Final Research Report
Agreement T2695, Task 74
TrafficTV

TrafficTV

Phase 2

by

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State Traffic Engineer

A report prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

November 2006

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 659.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
TrafficTV	November 2006
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Daniel J. Dailey and Joel Bradbury	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center (TRAC) University of Washington, Box 354802 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631	11. CONTRACT OR GRANT NO. Agreement T2695, Task 74

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Research Office Washington State Department of Transportation Transportation Building, MS 47372 Olympia, Washington 98504-7372 Doug Brodin, Project Manager, 360-705-7972	Research Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

TrafficTV is a traffic and traveler information resource available to be broadcast on cable television. It began operation June 1, 1998 (under the name Traffic Channel). From a series of meetings held in June 2003 involving personnel from the Washington State Department of Transportation and University of Washington came a set of recommended changes. These changes were made to TrafficTV and are documented in this report.

During the eight-year period of 1998 through 2005, the hardware and operating system supporting the TrafficTV application remained unchanged, and both became out of date. This project updated the automated TrafficTV application to use hardware and software that are more current. In addition, new functionality for communicating incident information and Amber Alerts were designed as part of this project and added to TrafficTV. This was done in coordination with WSDOT operations.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Advanced traveler information systems, cable television, intelligent transportation systems, traffic congestion	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None		

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Executive Summary

TrafficTV is a traffic and traveler information resource available to be broadcast on cable television. It began operation June 1, 1998, as part of the SmartTrek Operational Deployment under the name Traffic Channel on UWTV2 Channel 76.

A series of meetings was held in June 2003. These meetings involved personnel from the Washington State Department of Transportation (WSDOT) Northwest Region, WSDOT Advanced Technology Branch, WSDOT Olympia office, the University of Washington's UWTV, and the UW Intelligent Transportation Systems Research Program. From these meetings came a set of recommended changes. The changes discussed included (1) new video support hardware suitable for a modern digital TV studio, (2) updated system software for network security, (3) dynamic messaging for Amber Alert and other incident messages, and (4) improved graphics presentation based on new graphics technologies. These changes were made to TrafficTV and are documented in this report.

A market penetration audit conducted by Media Audit in June and July 2004 indicated that when viewers were asked about TrafficTV, over 94,000 had seen the program within the last week. This was deemed surprisingly high, given the lack of external exposure and that viewers would have found TrafficTV only by word of mouth or by "channel surfing." Again, a conclusion of the audit was that additional exposure would make TrafficTV more valuable as a traveler information tool.

This project updated the automated TrafficTV application to use hardware and software that are more current. During the eight-year period of 1998 through 2005, the

hardware and operating system supporting the application remained unchanged, and both became out of date. In addition, new functionality for communicating incident information and Amber Alerts was designed as part of this project and added to TrafficTV. This was done in coordination with WSDOT operations.

The new version of the software was completed in September of 2006. At the time of this writing, WSDOT's Northwest Region is working with Comcast Inc. to deploy the new version at the head end of the Comcast cable system.

1. Introduction and Background

TrafficTV is a traffic and traveler information resource available on cable television (UWTV2 Channel 76). It began operation June 1, 1998, as part of the SmartTrek Operational Deployment under the name Traffic Channel. The SmartTrek evaluation of May 2001 identified several problems with Traffic Channel and recommended some improvements. A previous project made changes in response to those concerns and renamed the application TrafficTV (Dailey and Bradbury 2005). This project updated the hardware, operating systems support, and software, as well as included message systems for both Amber Alert and incidents.

TrafficTV receives traffic congestion information from the regional Intelligent Transportation Systems (ITS) Backbone (in self-describing data format) and live traffic video (provided over a fiber optics network by the Washington State Department of Transportation (WSDOT)). The TrafficTV computer program fuses the data, adds digital video effects, and supplies the resulting presentation to a cable television provider for cablecasting (see Figure 1). This project added the capability to place dynamic text and images on the TV broadcast. Figure 2 is a simulation of an Amber Alert message being broadcast.

Initially, the TrafficTV application was located at the University of Washington's UWTV cable television "headend," and the program was cablecast on Comcast Cable Channel 76. However, TrafficTV was taken off UWTV in the summer of 2006 because the UW began requiring payment for airtime. This project made TrafficTV more

portable so that WSDOT can investigate ways to display the application on alternative community channels.

On TrafficTV the traffic congestion information is displayed on a regional map, where different colors on roadway segments indicate current travel speeds. TCI Cable, Inc., the predecessor to Comcast Cable, estimated that as of March 2000, about 485,000 households had the ability to access TrafficTV. Results from user surveys and focus groups can be found in the original TrafficTV report (Dailey and Bradbury 2005).

The remainder of this report describes the hardware and software for the newest version of TrafficTV.

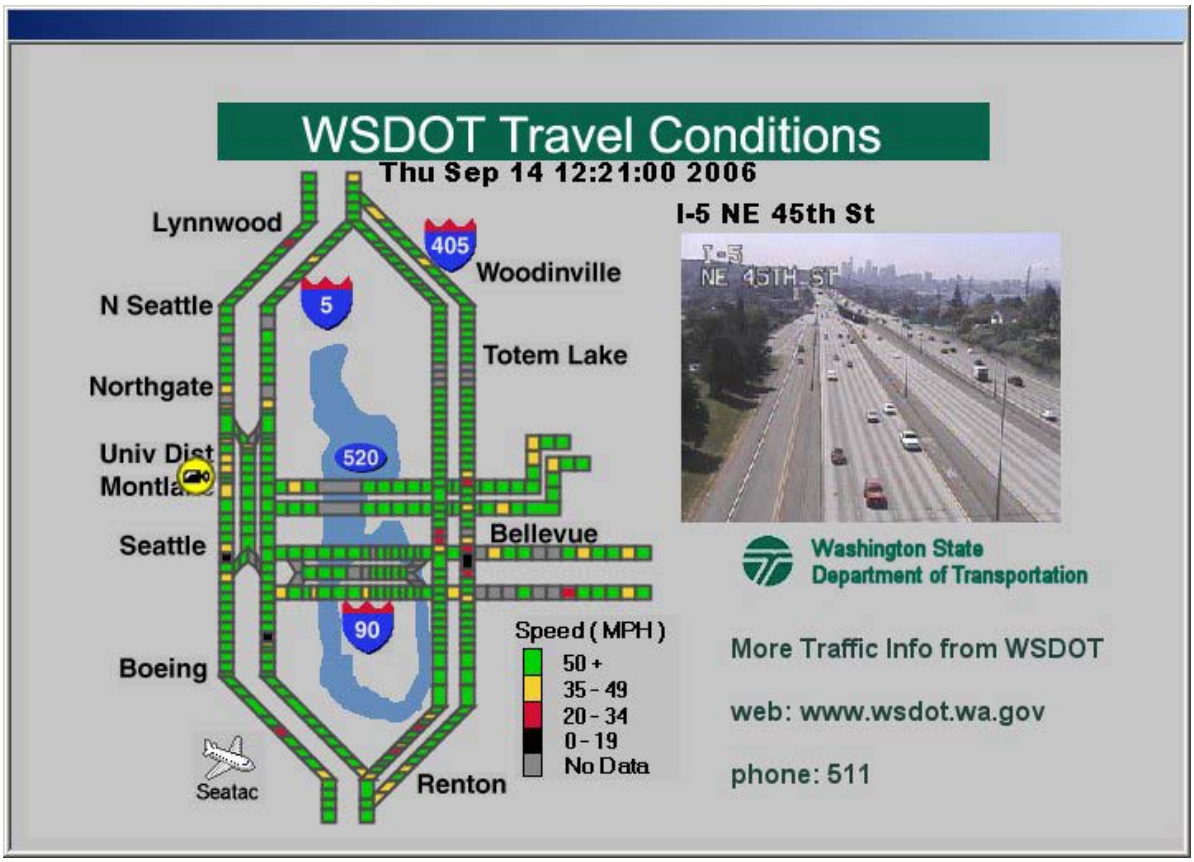

Figure 1: TrafficTV image as supplied to the cable provider.

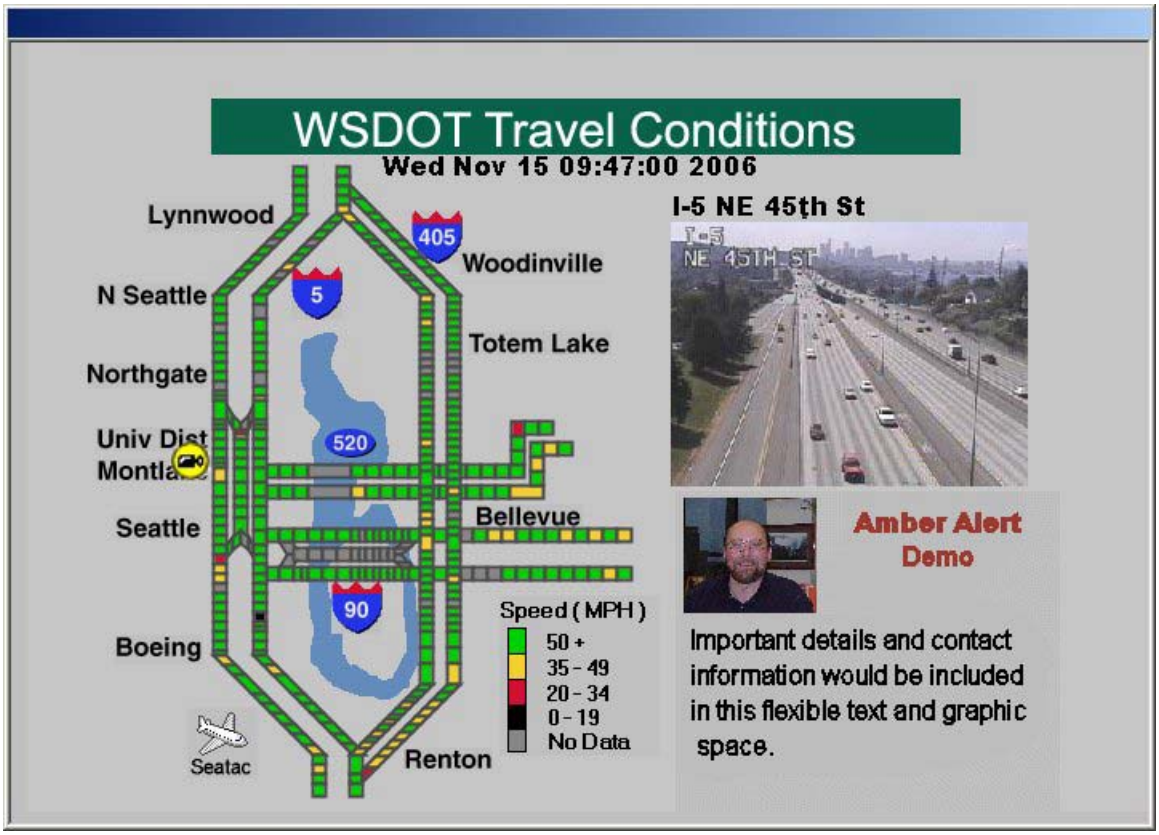

Figure 2: TrafficTV Image with Amber Alter information.

2. Hardware and Software

The TrafficTV application was designed to be modular, and this newest implementation is represented pictorially in Figure 3. The installation instructions for the original Traffic Channel application can be found in a 2001 report on the SmartTrek Model Deployment Initiative (Dailey 2001). This section summarizes the design of and highlights the changes and improvements made to the original software.

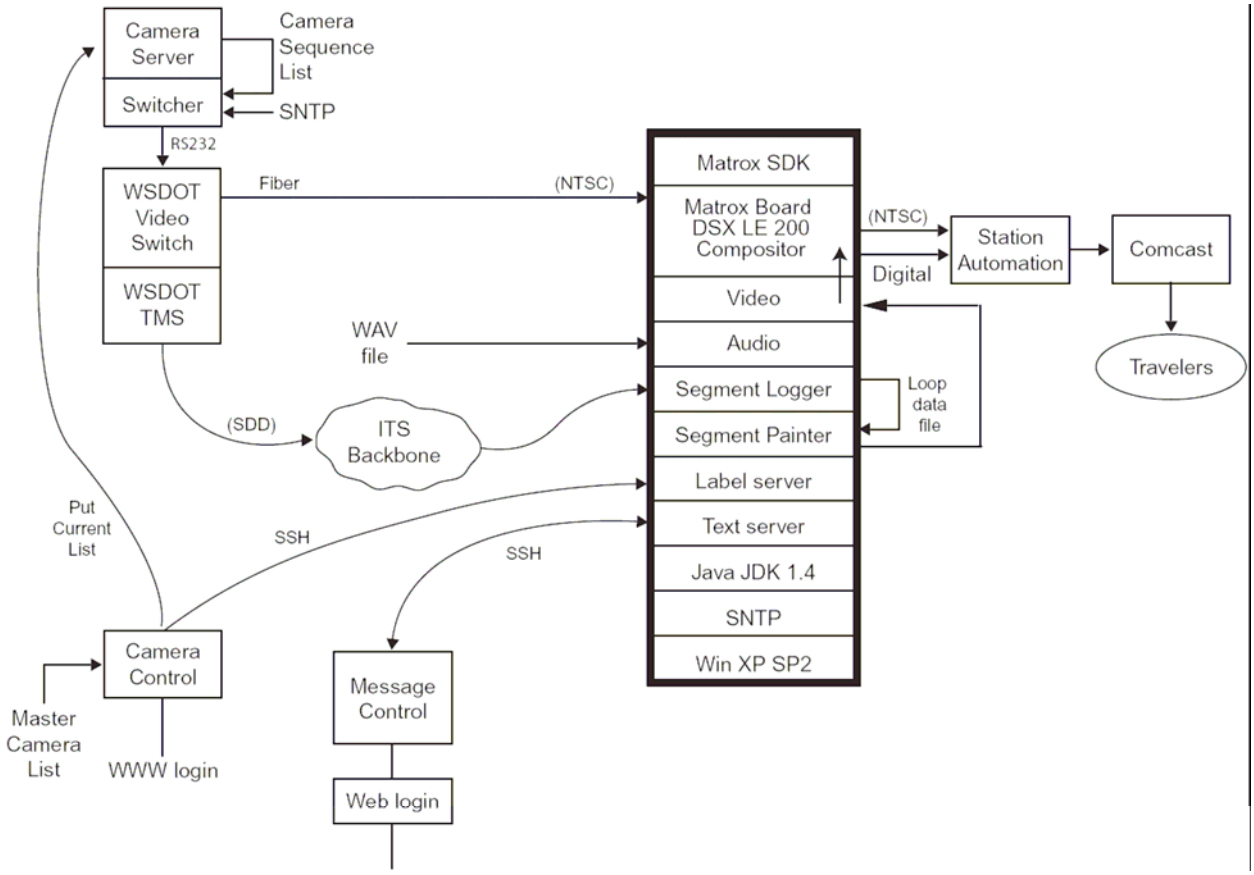

Figure 3: Diagram of the TrafficTV implementation.

The basic platform is a computer running Windows XP System Pack 2, represented by the large rectangle in Figure 3. This computer has a Matrox digital video effects (DVE) card that mixes the output from the computer display with the NTSC video

from the WSDOT video switch. The SegmentLogger software obtains loop data in self-describing data (SDD) format from the ITS Backbone and reformats the data to paint the segments. The Segment Paint module uses the loop data to create the colored map, shown in figures 1 and 2, and combines that map with information about the data location for the camera view and any text labels that have been added to the TextServer by way of the TextMessageControl Web application. The ability to change the text message and images on the screen in near-real time is an addition to previously deployed features.

The TrafficTV screen combines the traffic map just mentioned with real-time video obtained from the WSDOT Traffic Systems Management Center (TSMC). At the TSMC, a computer runs both a Switcher program and a CameraServer program. The Switcher program sends a series of ASCII commands to the WSDOT video switch so that it will output a specified camera view for a specified period and then switch to the next camera in the sequence. The CameraServer maintains the list, sequence order, and timing information for the display of the camera sequence. The CameraControl Web application allows the manager of the TrafficTV system to obtain the current sequence of cameras from the CameraServer, consult the master camera list for camera locations, change the properties of the camera display sequence, and then instruct the CameraServer to implement the new sequence.

The servers at WSDOT are kept locked to Network Time Protocol (NTP) time over the ITS Backbone. In parallel, the TrafficTV Server, located at the UW or other selected cable headend and portable to a traffic management center, is also locked to NTP time. The screen changes at both the TSMC and UW are coordinated only through the

use of this time base; no direct timing information is shared between the computer at UWTV control and the one at the TSMC (CameraServer).

It is also possible to have the TrafficTV Server output audio by supplying a WAV file for replay. The video, NTSC and digital, and audio outputs from the TrafficTV Server are provided to the Station Automation, and that output is provided to Comcast Cable for cable broadcast to travelers. This updated version of the software uses a Matrox DSX LE200 as the compositor that combines the computer generated traffic map graphic with the NTSC video from the freeway cameras. A block diagram of the Matrox card is found in Figure 4. This card is a replacement for the obsolete hardware used in the older implementation; however, unlike the predecessor that used a GUI user interface to configure the card, it requires detailed programming in C++ to control the card functions. Hardware and software similar to that used in the predecessor mixing board are no longer available.

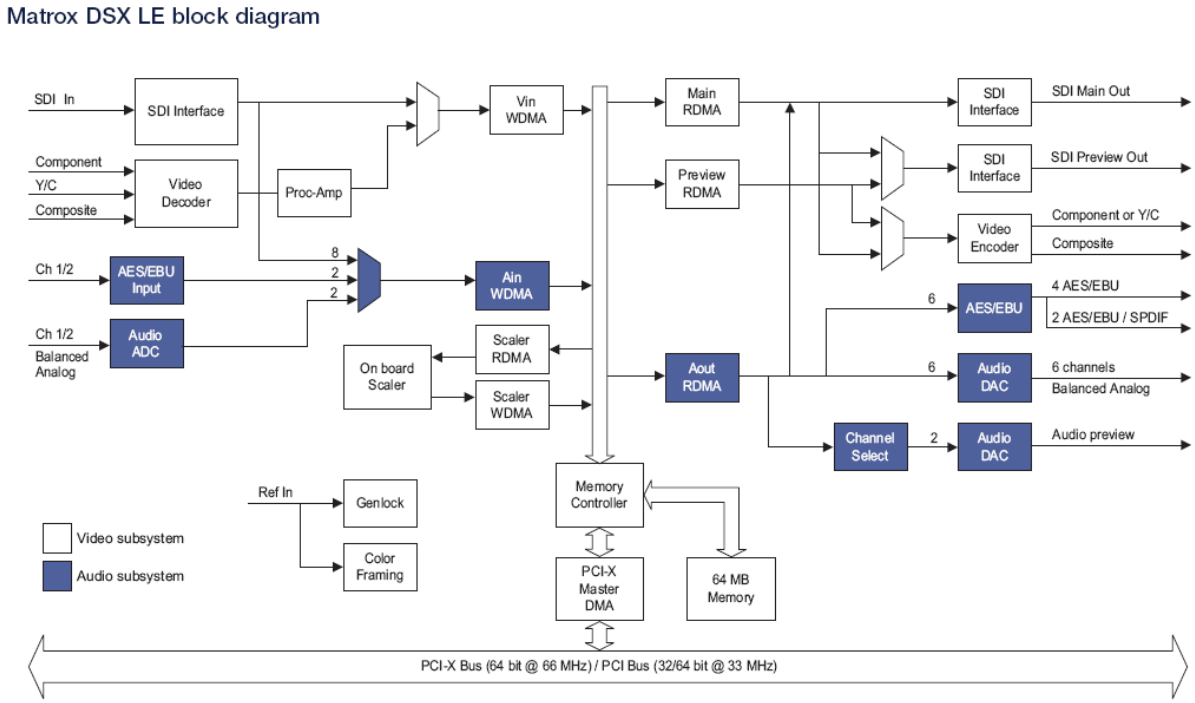

Figure 4: Block Diagram for Matrox Card.

3. Programming

The principle purpose of this project was to modify the programming of TrafficTV to allow the use of modern hardware, software, and a secure operating system. In addition, support for dynamic text and images to communicate messages such as Amber Alerts, travel times, or incidents are now present in the software.

3.1 Details of the Implementation

Details for the original Traffic Channel deployment are available in the SmartTrek report (Dailey 2001). Presented below is the equivalent information for the new TrafficTV implementation.

3.1.1 Timing Cycle

The sequence and timing for TrafficTV have changed in this version. The overall 2-minute period encompasses 16 cycles. Although each cycle displays a new map, in effect, the visible map display remains the same throughout, and the selected video (and label) changes. This is seen at the bottom of the sequence.txt file in Appendix A as a map file name and a duration in milliseconds that make up the configuration information.

3.1.2 Map Layout

The map has changed from that described in the SmartTrek report. The details of the map description for the new TrafficTV are included in Appendix B. The east end of the map has been expanded to present additional detector coverage, and data from the north portion of I-405 are now being reported on the map.

3.1.3 Map Segment Layout

The segments drawn on screen to represent the roadways and their relationship to individual loops and stations have changed. This information is found in the PugetSound2.seg file and is included in Appendix C.

3.2 New Software Design

The new software version is configured with the same configuration file structures as the previous versions. Much of the look and feel of the application can be created and modified by using only these files. A version of TrafficTV can be localized to another geographical location (e.g., Tacoma) solely by making changes to the configuration files.

The new software requirement was created by the need for new hardware. The software is written in object oriented C++ and embodies a set of steps that are necessary to create TrafficTV independent of the localized configuration. The sequence of operations in the new software that drives the Matrox card is as follows:

1. Create a Window, a buffer to hold an image, a bitmap in the buffer, two half-height buffers, and a pointer to the current half-height buffer.
2. Initialize the Matrox Card (Setup) to create the Matrox Flex Engine, Surface managers, and Graphics Thread class.
3. Pass the pointer to the half-height buffer to the Graphics Thread class and start the Graphics Thread. The Graphics Thread begins sampling NTSC, from the analog input connected to the WSDOT cameras, and placing the result on the outputs (both analog and digital) of the Matrox card.

4. Read the SEQUENCE.txt file (see Appendix A) to obtain the number of maps, the duration of the entire cycle for the application, and the duration for each map associated with a camera view. Build an array of Map objects, one per camera view.
5. Read the Map files (in this deployment, all of the map files are the same, TTV1.txt, see Appendix B). From this file is obtained
    - the timing for the video effects
    - the color palette to be compatible with TV broadcasting
    - the list of decorations that are static graphics, such as the background, Lake Washington, the location labels, the speed key, and other text
    - the file from which to obtain the traffic data
    - the segment definition file name that contains the geometric information to display the pictographic maps.
6. Read the segment definition file (PUGETSOUND2.seg, see Appendix C) to obtain pairs of (x,y) values for the corners of each polygon in the pictographic map and the associated traffic sensor ID. This file would have to be changed to construct pictographic traffic maps for other geographic locations such as Tacoma.
7. Read the camera sequence file (CAMSEQUENCE.txt, see Appendix D) that defines the sequence in which traffic cameras are placed on the display. It contains the location on the map in pixels for each camera and the label for each camera to be used in the display. This file is repeatedly read so that the camera sequence can be changed "on the fly."

8. Set timers for (1) the frequency of checking for new traffic data (5 seconds), (2) the frequency of playing a sound file (set in Sequence.txt to zero for no sound), and (3) the frequency for checking the need to switch maps (50 msec).
9. On the basis of the cycle time in SEQUENCE.txt, wait for an appropriate time boundary to match the camera switching process at WSDOT, in this case 2 minutes.
10. Draw the traffic map with the (1) background, (2) time stamp, (3) video label, (4) decorations, (5) camera icon to indicate camera location, and (6) traffic data on a windows buffer.
11. Copy the traffic map to a half-height buffer because of the interlased nature of the NTSC video, then pass the pointer to the half-height buffer to the Graphics Thread and copy the traffic map to the screen for display on the host computer.
12. Whenever the timers above expire, perform the function allocated to that timer. (e.g., check the traffic data file or play a sound).
13. The Graphics Thread obtains a frame of input NTSC video from the WSDOT cameras and puts it into a buffer. An image buffer is created, and the traffic map graphic, created above, is copied into that buffer.
14. A clipping rectangle is applied to the camera video to remove artifacts on the edges of the image. The resulting video rectangle is scaled down with Matrox onboard scaling hardware to fit into the assigned space on the final TrafficTV screen.
15. The traffic map graphic is color converted from RGB to YUV.

16. The two buffers are composited together to create the final TrafficTV image. When this compositing is done, the opacity of the WSDOT video is adjusted temporally to create the fade in and fade out effect.
17. This final graphic is copied to the Matrox card that converts it to both NTSC and digital SDI format for output as the final product.

The combination of the steps above, implemented in C++ by using the Matrox Software Development Kit, with the configuration and localization definitions in the configuration files make up the software infrastructure for TrafficTV.

4. Evaluation and Conclusions

A market penetration, share, and target audience evaluation was done by *The Media Audit* in June-July 2004. On the basis of 1,047 interviews conducted in June-July 2004 of adults who were asked if they had watched TrafficTV in the last week, the evaluation concluded that 94,000 people in King County watched TrafficTV during that period. A description of the audit and the actual numerical results are found in the first TrafficTV report (Dailey and Bradbury 2005). This audience was a result solely of word-of-mouth communication and channel surfing discovery.

Conclusions

A conclusion from these results is that WSDOT should put some information about TrafficTV on the Travel Information Web page to make more travelers aware of this additional source of information for the Puget Sound region.

The new implementation makes the hardware compatible with modern digital TV station automation. The updated system software makes it possible to ensure software security, which was no longer possible with the earlier version because Microsoft discontinued software support for Windows NT. The updated graphics improves the on-air presentation by allowing for anti-aliasing in the graphics to be used for broadcast.

The new version of the software was completed in September of 2006. At the time of this writing, WSDOT's Northwest Region is working with Comcast Inc. to deploy the new version at the head end of the Comcast cable system. The new version can either be physically deployed to the head end location or operated at the Northwest Region traffic control center, which will ship the video to Comcast. The latter

implementation is recommended by the authors, as it will allow for easier management of the hardware and software by Northwest Region personnel.

References

Dailey, D.J. May 2001. *Smart Trek: A Model Deployment Initiative*. Washington State Department of Transportation. WA-RD 505.1

Dailey, D.J. and J. Bradbury. January 2005. *TrafficTV*. Washington State Department of Transportation. WA-RD 603.1

Appendix A Sequence of Maps (SEQUENCE2.TXT)

```
# sequencer.txt
# The sequence definition for the UWTV TrafficChannel video presentation
#
# The UWTV presentation uses four maps, presented for 7500 milliseconds
# each for a total sequence time of thirty seconds.
#

16             # Number of maps in the sequence

# If map segments, defined in the following map file definitions
# have different foreground and background colors, then the specified
# colors are alternated this frequency
#500            # Duration in msec of flashing map segments
0

# Sequence Sound File:
# This sound file is started at the beginning of the first map
# in the sequence and is repeated each time the first map is displayed.
Sounds\incidents.wav

#time interval for playing sound, seconds; 0 for no play, -1 to loop without
timing
0

# Camera Image File:
#  used to show location of camera
StaticImages\camera2.png

120           # time sync;  The start of the sequence is scheduled
               # by the current time in seconds modulus this value

# The Map Definitions:
# -map definition filename-    -duration of map display in msec-
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
TrafficMaps\ttv1.txt     7500
```

Appendix B MAP File (TTV1.TXT)

```
# TrafficChannel Map/Layout Configuration
# Definition to display mainline traffic data on the left side
# of the display and video on the right
# Definition for layout of map on left-side of screen and video on right
#

# Number of video effects for this sequence
1

# The Genie effect definitions and start times.
#     starts are specified as msec from the start of the sequence
c:\TrafficChannel\Effects\tv1.eff     200   6500
# Map origin:
#   Origin is in the screen coordinate system. Used
#   to adjust the relative position of the segment display and the
#   components that are displayed relative to the segments
10 0

#
# Color Table Definition
#    The color table must contain 16 entries numbered 0-15.  Each
#    color table entry is used to lookup a given object on the display.
#
0  0     0   0      # Black;
1  255   0   0      # Flash Red;
2  0    24 127      # Dark Blue;
3  36   53 231      # Bright Blue, i.e. road sign bkgs
4  98  143 189      # Light Blue, i.e. lake background
5  0     0   0      # UNUSED
6  192 192 192      # Light Gray;
7  135 135 135      # Medium Gray;
8  75   75  75      # Dark Gray;
9  211  17  53      # Red;
10 0   210   0      # Green;
11 243 209  49      # Yellow;
12 255 116   4      # Orange
13 0     0   0      # UNUSED
14 0     0   0      # UNUSED
15 200 200 200      # White;

# segment closure information: -file name- -closure color ix- -bad data ix-
Closures\closures.seg 0 7

# Segment Type Definitions
#    segment record:
#  type#       : 0 - (N-1) where N is the number of segment types
#  capStyle    : horizontal | vertical
#  width       : width of the segment in pixels
#  borderWidth : width of the segment border in pixels
#  colorIndex  : 0-15 segment border color from the above color table
2   # number of segment types
0 horizontal 8 2 8
1 vertical  8 2 8
#0 horizontal 8 0 8
```

```
#1 vertical 8 0 8

# Segment Definitions
395   # number of segments
SegmentDefinitions\PugetSound.seg

# Static filled regions
0   # number of polygons to draw
# -x0- -y0- -x1- -y1- -x2- -y2- -x3- -y3- -color for fill- -color for flash-
#       If the foreground and background colors are equal, do no flashing
#       Color values are indexes to the above color table
#       Regions are restricted to 4-point polygons
#430 330 440 330 440 350 430 350 10 10
#430 350 440 350 440 370 430 370 11 11
#430 370 440 370 440 390 430 390 9 9
#370 390 380 390 380 410 370 410 9 6
#430 390 440 390 440 410 430 410 0 0
#430 410 440 410 440 430 430 430 7 7
#370 430 380 430 380 450 370 450 7 7

# Decoration Declarations
#    Decorations are pre-defined bitmaps to place on the display
20    # Number of decorations
# filename ux uy  (position is relative to the map origin) refresh
StaticImages\BackgroundWest.png 0 0 0     # background must come first
StaticImages\wsdotbanner.gif 115 35 0
StaticImages\I405.png 240 105 0
StaticImages\I5.png 165 140 0
StaticImages\520.png 185 240 0
StaticImages\I90.png 190 336 0
StaticImages\Lynnwood.png 75 100 0
StaticImages\NorthSeattle.png 43 150 0
StaticImages\Northgate.png 38 200 0
StaticImages\University.png 43 240 0
StaticImages\Montlake.png 43 260 0
StaticImages\Seattle.png 55 295 0
StaticImages\Boeing.png 55 370 0
StaticImages\Renton.png 235 440 0
#StaticImages\Factoria.png 280 360 0
StaticImages\Bellevue.png 280 288 0
#StaticImages\Kirkland.png 280 230 0
#StaticImages\redmond.png 290 220 0
#StaticImages\issaquah.png 320 311 0
StaticImages\TotemLake.png 275 180 0
StaticImages\Woodinville.png 270 130 0
StaticImages\Plane.png 100 415 0
StaticImages\speed2.gif 295 345 0
#StaticImages\label1.gif 395 75 1
#StaticImages\label1.gif 395 85 1
#StaticImages\textbox.gif 400 300 1
#StaticImages\wsdott.gif 545 315 0
#StaticImages\1.gif 570 120 0
#StaticImages\camera2.png 150 240 0
StaticImages\amber.gif 405 280 1

#
# ITS data file created by the Generic redistributor
```

```
c:\segmentLogger\sdd.output

# Data segments are alternated between the data dependent
# color and the static color to affect flashing
# -color index of data independent color-
6

# number of speed quanta for dividing colors
#  speeds are in triplets:
# -upperbound data value- -color index- -is flashable-
4        #  the number of colors to use
20 0    0
34 9    0
49 11   0
50 10   0  #  the top-end speed doesn't really need a lower bound

# Video Source:,
# -Camera ID- -Segment Name- -new image- -image to replace-
#     -Camera ID-: Text string descript of camera to use
#     -Segment Name-:  Data as referenced in the loops data stream
#     -new image-: Image file used to replace existing image file
#     -image to replace-: The existing default image
520Bridge no_hilite no_image no_image
```

Appendix C – Segment Definition File (PUGETSOUND2.SEG)

```
149 267 157 267 1 ES-502D:_MW_Stn  # 520 west
157 267 166 267 1 ES-504R:_MW_Stn  #
166 267 175 267 1 ES-506R:_MW_Stn   #
175 267 202 267 1 ES-000R:_MW_Stn  # no loops on 520 bridge
202 267 211 267 1 ES-514D:_MW_Stn  #
211 267 220 267 1 ES-516R:MMW_Stn  #
220 267 229 267 1 ES-519R:_MW_Stn  #
229 267 238 267 1 ES-520D:_MW_Stn  #
238 267 245 267 1 ES-521R:MMW_Stn  #
253 267 257 267 1 ES-524R:MMW_Stn  # (gap for 405 s)
257 267 262 267 1 ES-528D:_MW_Stn  #
270 267 274 267 1 ES-531R:MMW_Stn  #  (gap for 405 n)
274 267 283 267 1 ES-533D:_MW_Stn  #
283 267 292 267 1 ES-535D:_MW_Stn  #
292 267 301 267 1 ES-537R:MMW_Stn  #
301 267 310 267 1 ES-539D:_MW_Stn  #
306 263 306 254 0 ES-540R:MMW_Stn  #
306 254 306 245 0 ES-542R:MMW_Stn  #
306 245 306 236 0 ES-544D:_MW_Stn  #
310 240 319 240 1 ES-545R:MMW_Stn  #
319 240 328 240 1 ES-547D:_MW_Stn  #
149 280 157 280 1 ES-502D:_ME_Stn      # 520 east
157 280 166 280 1 ES-504R:MME_Stn  #
166 280 175 280 1 ES-506R:MME_Stn  #
175 280 202 280 1 ES-000R:MME_Stn  #
202 280 211 280 1 ES-514D:_ME_Stn  #
211 280 220 280 1 ES-516R:_ME_Stn  #
220 280 229 280 1 ES-519R:MME_Stn  #
229 280 238 280 1 ES-520D:_ME_Stn  #
238 280 245 280 1 ES-521R:_ME_Stn  #
253 280 257 280 1 ES-525R:MME_Stn  # (gap for 405 s)
257 280 262 280 1 ES-528D:_ME_Stn  #
270 280 274 280 1 ES-531R:_ME_Stn  # (gap for 405 n)
274 280 283 280 1 ES-533D:_ME_Stn  #
283 280 292 280 1 ES-535D:_ME_Stn  #
292 280 301 280 1 ES-538R:MME_Stn  #
301 280 322 280 1 ES-539D:_ME_Stn  #
318 276 318 267 0 ES-541R:MME_Stn  #
318 267 318 258 0 ES-543R:MME_Stn  #
318 258 318 249 0 ES-544D:_ME_Stn  #
322 253 331 253 1 ES-546D:_ME_Stn  #
331 253 340 253 1 ES-547D:_ME_Stn  #
161 311 166 319 0 ES-827D:_RE_Stn  #  I90 Reversible
161 327 166 319 0 ES-827D:_RE_Stn  #
166 319 175 319 1 ES-852D:_RE_Stn  #
175 319 184 319 1 ES-854D:_RE_Stn  #
184 319 193 319 1 ES-857D:_RE_Stn  #  midspan
193 319 202 319 1 ES-860D:_RE_Stn  #
202 319 207 319 1 ES-863R:_RE_Stn  #
207 319 211 319 1 ES-876R:_RE_Stn  #
211 319 216 319 1 ES-878D:_RE_Stn  #
216 319 220 319 1 ES-881R:_RE_Stn  #
220 319 225 319 1 ES-883D:_RE_Stn  #
229 319 234 315 0 ES-889R:_RE_Stn  #
```

```
229 319 234 324 0 ES-889R:_RE_Stn  #
234 315 238 311 0 ES-891D:_RE_Stn  #
234 324 238 328 0 ES-891D:_RE_Stn  #
225 319 229 319 1 ES-885D:_RE_Stn  #
149 307 157 307 1 ES-818D:_MW_Stn  # I-90 west
157 307 166 307 1 ES-826D:_MW_Stn  #
166 307 175 307 1 ES-852D:_MW_Stn  #
175 307 184 307 1 ES-854D:_MW_Stn  #
184 307 193 307 1 ES-857D:_MW_Stn  # midspan
193 307 202 307 1 ES-860D:_MW_Stn  #
202 307 207 307 1 ES-863R:MMW_Stn  #
207 307 211 307 1 ES-876R:NNW_Stn  #
211 307 216 307 1 ES-879R:MMW_Stn  #
216 307 220 307 1 ES-881R:_MW_Stn  #
220 307 225 307 1 ES-883D:_MW_Stn  #
225 307 229 307 1 ES-887R:MMW_Stn  #
229 307 234 307 1 ES-889R:_MW_Stn  #
234 307 238 307 1 ES-891D:_MW_Stn  #
238 307 245 307 1 ES-896D:_MW_Stn  #
253 307 262 307 1 ES-900R:MMW_Stn  # (gap for 405 s)
270 307 278 307 1 ES-903D:_MW_Stn  # (gap for 405 n)
278 307 287 307 1 ES-908R:MMW_Stn  #
287 307 296 307 1 ES-910D:_MW_Stn  #
296 307 305 307 1 ES-912D:_MW_Stn  #
305 307 314 307 1 ES-916D:_MW_Stn  #
314 307 323 307 1 ES-920R:MMW_Stn  #
323 307 332 307 1 ES-924D:_MW_Stn  #
332 307 341 307 1 ES-928D:_MW_Stn  #
341 307 350 307 1 ES-932D:_MW_Stn  #
350 307 359 307 1 ES-935R:MMW_Stn  #
359 307 368 307 1 ES-940D:_MW_Stn  #
368 307 377 307 1 ES-945R:MMW_Stn  #
149 331 157 331 1 ES-812D:_ME_Stn      # I-90 east
157 331 166 331 1 ES-822R:MME_Stn  #
166 331 171 331 1 ES-825R:MME_Stn  #
171 331 175 331 1 ES-852D:_ME_Stn  #
175 331 184 331 1 ES-855D:_ME_Stn  #
184 331 193 331 1 ES-858D:_ME_Stn  #  midspan
193 331 202 331 1 ES-861D:_ME_Stn  #
202 331 207 331 1 ES-863R:_ME_Stn  #
207 331 211 331 1 ES-876R:_ME_Stn  #
211 331 216 331 1 ES-879R:_ME_Stn  #
216 331 220 331 1 ES-881R:MME_Stn  #
220 331 225 331 1 ES-883D:_ME_Stn  #
225 331 229 331 1 ES-885D:_ME_Stn  #
229 331 234 331 1 ES-889R:MME_Stn  #
234 331 238 331 1 ES-891D:_ME_Stn  #
238 331 245 331 1 ES-896D:_ME_Stn  #
253 331 262 331 1 ES-900R:_ME_Stn  # (gap for 405 s)
270 331 278 331 1 ES-903D:_ME_Stn  # (gap for 405 n)
278 331 287 331 1 ES-908R:_ME_Stn  #
287 331 296 331 1 ES-910D:_ME_Stn  #
296 331 305 331 1 ES-912D:_ME_Stn  #
305 331 314 331 1 ES-916D:_ME_Stn  #
314 331 323 331 1 ES-920R:_ME_Stn  #
323 331 332 331 1 ES-924D:_ME_Stn  #
332 331 341 331 1 ES-928D:_ME_Stn  #
```

```
341 331 350 331 1 ES-932D:_ME_Stn  #
350 331 359 331 1 ES-935R:_ME_Stn  #
359 331 368 331 1 ES-940D:_ME_Stn  #
368 331 377 331 1 ES-945R:_ME_Stn  #
124 229 128 236 1 ES-154D:_RN_Stn  # I5 express lanes, north entrance
128 236 133 241 1 ES-152D:_RN_Stn  #
133 241 138 236 1 ES-152D:_RN_Stn  #
138 236 141 229 1 ES-154D:_RN_Stn  #
133 241 133 244 0 ES-148D:_RN_Stn  #
133 244 133 247 0 ES-146R:_RN_Stn  #
133 247 133 253 0 ES-143D:_RN_Stn  #
133 253 133 259 0 ES-139R:_RN_Stn  #
133 259 133 265 0 ES-136R:_RN_Stn  #
133 265 133 274 0 ES-132D:_RN_Stn  #
133 274 133 283 0 ES-126D:_RN_Stn  #
133 283 133 289 0 ES-125R:_RN_Stn  #
133 289 133 296 0 ES-124D:_RN_Stn  #
133 296 133 308 0 ES-123D:_RN_Stn  #
124 317 128 312 1 ES-111R:_RN_Stn  # express lanes, south entrance
128 312 133 308 1 ES-118R:_RN_Stn  #
133 308 138 312 1 ES-118R:_RN_Stn  #
138 312 141 317 1 ES-111R:_RN_Stn  #
198 89 206 97 0 ES-764D:_MN_Stn    # east side outer loop, 405 north bound
206 97 215 106 0 ES-763D:_MN_Stn   #
215 106 220 111 0 ES-762D:_MN_Stn  #
220 111 226 117 0 ES-759D:_MN_Stn  #
226 117 232 123 0 ES-757D:_MN_Stn  #
232 123 237 128 0 ES-756R:MMN_Stn  #
237 128 243 134 0 ES-754D:_MN_Stn  #
243 134 249 140 0 ES-752D:_MN_Stn  #
249 140 254 145 0 ES-750D:_MN_Stn  #
254 145 260 151 0 ES-748R:_MN_Stn  #
260 151 266 157 0 ES-746D:_MN_Stn  #
266 157 266 162 0 ES-744R:_MN_Stn  #
266 162 266 167 0 ES-742D:_MN_Stn  #
266 167 266 172 0 ES-741R:MMN_Stn  #
266 172 266 177 0 ES-740R:_MN_Stn  #
266 177 266 182 0 ES-739D:_MN_Stn  #
266 182 266 187 0 ES-738D:_MN_Stn  #
266 187 266 192 0 ES-736D:_MN_Stn  #
266 192 266 197 0 ES-734D:_MN_Stn  #
266 197 266 202 0 ES-731R:MMN_Stn  #
266 202 266 207 0 ES-730R:_MN_Stn  #
266 207 266 212 0 ES-726R:_MN_Stn  #
266 212 266 217 0 ES-724D:_MN_Stn  #
266 217 266 222 0 ES-722D:_MN_Stn  #
266 222 266 227 0 ES-720D:_MN_Stn  #
266 227 266 232 0 ES-717R:MMN_Stn  #
266 232 266 237 0 ES-716R:_MN_Stn  #
266 237 266 242 0 ES-711R:MMN_Stn  #
266 242 266 247 0 ES-710R:_MN_Stn  #
266 247 266 252 0 ES-709D:_MN_Stn  #
266 252 266 257 0 ES-708D:_MN_Stn  #
266 257 266 262 0 ES-706D:_MN_Stn  #
266 262 266 267 0 ES-704D:_MN_Stn  #
266 267 266 272 0 ES-698D:_MN_Stn  # (at SR520)
266 272 266 277 0 ES-696D:_MN_Stn  #
```

```
266 277 266 282 0 ES-694R:MMN_Stn  #
266 282 266 287 0 ES-687R:MMN_Stn  #
266 287 266 292 0 ES-684D:_MN_Stn  #
266 292 266 297 0 ES-682R:MMN_Stn  #
266 297 266 302 0 ES-678D:_MN_Stn  #
266 302 266 307 0 ES-677D:_MN_Stn  #
266 307 266 317 0 ES-676D:_MN_Stn  # (at I90)
266 317 266 322 0 ES-672D:_MN_Stn  #
266 322 266 327 0 ES-667D:_MN_Stn  #
266 327 266 332 0 ES-665D:_MN_Stn  #
266 332 266 337 0 ES-662R:_MN_Stn  #
266 337 266 342 0 ES-659D:_MN_Stn  #
266 342 266 347 0 ES-657D:_MN_Stn  #
266 347 266 352 0 ES-656D:_MN_Stn  #
266 352 266 357 0 ES-654R:MMN_Stn  #
266 357 266 362 0 ES-651D:_MN_Stn  #
266 362 266 367 0 ES-648R:MMN_Stn  #
266 367 266 377 0 ES-645D:_MN_Stn  #
266 377 266 387 0 ES-643R:MMN_Stn  #
266 387 266 400 0 ES-638R:MMN_Stn  #
266 400 261 405 0 ES-634R:MMN_Stn  #
261 405 256 410 0 ES-632D:_MN_Stn  #
256 410 251 415 0 ES-630D:_MN_Stn  #
251 415 246 420 0 ES-628D:_MN_Stn  #
246 420 241 425 0 ES-626D:_MN_Stn  #
241 425 236 430 0 ES-623D:_MN_Stn  #
236 430 231 435 0 ES-621D:_MN_Stn  #
231 435 226 440 0 ES-619D:_MN_Stn  #
226 440 221 445 0 ES-617R:MMN_Stn  #
221 445 214 452 0 ES-614D:_MN_Stn  #
214 452 206 460 0 ES-612D:_MN_Stn  #
170 77 170 83 0  ES-211D:_MS_Stn    # west side outer loop, I5 south
170 83 170 89 0 ES-210D:_MS_Stn  #
170 89 170 95 0 ES-209D:_MS_Stn  #
170 95 170 101 0 ES-207R:MMS_Stn  #
170 101 170 107 0 ES-205D:_MS_Stn  #
170 107 165 112 0 ES-203R:MMS_Stn  #
165 112 160 117 0 ES-201D:_MS_Stn  #
160 117 155 122 0 ES-196D:_MS_Stn  #
155 122 150 127 0 ES-193R:MMS_Stn  #
150 127 145 132 0 ES-191D:_MS_Stn  #
145 132 140 137 0 ES-189D:_MS_Stn  #
140 137 135 142 0 ES-187R:MMS_Stn  #
135 142 130 147 0 ES-186D:_MS_Stn  #
130 147 125 152 0 ES-184R:_MS_Stn  #
125 152 120 157 0 ES-182R:MMS_Stn  #
120 157 120 163 0 ES-179D:_MS_Stn  #
120 163 120 169 0 ES-177D:_MS_Stn  #
120 169 120 175 0 ES-174R:MMS_Stn  #
120 175 120 181 0 ES-174R:MMS_Stn  #
120 181 120 187 0 ES-172R:MMS_Stn  #
120 187 120 193 0 ES-170D:_MS_Stn  #
120 193 120 199 0 ES-167D:_MS_Stn  #
120 199 120 205 0 ES-165D:_MS_Stn  #
120 205 120 211 0 ES-163R:MMS_Stn  #
120 211 120 217 0 ES-161D:_MS_Stn  #
120 217 120 220 0 ES-158R:MMS_Stn  #
```

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120 220 120 223 0 ES-156R:_MS_Stn  #
120 223 120 235 0 ES-154D:_MS_Stn  #
120 235 120 238 0 ES-152D:_MS_Stn  #
120 238 120 241 0 ES-149R:MMS_Stn  #
120 241 120 247 0 ES-145D:_MS_Stn  #
120 247 120 253 0 ES-143D:_MS_Stn  #
120 253 120 259 0 ES-141R:MMS_Stn  #
120 259 120 262 0 ES-136R:MMS_Stn  #
120 262 120 265 0 ES-134R:MMS_Stn  #
120 265 120 274 0 ES-130D:_MS_Stn  #
120 274 120 283 0 ES-126D:_MS_Stn  #
120 283 120 289 0 ES-125R:MMS_Stn  #
120 289 120 295 0 ES-124D:_MS_Stn  #
120 295 120 301 0 ES-123D:_MS_Stn  #
120 301 120 307 0 ES-121R:MMS_Stn  #
120 307 120 313 0 ES-118R:_MS_Stn  #
120 313 120 319 0 ES-111R:_MS_Stn  #
120 319 120 325 0 ES-108D:_MS_Stn  #
120 325 120 331 0 ES-105D:_MS_Stn  #
120 331 120 337 0 ES-102R:_MS_Stn  #
120 337 120 343 0 ES-100R:MMS_Stn  #
120 343 120 349 0 ES-093D:_MS_Stn  #
120 349 120 355 0 ES-090D:_MS_Stn  #
120 355 120 361 0 ES-088D:_MS_Stn  #
120 361 120 367 0 ES-085R:MMS_Stn  #
120 367 120 373 0 ES-083D:_MS_Stn  #
120 373 120 379 0 ES-082D:_MS_Stn  #
120 379 120 382 0 ES-081D:_MS_Stn  #
120 382 126 388 0 ES-080D:_MS_Stn  #
126 388 132 394 0 ES-079D:_MS_Stn  #
132 394 144 406 0 ES-077R:_MS_Stn  #
144 406 150 412 0 ES-075R:MMS_Stn  #
150 412 156 418 0 ES-074D:_MS_Stn  #
156 418 163 425 0 ES-073R:_MS_Stn  #
163 425 169 431 0 ES-071R:MMS_Stn  #
169 431 176 438 0 ES-069D:_MS_Stn  #
176 438 182 444 0 ES-068D:_MS_Stn  #
182 444 182 450 0 ES-061R:MMS_Stn  #
182 450 182 456 0 ES-059D:_MS_Stn  #
182 456 182 462 0 ES-057D:_MS_Stn  #
182 462 182 470 0 ES-055D:_MS_Stn  #
197 77 197 83 0 ES-211D:_MN_Stn       # west side inner loop, I5 North
197 83 197 89 0 ES-210D:_MN_Stn  #
197 89 197 95 0 ES-209D:_MN_Stn  #
197 95 197 101 0 ES-208R:MMN_Stn  #
197 101 197 107 0 ES-205D:_MN_Stn  #
195 107 190 112 0 ES-204D:_MN_Stn  #
190 112 185 117 0 ES-201D:_MN_Stn  #
185 117 180 122 0 ES-196D:_MN_Stn  #
180 122 175 127 0 ES-193R:_MN_Stn  #
175 127 170 132 0 ES-191D:_MN_Stn  #
170 132 165 137 0 ES-189D:_MN_Stn  #
165 137 160 142 0 ES-188R:MMN_Stn  #
160 142 155 147 0 ES-186D:_MS_Stn  #
155 147 150 152 0 ES-184R:MMN_Stn  #
150 152 145 157 0 ES-181R:_MN_Stn  #
145 157 145 163 0 ES-179D:_MN_Stn  #
```

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145 163 145 172 0 ES-177D:_MN_Stn  #
145 172 145 181 0 ES-175R:MMN_Stn  #
145 181 145 187 0 ES-172R:_MN_Stn  #
145 187 145 193 0 ES-170D:_MN_Stn  #
145 193 145 199 0 ES-168R:MMN_Stn  #
145 199 145 205 0 ES-165D:_MN_Stn  #
145 205 145 214 0 ES-163R:_MN_Stn  #
145 214 145 220 0 ES-159R:MMN_Stn  #
145 220 145 223 0 ES-156R:_MN_Stn  #
145 223 145 235 0 ES-154D:_MN_Stn  #  reversible lanes merge to NB here
145 235 145 238 0 ES-151R:MMN_Stn  #
145 238 145 241 0 ES-148D:_MN_Stn  #
145 241 145 247 0 ES-146R:MMN_Stn  #
145 247 145 253 0 ES-143D:_MN_Stn  #
145 253 145 259 0 ES-139R:MMN_Stn  #
145 259 145 265 0 ES-137R:MMN_Stn  #
145 265 145 274 0 ES-130D:_MN_Stn  # 520 meets I-5 NB lanes
145 274 145 283 0 ES-126D:_MN_Stn #
145 283 145 289 0 ES-125R:_MN_Stn #
145 289 145 295 0 ES-124D:_MN_Stn #
145 295 145 304 0 ES-123D:_MN_Stn #
145 304 145 313 0 ES-118R:MMN_Stn # I-90 meets I-5 NB lanes
145 313 145 319 0 ES-111R:MMN_Stn #
145 319 145 325 0 ES-108D:_MN_Stn #
145 325 145 331 0 ES-104D:_MN_Stn #
145 331 145 337 0 ES-102R:_MN_Stn #
145 337 145 343 0 ES-094R:MMN_Stn #
145 343 145 349 0 ES-093D:_MN_Stn #
145 349 145 355 0 ES-090D:_MN_Stn #
145 355 145 361 0 ES-088D:_MN_Stn  #
145 361 145 364 0 ES-087R:MMN_Stn  #
145 364 145 367 0 ES-086R:MMN_Stn  #
145 367 145 373 0 ES-083D:_MN_Stn  #
145 373 145 379 0 ES-082D:_MN_Stn  #
145 379 145 382 0 ES-081D:_MN_Stn  #
145 382 151 388 0 ES-080D:_MN_Stn  #
151 388 157 394 0 ES-079D:_MN_Stn  #
157 394 169 406 0 ES-077R:MMN_Stn  #
169 406 175 412 0 ES-076R:MMN_Stn  #
175 412 181 418 0 ES-074D:_MN_Stn  #
181 418 187 424 0 ES-073R:MMN_Stn  #
187 424 194 431 0 ES-070R:_MN_Stn  #
194 431 200 437 0 ES-069D:_MN_Stn  #
200 437 207 444 0 ES-068D:_MN_Stn  #
205 444 205 456 0 ES-059D:_MN_Stn  #
205 456 205 462 0 ES-057D:_MN_Stn  #
205 462 205 470 0 ES-055D:_MN_Stn  #
198 106 204 112 0 ES-764D:_MS_Stn       # east side inner loop 405 south
204 112 211 119 0 ES-763D:_MS_Stn  #
211 119 215 123 0 ES-762D:_MS_Stn  #
215 123 219 127 0 ES-759D:_MS_Stn  #
219 127 224 132 0 ES-757D:_MS_Stn  #
224 132 228 136 0 ES-756R:_MS_Stn  #
228 136 233 141 0 ES-754D:_MS_Stn  #
233 141 237 145 0 ES-751D:_MS_Stn  #
237 145 240 148 0 ES-750D:_MS_Stn  #
240 148 245 153 0 ES-748R:MMS_Stn  #
```

```
245 153 249 157 0 ES-746D:_MS_Stn  #
249 157 249 162 0 ES-744R:MMS_Stn  #
249 162 249 167 0 ES-742D:_MS_Stn  #
249 167 249 172 0 ES-741R:_MS_Stn  #
249 172 249 177 0 ES-740R:MMS_Stn  #
249 177 249 182 0 ES-739D:_MS_Stn  #
249 182 249 187 0 ES-738D:_MS_Stn  #
249 187 249 192 0 ES-736D:_MS_Stn  #
249 192 249 197 0 ES-734D:_MS_Stn  #
249 197 249 202 0 ES-731R:_MS_Stn  #
249 202 249 207 0 ES-730R:MMS_Stn  #
249 207 249 212 0 ES-726R:MMS_Stn  #
249 212 249 217 0 ES-724D:_MS_Stn  #
249 217 249 222 0 ES-722D:_MS_Stn  #
249 222 249 227 0 ES-720D:_MS_Stn  #
249 227 249 232 0 ES-717R:_MS_Stn  #
249 232 249 237 0 ES-716R:MMS_Stn  #
249 237 249 242 0 ES-711R:_MS_Stn  #
249 242 249 247 0 ES-710R:MMS_Stn  #
249 247 249 252 0 ES-709D:_MS_Stn  #
249 252 249 257 0 ES-708D:_MS_Stn  #
249 257 249 262 0 ES-706D:_MS_Stn  #
249 262 249 267 0 ES-704D:_MS_Stn  #
249 267 249 277 0 ES-698D:_MS_Stn  #
249 277 249 282 0 ES-696D:_MS_Stn  #
249 282 249 287 0 ES-689R:MMS_Stn  #
249 287 249 292 0 ES-684D:_MS_Stn  #
249 292 249 297 0 ES-681R:MMS_Stn  #
249 297 249 302 0 ES-678D:_MS_Stn  #
249 302 249 307 0 ES-677D:_MS_Stn  #
249 307 249 317 0 ES-676D:_MS_Stn  #
249 317 249 322 0 ES-672D:_MS_Stn  #
249 322 249 327 0 ES-667D:_MS_Stn  #
249 327 249 332 0 ES-665D:_MS_Stn  #
249 332 249 337 0 ES-662R:MMS_Stn  #
249 337 249 342 0 ES-659D:_MS_Stn  #
249 342 249 347 0 ES-657D:_MS_Stn  #
249 347 249 352 0 ES-656D:_MS_Stn  #
249 352 249 357 0 ES-653R:MMS_Stn  #
249 357 249 362 0 ES-651D:_MS_Stn  #
249 362 249 367 0 ES-647R:MMS_Stn  #
249 367 249 377 0 ES-645D:_MS_Stn  #
249 377 249 387 0 ES-642R:MMS_Stn  #
249 387 249 400 0 ES-638R:_MS_Stn  #
245 404 249 400 0 ES-633R:MMS_Stn  #
241 408 245 404 0 ES-632D:_MS_Stn  #
238 411 241 408 0 ES-630D:_MS_Stn  #
234 415 238 411 0 ES-628D:_MS_Stn  #
230 419 234 415 0 ES-625D:_MS_Stn  #
227 422 230 419 0 ES-622D:_MS_Stn  #
224 425 227 422 0 ES-621D:_MS_Stn  #
220 429 224 425 0 ES-619D:_MS_Stn  #
216 433 220 429 0 ES-616R:MMS_Stn  #
213 436 216 433 0 ES-614D:_MS_Stn  #
209 440 213 436 0 ES-612D:_MS_Stn  #
205 444 209 440 0 ES-610D:_MS_Stn  #
```

Appendix D Camera Sequence File (CAMSEQUENCE.TXT)

```
167,246,SR520 Lk Wash Blvd
188,241,SR520 Midspan
232,243,SR520 Bellevue Way NE
308,245,SR520 NE 51st St
190,309,I-90 Midspan EB
217,311,I-90 E Mercer Way
310,311,I-90 161st Ave SE
99,150,I-5 NE 145th St
99,248,I-5 NE 45th St
99,283,I-5 Denny Way
135,326,I-5 Yesler Way
198,442,I-5 Duwamish River
236,420,I-405 SR 167
252,404,I-405 SR 169
280,293,I-405 Main St
280,223,I-405 NE 85th St
```