	12	825	63.4	30	77%	2%	20	83%	9%	8%	0:09	41%	00:46	0:52
072 - Killingsworth-82nd Ave (Inbound) - Midday	46	3,556	67.8	32	83%	3%	24	82%	11%	7%	0:09	40%	00:40	0:51
072 - Killingsworth-82nd Ave (Outbound) - PM Peak	16	1,251	63.2	30	78%	2%	6	74%	13%	14%	0:08	45%	00:40	0:51
109 - Powell (Inbound) - PM Peak	10	577	76.3	31	71%	2%	2	83%	4%	14%	0:12	38%	00:53	0:50
006 - ML King Jr Blvd (Outbound) - PM Peak	9	431	60.2	35	82%	3%	1	71%	8%	21%	0:13	43%	01:04	0:50
005 - Interstate (Inbound) - PM Peak	10	536	91.4	32	73%	5%	3	82%	3%	15%	0:12	42%	00:54	0:48
014 - Hawthorne (Outbound) - PM Peak	20	1,177	82.0	44	102%	22%	57	54%	1%	45%	0:07	59%	00:50	0:48
072 - Killingsworth-82nd Ave (Outbound) - Midday	45	3,239	63.5	29	75%	1%	14	78%	9%	13%	0:09	39%	00:39	0:47
009 - Broadway (Outbound) - PM Peak	10	387	67.1	38	88%	5%	4	64%	8%	28%	0:12	44%	01:11	0:45
099 - McLoughlin Express (Outbound) - PM Peak	8	321	52.0	36	86%	5%	6	66%	6%	28%	0:16	38%	01:07	0:45
075 - 39th Avenue-Lombard (Outbound) - Midday	31	2,253	53.8	26	66%	1%	1	79%	7%	14%	0:13	30%	00:38	0:45
075 - 39th Avenue-Lombard (Inbound) - Midday	30	2,307	58.3	27	68%	1%	12	77%	8%	15%	0:14	29%	00:35	0:45
014 - Hawthorne (Inbound) - PM Peak	12	503	58.7	25	58%	0%	0	83%	7%	10%	0:10	46%	01:04	0:44
109 - Powell (Outbound) - PM Peak	11	624	59.8	39	92%	8%	2	63%	9%	28%	0:11	38%	00:47	0:44
104 - Division (Outbound) - PM Peak	15	742	54.4	37	95%	6%	5	59%	6%	35%	0:09	54%	00:54	0:44
008 - NE 15th Avenue (Outbound) - PM Peak	11	495	63.6	40	104%	8%	13	43%	2%	55%	0:11	46%	00:56	0:42
004 - Fessenden (Outbound) - PM Peak	10	706	75.9	42	109%	10%	8	68%	4%	28%	0:13	32%	00:36	0:42
110 - Harold (Outbound) - PM Peak	9	335	48.0	31	71%	1%	2	58%	2%	40%	0:14	43%	01:09	0:42


Actual Headway to Passenger Load Relationship
Line 14 Hawthorne (Outbound - PM Peak)
Passenger Load
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
Actual Headway (minutes)

Line 115 - NW 23rd Avenue - Trip Level Passenger Census (Fall 1999)

Direction: Outbound

Start Time: 5:10 PM **End Time: 5:29 PM**

SCHED TIME	LOC_ID	BUS STOP	ONS	OFFS
5:10:00 PM	6160	WASHINGTON / 5TH	21.0	0.0
5:11:11 PM	6137	WASHINGTON / BROADWAY	2.1	0.8
5:11:56 PM	6169	WASHINGTON / 9TH	2.1	0.6
5:13:28 PM	9600	11TH / ALDER (SW)	0.6	1.7
5:14:28 PM	9598	MORRISON / 12TH (SW)	2.5	0.7
5:15:32 PM	9708	MORRISON / 14TH (SW)	0.2	0.4
5:16:36 PM	9613	MORRISON / 16TH (SW)	0.4	0.5
5:17:27 PM	9599	MORRISON / 17TH (SW)	2.4	0.9
5:19:00 PM	735	BURNSIDE / 19TH	0.3	1.2
5:19:33 PM	741	BURNSIDE / 20TH (WEST)	0.5	1.9
5:19:51 PM	742	BURNSIDE / 20TH PL	1.3	3.0
5:20:22 PM	747	BURNSIDE / 21ST (WEST)	0.3	1.2
5:20:57 PM	720	BURNSIDE / ST CLAIR	0.1	2.0
5:21:21 PM	755	BURNSIDE / 23RD	0.1	2.0
5:22:11 PM	7157	23RD / FLANDERS	0.1	2.2
5:23:04 PM	7161	23RD / IRVING	0.2	3.6
5:24:00 PM	7163	23RD / LOVEJOY	0.3	4.3
5:24:32 PM	8981	23RD / OVERTON	0.0	1.6
5:24:56 PM	9031	23RD / RALEIGH	0.0	1.5
5:25:53 PM	6014	VAUGHN / 24TH	0.0	0.7
5:26:13 PM	6016	VAUGHN / 25TH	0.0	0.5
5:26:31 PM	8414	VAUGHN / 26TH	0.0	0.7
5:26:51 PM	8802	VAUGHN / 27TH	0.1	1.8
5:27:06 PM	8481	WARDWAY / MONTGOMERY PK	0.0	0.8
5:27:53 PM	8482	NICOLAI / WARDWAY	0.1	0.5
5:28:19 PM	4105	NICOLAI / 27TH	0.1	0.1
5:28:49 PM	8483	27TH / WILSON	1.2	0.4
5:29:00 PM	8484	27TH / VAUGHN	0.0	0.7
		Trip Total:	36	36

Tri-Met Passenger Census - Fall 1999
Weekday All-Day Ons and Offs by Route and Stop

Route: 115 - NW 23rd Avenue **Outbound to Montgomery Pk / 27th & Thur**

Stop Location	*Location ID*	*Ons*	*Offs*	*Total*
WASHINGTON / 5TH	6160	1,001	0	1,001
WASHINGTON / BROADWAY	6137	114	71	185
WASHINGTON / 9TH	6169	97	108	205
11TH / ALDER (SW)	9600	31	122	153
MORRISON / 12TH (SW)	9598	122	103	225
MORRISON / 14TH (SW)	9708	23	51	74
MORRISON / 16TH (SW)	9613	56	46	102
MORRISON / 17TH (SW)	9599	172	45	217
BURNSIDE / 19TH	735	42	73	115
BURNSIDE / 20TH (WEST)	741	29	104	133
BURNSIDE / 20TH PL	742	63	137	200
BURNSIDE / 21ST (WEST)	747	14	69	83
BURNSIDE / ST CLAIR	720	21	114	135
BURNSIDE / 23RD	755	14	94	108
23RD / FLANDERS	7157	15	112	127
23RD / IRVING	7161	12	165	177
23RD / LOVEJOY	7163	19	267	286
23RD / OVERTON	8981	4	91	95
23RD / RALEIGH	9031	2	94	96
THURMAN / 23RD PL	8984	1	44	45
THURMAN / 25TH	8985	1	19	20

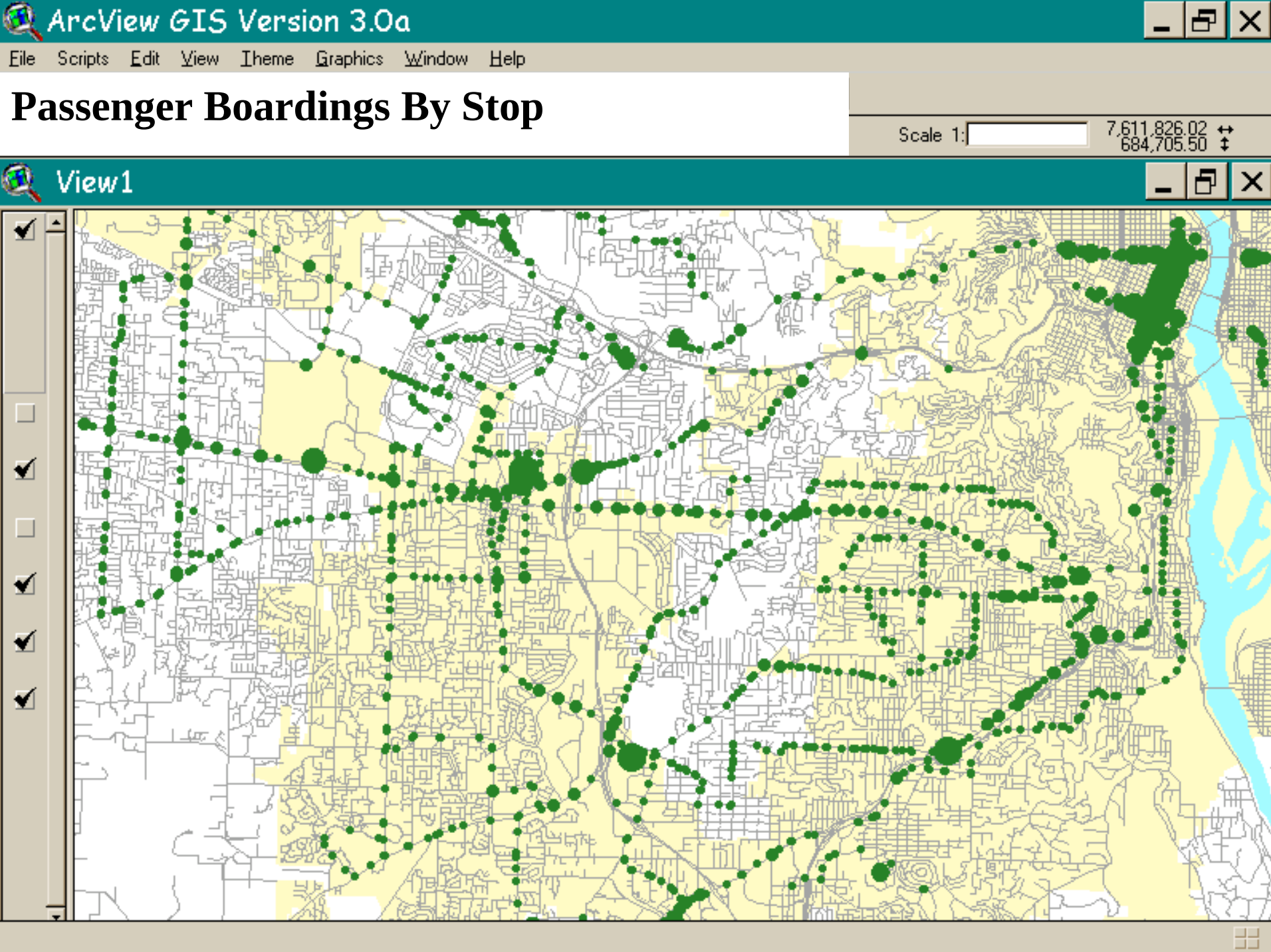
115 - NW 23rd Avenue

Outbound to Montgomery Pk / 27th & Thurman

Beginning Time Point	Ending Timepoint	Revenue Hours	Trips	Ons	Offs	Total	Total/ Rev.Hr.
SW Washington at 5th	Burnside & 19th	11:28	98	1,615	619	2,234	194.8
Burnside & 19th	23rd & Lovejoy	7:22	98	211	1,062	1,273	172.8
23rd & Loveiov	Thurman & 27th	2:29	42	16	223	239	96.2
23rd & Loveiov	Montgomery Park	3:57	56	78	365	443	112.2
Thurman & 27th	Gordon & Thurman	1:21	27	3	47	50	37.0
Gordon & Thurman	Thurman & 27th	1:21	27	8	19	27	20.0
	Totals	27:58	98	1,931	2,335	4,266	152.5

Inbound to Portland

Beginning Time Point	Ending Timepoint	Revenue Hours	Trips	Ons	Offs	Total	Total/ Rev.Hr.
Montgomery Park	23rd & Loveiov	3:33	55	335	12	347	97.7
Thurman & 27th	Gordon & Thurman	0:51	17	30	4	34	40.0
Gordon & Thurman	Thurman & 27th	1:08	17	26	0	26	22.9
Thurman & 27th	23rd & Loveiov	2:53	43	257	15	272	94.3
23rd & Loveiov	Burnside & 19th	9:10	98	1,086	354	1,440	157.1
Burnside & 19th	SW Salmon at 5th	11:29	98	475	991	1,466	127.7
SW Salmon at 5th	SW Washington at 5th	0:36	9	3	7	10	16.7
	Totals	29:40	98	2,212	1,383	3,595	121.2


ArcView GIS Version 3.0a
File Scripts Edit View Theme Graphics Window Help
Passenger Boardings By Stop
Scale 1:
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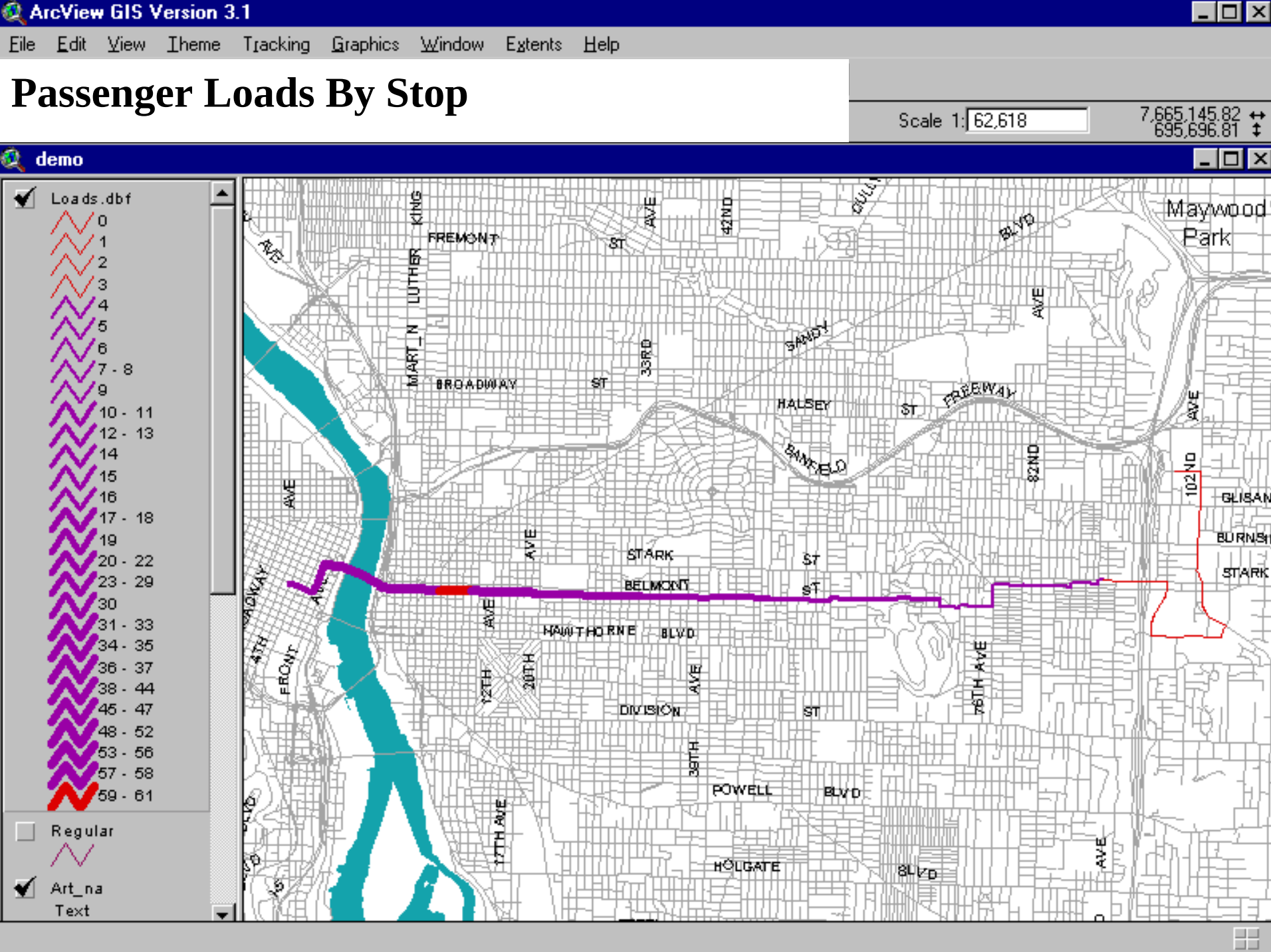
684,705.50
View1

Passenger Loads By Stop



Service Reliability Improvements

System-Level Improvements (since BDS implementation)

- **Overall OTP improved 69 to78%**
- **Percent early declined 15 to 5%**

Line 15 Test Project (using BDS data to revise schedule)

- **OTP improved 70 to 83%**
- **P.M. peak percent late declined 42 to 24%**

Line 72 Evaluation (Fall 1998 vs. Fall 1999)

- **OTP improved 62 to 77%**
- **Headway regularity improved 36%**
- **Overloaded trips declined from 24 to %2**
- **Number of reported passups reduced 60%**

Operations Planning Research

- **Pre-Post Analysis of Transit Service Reliability**
  - Study designed to assess impacts of BDS
  - Pre-operational period- manual data collection (Nov. 1986)
  - Post-operational period- automatic data collection (Mar. 1988)
  - Matched trips approach, 8 study routes
  - OTP improved from 61-67%
    - Largest improvement in % early departures
  - Reduction in headway variability of 15%
  - Average run time decreased by 1.45 minutes per trip

  - Extrapolation of results to system-level
    - $1.9 million annual savings in operating costs
    - $3.5 million annual savings in passenger wait time and travel time

Operations Planning Research, Continued

- **Time Point-Level Analysis of Service Reliability (Aug., 2000)**
  - Study sought to explain departure delay variation or headway delay variation depending upon time period
  - Regression analysis, 7 study routes, 19 days of observations
  - Separate models run according to route typology and time period
  - Results- delay variability adversely affected by boardings, sched. stops, delay variability at previous TP, lifts, nonrecurring events, link speed.
    - Parameter estimate for delay variability at previous TP approx. 1 minute (consistent across all models)

Operations Planning Research, Continued

- **Time Point-Level Analysis of Passenger Demand (Aug., 2000)**
  - Study sought to explain mean passenger boardings
  - Same data as previous study aggregated over all days, linked with additional data using GIS
  - Comparison of automated vs. manual data collection techniques
    - Previous research Abkowitz and Engelstein, 1983 and 1984
    - LA- 1 day data collection, 1 route, 49 TP observations
      - Cincy- 1 day data collection, 2 routes, 56 TP observations
      - Portland- 19 days data collection, 7 routes, 3000 TP observations
  - Results- mean boardings in TP positively affected by population, employment, transit center and negatively affected by income, sched. headway, existing levels of unreliability (off-peak only)

Operations Control

- *Concerned with maintaining service quality/minimizing the effects of service disruptions in real-time*

- Q: How does archived BDS data help with real-time decision making?
- A: Identification of problems, initial tweaking of plan, analysis of results

Headway Control Study (Nov. 1999)

  - Operational issue (headway irregularity)- “trippers” leaving according to schedule, resulting in uneven passenger loads and poor use of resources
  - Objective- hold candidate trippers until desirable spacing reached
  - Pre-post study design, 6 routes, 11 trippers, 3 weeks
  - Dedicated dispatcher and field supervisor
  - Results of study- headway variance declined 15.8% at control point and 3.8% overall, leading to more balanced loads

Operations Control, Continued

- **Headway Management of Bus Lines (upcoming research)**
  - 6 month demonstration project
  - Long range plan- several routes operating midday headways <= 10 min.
  - 1-3 routes, either P.M. peak or all day
  - Shift from schedule-based to headway-based performance measures
  - Possible technology enhancement- automated bus spacing information

Benefits of Archived BDS Data

- Complete operational data for the system
- All data is spatially referenced (GIS)
- Increased accuracy (reduce/eliminate manual counts)
- Multiple levels of data aggregation possible
- Improved statistical measures
- Improved interagency communication
- More efficient use of agency resources
- Better service to passengers