Design and Implementation of Video for Rural ITS

Western States Forum 2013

V2W and V2P Presentation by

Israel Anthony Lopez on

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NDOT Traffic Operations, Technology Section (TOTS)

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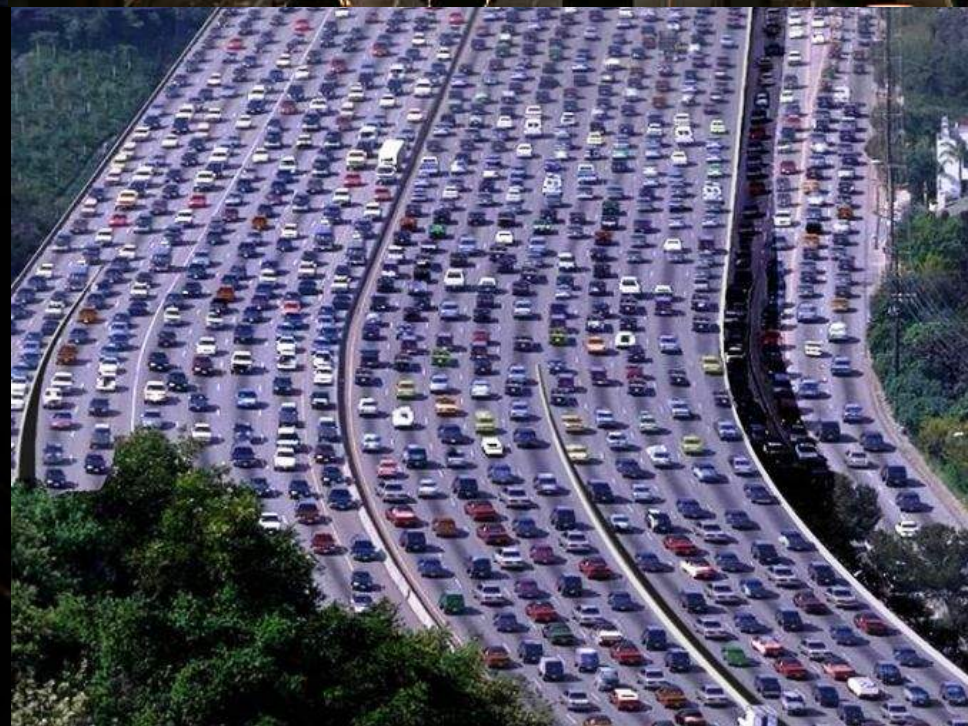
Normal Freeway Conditions

Congested Freeway Conditions



Freeway and Roadway Conditions

Incidents Related to Freeway Conditions

Freeway Conditions or Incidents can make it feel like….

A Little Something About Me

- 17 years experience in Data and Video transport in Tactical, Enterprise, and ITS environments
- Spent three years in high school programming in Cobol, Fortran, Corba, C, etc, and Micro VAX II Admin in (1987 – 1990 – Carl Hayden HS Center for Computer Studies)
- Worked as Server Administrator (6+ years)
- Worked as Network Administrator (6+ years)
- Worked as HF, UHF, Satellite & FM radio technician (6+ years)
- Worked as Information Security Analyst (6+ years)
- Worked as Instructor for Fiber Master Journeyman Training Courses

http://www.linkedin.com/pub/israel-anthony-lopez/b/210/477

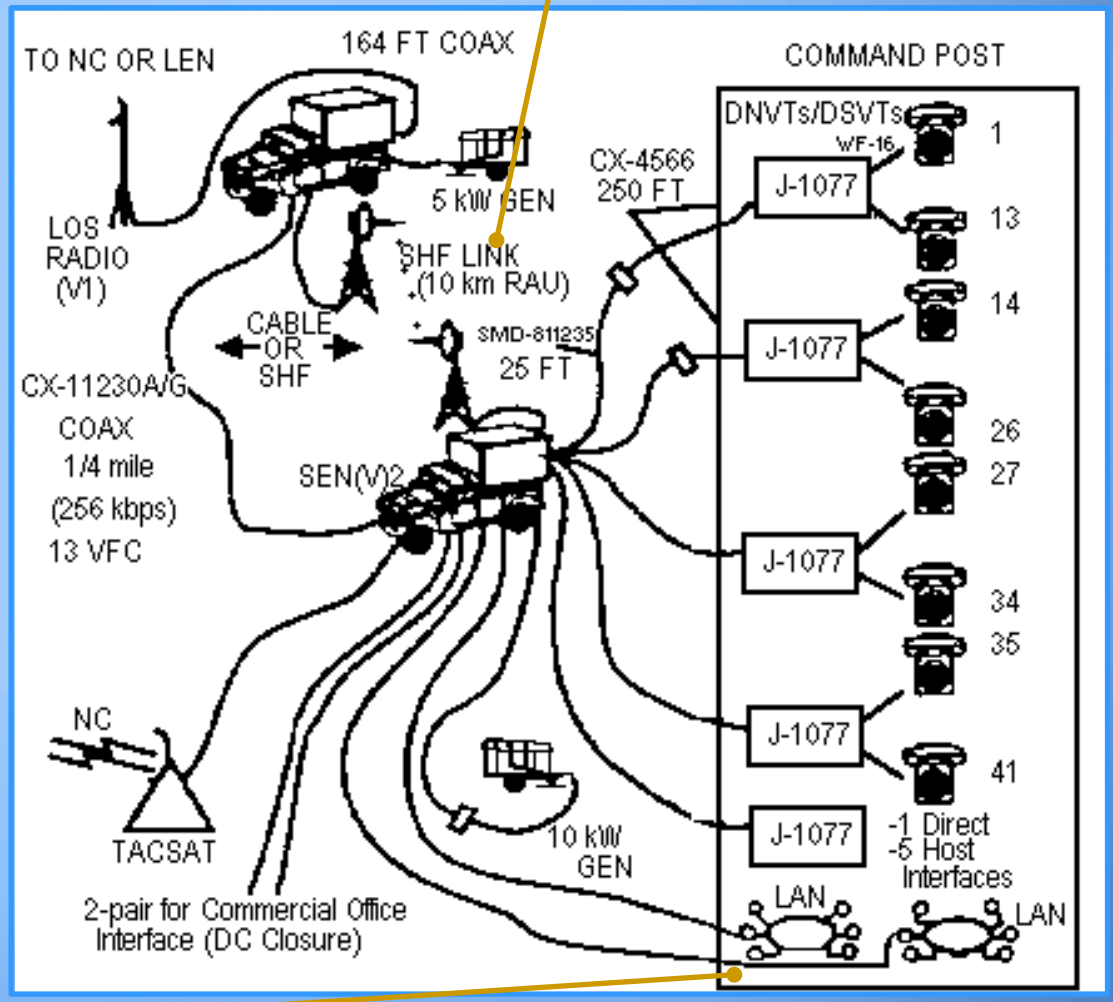
My First IT Job

Super High Frequency – 3GHz to 30GHz

A Little Something About Me

Tactical – 1995 to 2001

- 128 Kbps / 256 Kbps / 512 Kbps / 1 Mbps
- Tactical packet switched wide area network
- Windows Server 3.5
- Microsoft Exchange Server 4.0
- Local Area Network
- Tactical Telephones
- Video Conferencing (business class 128 kbps to 384 Kbps)



A Little Something About Me

- **Bit Rate:** 128 Kbps to 1 Mbps
- **Voice Channels:** 8 Kbps, 16 Kbps, 32 Kbps and 64 Kbps
- **Packet Switch Connections:** 2 IEEE 802.3 LANs, 5 x.25 HOSTS
- **Channels Used:**

  --(V)1: 10 Voice; 1 Packet SW; 1 Overhead; 4 Unused; 16 Total – 128 Kbps

  --(V)2: 10 Voice; 1 Packet SW; 1 Overhead; 4 Unused; 16 Total – 128 Kbps

A Little Something About Me

- X.25 is an ITU-T standard protocol suite for packet switched wide area network (WAN) communication.
- An X.25 WAN consists of packet-switching exchange (PSE) nodes as the networking hardware, and leased lines, plain old telephone service connections or ISDN connections as physical links.
- X.25 is a family of protocols that was popular during the 1980s with telecommunications companies and in financial transaction systems such as automated teller machines

Video-to-Public (V2P) and Video-to-Web (V2W) Overview

Axis Releases 1st Network Camera: http://www.axis.com/corporate/about/history.htm
Smart Sight Manual: http://goo.gl/VReru
Air Force Report on EnerDyne LNX7000: http://goo.gl/KmdTa

Industry Environment in 2002

- Axis released the first network camera in 1996. This marks the first use of IP cameras in the industry
- Enerdyne developed a MJPEG video encoder in 2000. The device was built for high latency applications and was used for Air Force Unmanned Aerial Vehicles (UAV)
- Smart Sight released their wireless IP video system in 2000.

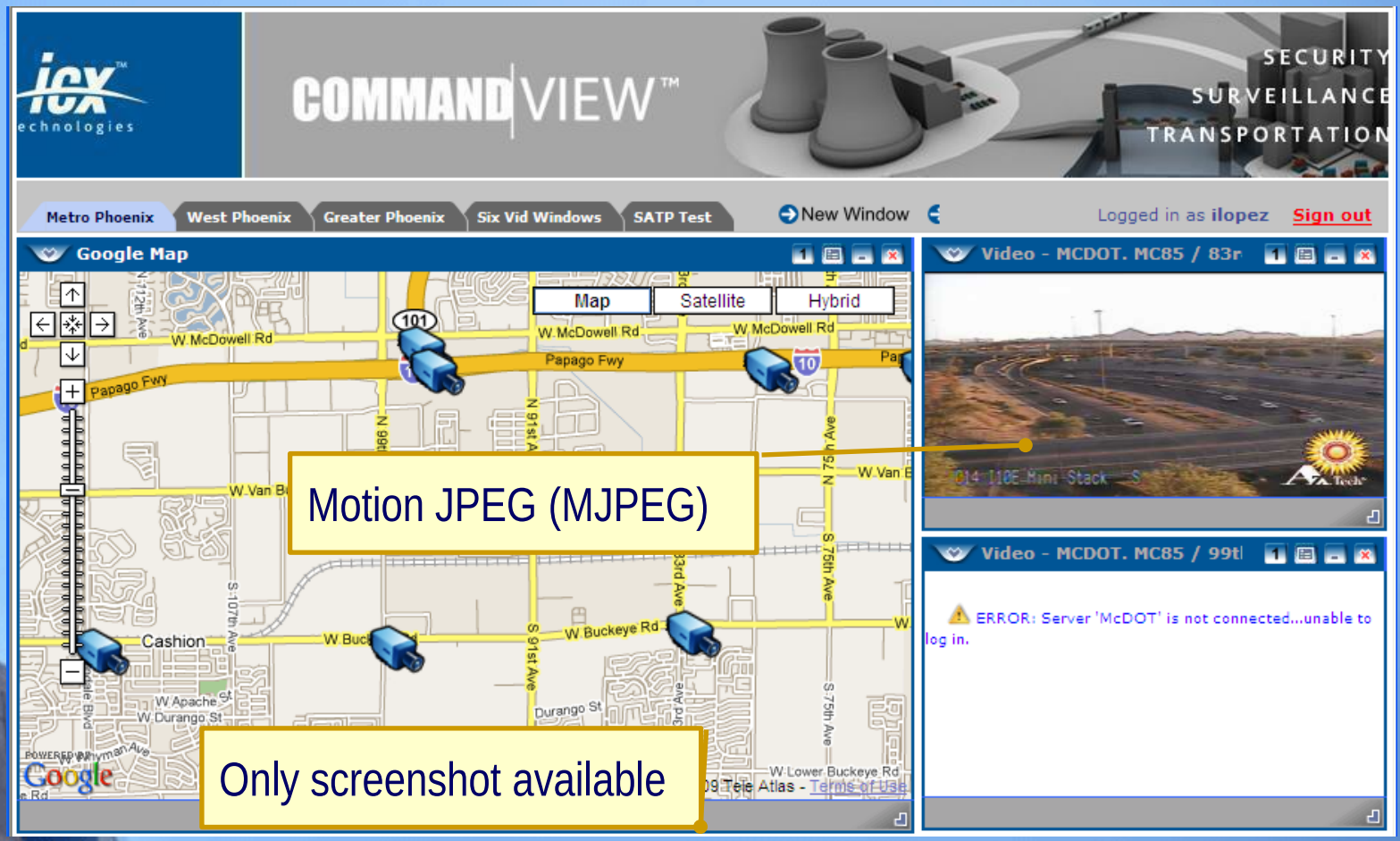
V2P and V2W Overview

- The V2W / V2P concept had a very humble beginning
- The original test project was deployed for City of Phoenix. This was funded solely by the City
- The original project with the current functionality was deployed for MCDOT and ADOT (MJPEG Version) under a RFP
- The second deployment was in Reno and Elko (WMV / H.263 / H.264)

V2P and V2W Overview

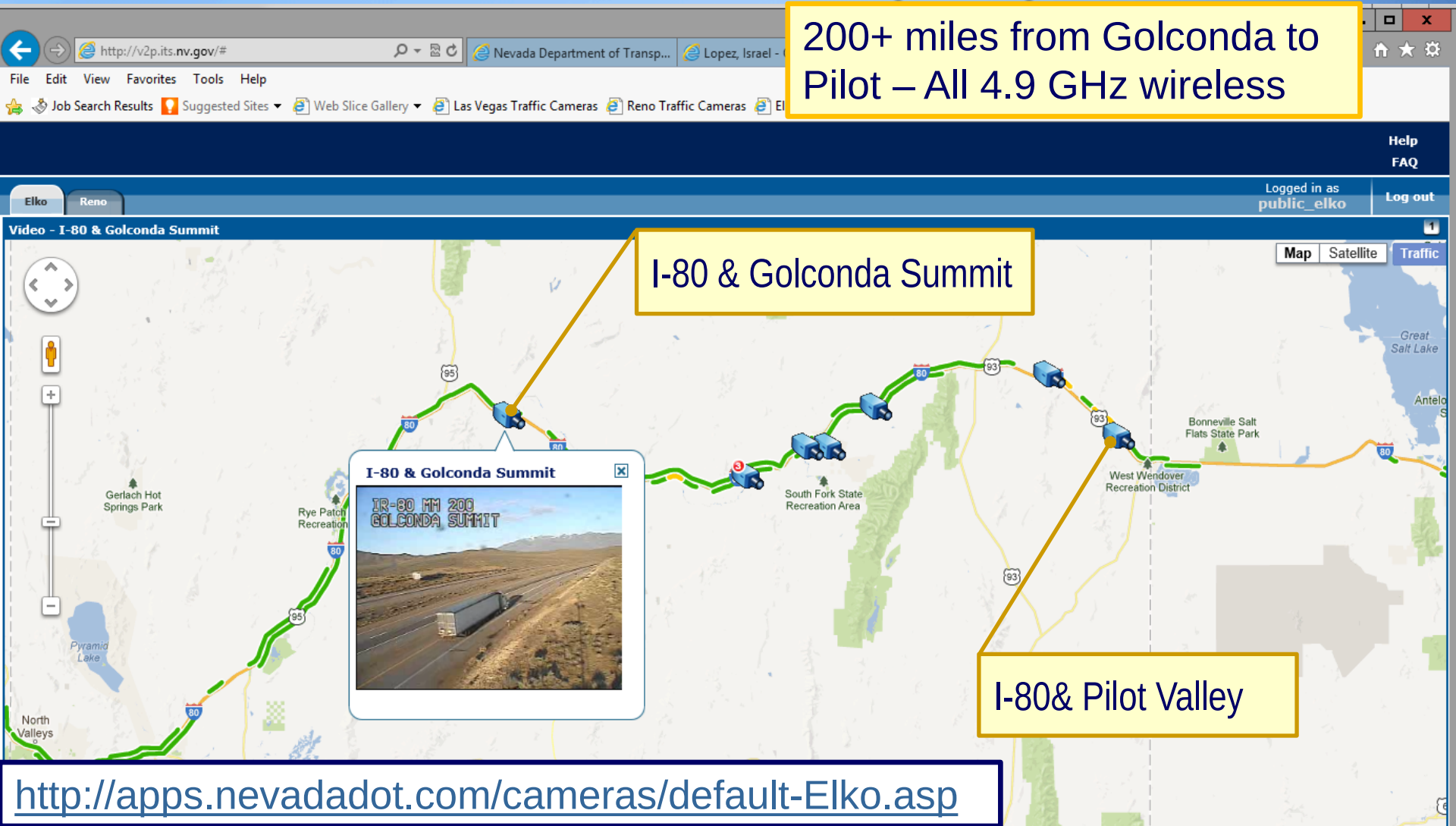
- The third deployment was in Las Vegas (WMV / H.263 / H.264)
- A future improvement will transcode all V2P feeds to H.264 to support mobile applications
- The system can scale from any size to any size without a forklift upgrade
- The cost revolves around a one-time license fee, a software assurance fee, and the cost of integration

ADOT and MCDOT V2W Screenshot



Elko Video to Public (V2P) Screenshot

200+ miles from Golconda to Pilot – All 4.9 GHz wireless



http://apps.nevadadot.com/cameras/default-Elko.asp

Elko V2P and V2W

- Elko – 8 cameras, 16 camera feeds distributed
- 8 camera feeds to V2P and 8 camera feeds to V2W
- Consists of 200+ Linear Miles of Wireless Backhaul
- Multicast over 4.9 GHz

Elko V2P and V2W

- Latency < 25 ms (Hot Springs -> HQs -> COLO -> D3 TMC -> D3 Field = 313 Miles. Wireless -> Fiber -> Wireless. – Lamoille Camera)
- Teleste and CoreTec Encoders: MPEG4 part 2 (H.263), 30 frames-per-second (FPS), & 4 Mbps

Reno Video to Web (V2W) Screenshot

Reno V2P and V2W

- 30 cameras distributed to the Public, 40+ cameras actual (the remaining 10 cameras are 3G/4G cameras)
- 30 camera feeds to V2P and 30 camera feeds to V2W
- Multicast over fiber, multicast over 4.9 GHz, and Unicast over 3G/4G

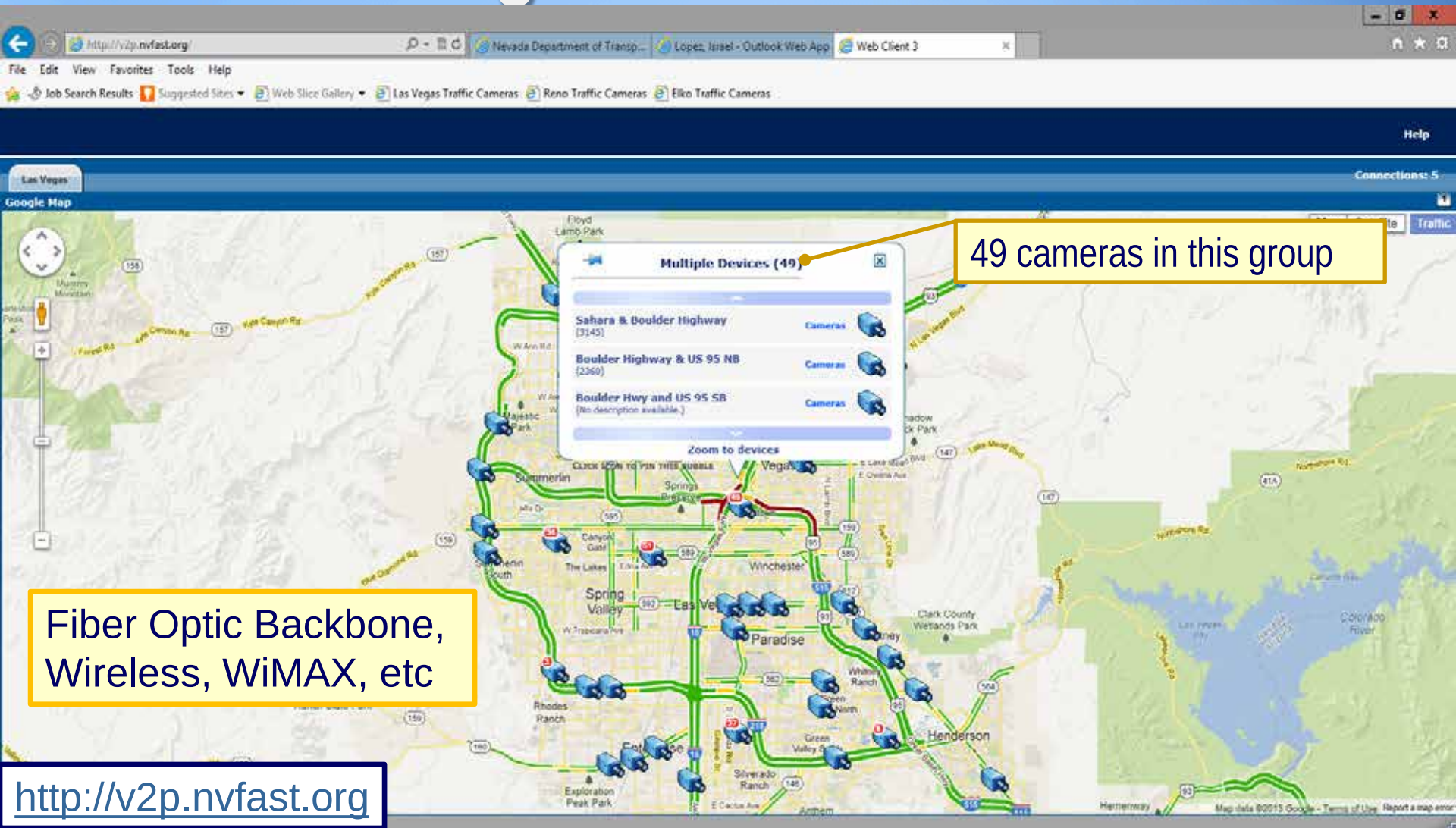
Reno V2P and V2W

- **Fiber Latency < 4 ms:** (Hot Springs -> HQs -> COLO -> D2 TMC - > Field = 35 Miles. Wireless to Fiber - I580 & Plumb Camera)
- Teleste and CoreTec Encoders 6401 (Fiber/Wireless): MPEG4 part 2 (H.263), 30 FPS, & 4 Mbps
- CoreTec Encoder 7401 & Axis (3G / 4G): MPEG4 part 10 (H.264), CIF, 30 FPS, & 200 Kbps (57 locations + 123 count stations)

Reno V2P and V2W

- Average Latency for 3G / 4G depends on device & location. Usual is around 200 to 300 milliseconds
- Most of the cameras where installed using 4.9 GHz wireless until the fiber was in place
- Average latency for the wireless cameras was 25 milliseconds
- No wireless cameras are installed at this time
- There is plan to convert most of the 3G/4G locations to licensed wireless (3.5 GHZ / 3.65 GHZ)

Las Vegas V2P Screenshot



Las Vegas V2P and V2W

- 230 camera feeds for distribution to the public, 500+ cameras actual
- 230 camera feeds to V2P and 230 camera feeds to V2W
- Multicast over fiber, multicast over WiMAX, and other transport means
- Teleste, Cornet, and CoreTec Encoders (Fiber/Wireless): MPEG4 part 2, 4CIF, 30 frames-per-second (FPS), & 4 Mbps
- Axis Encoders (Fiber/Wireless): MPEG4 part 10, 4CIF, 30 frames-per-second (FPS), & 2.5 Mbps

Before we start the “how” I want to discuss the “why” for the project

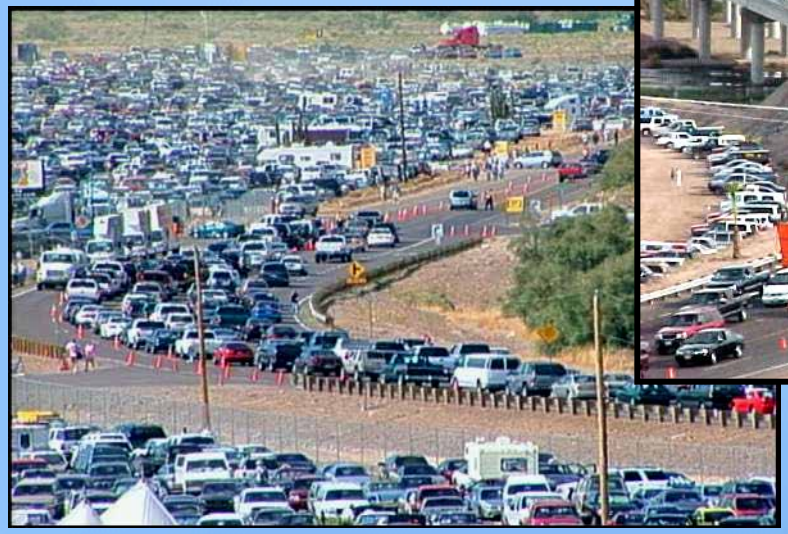

The Beginning

Phoenix Internal Raceway (PIR)

Phoenix International Raceway

Access (freeway and arterial) - Few alternate inbound/outbound routes

2 Hours Prior to Event



Phoenix International Raceway

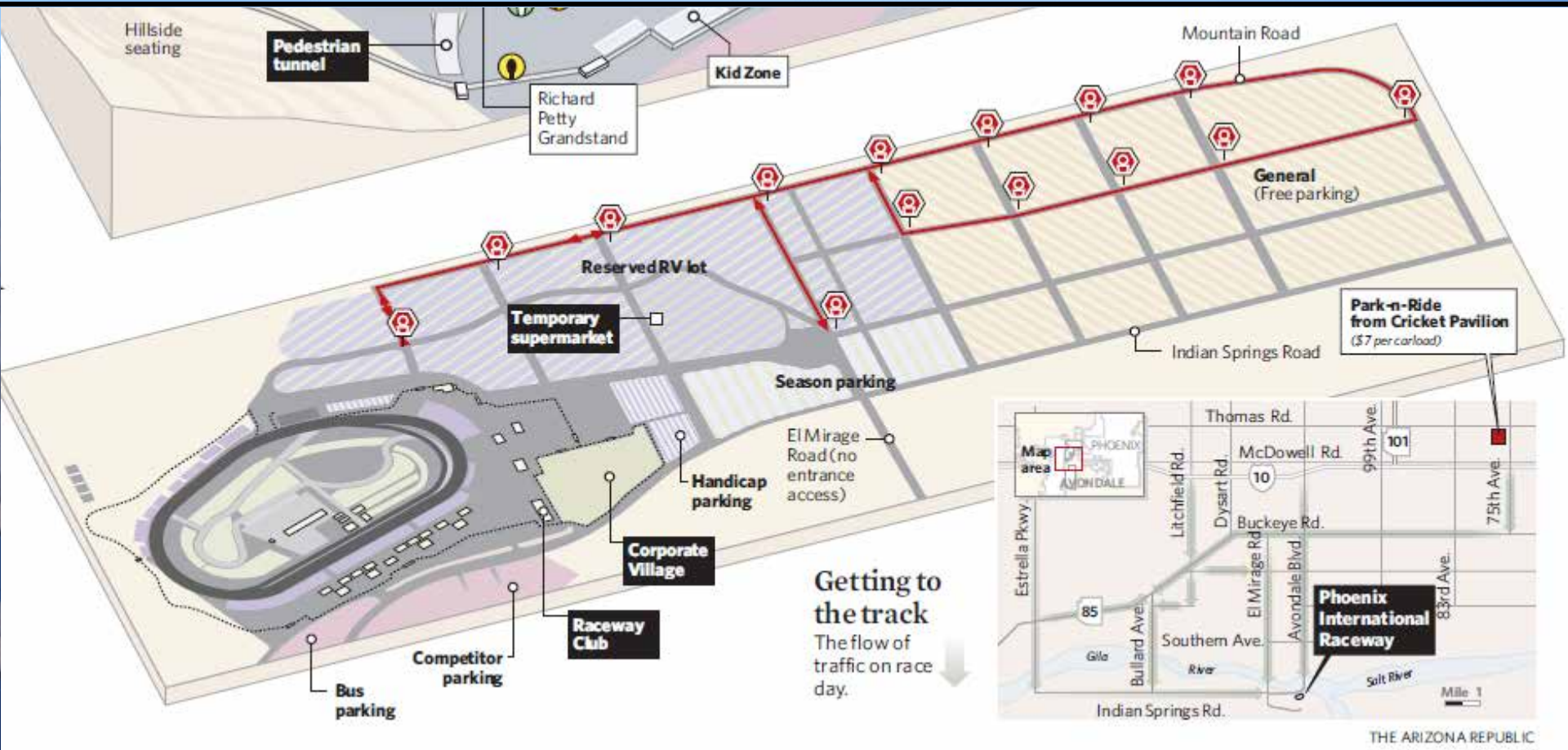
The Fans

At the Event

PHOENIX
INTERNATIONAL
RACEWAY

Phoenix International Raceway

Event Parking



Phoenix International Raceway

Event Parking Days Before the Main Event

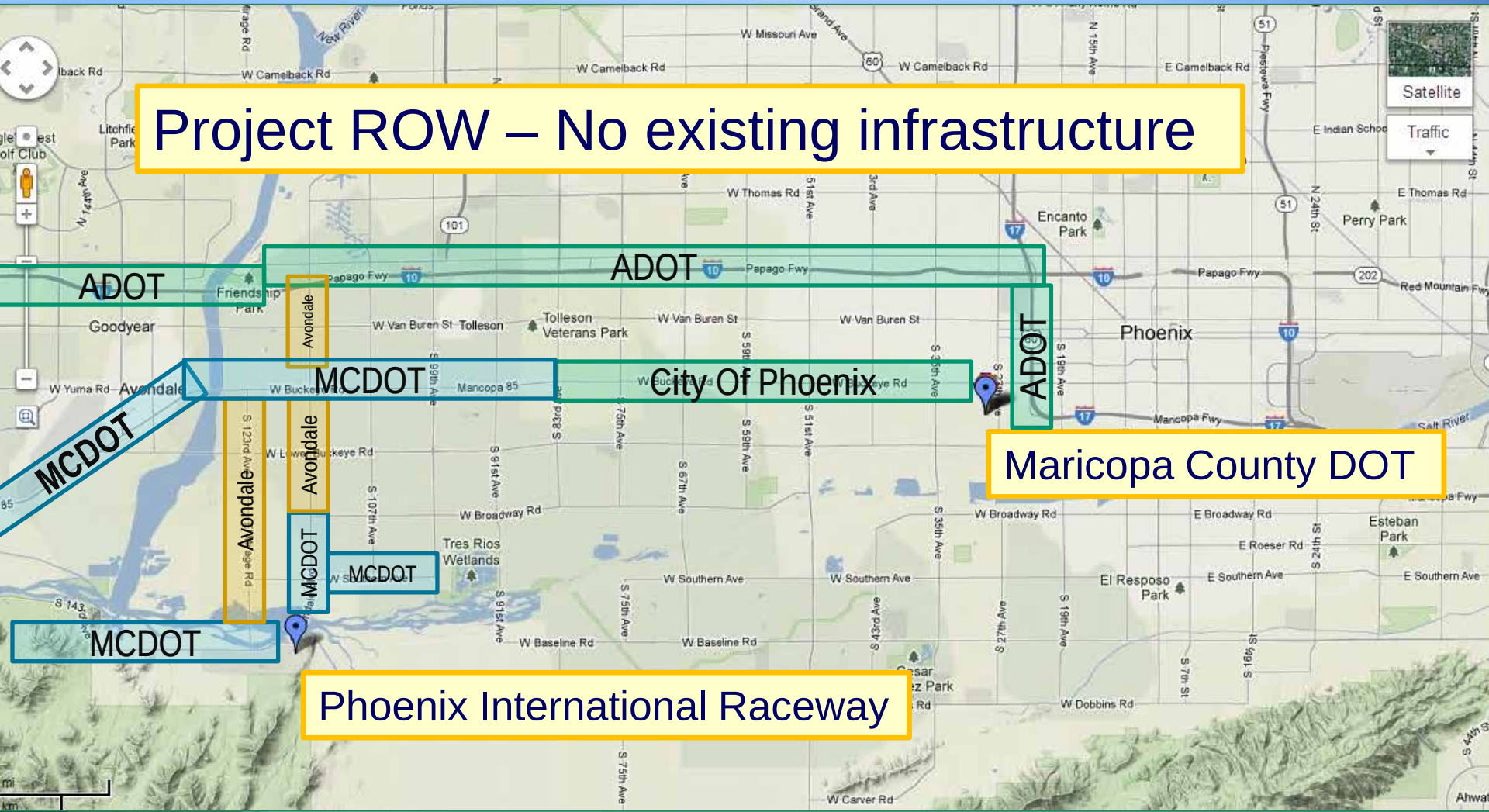
People often camp at the state park

PIR = 400 Acres

RV Parking a few days prior to the race

Parking is completely full

Maricopa County Right-of-Way



PIR Technology Time Line

- 2001 – Wireless Camera Backhaul
- 2002 – Microcell based user wireless network with unique SSID per cell and fixed CDMA user access
- 2003 – Single SSID for user wireless network and mobile CDMA access
- 2004 / 2005 – Permanent installation of all MC85 cameras and installation of T1 routers and encoders
- 2005 – Second race added to PIR (Nov / Mar)

PIR Technology Time Line

- Management of event moved from Command Tower to TMC

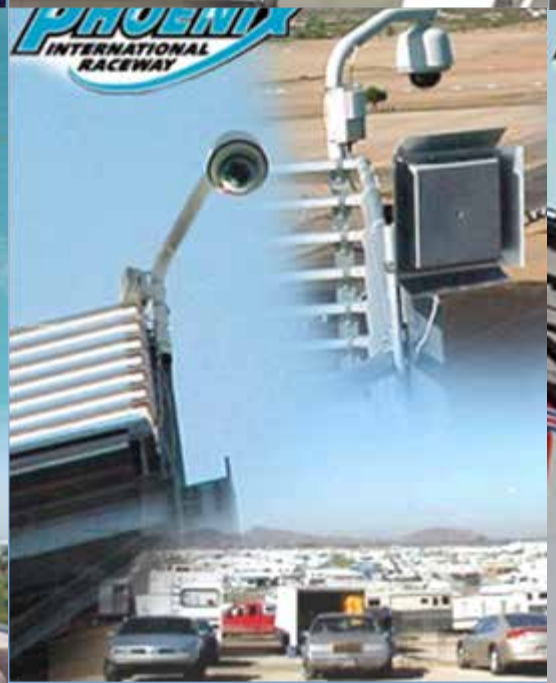
- 2006 – Bell Road Fiber Optic Project
  - Video Multicast
  - Wireless 5.8 & 4.9 GHz extensions over T1s
- 2007 – Core Switch & Core Router Install
- 2008 – V2W RFI / V2W RFP
- 2009 – V2W Installation

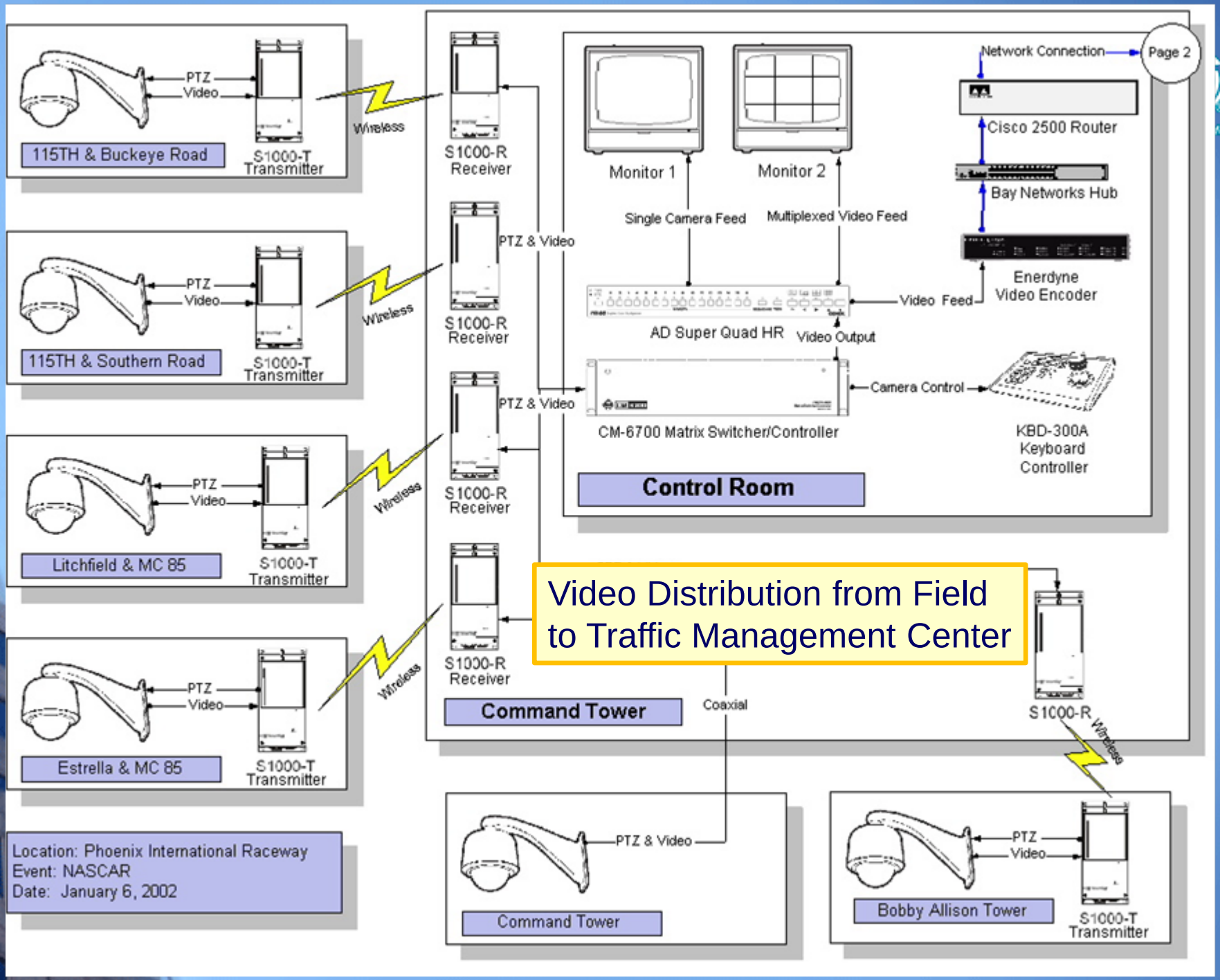
Phoenix International Raceway

- 2001 to 2004 – Wireless Camera Backhaul

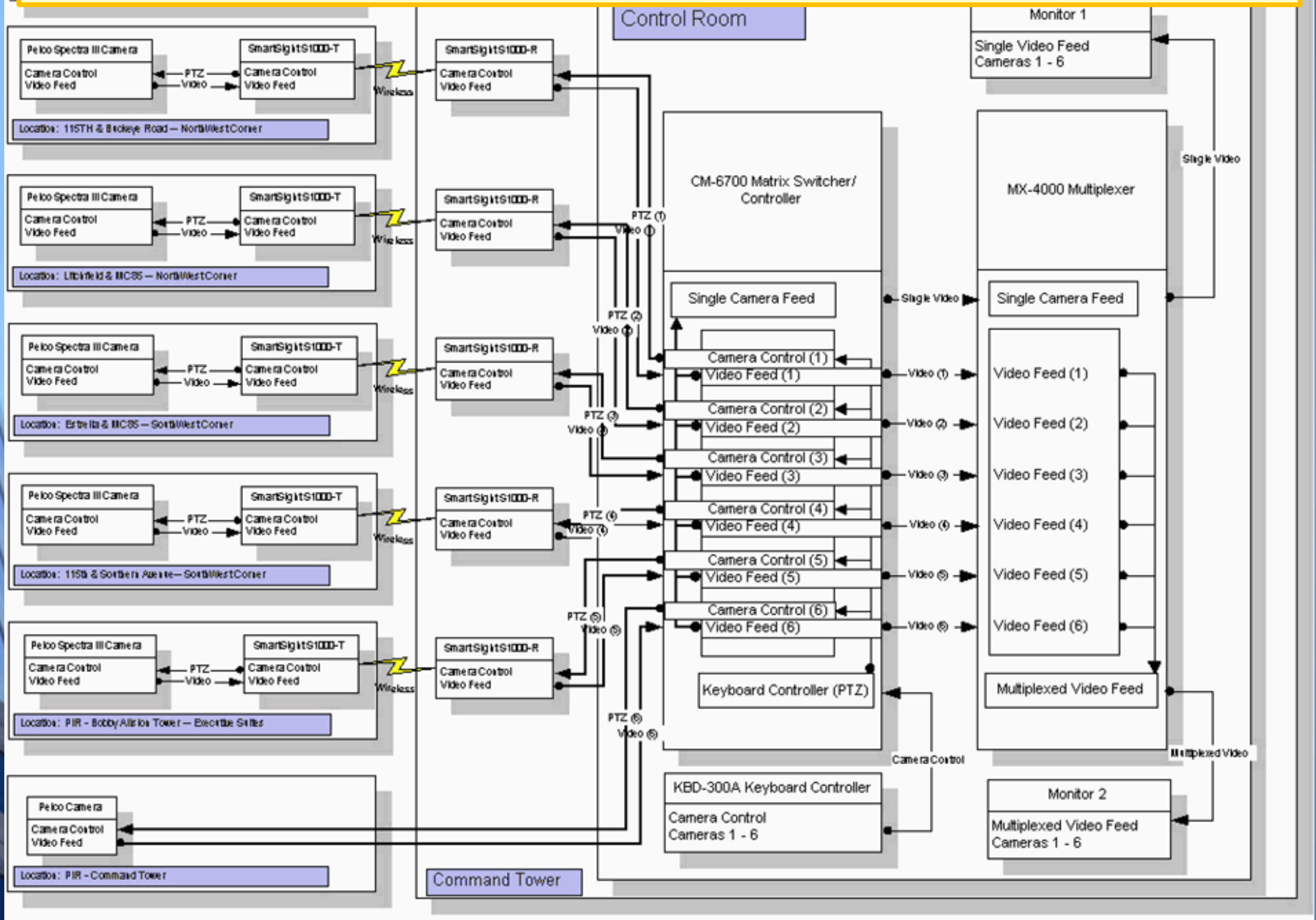
511
da Travel Info

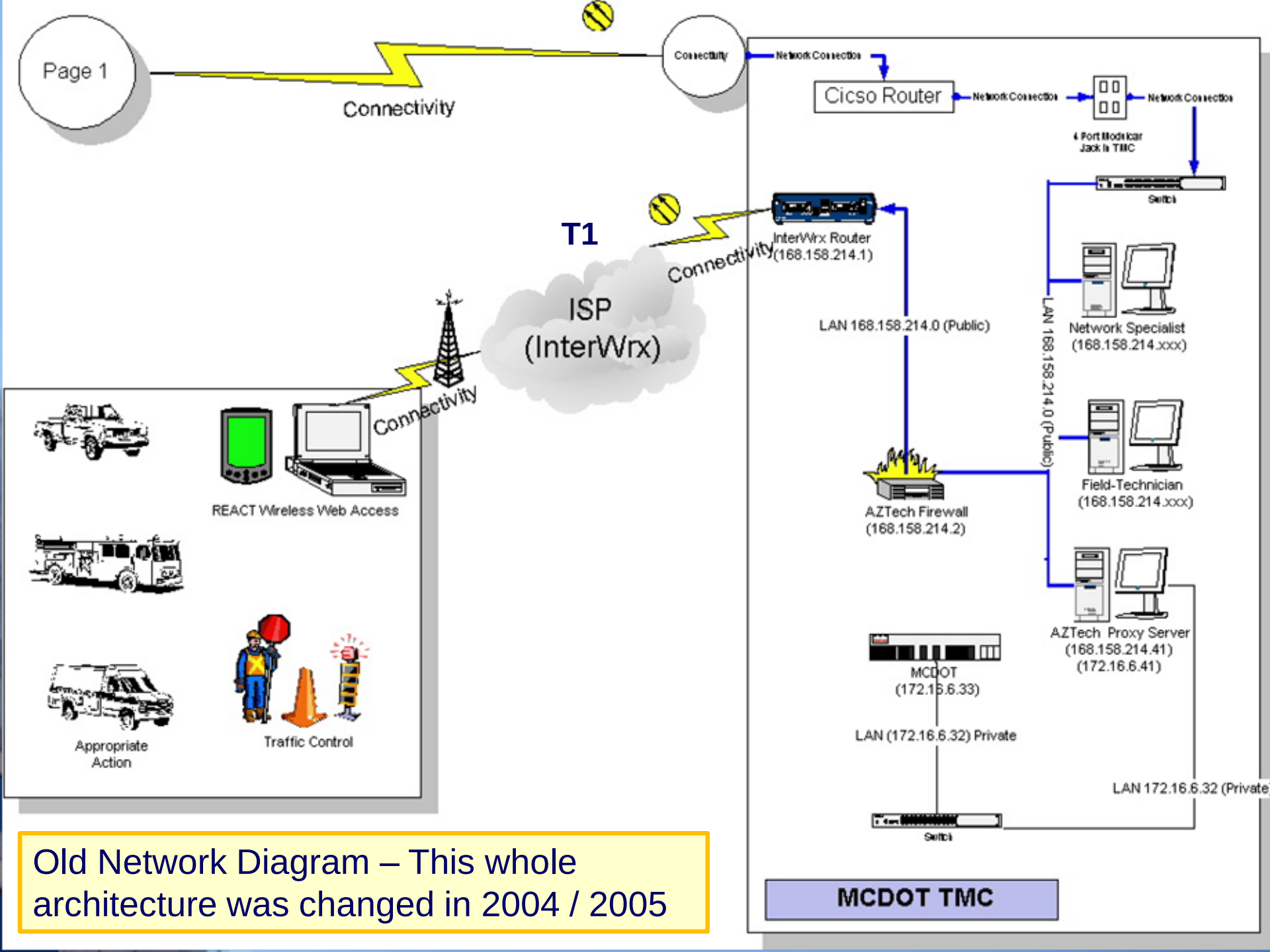
2001 – 2004: Wireless Camera Backhaul Locations.




Video Distribution from Field to Traffic Management Center
115TH & Buckeye Road
PTZ
Video
S1000-T Transmitter
Wireless
S1000-R Receiver
115TH & Southern Road
Litchfield & MC 85
Estrella & MC 85
PTZ & Video
Monitor 1
Monitor 2
Single Camera Feed
Multiplexed Video Feed
Network Connection
Page 2
Cisco 2500 Router
Bay Networks Hub
Enerdyne Video Encoder
Video Feed
AD Super Quad HR
Video Output
CM-6700 Matrix Switcher/Controller
Camera Control
KBD-300A Keyboard Controller
Control Room
Command Tower
Coaxial
Location: Phoenix International Raceway
Event: NASCAR
Date: January 6, 2002
Bobby Allison Tower

This document is the same as the previous document but shows the interfaces connected through the system in more detail





Old Network Diagram – This whole architecture was changed in 2004 / 2005

Phoenix International Raceway

- The cameras where installed and operational twice a year, every year for two weeks from 2001 to 2005
- Traffic was managed out of the Command Tower until 2005
- To backhaul the video feeds we used the Smart Sight S1000 with settings configured at 800 kbps, MPEG4, and 30 FPS over a 1 Mbps link. NTSC in/out device
- Each paired units used 2.4 GHz Direct-Sequence Spread Spectrum (DSSS) with a built-in MPEG4 encoder or decoder

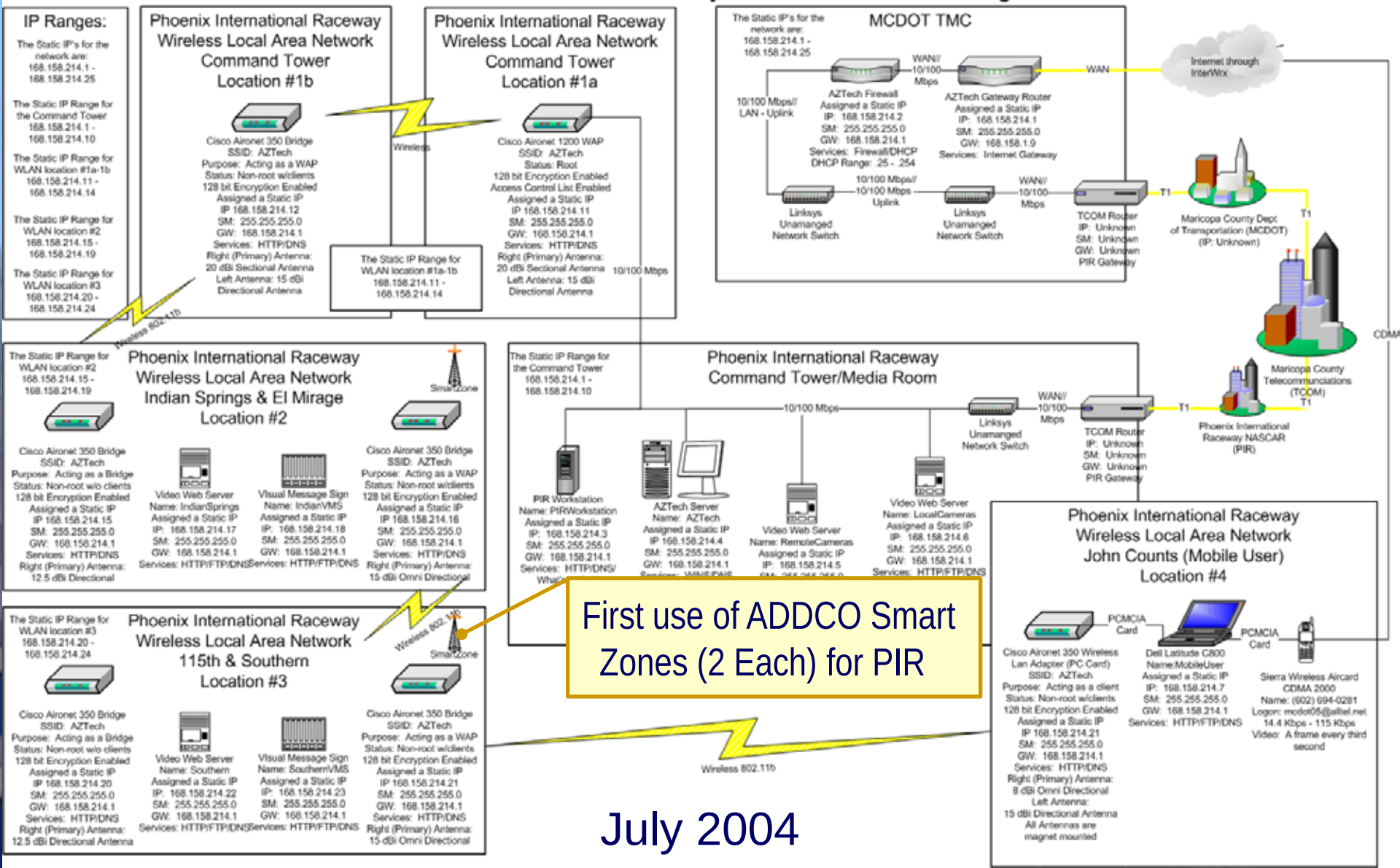
Phoenix International Raceway

- The Enerdyne LNX7000 encoder was used to re-encode the video feeds to MJPEG streams for distribution to the Internet
  - The User received a quaded still image video feed and the user could click into one of the quads for streaming video
- The Enerdyne streamed the selected video feed to the user
  - CDMA users received a MJPEG stream at 3 to 15 Frames-per-Second.

Phoenix International Raceway

- CDMA 2000 had a max capacity of 115 Kbps
- TMC users received full motion video (Full T1) at the MCDOT TMC
- The only caveat is that the “user’s wireless” network which was 802.11b only worked well until the race commenced

Phoenix International Raceway Communications Diagram



First use of ADDCO Smart Zones (2 Each) for PIR

July 2004

ADDCO Trailers for PIR

Phoenix International Raceway

- In 2004, we added the use of the ADDCO Smart Zone trailers
- In 2005 we converted all the MC-85 cameras to T1s (DS1s) and the cameras stayed up permanently.
- The User Wireless network covered a majority of the major roadways into PIR
- Whatever solution we implemented had to be applicable to rural and urban environments

PIR Wireless Local Area Network

Phoenix International Raceway

- We received extensive interference from racecar headsets, spotter headsets, and broadcast interference from the sports and news stations once the race started. The event had very little vehicle traffic once cars where actually racing
- We had Verizon install a temporary tower two times a year for our needs as well as the needs of the public
- We got better at setting up the User's Wireless network
- This allowed Users to view the camera on the Wireless Local Area Network (WLAN)

PIR Lessons Learned

PIR Lessons Learned

1. Know the technology better than the manufacturer's service representatives by reading the manual cover-to-cover for all devices. Equipment manuals are free and are available upon request from the vendor
2. Keep It Simple, Stupid (KISS) – Wireless SSID
3. Build It Once. Consider every option to include the most expensive. It is better to build out the equipment, site, or application to support any new functionality for the next five to seven years than to replace it every time a change needs to occur. Build it once and you won't have to worry about it again

PIR Lessons Learned

4. Review your design concept with others (But remember #1)
5. Your probably not going to have any more time than you already have. Plan accordingly!
6. Your probably not going to get any more help than you already have. See # 5, second sentence
7. Sometimes you fail! Now, you know what doesn't work
8. Do not be afraid to take risks in design & equipment but refer to #1

PIR Lessons Learned

9. Diagram every process, interface, or interaction. This helps to identify anything that you might have missed

10. You can not account for every possible factor but be prepared as much as you can

11. Remember to test your equipment on the bench three weeks prior to deployment for a minimum of one week using the field settings. If it is going to break it will break within the first couple of days.

V2W and V2P Project Needs and Requirements

Project Needs and Requirements

- Video Monitoring for Event Management
- Incident Management (Fatalities / Accidents)
- Regional Video Sharing (Public and Private Strategic Partners)
- Video Sharing with the Public (Live Streaming Video)

Original Design Requirements - 2007

- AZTech Public and Private Partners needed access to full motion video feeds and have the ability to control CCTV cameras
- There was a demand for use of a web client for Incident and Event Management personnel in the field using 3G or other wireless communications
- The application had to be simple to use and the system should support the current State and County Operating System of choice (Windows XP / IE8)

Many more requirements but these are the most essential – Original RFP

Current Design Constraints- 2010

- The solution should not require multiple vendors for distribution of video
- The proposed system must have a low intervention and systems management level
- Minimal development should be needed to meet the requirements
- The CCTV camera icons need to be mapped to a web-based map (autonomously)

Current Design Requirements - 2010

- The system will need to authenticate users against the State's Freeway Management System (FMS) known as Central System Software (CSS) for camera switching, presets, and camera control
- The system would need to query CSS for an inventory of CCTV cameras
- The distributed video streams had to be usable by a third party
- The system had to use Windows Media Video for the Public side and H.262, H.263, and H.264 for Strategic partners

Current Design Requirements - 2010

- The proposed system must be expandable without a forklift upgrade to a different / improved platform

NDOT Finalized on a Solution

FLIR – 360 Surveillance – Camera Cameleon

- Video to Web (V2W) – Web Client for Public and Private Strategic Partners (underlying system)
- Video to Public (V2P) – Public Web Interface
- FLIR did not support Windows Media Video. A Windows Media Video transcoder was needed for the project
- FLIR had to develop the CSS interface

http://360surveillance.com/

CSS to Camera Cameleon Interface

Camera Cameleon to CSS Interface

- A Video Management Server (VMS) is installed to manage devices as objects. A user generally enters the device names, device manufacture information, device model #, GIS locations, multicast addresses / multicast port #s, or unicast information into the server
- The VMS often integrates with third party applications and devices
- The VMS controls devices, schedules events, and obtains status on devices. For CCTV cameras, a VMS provides a viewing platform and allows for PTZ control

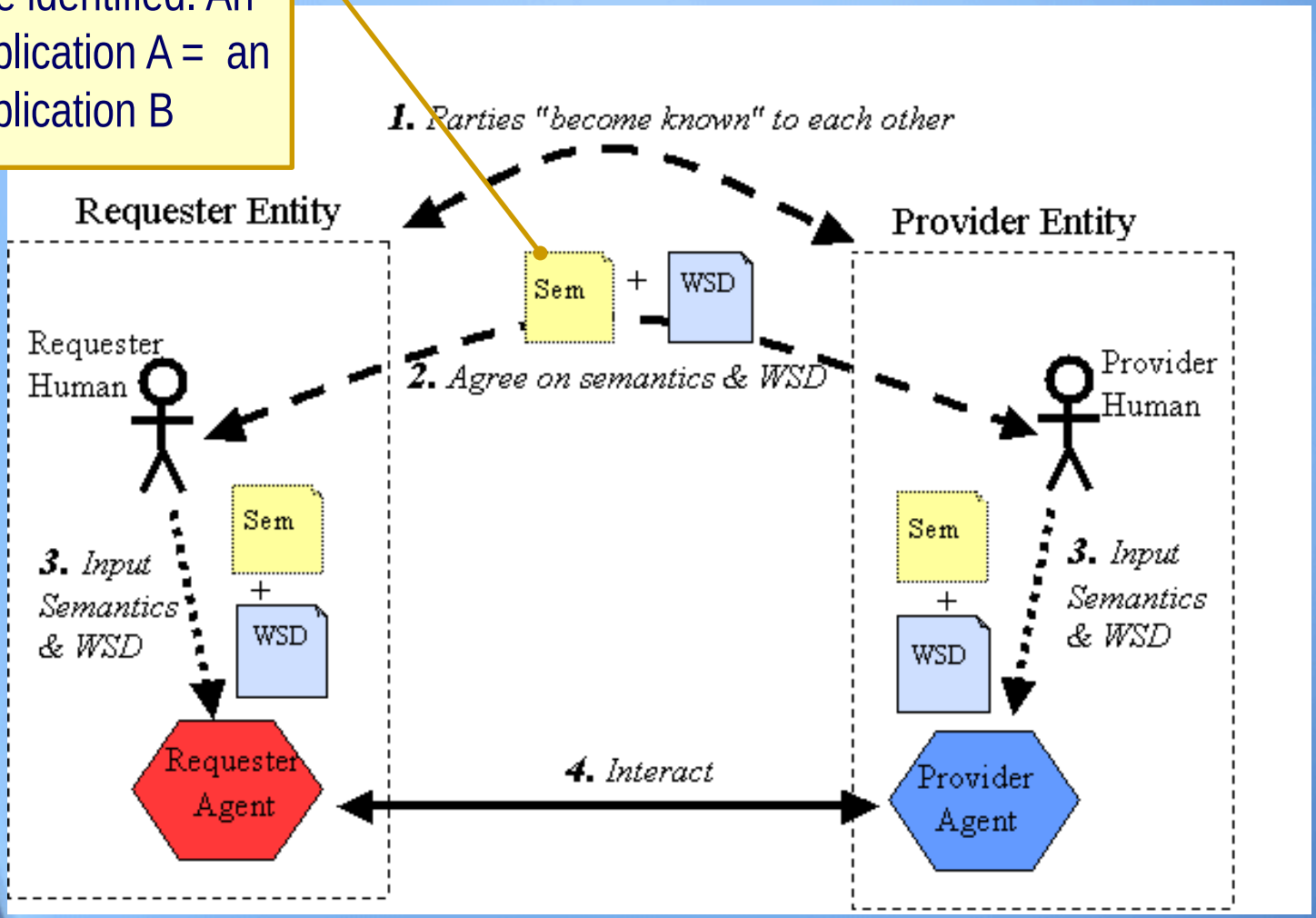
Camera Cameleon to CSS Interface

Authentication, Authorization, and Accounting (AAA) integration between iCX and KHA CSS

- KHA developed a Web Services Description Language (WSDL) to allow third parties to interface with their CSS software
- FLIR developed a VMS interface that queries the KHA CSS WSDL web service
- Users are validated against their permissions in KHA CSS prior to being able to select, view, and PTZ each camera.

Web Services Description Language (WSDL)

Semantics are identified. An apple on application A = an apple on application B



Web Services Description Language (WSDL)

- WSDL is an XML-based interface description language that is used for describing the functionality offered by a web service
- WSDL provides a machine-readable description of how the service can be called, what parameters it expects, and what data structures it returns.
- The WSDL describes services as collections of network endpoints, or ports

Web Services Description Language

- WSDL is often used in combination with Simple Object Access Protocol (SOAP) and an XML Schema to provide Web services over the Internet
- SOAP is a simple XML-based protocol to let applications exchange information over HTTP
- A message can be sent oneTime, periodic, onChange, or onRequest

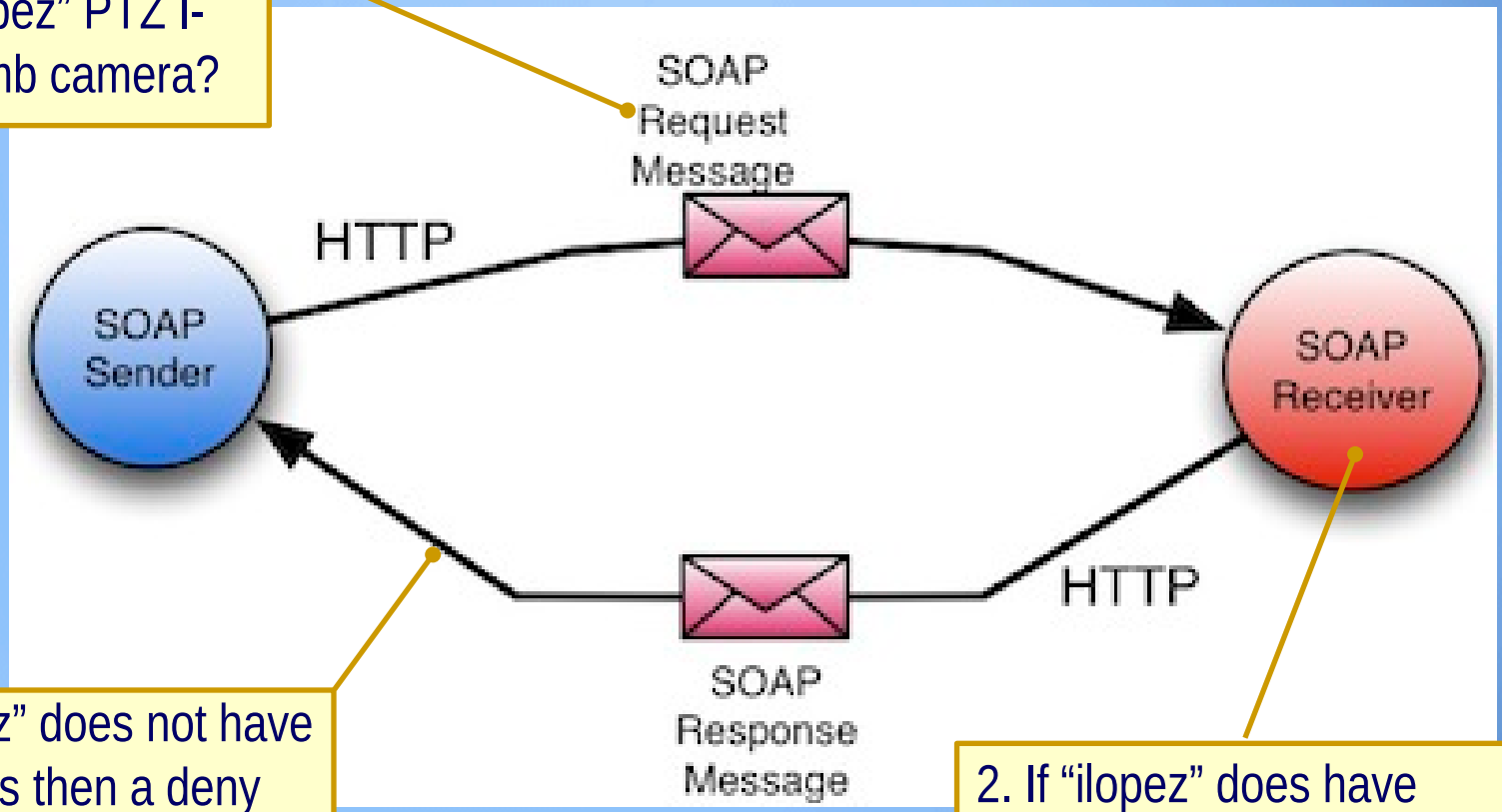
Web Services Description Language

Information sent or received (Camera Cameleon)

- Camera name query
- Camera number query
- Camera location (latitude / longitude) query
- CCTV camera presets query
- Suppression flag query
- Device control requests
  - Video Switch
  - Preset
  - Pan, Tilt, and Zoom (PTZ)
  - FocusIn and FocusOut

Web Services Description Language (WSDL)

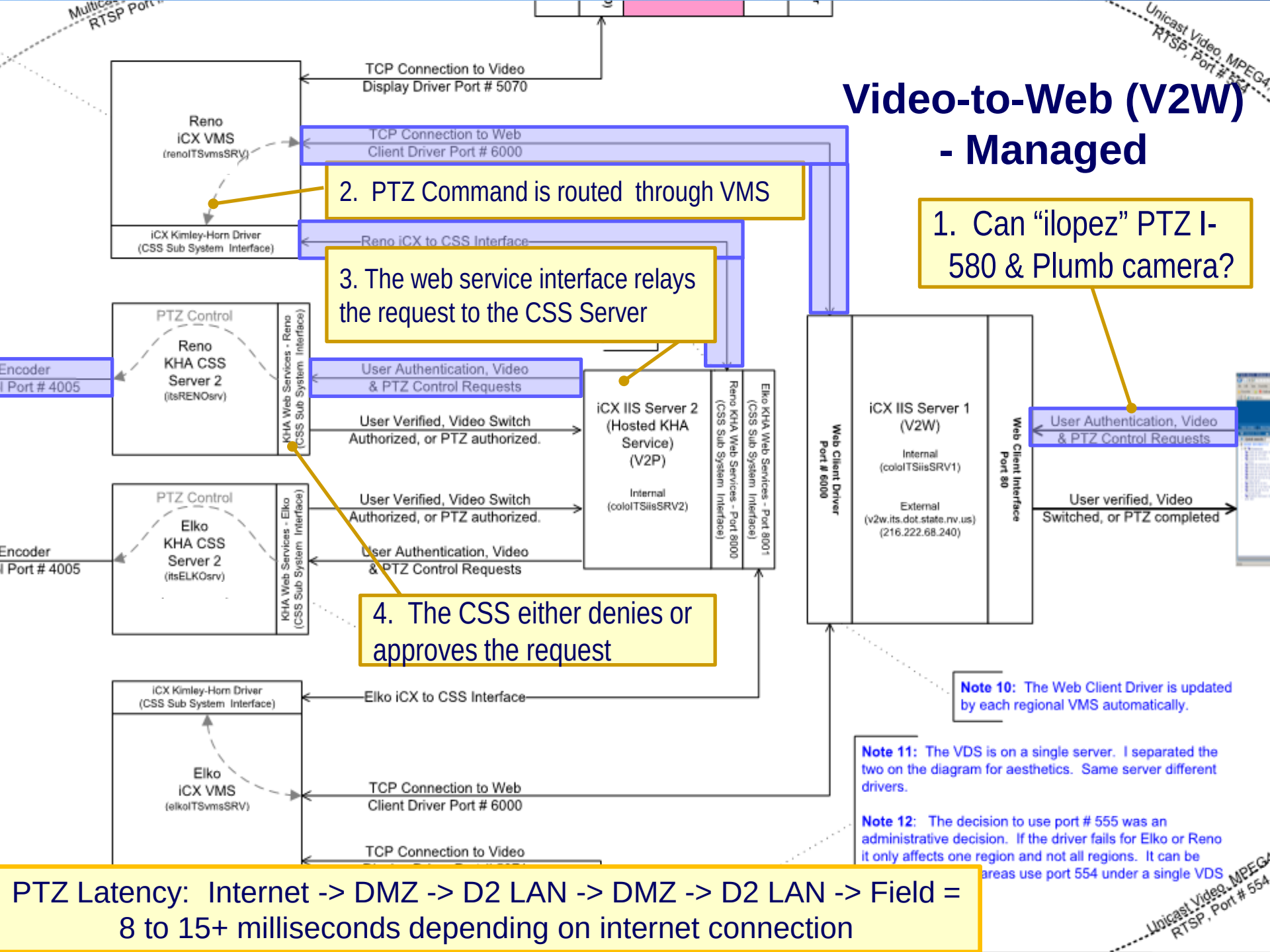
1. Can “ilopez” PTZ I-580 & Plumb camera?



3. If “ilopez” does not have permissions then a deny notification is sent

2. If “ilopez” does have permissions. CSS issues a PTZ command to Camera

Video-to-Web (V2W) - Managed



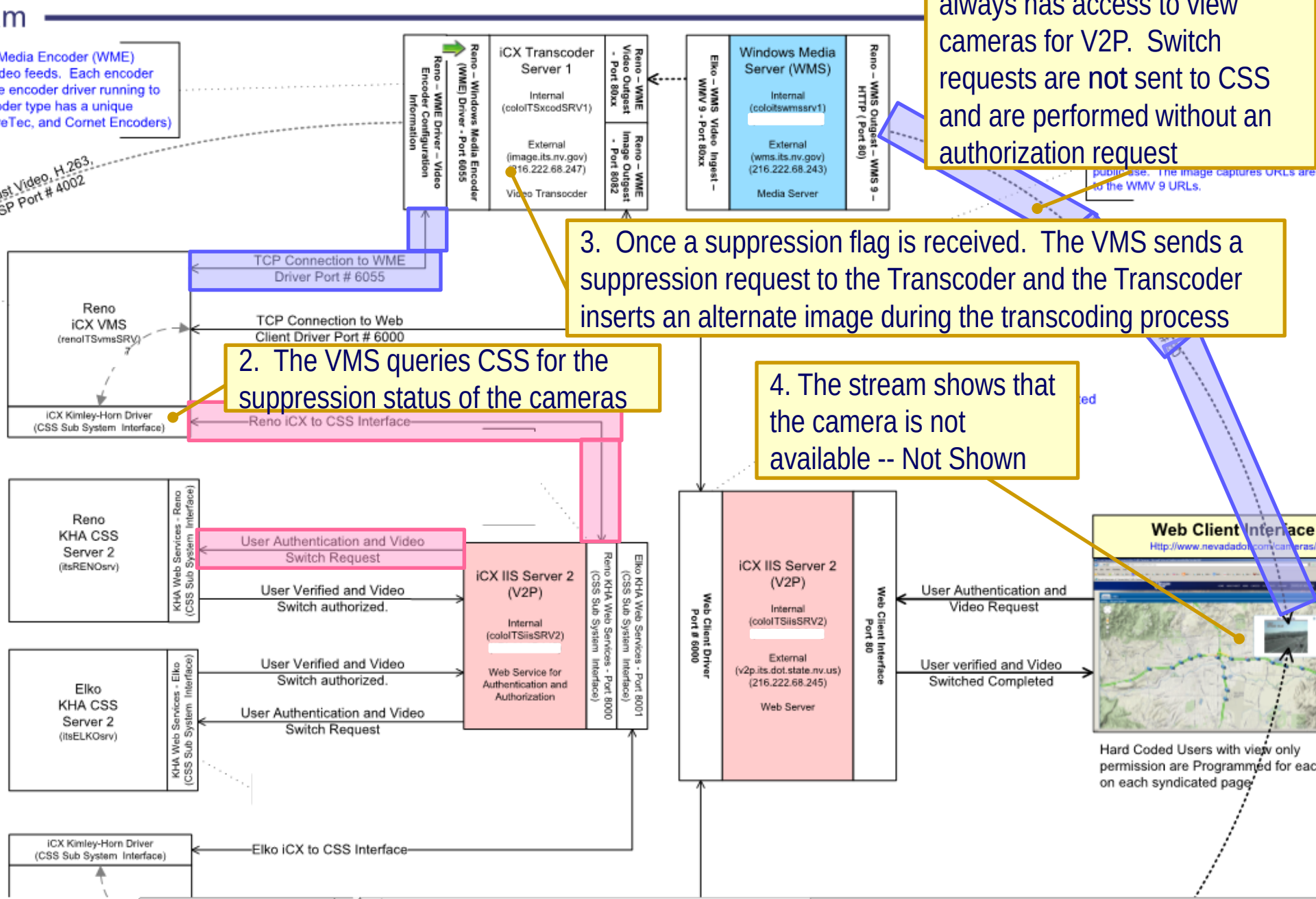
Note 10: The Web Client Driver is updated by each regional VMS automatically.

Note 11: The VDS is on a single server. I separated the two on the diagram for aesthetics. Same server different drivers.

Note 12: The decision to use port # 555 was an administrative decision. If the driver fails for Elko or Reno it only affects one region and not all regions. It can be areas use port 554 under a single VDS

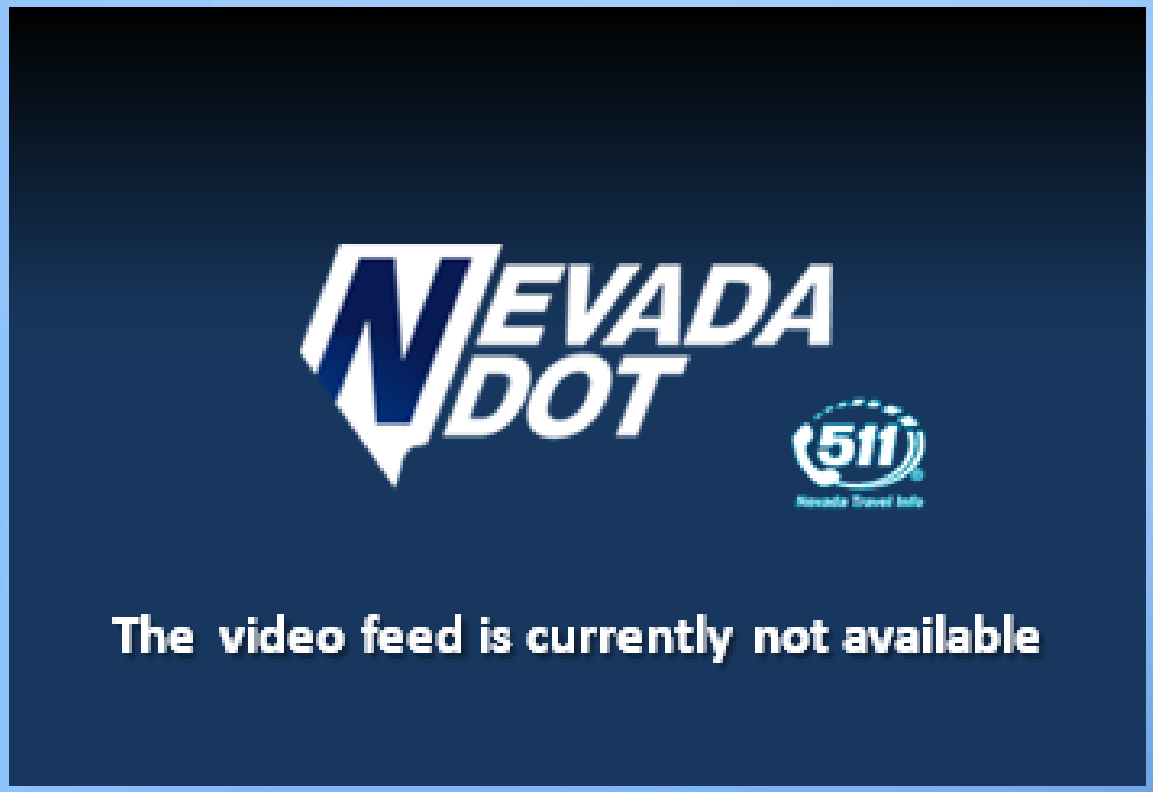
PTZ Latency: Internet -> DMZ -> D2 LAN -> DMZ -> D2 LAN -> Field = 8 to 15+ milliseconds depending on internet connection

Video-to-Public (V2P) – Unman



Web Services Description Language (WSDL)

- Video suppression image for V2P (Still & Streaming)



WSDL Lessons Learned

- WSDL should have included the IP and network configuration information for each camera for easier configuration by Administrators
- The configuration information for each camera must be entered manually and is often unique to a particular brand
- Create an established method for determining the health of the WSDL through a secondary Web UI for CSS. FLIR currently has this interface

WSDL Lessons Learned

- Have the ability to stop and restart the WSDL web services at pre-determined times through the WebUI for continued operations
- Stop and Restarting a service can be done manually by going to each CSS web service server
- The system in Las Vegas is 12x bigger (480 cameras) than the Reno and Elko Project. FLIR still polls all cameras regardless of their distribution status

WSDL Lessons Learned

- There have been several instance when the WSDL has failed for Las Vegas
  - This has been corrected by having FLIR log what cameras are suppressed at the time they query CSS to help identify if the problem is a WSDL issue or network issue
  - Additional improvements have been made such as changing the poll frequency from 5 seconds to 30 seconds

Video Distribution Infrastructure

Video Distribution Infrastructure for Elko / Reno

- NDOT has a 100 Mbps internet circuit for V2P and V2W
- V2P has been designed to provided access to 292 simultaneous internet users at 75% capacity.
- V2W (Reno / Elko) has been designed to provide access to 30 web users for District 2 and District 3 (combined). Viewing 18 CCTV camera feeds at 4CIF, 4 Mbps, & 30 FPS will utilize 75% of our 100 Mbps internet circuit
- Internal users are not included in these counts. They connect directly to the servers using internal infrastructure

Video Distribution Infrastructure for Elko / Reno

- This particular deployment does not have enough bandwidth for both simultaneous demands
- V2P is extremely popular and averages roughly to 200 to 250 unique visitors a day. This product was released in January 2012. Summer months are our slowest months.
- V2W is often used by staff working remotely, technicians, and other strategic partners. Though equally important it is not the celebrity of V2P until an emergency occurs

Video-to-Public (V2P) Reno / Elko – Google Analytics

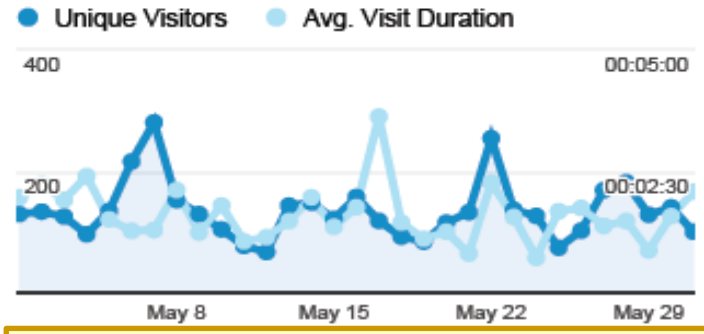
Unique Visitors and Pageviews by …

Visitor Type	Unique Visitors	Pageviews
New Visitor	2,529	3,311
Returning Visitor	867	2,797

Unique Visitors and Avg. Time on …

Page	Unique Visitors	Avg. Time on Page
/cameras/default-Reno.asp	1,638	00:04:58
/cameras/default-vegas.asp	1,310	00:06:31
/cameras/default-Elko.asp	418	00:04:04
/cameras/default-elko.asp	1	00:00:00
/CAMERAS/DEFAULT-ELKO.ASP	1	00:00:00
/translate_c?depth=1&hl=en&langpair=en|es&rurl=translate.google.com&u=http://apps.nevadadot.com/cameras/default-	1	00:00:00

Unique Visitors and Avg. Visit Duration



We have a version of the FAST camera site at NDOT

Unique Visitors and Visit Duration by Source / Me…

Source / Medium	Unique Visitors	Visit Duration
nevadadot.com / referral	2,134	74:32:53
(direct) / (none)	573	34:58:03
google / organic	158	08:11:33
sharepoint / referral	109	02:37:10
magnifeye.com / referral	61	01:01:13
shptsrv1 / referral	45	03:05:16
bing / organic	17	00:33:52
renotahoeweather.com / referral	13	00:06:09
yahoo / organic	11	00:08:56
nvroads.com / referral	6	00:00:34

Unique Visitors and Pageviews by …

City	Unique Visitors	Pageviews
Reno	524	1,112
Las Vegas	504	1,000
Carson City	215	426
Mesa	69	82
San Francisc	68	132
Phoenix	57	104
Elko	57	92
Henderson	55	102
North Las Vegas	51	95
Sparks	44	68

Time on Site by Country

Browser	Unique Visitors	Pageviews
Internet Explorer	1,910	4,135
Chrome	394	642
Firefox	386	652

Video Distribution Infrastructure for Las Vegas

- Las Vegas has a dedicated 1 Gbps internet connection for V2W and V2P
- V2P Las Vegas has a theoretical service limit of 2,930 simultaneous video feeds based on the internet connection. Actual is 600 simultaneous users
- V2W Las Vegas is designed to provide access to 30 web users for D1 / FAST. Viewing 188 CCTV camera feeds at 4CIF, 4 Mbps, & 30 FPS will utilize 75% of our 1 Gbps internet circuit

Video Distribution Infrastructure for Las Vegas

- This particular deployment has enough bandwidth for both simultaneous demands and can provide a high service level to users
- V2P Las Vegas is popular as well and averages roughly to 200 to 300 unique visitors a day. This product was released at the at the beginning of the year (Jan 2013) and is in the final stages of testing
- NDOT is establishing a 300 Mbps fiber optic connection from Reno to Elko to Salt City to Las Vegas (Approx. 950 miles) through a provider

Video-to-Public (V2P) Las Vegas – Google Analytics

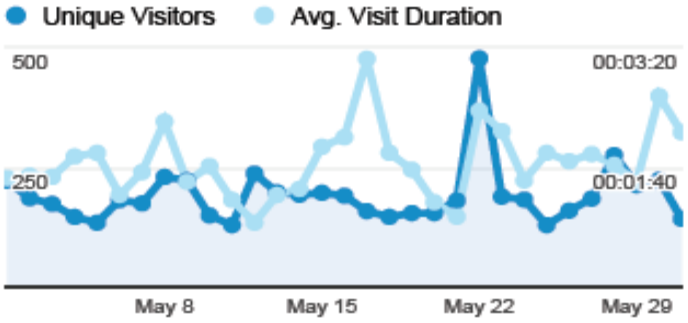
Unique Visitors and Pageviews by …

Visitor Type	Unique Visitors	Pageviews
New Visitor	4,258	5,531
Returning Visitor	768	3,440

Unique Visitors and Avg. Time on …

Page	Unique Visitors	Avg. Time on Page
/	4,601	00:05:51
/translate_c?depth=1&hl=de&prev=/search?q=las+vegas+strip+bus+stop&hl=de&biw=1024&bih=672&rurl=translate.google.de&sl=en&u=http://v2p.nvfast.org/&usg=ALkJrhirLFmkYtqSpIRw8AVQ-7KF1K_HcA	1	00:00:12
/translate_c?depth=1&hl=en&rurl=translate.google.com&sl=en&tl=el&u=http://v2p.nvfast.org/&usg=ALkJrhhKBq-q-UOuBWPPz5HRC5zz	1	00:00:00

Unique Visitors and Avg. Visit Duration



NDOT version of FAST cameras is listed as referral

Unique Visitors and Visit Duration by Source / Me…

Source / Medium	Unique Visitors	Visit Duration
rtcsnv.com / referral	3,035	123:49:15
apps.nevadadot.com / referral	1,129	63:56:27
rtcsouthernnevada.com / referral	429	12:00:02
(direct) / (none)	46	02:36:06
catride.com / referral	3	00:05:12
translate.google.com / referral	2	00:00:23
google-analytics.com / referral	1	00:00:00
translate.google.com.br / referral	1	00:01:41

Unique Visitors and Pageviews by …

City	Unique Visitors	Pageviews
Las Vegas	1,658	3,182
Henderson	248	441
Hartford	156	183
North Las Vegas	150	264
geles	86	211
(not set)	74	117
Carson City	62	84
Phoenix	56	108
Oakland	40	83
New York	28	43

Unique Visitors and Pageviews by …

Browser	Unique Visitors	Pageviews
Internet Explorer	2,551	5,235
Chrome	1,001	1,645
Firefox	660	1,122
Android Brows	170	285

511 and V2P web sites

- The new 511 system was released at the end of April 2013
- The new 511 uses all the V2P URLs for Las Vegas and Reno/Elko areas as part of their system
- Utilization of the URLs is not included in the Google Analytics page for Reno, Elko, and Las Vegas
- The numbers for the 511 CCTV cameras is in addition to the existing utilization for the V2P websites
- Google Analytics only counts actual visits to the web client

511 and V2P web sites

- The new 511 system utilizes a unique ID for each camera which is triggered as an event in Google Analytics. This allows NDOT to identify camera utilization as a group or individually

511 and V2P web sites

- The 511 system continues to have the same limitation of not being able track the URL for the video stream
- In the current V2P system we cannot track utilization by individual camera. For instance, we cannot track the most popular cameras being used by the Public
- This issue has been resolved in the new 511 system

511 System – Google Analytics

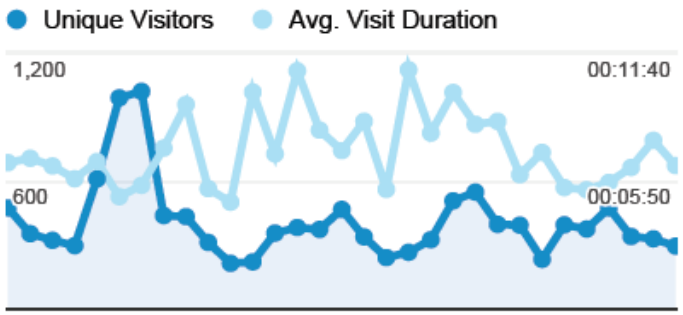
Unique Visitors and Pageviews by …

Visitor Type	Unique Visitors	Pageviews
New Visitor	8,925	14,760
Returning Visitor	1,727	11,939

Unique Visitors and Avg. Time on …

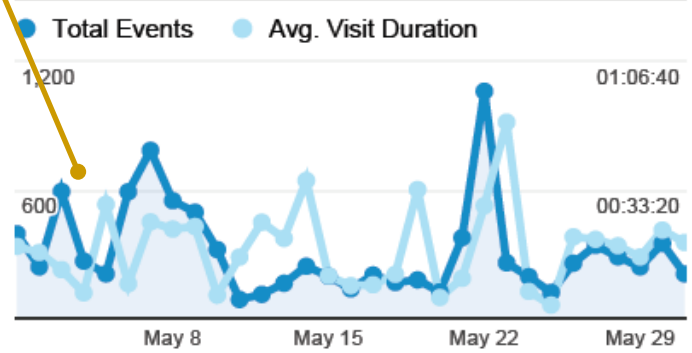
Page	Unique Visitors	Avg. Time on Page
/	9,178	00:10:54
/icx/pages/incidentlist.aspx	902	00:01:42
/511-home	593	00:06:18
/icx/pages/Comment.aspx	170	00:01:34
/icx/pages/IncidentList.aspx?listType=Incidents	166	00:02:14
/about-511-nevada/overview	111	00:01:01
/icx/pages/IncidentList.aspx?listType=All	97	00:01:56

Unique Visitors and Avg. Visit Duration



Each Camera has a unique event ID and can be tracked for usage

Unique Visitors and Avg. Visit Duration -- CCTV r…



Unique Visitors and Visit Duration by Source / Me…

Source / Medium	Unique Visitors	Visit Duration
(direct) / (none)	3,305	814:12:44

Unique Visitors and Pageviews by …

City	Unique Visitors	Pageviews
Reno	1,432	4,807
Las Vegas	799	2,591
San Francisco	778	1,911
Carson City	554	3,529
Los Angeles	233	438
Gardnerville	181	543
South Lake Tahoe	173	388
(not set)	171	376
Phoenix	161	334
Elko	136	387

Unique Visitors and Pageviews by …

Browser	Unique Visitors	Pageviews
Internet Explorer	3,957	13,092
Safari	2,010	4,412

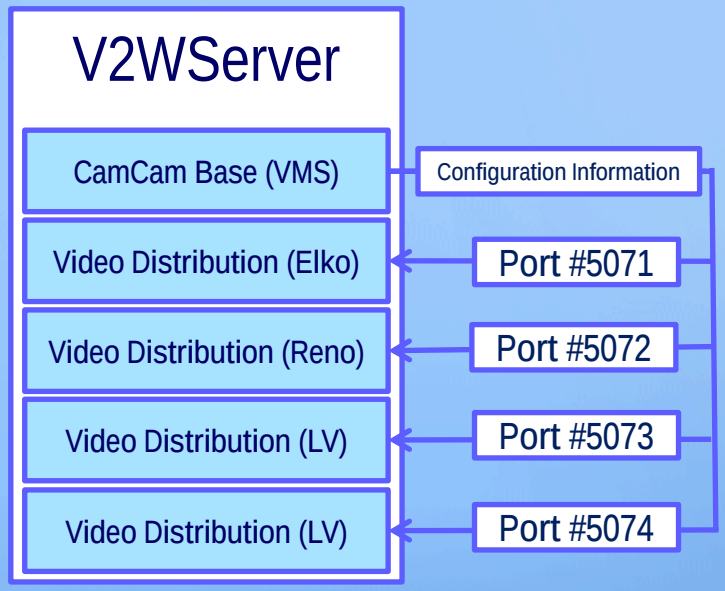
V2W Video Distribution

V2W Video Distribution

- The Video Management Server (VMS) obtains the device information from Central System Software (CSS)
- Unfortunately, this excludes any IP or networking configuration information for the camera. This information must be obtained from the District and is entered into the VMS
- The Video Distribution Server (VDS) is configured through the VMS. All virtual connections are configured in the VMS then the information is pushed to the VDS through a VDS driver

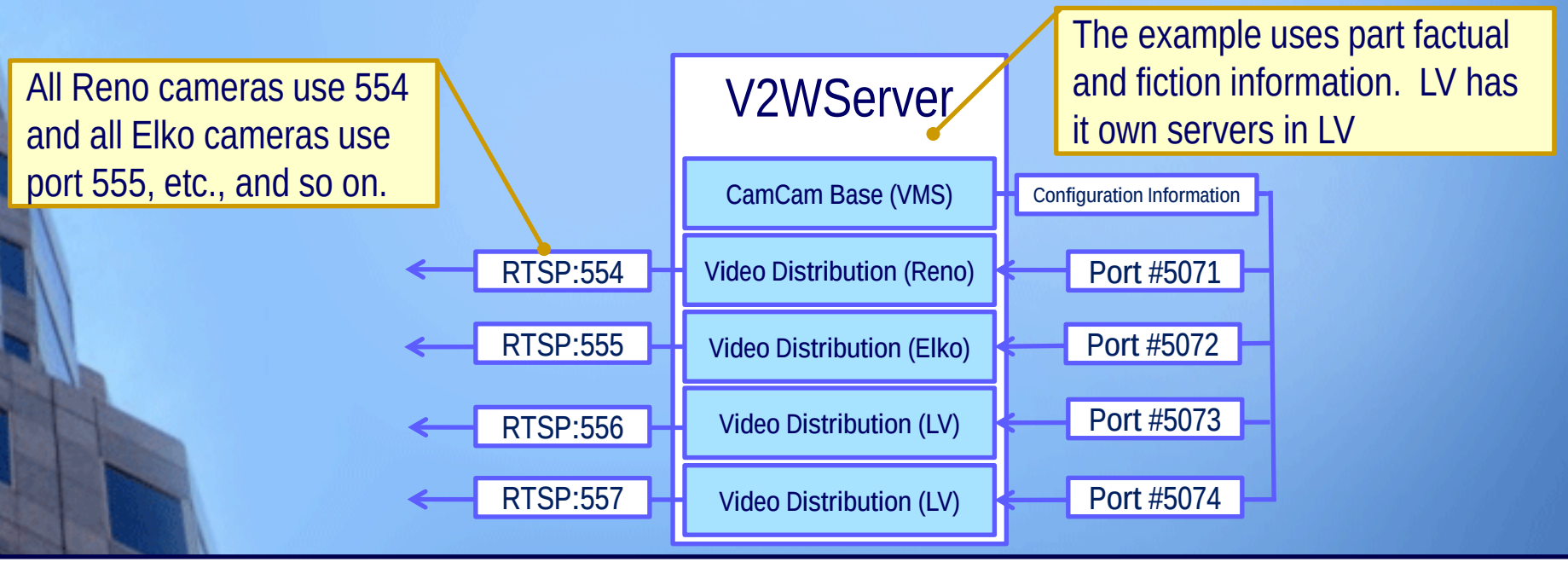
V2W Video Distribution

- The driver can be unique to a particular entity or function. We can have multiple versions of the same driver for different entities on the same server



V2W Video Distribution

- The system uses RTSP for video distribution over port 554 for Reno and port 555 for Elko. You can only have one instance for a particular port so you have to assign RTSP over other non-standard ports. This an example:



Test case: rtsp://vds.its.nv.gov:554/vdd_-_galletti_at_kietzke / rtsp://vds.its.nv.gov:555/VDD_-_I80_and_Carlin_Tunnel_West

V2W Video Distribution

- The V2W system is a Video-on-Demand (VOD) based system
- The VDS does not ingest video until a user requests a video feed. It discards the packets until a video switch request is made
- This saves on server resources and only utilizes the resources needed to serve the video at request
- Though this does absorb network resources (bandwidth of camera) and some minor server resources for monitoring

V2W Video Distribution

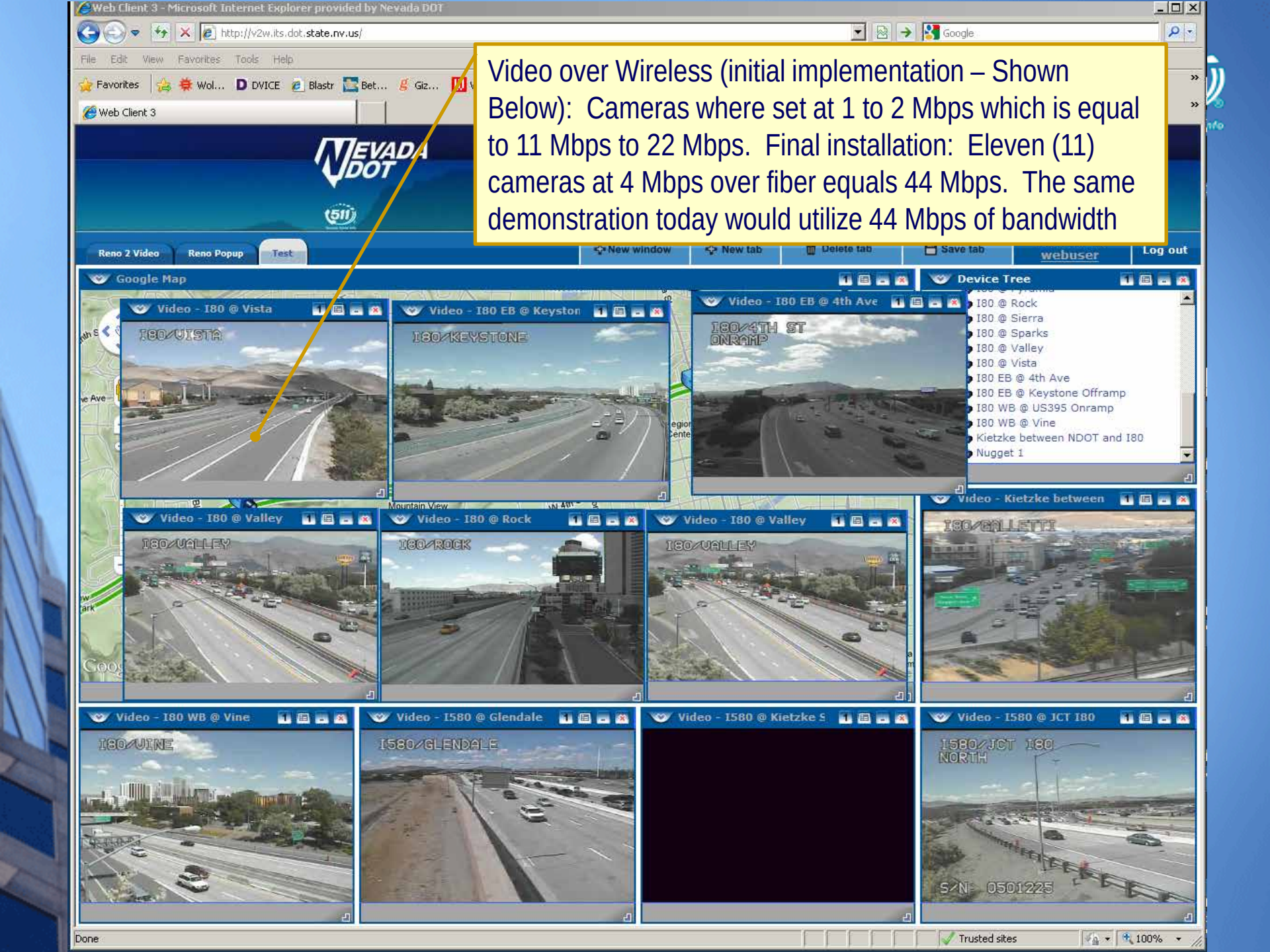
- The VDS ingests a multicast feed for distribution as a Unicast stream. None of the original variables change on the video feed. 4CIF, 4 Mbps, 30FPS -> VDS - > 4CIF, 4 Mbps, 30FPS
- The system essential maps an outside internet URL to the original feed
- The system uses RTSP as the distribution method
- Multiple users can access the system simultaneously

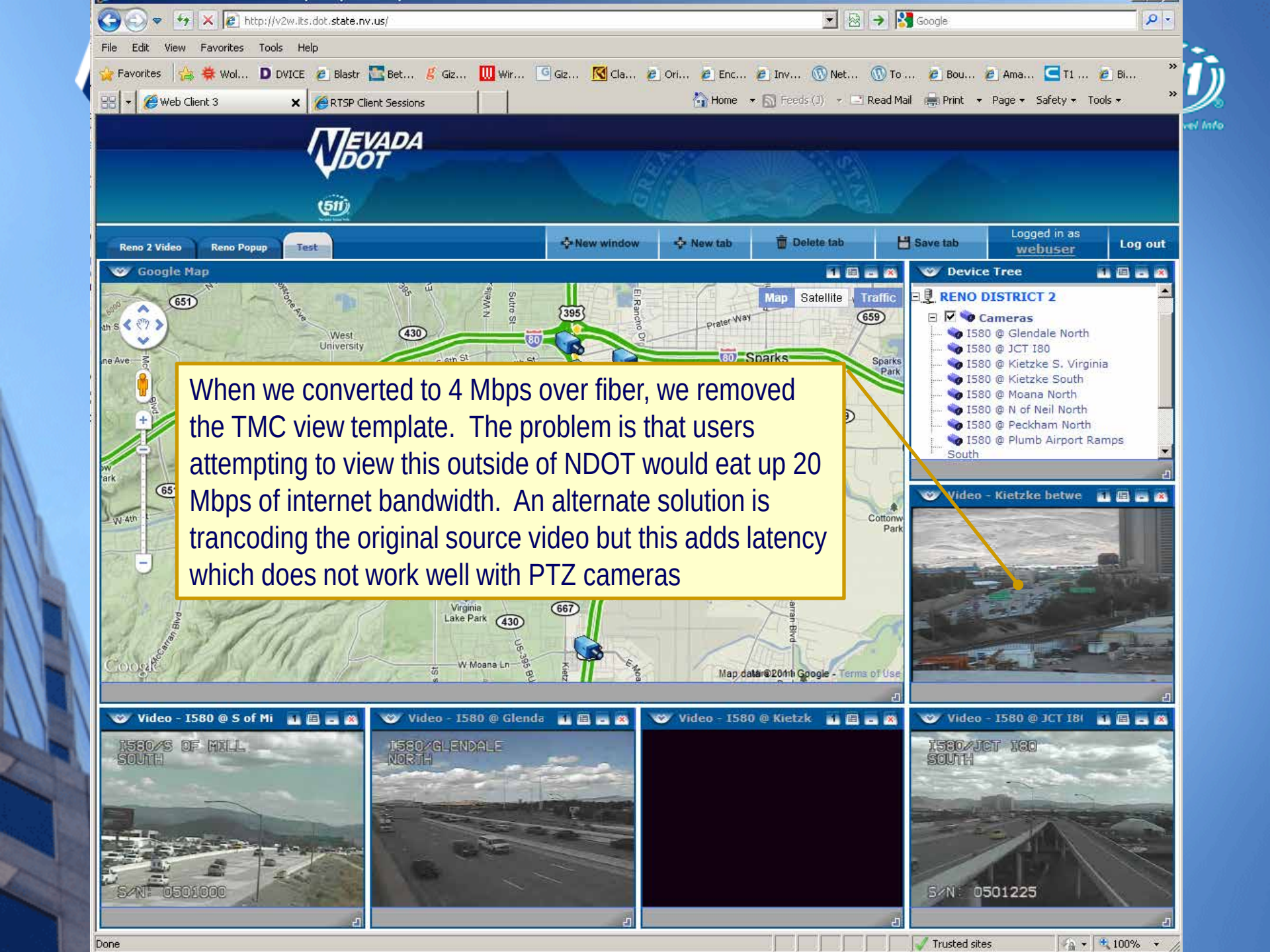
V2W Video Distribution

- Multiple users can access the same video feed simultaneously
- The RTSP URL can be played on desktop and mobile devices
- Always remember the one application one port rule. For TCP/IP, we can only have one application listening on a single port at one time

V2W Video Distribution Lessons Learned

- No real lesson learned by the platform. The system effectively does the following:
  - Minimum use of server resources
  - Dynamic configuration of CCTV camera feeds
  - Video distribution within the same platform (A media server is normally needed)
  - Availability of video outside the web client
  - Distribution using a common protocol (RTSP)
- The only lesson learned is having two feeds. One for distribution to the public/partners and one for internal consumption


Video over Wireless (initial implementation – Shown Below): Cameras where set at 1 to 2 Mbps which is equal to 11 Mbps to 22 Mbps. Final installation: Eleven (11) cameras at 4 Mbps over fiber equals 44 Mbps. The same demonstration today would utilize 44 Mbps of bandwidth
Web Client 3 - Microsoft Internet Explorer provided by Nevada DOT
http://v2w.its.dot.state.nv.us/
Web Client 3
NEVADA DOT
Reno 2 Video
Reno Popup
Test
New window
New tab
Delete tab
Save tab
webuser
Log out
Google Map
Device Tree
I80 @ Rock
I80 @ Sierra
I80 @ Sparks
I80 @ Valley
I80 @ Vista
I80 EB @ 4th Ave
I80 EB @ Keystone Offramp
I80 WB @ US395 Onramp
I80 WB @ Vine
Kietzke between NDOT and I80
Nugget 1
Video - I80 @ Vista
I80/VISTA
Video - I80 EB @ Keyston
I80/KEYSTONE
Video - I80 EB @ 4th Ave
I80/4TH ST ONRAMP
Video - I80 @ Valley
I80/VALLEY
Video - I80 @ Rock
I80/ROCK
Video - I80 @ Valley
I80/VALLEY
Video - Kietzke between
I80/GALLETTI
Video - I80 WB @ Vine
I80/VINE
Video - I580 @ Glendale
I580/GLENDALE
Video - I580 @ Kietzke S
Video - I580 @ JCT I80
I580/JCT I80 NORTH
S/N 0501225
Done
Trusted sites
100%


When we converted to 4 Mbps over fiber, we removed the TMC view template. The problem is that users attempting to view this outside of NDOT would eat up 20 Mbps of internet bandwidth. An alternate solution is trancoding the original source video but this adds latency which does not work well with PTZ cameras
NEVADA DOT
Reno 2 Video
Reno Popup
Test
New window
New tab
Delete tab
Save tab
Logged in as webuser
Log out
Google Map
Device Tree
RENO DISTRICT 2
Cameras
I580 @ Glendale North
I580 @ JCT I80
I580 @ Kietzke S. Virginia
I580 @ Kietzke South
I580 @ Moana North
I580 @ N of Neil North
I580 @ Peckham North
I580 @ Plumb Airport Ramps South
Video - Kietzke betwe
Video - I580 @ S of Mi
I580/S OF MILL SOUTH
S/N: 0501000
Video - I580 @ Glenda
I580/GLENDALE NORTH
Video - I580 @ Kietzk
Video - I580 @ JCT I8
I580/JCT I80 SOUTH
S/N: 0501225

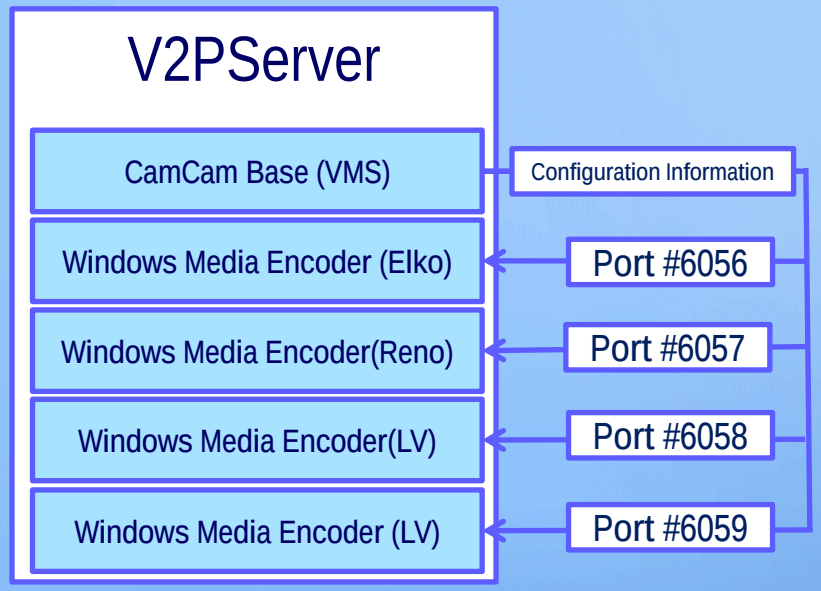
V2P Video Distribution

V2P Video Distribution

- V2P has similar limitations to V2W for device configuration
- The Windows Media Encoder (WME) driver is configured through the VMS. All virtual connections are configured in the VMS then the information is pushed to the WME through a WME driver

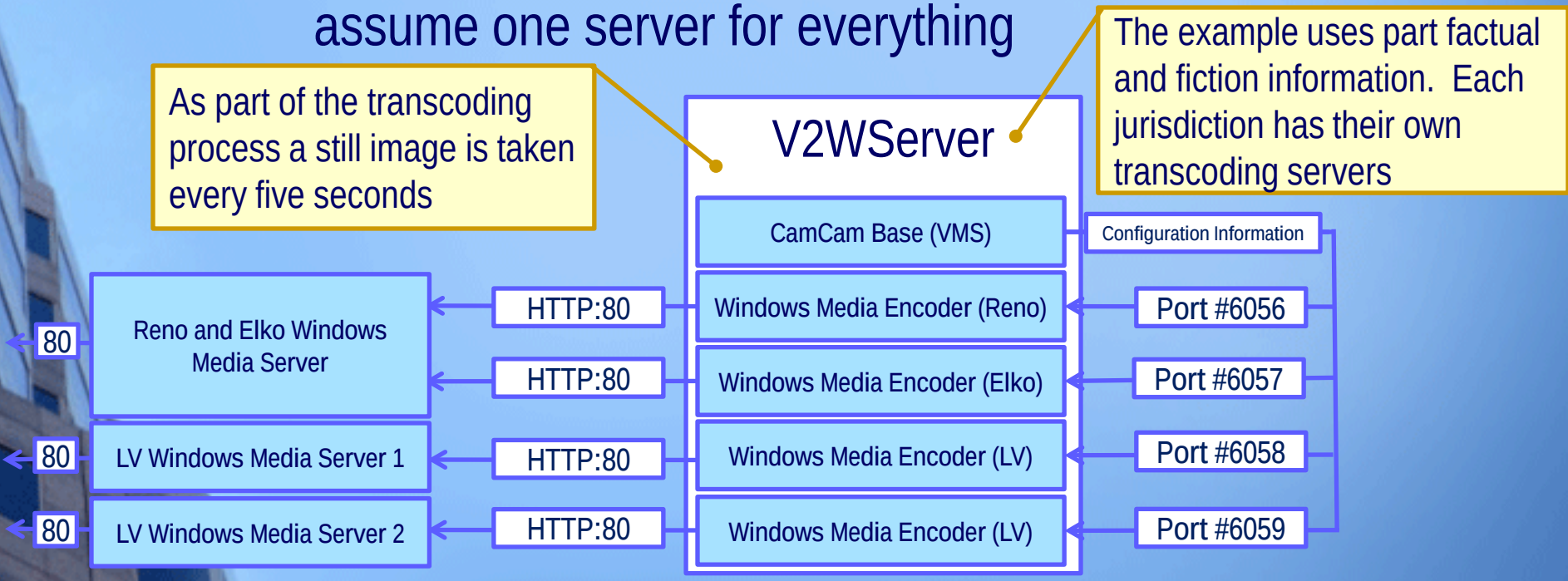
V2P Video Distribution

- The driver can be unique to a particular entity or function. We can have multiple versions of the same driver for different entities on the same server



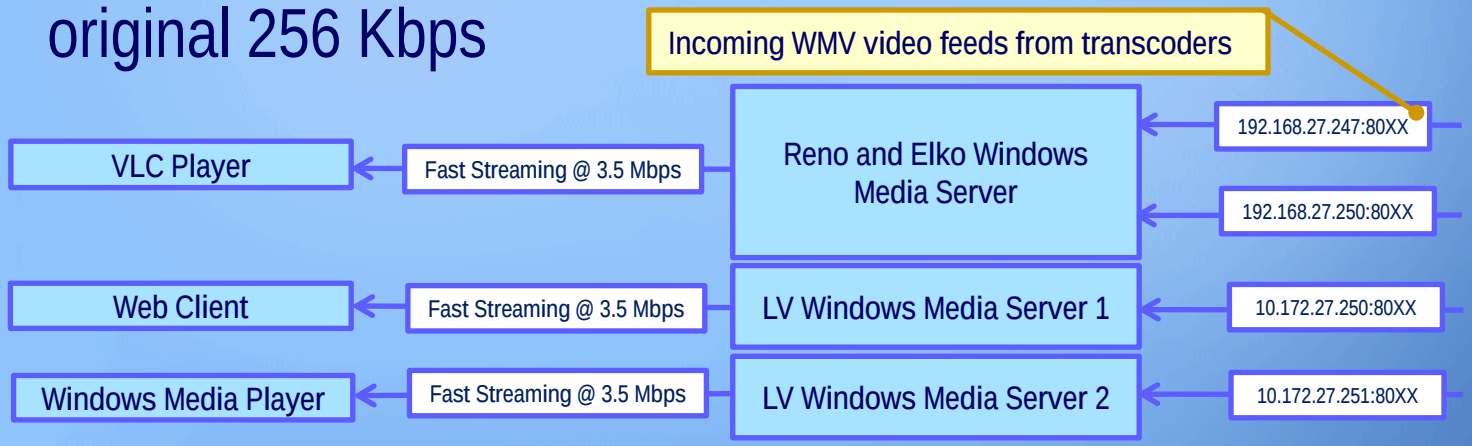
V2P Video Distribution

- The system uses HTTP for video distribution over port 80 for Reno and Elko. Reno and Elko have their own individual transcoding servers. In this instance lets assume one server for everything



V2P Video Distribution

- The system uses Windows Media Server Fast Streaming capabilities. The Fast Streaming functionality allows a user to receive the first 30 to 50 seconds of video within first 1 second at 3.5 Mbps. The connection then slowly normalizes back to 256 Kbps over the next 60 seconds. The 3.5 Mbps is approximately 14 times faster than original 256 Kbps



V2P Video Distribution

- The V2P system is a Always-On (AO) based system. A transcoder is generally a brute force device built for the sole purpose of converting video to other formats, bit rates, resolutions, and FPS
- The WME transcoder is constantly ingesting video regardless if a user requests a video feed
- There is a delay in the transcoding process of approximately 20 to 40 seconds (depends on complexity)
- The transcoder absorbs network resources (bandwidth of camera) and server resources for monitoring

V2P Video Distribution

- The WME transcoder ingests a multicast feed for distribution as a Unicast stream. Most of the original variables change on the video feed. 4CIF, 4 Mbps, 30FPS -> WME - > CIF, 256 Kbps, 30FPS (1/16th the original size)
- The WME transcoder sends the transcoding stream to a Windows Media Server
- The system uses HTTP as the distribution method
- Multiple users can access the system simultaneously

V2P Video Distribution

- Multiple users can access the same video feed simultaneously
- The same HTTP URL cannot be played on a Windows desktop platform and mobile device. The URL must be modified

V2P Video Distribution Lessons Learned

- The system uses Windows Media Video (WMV) and is not natively supported in other browsers (Firefox, Chrome, etc). A plug-in must be installed by the user.
  * At the time of design Windows had 86% of the market share
- Video can be displayed on iPad or iPhone using Good Player App with a modified version of the URL. The mobile URL does not work with Windows desktop
- During design in 2010, HTML 5 was being developed as a standard and the final standard to be released in April 2014

Good Player iPhone or iPad URL: mmsh://wms.its.nv.gov:80/wme_-_galletti_at_kietzke_MSWMExt=.wmv

V2P Video Distribution Lessons Learned

- Over the last several years H.264 has become the official champion of internet video distribution. The choice to use WMV was a valid choice at the time
- We plan to convert all streams to H.264 for V2W and V2P. We will ingest the original video stream and convert the stream to two smaller video feeds. One for distribution to the Public / mobile devices at 256 Kbps or higher and another for Strategic partners at 1 Mbps or higher.
- After talking with the vendor, they agreed to provide a demo for testing purposes in July

DVEO Brutus Transcoder: http://www.dveo.com/Streaming-Video-HTTP-RTSP-Flash-IPTV/Cloud-Based-Transcoders.html

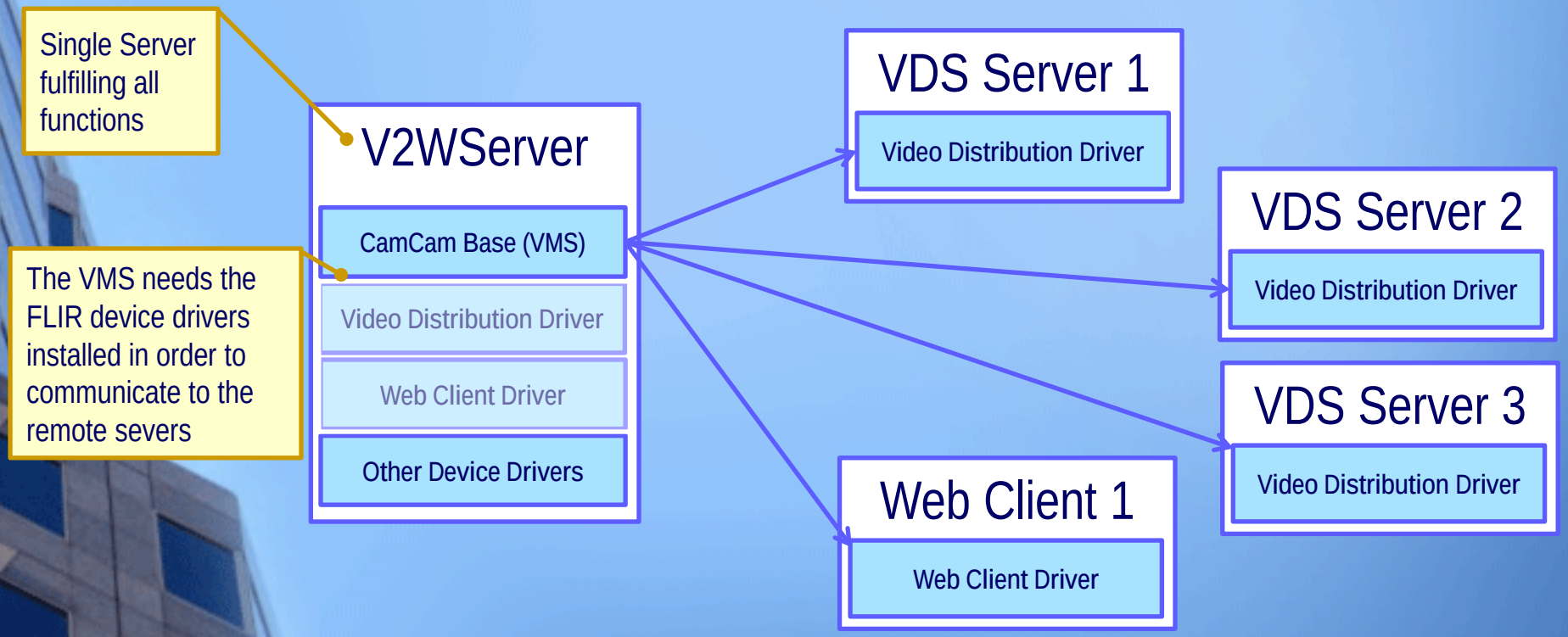
System Scalability

System Scalability

- Camera Cameleon (CamCam) is a video management software (VMS) that controls devices such as CCTV cameras, DMS signs, and other ITS devices
- The system uses a driver based architecture
- The base software is installed on each server
- A specific driver for a particular device is installed on the VMS server (CCTV camera, DMS sign, etc.)
- Only those drivers relevant to your system are installed

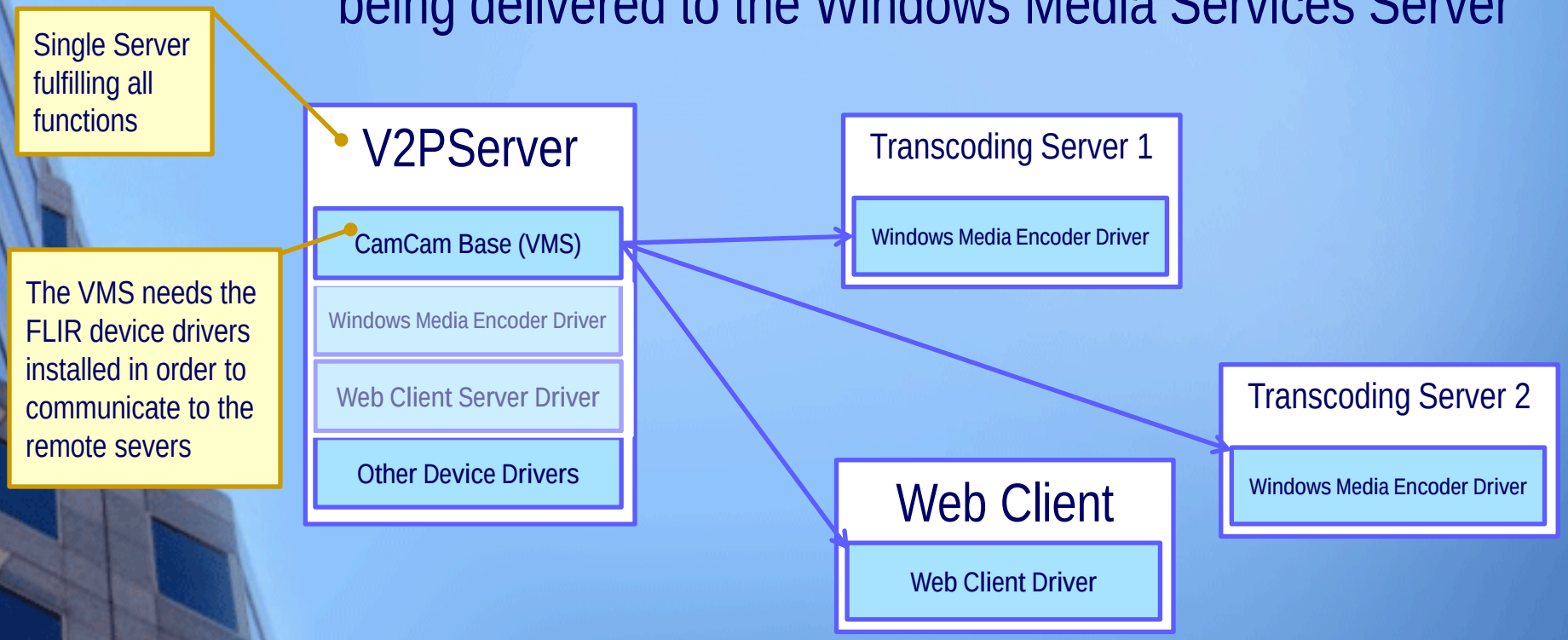
V2W System Scalability

- Drivers specific to your environment can be installed on the same server or other servers for expandability



V2P System Scalability

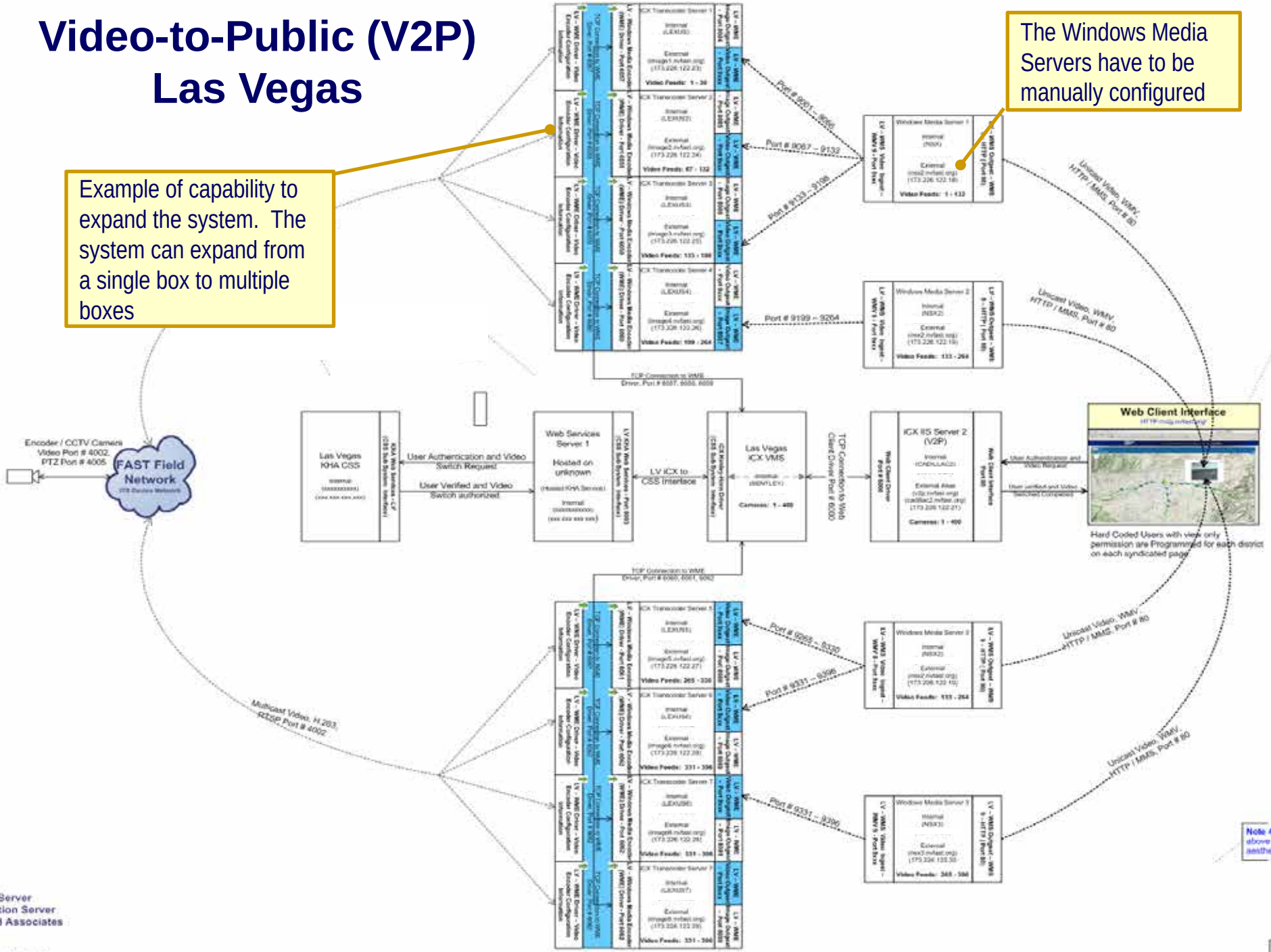
- V2P has the same expandability and functionality as V2W
- The diagram does not include the transcoded stream being delivered to the Windows Media Services Server



Video-to-Public (V2P) Las Vegas

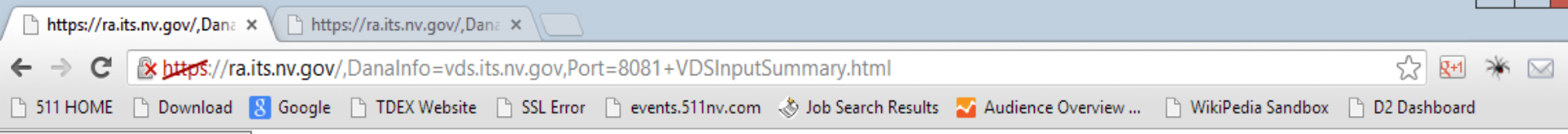
Example of capability to expand the system. The system can expand from a single box to multiple boxes

The Windows Media Servers have to be manually configured



System Scalability Lessons Learned

- The V2P system does not track the URLs similar to V2W
- An Excel spreadsheet must be compiled and verified to ensure accurate information
- V2P uses Windows Media Services for distribution. FLIR would have to develop an interface to extrapolate the URLs for still images out of the VMS and streaming URLs for Windows Media Services



SURVEILLANCE

MEDIA VIEW™

SECURITY
SURVEILLANCE
TRANSPORTATION

CPU Load: 01%
Version: 1.5.314
Initialized: 6/4/2013 2:57:46 PM
Time: 6/4/2013 9:57:15 PM
Uptime: 6h

Video-to-Web (V2W) URLs
Reno

Input Media Summary | Output Client Sessions

NVR	Sessions	IP Address	Uptime	Kbps
Reno NVM	29	127.0.0.1	7h	93672

V2W can track all camera URLs and usage. No historical information though

Reno NVM Details

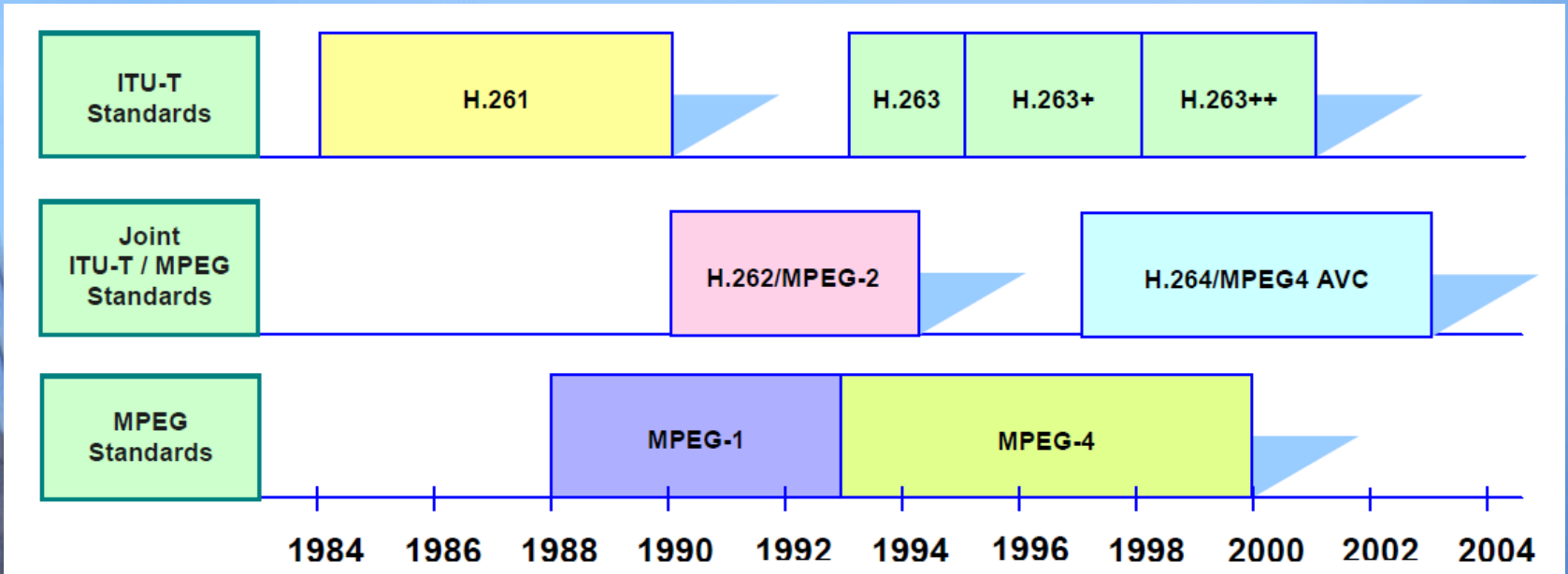
Live Streams

Name	URI	Payload	Uptime	Port	ID	Archiving	FPS	Kbps	GB Received
vdd_-_galletti_at_kietzke	rtsp://vds.its.nv.gov/vdd_-_galletti_at_kietzke	MPEG4	7h	59159	53	Disabled	31	969	0
vdd_-_i580_at_browns_creek_bridge	rtsp://vds.its.nv.gov/vdd_-_i580_at_browns_creek_bridge	MPEG4	7h	59159	78	Disabled	31	4015	0
vdd_-_i580_at_galena_creek_bridge	rtsp://vds.its.nv.gov/vdd_-_i580_at_galena_creek_bridge	MPEG4	7h	59159	77	Disabled	31	4005	0
vdd_-_i580_at_galena_forest_bridge	rtsp://vds.its.nv.gov/vdd_-_i580_at_galena_forest_bridge	MPEG4	6h	59159	75	Disabled	31	4048	0
vdd_-_i580_at_glendale_ave	rtsp://vds.its.nv.gov/vdd_-_i580_at_glendale_ave	MPEG4	7h	59159	49	Disabled	31	3916	0
vdd_-_i580_at_i80_n_e	rtsp://vds.its.nv.gov/vdd_-_i580_at_i80_n_e	MPEG4	7h	59159	46	Disabled	31	3494	0
vdd_-_i580_at_i80_s_w	rtsp://vds.its.nv.gov/vdd_-_i580_at_i80_s_w	MPEG4	7h	59159	47	Disabled	31	3488	0
vdd_-_i580_at_kietzke_lane	rtsp://vds.its.nv.gov/vdd_-_i580_at_kietzke_lane	MPEG4	7h	59159	48	Disabled	31	3504	0
vdd_-_i580_at_mill_st	rtsp://vds.its.nv.gov/vdd_-_i580_at_mill_st	MPEG4	7h	59159	50	Disabled	31	4011	0
vdd_-_i580_at_plumb_airport	rtsp://vds.its.nv.gov/vdd_-_i580_at_plumb_airport	MPEG4	7h	59159	52	Disabled	31	3605	0
vdd_-_i580_at_steamboat_hill_bridge	rtsp://vds.its.nv.gov/vdd_-_i580_at_steamboat_hill_bridge	MPEG4	7h	59159	73	Disabled	31	4000	0
vdd_-_i580_at_villanova_on_ramp	rtsp://vds.its.nv.gov/vdd_-_i580_at_villanova_on_ramp	MPEG4	7h	59159	51	Disabled	31	3528	0
vdd_-_i80_at_center_st_on_ramp	rtsp://vds.its.nv.gov/vdd_-_i80_at_center_st_on_ramp	MPEG4	7h	59159	62	Disabled	31	3003	0
vdd_-_i80_at_e_4th_st_kietzke_ln	rtsp://vds.its.nv.gov/vdd_-_i80_at_e_4th_st_kietzke_ln	MPEG4	7h	59159	64	Disabled	31	3012	0

Video Compression Algorithms

MPEG4 VS. MJPEG (Real-Time Video)

History of video Compression Development from 1984 to 2004. *A H.263 stream can be decoded by an MPEG-4 Video decoder



Comparing Media Codecs for Video Content : http://www.media-matters.net/docs/resources/Digital%20Files/General/Comparing%20Media%20Codecs%20for%20Video%20Content.pdf

MPEG4 VS. MJPEG (Real-Time Video)

Uncompressed Video Bandwidth

- The amount of H.264 compression required to transmit 1080p video over a 3 Mbps link is 332:1

Table 1. Display Resolution Format Comparison

Format	Horizontal Pixels	Vertical Lines	Pixels	Megabits per second (Mbps)
QVGA	320	240	76,800	37
VGA	640	480	307,200	147
720p	1280	720	921,600	442
1080p	1920	1080	2,073,600	~~995~~ **(1.45 Gbit/s)**

H.264 AVC Standard: http://www.logitech.com/assets/45120/logitechh.pdf

MPEG4 VS. MJPEG (Real-Time Video)

Uncompressed Video Bandwidth Requirements

Table 2. Compression Standards, Specs & Applications

ITU-T Recommendation		Year Ratified	Target Resolutions	Target Bit Rates	Target Applications
MPEG1	H.261	1988	352Q288 (CIF) 176Q144 (QCIF)	40 kbps - 2 Mbps	ISDN videophones
MPEG2 Part 2	H.262	1995	720Q480 720Q576 1280Q720 1920Q1080	1 - 25 Mbps	SD/HD Broadcast, DVD, HDV
MPEG4 Part 2 ~	H.263	1996	128Q96 176Q144 352Q288 704Q576 1408Q1152	20 kbps – 4 Mbps	Videoconferencing MMS Streaming Internet Video
MPEG4 Part 10	H.264	2003	128Q96 up to 4,096Q2,304	64 kbps up to 25 Mbps	Videoconferencing Broadcast Blu-ray Disc DV & Mobile phone cameras

H.264 AVC Standard: http://www.logitech.com/assets/45120/logitechh.pdf

MPEG4 VS. MJPEG (Real-Time Video)

Recommended Video Compression Settings

Please refer to Uncompressed Video Bandwidth table

MPEG1 (H.261) - Designed for 352x240 at 30 fps with a bit rate 1.15 Mbps with a targeted compression rate of 25:1

MPEG2 Part 2 (H.262) – Designed for 720x480 at 60 fps with a bit rate of 4 – 8 Mbps with a targeted compression rate of 30:1

MPEG4 Part 2 (H.263++, H263v3, H.263-2000) – The most confusing of all the standards and provides two other opportunities for incompatibility. No specific design requirement but a rule thumb is a compression ratio of 30:1. An example configuration is 640x480 (VGA) at 30 fps with a bit rate of 5 Mbps (4.9)

Comparing Media Codecs for Video Content : http://www.media-matters.net/docs/resources/Digital%20Files/General/Comparing%20Media%20Codecs%20for%20Video%20Content.pdf

MPEG4 VS. MJPEG (Real-Time Video)

Recommended Video Compression Settings

Please refer to Uncompressed Video Bandwidth table

MPEG4 part 10 AVC (H.264) and Windows Media Video – The rule of thumb for H.264 and WMV is a 60:1 compression ratio. An example configuration is 640x480 (VGA) at 30 fps with a bit rate of 2.45 Mbps

Comparing Media Codecs for Video Content : http://www.media-matters.net/docs/resources/Digital%20Files/General/Comparing%20Media%20Codecs%20for%20Video%20Content.pdf

MPEG4 VS. MJPEG (Real-Time Video)

- MJPEG – Motion JPEG
  - Each video frame is compressed into a separate JPEG image
  - Sends an intermediate frame (full image) every time
  - Works similar to a cartoon flip book
  - Images resolution must be reduced to meet the 400 – 600 kbps bandwidth requirement
  - Users are not required to receive all sent frames
  - Works well with latency or low bandwidth

OnSSI MPEG4 vs. MJPEG: http://www.onssi.com/downloads/OnSSI_WP_compression_techniques.pdf

MPEG4 VS. MJPEG (Real-Time Video)

- MPEG4 part 2 – Video Compression Algorithm
  - Sends an intermediate frame (full image) with updates
  - The updates are partial frames with pixel changes only
  - Users are required to receive all sent frames
  - Does not respond well to latency or low bandwidth
  - Does not scale well from fixed to mobile applications
  - Provides superior image quality than MJPEG
  - The amount data of transmitted is less than MJPEG by increasing complexity (more video processing)
  - More motion per frames requires an increase in bandwidth

OnSSI MPEG4 vs. MJPEG: http://www.onssi.com/downloads/OnSSI_WP_compression_techniques.pdf

MPEG4 VS. MJPEG (Real-Time Video)

- H.264 – Video Compression Algorithm
  - H.264 uses the same general coding techniques with new features
  - H.264 achieves a 2x~ reduction in bit rate versus MPEG-2 and MPEG-4 simple profile (SP)
  - H.264 can provide VHS quality (352 x 240) video at 600 Kbps
  - These encoding algorithm offers high compression at the expense of processing power at the encode and decode points

Comparing Media Codecs for Video Content : http://www.media-matters.net/docs/resources/Digital%20Files/General/Comparing%20Media%20Codecs%20for%20Video%20Content.pdf

An Alternate Perspective: Cable Company Video Transport

Cable Company Video Transport

Digital Cable (QAM)

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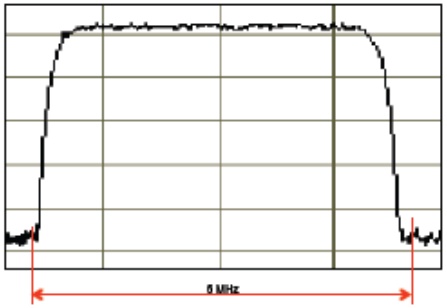


Type: Digital Cable (since 1990)
Name: QAM (Quadrature Amplitude Modulation)
Bandwidth: 6MHz
Capacity: Variable – depends of modulation scheme
QAM 64 modulation = 26.9 Mbps
QAM 256 modulation = 38.8 Mbps

QAM 64
64-Point Signal Constellation
26.9 Mbps bitrate
Can accommodate:
1x1080i HD program @ 17.9 Mbps,
or 4x480i SD programs each @ 4.2 Mbps,
or 1x720p HD program @ 8.8 Mbps + 2x480i SD programs at 4.2 Mbps,
or any combination not to exceed 26.9 Mbps

QAM 256
256-Point Signal Constellation
38.8 Mbps bitrate
Can accommodate:
1x1080i HD program @ 36.5 Mbps,
or 2x720p HD programs each @ 17.6 Mbps,
or 4x480i SD programs each @ 8.8 Mbps,
or 1x720p HD program @ 17.6 Mbps + 2x480i SD programs at 8.8 Mbps,
or any combination not to exceed 38.8 Mbps

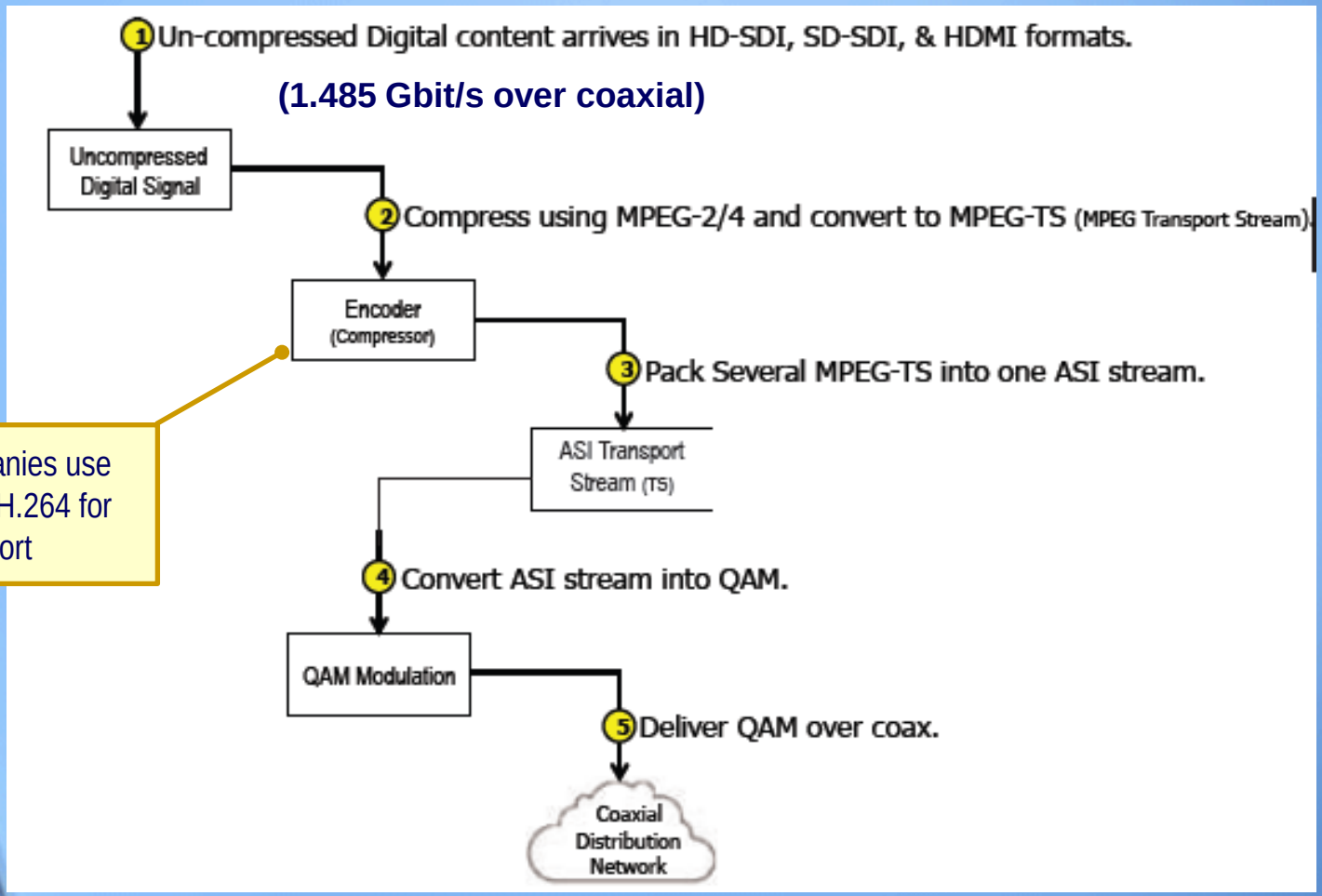
QAM64 = 26.9 Mbps

QAM256 = 38.8 Mbps

The system can accommodate multiple simultaneous streams

Blonder Tongue – Broadband Reference Guide: http://www.blondertongue.com/UserFiles/file/documents/2012%20BRG%20FINAL_lo-res.pdf

Cable Company Video Transport



Cable Companies use MPEG2 and H.264 for Video Transport

Blonder Tongue – Broadband Reference Guide: http://www.blondertongue.com/UserFiles/file/documents/2012%20BRG%20FINAL_lo-res.pdf

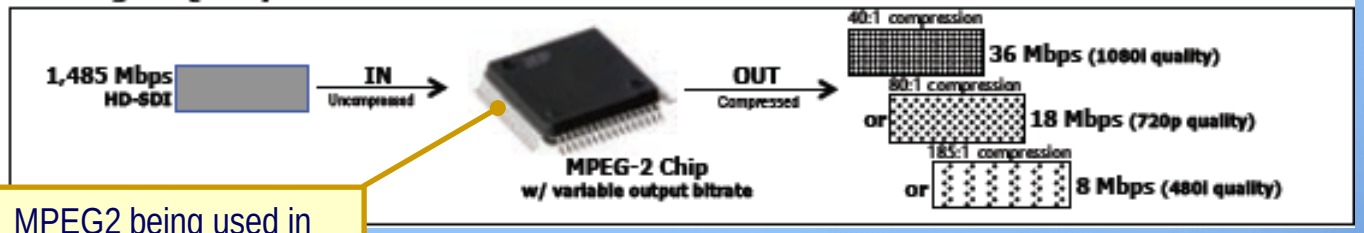
Cable Company Video Transport

Many MPEG Transport Stream can be encoded and carried simultaneously over ASI

Bitrates vs Bandwidth

Format	Description	Bitrate (Mbits/sec)	Bandwidth (MHz)
HD-SDI	Uncompressed High-Def digital stream	1,485	N/A
SD-SDI	Uncompressed Standard-Def digital stream	270	N/A
ASI	Typically carries multiple compressed HD/SD-SDI programs (via MPEG Transport Stream)	270	N/A
QAM-256	Digital Cable	38.8	6
QAM-64	Digital Cable	26.9	6
8VSB	Digital Over-the-Air	19.8	6

Encoding-vs-Quality Tradeoff



MPEG2 being used in this instance

Blonder Tongue – Broadband Reference Guide: http://www.blondertongue.com/UserFiles/file/documents/2012%20BRG%20FINAL_lo-res.pdf

Cable Company Video Transport

The system can decode 24 HD MPEG-2/H.264 streams

Cable company version of a video decoder

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EQAM-420 SERIES

EDGEQAM

1X GbE ▶ 8X QAM (CLEAR OR PRO:IDIOM™)

The EQAM-420 is designed to allow CATV operators to aggregate multiple HDTV programs received in IP format and to deliver them over a standard coaxial distribution network.

The EQAM-420 accepts up to twenty four (24) HD MPEG-2/H.264 Transport Stream (TS) in unencrypted (clear) 1000Base-T Ethernet (GbE) format, and aggregates them in up to eight (8) QAM RF channels in the 54-996 MHz range. The EQAM-420 can be configured with one or two output modules, each capable of delivering four (4) adjoining QAM channels. Each QAM channel can contain up to three (3) HD programs.

The EQAM-420 allows the operator to maintain the QAM RF output unencrypted, or to encrypt it with Pro:Idiom™ against content piracy. When Pro:Idiom™ encryption is activated, all QAM RF outputs will be encrypted regardless of the number of output modules present or the number of QAM RF channels assigned on each module. Pro:Idiom™ encryption is available to Pro:Idiom™ licensees only.

Comprehensive GUI-based remote monitoring and control capabilities, including SNMP-based management, allow CATV operators to remotely manage, operate, and trouble shoot the network via any standard Web browser.

Blonder Tongue – Broadband Reference Guide: http://www.blondertongue.com/UserFiles/file/documents/2012%20BRG%20FINAL_lo-res.pdf

Live Demo

Live Demo

The iCX Web Client requires an ActiveX plug-in in order to work. To demonstrate the flexibility of the platform I have not installed the plug-in prior to the presentation.

- http://www.nevadadot.com/cameras
- http://v2p.nvfast.org or http://v2p.its.nv.gov
- https://v2w.its.nv.gov or https://v2w.nvfast.org
- http://www.nvroads.com

The Scope of Work (SOW) for all V2W projects are available upon request for State and City agencies